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Age- and Sex-Related Variations in Serum Lipid Profile Parameters among Adults: A Comparative Cross-Sectional Study

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Abstract

Background: Abnormal lipid profiles are important risk factors for cardiovascular diseases. Age and sex may influence lipid metabolism and contribute to variations in serum lipid concentrations. Understanding these variations is essential for assessing cardiovascular risk in different population groups. **Aim:** This study aimed to investigate age- and sex-related variations in serum lipid profile parameters, including total cholesterol, triglycerides (TG), high-density lipoprotein cholesterol (HDL), and low-density lipoprotein cholesterol (LDL). **Methods:** A cross-sectional study was conducted involving 97 individuals, including 49 females and 48 males. Participants were classified into six age groups. Mean and standard deviation (Mean ± SD) were calculated for each lipid parameter. One-way analysis of variance (ANOVA) was used to compare lipid profile parameters across age groups, while Welch's independent samples t-test was applied to compare males and females. Age-adjusted comparisons were also considered using analysis of covariance (ANCOVA). **Results:** The findings revealed variations in lipid profile parameters across different age groups in both sexes; however, these differences were not statistically significant ($p > 0.05$). Comparison between sexes showed significantly higher mean total cholesterol levels among females (197.96 ± 43.63 mg/dL) compared with males (166.42 ± 54.73 mg/dL; $p = 0.002$). Similarly, LDL levels were significantly higher in females (129.49 ± 34.57 mg/dL) than in males (109.63 ± 45.30 mg/dL; $p = 0.017$). These differences remained significant after adjusting for age for total cholesterol ($p = 0.005$), while the LDL difference was significant before age adjustment but did not remain significant after correction for multiple comparisons. No statistically significant differences were observed in TG or HDL concentrations between sexes. **Conclusion:** The study demonstrated that sex-related differences were more evident than age-group differences in the investigated lipid profile parameters. Females exhibited higher total cholesterol and LDL concentrations than males, suggesting potential sex-related variations in lipid metabolism within the studied population. Further studies involving larger samples and more balanced age distributions are recommended to confirm these findings.

Keywords: Lipid profile; Total cholesterol; Triglycerides; HDL; LDL; Age; Sex differences; Cardiovascular risk.

1. Introduction

Dyslipidemia is one of the major modifiable risk factors associated with cardiovascular diseases (CVDs), which remain a leading cause of morbidity and mortality worldwide. It is characterized by abnormal concentrations of blood lipids, including elevated total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), as well as reduced high-density lipoprotein cholesterol (HDL-C). These abnormalities contribute to the development and progression of atherosclerosis, increasing the risk of coronary artery disease, stroke, and other cardiovascular complications (WHO, 2023). Blood lipid concentrations are influenced by several factors, including age, sex, genetic background, dietary habits, physical activity, obesity, and hormonal status. Age-related changes in lipid metabolism may result from alterations in hepatic lipid regulation, body composition, and endocrine function. In particular, cholesterol and LDL-C concentrations tend to change throughout adulthood, although these patterns may differ between males and females (Ference *et al.,* 2017).

Sex differences are also important determinants of lipid metabolism. Generally, females tend to have higher HDL-C concentrations than males during reproductive years, whereas hormonal changes associated with menopause may contribute to increases in total cholesterol, LDL-C, and triglycerides. Estrogen plays an important role in regula lipid metabolism through its effects on hepatic lipoprotein production and clearance.

Consequently, the menopausal transition may be accompanied by unfavorable changes in cardiovascular risk profiles **(Palmisano *et al.,* 2018; Ambikairajah et al., 2019).**

Among the different lipid parameters, LDL-C is considered a major causal factor in atherosclerotic cardiovascular disease. Evidence from genetic, epidemiological, and clinical studies has demonstrated that prolonged exposure to elevated LDL-C concentrations increases cardiovascular risk. In contrast, HDL-C participates in reverse cholesterol transport, although its concentration alone does not fully reflect its functional role or provide a complete assessment of cardiovascular protection **(Ference *et al*., 2017; Visseren *et al*., 2021).**

