Original Article

Association Between the Difference in Age, Sex, and the Atherogenic Index of Plasma

Difference in Age, Sex, and the AIP

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ABSTRACT

Objective: This study aimed to examine the association between differences in both age and sex with AIP.
Study Design: Cross-sectional study
Place and Duration of Study: This study was conducted at the Department of Clinical Laboratory Sciences, College of Pharmacy, University of Al-Ameed, Karbala, Iraq, from 28 Aug 2024 to 30 March 2025.
Methods: Eight hundred participants were included, equally divided into two groups: males and females. Total cholesterol (TC), triglyceride (TG), and high-density lipoprotein cholesterol (HDL) were examined by the colorimetric method, while the Friedewald equation estimated low-density lipoprotein cholesterol (LDL-c). AIP was determined using (log_{10} TG/HDL-c).
Results: The study reveals that females under 40 years tend to have a more favorable lipid profile, with lower levels of AIP, TC, TG, and LDL-c compared to males of the same age. Above 45years, both females and males have higher AIP and lipid levels. Among male groups, there are no significant differences between the younger and older groups. There was a statistical difference between the two female groups, with the younger one having a better AIP and lipid profile.
Conclusion: The study shows a significant association between age and sex with AIP among the study population.
Key Words: AIP; Lipid; Atherogenic; Females; Males

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INTRODUCTION

The AIP is an easily estimated value that depends on the lipid profile measured. Its calculation is based on the logarithmic ratio of TG to HDL-c[1]. When compared with the measurement of each lipid parameter, the AIP is considered a good indicator for cardiovascular risk. It is related to the distribution of small dense LDL particles and determines the rate of HDL-c esterification[2]. It also acts as a diagnostic index; it's more beneficial than a routine lipid profile due to its ability to identify when other risk lipid parameters appear normal. The AIP measurement refers to the zone of atherogenic risk[3]. Recent studies have revealed that AIP not only refers to the relationship between atherogenic and non-atherogenic lipoproteins but also acts as a vital marker of atherosclerosis and its related heart conditions[4,5].

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It has been found that AIP is associated with both age and sex, with higher AIP levels reflecting increased incidence of atherogenic cardiovascular diseases[6]. Studies also show that AIP is typically higher in males compared with females. Age is a significant factor, with older individuals generally showing higher AIP levels and thus a greater risk[7,8]. However, the relationship between age, sex, and AIP can be more complex and may vary depending on other factors. Therefore, this study aimed to investigate the relationship between age, sex, and AIP in a specific, well-defined group.

METHODS

The study involved 400 healthy males and 400 healthy females with a normal body mass index. The AIP, BMI, and lipid levels were estimated for every participant. Each group was categorized into two subgroups: one, ranging from 20 to 40 years, and the other, ranging from 45 to 65 years. Blood samples were collected after 12 hours of fasting to measure the Lipid parameters. Information concerning the lipid abnormality history, physical activity, and smoking behavior was collected through a questionnaire. The inclusion criteria for the study population were healthy participants, moderate physical activity, no evidence of chronic conditions, and the absence of liver, renal, thyroid, or other conditions, as well as the participant not being a smoker.

Estimation of Serum Lipid Levels: Lipid investigations were conducted on fasting participants. Colorimetric methods (Biolabo/France) were used to calculate serum TC, TG, and HDL-c levels, whereas LDL-c levels were estimated using the Friedewald formula [9].

Statistical Tests: The data were summarised by mean ± S.D. and analyzed using IBM SPSS Statistics version 24. A t-test was applied to determine the relationship between AIP, lipid parameters, and different age groups. ANOVA test was used to compare the mean levels of lipid parameters in various sex groups. The results were statistically significant at p-value < 0.05. Lipid profiles were measured in mmol/l, while body mass index was in kg/m2.

RESULTS

The study revealed that the levels of AIP, TG, TC, and LDL-c were elevated significantly in males group when compared with females (P value < 0.05), (Table 1).

Table No. 1: Demographic and Biochemical Parameters for the study population

Parameters	Female n = 400	Male n = 400	P-value
Age (years)	41.988 ± 11.844	41.011 ± 10.701	NS
TC	4.247 ± 1.069	5.253 ± 1.472	< 0.00001*
TG	1.631± 0.730	2.204 ± 1.568	< 0.00001*
HDL-c	1.121± 0.311	1.167 ± 0.596	0.2763
LDL-c	2.110 ± 0.795	2.491 ± 1.245	0.0001*
BMI	24.640 ± 0.503	24.369 ± 1.111	NS
AIP	0.135 ± 0.225	0.210 ± 0.274	0.0023*

*P < 0.05, TC: total cholesterol, TG: triglyceride, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol, BMI: body mass index, AIP: atherogenic index of plasma. NS : not significant

The study demonstrates that females under 40 years old have more favorable AIP and lipid profiles than males (Table 2).