Triglycerides are another important component of the lipid profile. Elevated TG concentrations are frequently associated with obesity, insulin resistance, diabetes mellitus, and metabolic syndrome. Increased triglyceride-rich lipoproteins and their remnants may contribute to atherosclerotic cardiovascular disease, particularly when accompanied by elevated LDL-C or reduced HDL-C concentrations **(**Ginsberg et al. (2021) **.**In addition to biological factors, lifestyle and environmental conditions may contribute to differences in lipid profiles between individuals. Dietary patterns, physical inactivity, smoking, and metabolic disorders can influence lipid concentrations and modify cardiovascular risk. Therefore, evaluating lipid profile parameters in different age and sex categories may provide useful information for identifying population groups that require closer monitoring and preventive interventions **(Visseren *et al*., 2021).** Despite the established relationship between dyslipidemia and cardiovascular diseases, lipid profile patterns may vary among populations according to demographic, genetic, and lifestyle characteristics. Local laboratory data can provide valuable information about these variations and help identify potential differences between males and females in specific communities.

Therefore, the present study aimed to investigate age- and sex-related variations in serum lipid profile parameters among individuals attending hospital laboratories in Zolten City, Libya, during August and September. Specifically, the study evaluated total cholesterol, triglycerides, HDL-C, and LDL-C concentrations across different age groups and compared these parameters between males and females. The findings are expected to contribute to a better understanding of lipid profile patterns in the studied population and provide baseline information for future epidemiological investigations and cardiovascular health assessment.

Methodology

Study Design and Setting

A retrospective cross-sectional study was conducted using laboratory records obtained from hospital laboratories in Zolten City, Libya. The study covered the period from August to September 2026. The investigation aimed to evaluate variations in serum lipid profile parameters according to age and sex among individuals attending the selected hospital laboratories.

Study Population and Sample Size

The study included 97 individuals, comprising 49 females and 48 males. Laboratory records were selected based on the availability of complete information regarding age, sex, and lipid profile measurements. Participants were classified into six age groups:

Biochemical Parameters

The lipid profile parameters investigated included:

1. Total cholesterol (TC): Measurement of total cholesterol concentration in serum.
2. Triglycerides (TG): Assessment of circulating triglyceride concentrations.
3. High-density lipoprotein cholesterol (HDL-C): Measurement of the high-density lipoprotein fraction.

4. Low-density lipoprotein cholesterol (LDL-C): Assessment of low-density lipoprotein cholesterol concentration.

All lipid profile results were recorded in mg/dL, according to the units reported in the laboratory records.

Data Collection and Organization

Data were extracted from hospital laboratory records and organized into a structured database using Microsoft Excel. The collected information included age, sex, total cholesterol, triglycerides, HDL-C, and LDL-C.

The participants were categorized according to sex and age group to facilitate comparisons of lipid profile parameters. Records with missing essential information were intended to be excluded from the statistical analysis.

Statistical Analysis

Statistical analysis was performed to investigate differences in lipid profile parameters between age groups and sexes. Results were expressed as mean ± standard deviation (Mean ± SD).

The following statistical procedures were applied: Descriptive statistics: Mean and standard deviation were calculated for total cholesterol, TG, HDL-C, and LDL-C within each age group, separately for males and females. One-way analysis of variance (ANOVA): This test was used to evaluate differences in lipid profile parameters among the six age groups within each sex. Welch's independent samples t-test: This test was applied to compare mean lipid profile parameters between males and females, accounting for potential inequality in variances.

Analysis of covariance (ANCOVA): Age was incorporated as a covariate to assess whether observed differences in lipid profile parameters between sexes remained significant after adjustment for age. The statistical significance level was set at $p < 0.05$. All statistical tests were two-tailed.

Ethical Considerations

The study was based on previously recorded laboratory data. Patient confidentiality and privacy were maintained throughout data collection and analysis. Personal identifiers were not included in the research database. Permission to access laboratory records was obtained from the relevant hospital authorities, and ethical approval was obtained from the appropriate institutional ethics committee, where required.

Results

A total of 97 participants were included in this study, comprising 49 females and 48 males. The serum lipid profile parameters investigated included total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL), and low-density lipoprotein cholesterol (LDL). The results were analyzed according to sex to evaluate differences in lipid profile patterns between male and female participants. Descriptive statistics were expressed as mean ± standard deviation (SD), while differences between the two groups were assessed using Welch's independent samples t-test. Statistical significance was considered at $p < 0.05$.

Table (1): Comparison of Lipid Profile Parameters Among Different Age Groups of Females Using One-Way ANOVA

Age group (years)	N	Cholesterol mg/dL	TG mg/dL	HDL mg/dL	LDL mg/dL
19–30	7	181.00 ± 55.38	139.71 ± 154.12	48.86 ± 3.89	117.86 ± 36.53
31–40	4	191.50 ± 36.95	162.00 ± 99.78	45.25 ± 11.38	117.75 ± 26.95
41–50	18	187.67 ± 38.02	171.17 ± 149.51	46.28 ± 12.90	121.00 ± 30.03

51–60	9	227.56 ± 28.36	141.00 ± 37.09	55.67 ± 14.10	150.11 ± 16.27
61–70	3	205.00 ± 26.63	136.33 ± 80.33	54.67 ± 17.95	132.00 ± 32.45
71+	8	203.25 ± 58.68	155.75 ± 72.20	39.38 ± 5.60	140.50 ± 53.47
ANOVA (F)	—	1.343	0.131	2.002	1.316
P-value	—	0.265	0.984	0.098	0.275
Significance	—	NS	NS	NS	NS

NS: Not statistically significant ($p > 0.05$).

Data presented in table (1) shows that, the highest mean cholesterol level was observed in the 51–60-year age group (227.56 ± 28.36 mg/dL), whereas the lowest mean was recorded in the 19–30-year age group (181.00 ± 55.38 mg/dL). However, these differences were not statistically significant ($F = 1.343$, $p = 0.265$). Triglycerides (TG): The highest mean triglyceride level was observed among females aged 41–50 years (171.17 ± 149.51 mg/dL), while the lowest mean was found in the 61–70-year group (136.33 ± 80.33 mg/dL). No significant differences were detected among age groups ($F = 0.131$, $p = 0.984$). High-Density Lipoprotein (HDL): The highest mean HDL level was recorded in the 51–60-year age group (55.67 ± 14.10 mg/dL), while the lowest was observed among females aged 71 years and above (39.38 ± 5.60 mg/dL). Although variations were observed, they did not reach statistical significance ($F = 2.002$, $p = 0.098$). Low-Density Lipoprotein (LDL): The highest mean LDL level was recorded in the 51–60-year group (150.11 ± 16.27 mg/dL), compared with the lowest value in the 31–40-year group (117.75 ± 26.95 mg/dL). However, the differences were not statistically significant ($F = 1.316$, $p = 0.275$).

The findings indicate variations in lipid profile parameters across different age groups among females, particularly in total cholesterol and LDL levels, which showed relatively higher mean values in the 51–60-year age group. HDL levels were comparatively lower among females aged 71 years and above. Nevertheless, one-way ANOVA demonstrated that none of these differences was statistically significant ($p > 0.05$). These findings suggest that age group alone was not significantly associated with variations in lipid profile parameters in the studied female population.

Table (2): Mean Lipid Profile Parameters Among Different Age Groups of Males and One-Way ANOVA Results

Age group (years)	**n**	**Total Cholesterol**	**TG**	**HDL**	**LDL**
≤30	7	156.57 ± 35.17	115.00 ± 66.55	43.86 ± 8.55	99.29 ± 33.70
31–40	15	157.60 ± 47.78	130.87 ± 96.29	39.40 ± 11.01	105.13 ± 33.20
41–50	7	178.29 ± 46.08	142.43 ± 52.22	43.71 ± 11.34	115.43 ± 49.75
51–60	11	184.18 ± 63.18	191.91 ± 111.27	50.27 ± 38.38	125.36 ± 57.42
61–70	6	156.00 ± 89.20	170.83 ± 122.14	34.67 ± 7.87	97.83 ± 63.05
>70	2	159.00 ± 43.84	73.00 ± 12.73	42.00 ± 2.83	108.00 ± 41.01
ANOVA (F)	—	0.444	1.081	0.561	0.445
P-value	—	0.815	0.385	0.729	0.815
Significance	—	NS	NS	NS	NS

NS: Not statistically significant (p > 0.05).

Data presented in table (2) indicated that, the highest mean total cholesterol level was recorded in males aged 51–60 years (184.18 ± 63.18 mg/dL), whereas the lowest mean was observed in the 61–70-year age group (156.00 ± 89.20 mg/dL). However, no statistically significant differences were detected among age groups (F = 0.444, p = 0.815). The highest mean triglyceride concentration was observed in the 51–60-year age group (191.91 ± 111.27 mg/dL), while the lowest was recorded among males older than 70 years (73.00 ± 12.73 mg/dL). Nevertheless, these differences were not statistically significant (F = 1.081, p = 0.385). The highest mean HDL concentration was found in the 51–60-year age group (50.27 ± 38.38 mg/dL), whereas the lowest was observed in the 61–70-year group (34.67 ± 7.87 mg/dL). The differences were not statistically significant (F = 0.561, p = 0.729). The highest mean LDL concentration was recorded in males aged 51–60 years (125.36 ± 57.42 mg/dL), compared with the lowest mean in the 61–70-year group (97.83 ± 63.05 mg/dL). However, the differences were statistically insignificant (F = 0.445, p = 0.815).

The results demonstrated variations in lipid profile parameters across different age groups among males. The 51–60-year age group showed the highest mean concentrations of total cholesterol, triglycerides, HDL, and LDL. In contrast, the 61–70-year age group exhibited the lowest mean total cholesterol, HDL, and LDL levels. However, one-way ANOVA revealed no statistically significant differences among age groups for any of the investigated lipid parameters (p > 0.05). These findings suggest that age-group differences were not significantly associated with lipid profile variations in the studied male population.

Comparison of lipid profile between males and females

Table (3) presents a comparison of serum lipid profile parameters between females (n = 49) and males (n = 48) using Welch's independent samples t-test. The results revealed statistically significant differences in total cholesterol and LDL levels between the two sexes. Females exhibited significantly higher mean total cholesterol levels (197.96 ± 43.63 mg/dL) than males (166.42 ± 54.73 mg/dL) (t = 3.135, p = 0.002). Similarly, LDL levels were significantly higher among females (129.49 ± 34.57 mg/dL) compared with males (109.63 ± 45.30 mg/dL) (t = 2.424, p = 0.017). In contrast, no statistically significant differences were observed in triglyceride (TG) levels (p = 0.675) or HDL levels (p = 0.146) between females and males. Although females showed slightly higher mean values for both parameters, these differences were not statistically significant. Overall, the findings indicate that sex-related differences in lipid profiles were primarily associated with total cholesterol and LDL levels, with females exhibiting higher concentrations than males. Female participants demonstrated significantly higher total cholesterol and LDL levels, suggesting a potentially less favorable lipid profile regarding these two cardiovascular risk markers compared with male participants. However, further investigation considering age, menopausal status, lifestyle, and other cardiovascular risk factors is recommended.

Table (3): Comparison of Serum Lipid Profile Parameters Between Female and Male Participants Using Welch's Independent Samples t-test

Lipid parameter	Females (n=49)	Males (n=48)	t-value	P-value	Significance
Total Cholesterol	197.96 ± 43.63	166.42 ± 54.73	3.135	0.002	Significant
Triglycerides (TG)	155.73 ± 113.84	146.81 ± 94.42	0.420	0.675	NS
HDL	47.67 ± 12.16	42.69 ± 20.19	1.470	0.146	NS
LDL	129.49 ± 34.57	109.63 ± 45.30	2.424	0.017	Significant

NS: Not statistically significant (p > 0.05).

Discussion

The present study investigated age- and sex-related variations in serum lipid profile parameters among 97 individuals (49 females and 48 males) whose laboratory records were obtained from hospital laboratories in Zolten City, Libya, during August and September. The investigated parameters included total cholesterol, triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). The findings demonstrated differences in lipid profile patterns between males and females, particularly in total cholesterol and LDL-C, whereas age-group comparisons did not reveal statistically significant differences.

The analysis of lipid profile parameters across different age groups showed no statistically significant differences in total cholesterol, TG, HDL-C, or LDL-C among either males or females ($p > 0.05$). Nevertheless, some variations in mean concentrations were observed across age categories. Among females, the highest mean concentrations of total cholesterol (227.56 ± 28.36 mg/dL) and LDL-C (150.11 ± 16.27 mg/dL) were recorded in the 51–60-year age group. Similarly, males in the same age category exhibited the highest mean concentrations of total cholesterol (184.18 ± 63.18 mg/dL) and LDL-C (125.36 ± 57.42 mg/dL). These observations suggest a tendency toward higher cholesterol concentrations during middle and older adulthood in the studied population, although the differences were not statistically significant.

Age-related changes in lipid metabolism may be influenced by several physiological and hormonal factors. In women, the menopausal transition is associated with changes in estrogen concentrations, which may contribute to increased total cholesterol, LDL-C, and triglyceride levels. Holven and Roeters van Lennep (2023) explained that lipid concentrations and their trajectories differ between males and females throughout life, with menopause representing an important physiological transition affecting lipid metabolism. Similarly, Ambikairajah *et al.* (2019), in a systematic review and meta-analysis involving more than 114,000 women, reported higher total cholesterol, LDL-C, and triglyceride concentrations among postmenopausal women compared with premenopausal women.

The absence of statistically significant age-related differences in the present study may be partly attributed to the relatively small sample size within some age categories, particularly the oldest age groups. Therefore, the observed numerical differences should be interpreted cautiously. An important finding of the present study was the significantly higher mean total cholesterol concentration among females (197.96 ± 43.63 mg/dL) compared with males (166.42 ± 54.73 mg/dL), with a statistically significant difference ($p = 0.002$). This difference remained statistically significant after adjustment for age ($p = 0.005$).

The higher cholesterol concentration among females may partly reflect age-related hormonal changes, particularly the reduction in estrogen levels during menopause. Estrogen influences hepatic lipoprotein metabolism and cholesterol regulation. Palmisano *et al.* (2018) highlighted the important role of endogenous sex hormones in regulating lipid metabolism and cardiovascular risk in both sexes. The present findings are also consistent with the life-course perspective described by Holven and Roeters van Lennep (2023), who reported that lipid differences between males and females change with age and become particularly evident during the menopausal transition and later adulthood.

In the present study, females showed a slightly higher mean triglyceride concentration (155.73 ± 113.84 mg/dL) than males (146.81 ± 94.42 mg/dL). However, this difference was not statistically significant ($p = 0.675$). Similarly, age-adjusted analysis did not demonstrate a significant difference between sexes. The considerable standard deviations observed in both groups indicate substantial individual variability in triglyceride concentrations. This variation may be associated with differences in dietary habits, body weight, physical activity, insulin resistance, diabetes, and fasting status at the time of blood collection.

According to the European Society of Cardiology guidelines, elevated triglyceride concentrations are associated with increased cardiovascular risk, particularly when accompanied by other metabolic risk factors

(Visseren *et al.,* 2021). Furthermore, triglyceride concentrations may be affected by non-fasting blood collection, making fasting status an important consideration when interpreting laboratory results.

The mean HDL-C concentration was higher among females (47.67 ± 12.16 mg/dL) than males (42.69 ± 20.19 mg/dL). Nevertheless, the difference was not statistically significant (p = 0.146). This observation is consistent with previous research suggesting that women generally exhibit higher HDL-C concentrations than men during certain stages of adulthood. Holven and Roeters van Lennep (2023) reported that sex-related differences in HDL-C vary throughout the life course and are influenced by hormonal and physiological changes. Palmisano *et al.* (2018) also emphasized the influence of estrogen and androgen hormones on lipid and lipoprotein metabolism. However, the absence of a statistically significant difference in the present study may be related to the relatively small sample size and considerable variability in HDL-C concentrations, particularly among males. It is also important to note that HDL-C should not be interpreted independently as a protective cardiovascular indicator. Current evidence indicates that increasing HDL-C concentrations alone does not necessarily reduce cardiovascular risk (Visseren *et al*., 2021).

The present study demonstrated higher mean LDL-C concentrations among females (129.49 ± 34.57 mg/dL) compared with males (109.63 ± 45.30 mg/dL). This difference was statistically significant according to Welch's t-test (p = 0.017). The age-adjusted analysis also indicated a significant difference (p = 0.030), although this finding should be interpreted cautiously after accounting for multiple comparisons. The higher LDL-C concentration observed among females may be partly associated with hormonal changes, particularly the decline in estrogen levels during menopause. Previous studies have demonstrated that menopause is associated with unfavorable changes in lipid metabolism, including increases in LDL-C and total cholesterol (Ambikairajah *et al.,* 2019). LDL-C is particularly important because of its established causal role in atherosclerotic cardiovascular disease. Visseren et al. (2021) emphasized that LDL-containing lipoproteins contribute directly to atherosclerotic plaque development and that reducing LDL-C concentrations is an important strategy for cardiovascular disease prevention.

Conclusion

The present study demonstrated differences in serum lipid profile parameters between males and females in Zolten City, Libya. Females exhibited significantly higher total cholesterol and LDL-C concentrations than males, whereas triglyceride and HDL-C levels did not differ significantly between the two sexes. Furthermore, no statistically significant differences were observed across age groups in either sex. These findings suggest that sex-related variations, particularly in total cholesterol and LDL-C, may be important considerations when evaluating lipid profiles in the studied population. However, further investigations involving larger samples and additional clinical and lifestyle factors are necessary to confirm these observations.

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