Table No. 2: Comparison of AIP and Lipid Parameters between Younger Age Females and Males groups

Parameters (mmol/l)	Female n = 200 20-40 year	Male n = 200 20-40 year	P-value
TC	3.687 ± 0.563	4.572 ± 1.363	< 0.00001*
TG	1.363 ± 0.606	2.462 ± 1.454	< 0.00001*
LDL	1.907 ± 0.530	2.372 ± 1.053	0.00001*
HDL	1.150 ± 0.248	1.175 ± 0.667	0.19815
AIP	0.042 ± 0.205	0.195 ± 0.277	< 0.00001*

*P < 0.05, TC: total cholesterol, TG: triglyceride, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoprotein cholesterol, AIP: atherogenic index of plasma.

Concerning females and males above 45 years, the study revealed that females also have a more favorable AIP and lipid profile than males (Table 3).

Table No. 3: Comparison of AIP and Lipid Parameters between Older Age Females and Males groups

Parameters (mmol/l)	Female n = 200 45-65 year	Male n = 200 45-65 year	P-value
TC	4.833± 1.115	4.894± 1.092	0.16432
TG	1.899± 0.746	2.344± 1.742	0.00328*
LDL	2.305± 0.953	2.588± 1.181	0 .041257*
HDL	1.092± 0.361	1.156± 0.298	0.180622
AIP	0.227± 0.207	0.238± 0.232	0.7098

*P < 0.05, TC: total cholesterol, TG: triglyceride, LDL-c: low-density lipoprotein cholesterol, HDL-c: high-density lipoprotein cholesterol, AIP: atherogenic index of plasma.

Additionally, there was an increasing trend in AIP with advancing age, particularly after the age of 45 years, for both females and males; the results were significant for females, but not for males (Tables 4 and 5).

Table No. 4: Comparison of AIP and Lipid Parameters between Younger and Older Age Female Groups

Para-meters (mmol/l)	Female n = 200 20-40 year	Female n = 200 45-65 year	P-value
TC	3.660 ± 0.598	4.833 ± 1.115	< 0.00001*
TG	1.361 ± 0.607	1.899 ± 0.746	< .00001*
LDL	1.910± 0.531	2.305± 0.953	<0 .00001*
HDL	1.150 ± 0.248	1.092 ± 0.361	0.063455
AIP	0.0410± 0.203	0.227± 0.207	<0 .00001*

*P < 0.05, TC: total cholesterol, TG: triglyceride, LDL-c: low-density lipoprotein cholesterol, HDL-c: high-density lipoprotein cholesterol, AIP: atherogenic index of plasma.

Table No. 5: Comparison of AIP and Lipid Parameters between Younger and Older Age Male Groups

Para-meters (mmol/l)	Male n = 200 20-40 year	Male n = 200 45-65 year	P-value
TC	4.666 ± 1.304	4.911 ± 1.089	0.192344
TG	1.982 ± 0.996	2.344 ± 1.742	0.092127
LDL	2.342 ± 1.053	2.582 ± 1.188	0.167189
HDL	1.176 ± 0.627	1.160 ± 0.295	0.838157
AIP	0.206 ± 0.269	0.237 ± 0.231	0.4405

TC: total cholesterol, TG: triglyceride, LDL-c: low-density lipoprotein cholesterol, HDL-c: high-density lipoprotein cholesterol, AIP: atherogenic index of plasma.

DISCUSSION

The AIP is a crucial predictive parameter for atherosclerotic heart risk; it's measured based on the ratio of TG to HDL-c[10]. The study findings exhibit that both sex and AIP show a significant association, with males having higher mean AIP values than females Table 1. This agrees with previous literature indicating that males generally have a more atherogenic lipid profile due to higher levels of TG[11]. The study shows that women under 40 tend to have a more beneficial lipid profile, with lower AIP, TC, TG, and LDL-c levels compared to men of the same age Table 2. On the other hand, there were no significant differences between the older female and male groups, except for TG and LDL-c Table 3.

The sex difference may be due to several factors. The decrease in estrogen concentration during menopause, hormonal changes, and lipid variance in females increases the risk of atherogenic lipid biomarkers[12]. In terms of age, AIP showed an increasing trend with advancing age, particularly after the age of 40. This relationship was clearer in the female population, particularly between younger and older women Table 4. Between the ages of 45 and 65 years, there was a decline in estrogen levels, which may lead to metabolic disorders, and this might explain the stronger relation between AIP and females' age[13]. However, the variation in the hormone and physiological cycles in females and males during their lives affects the mechanism of dyslipidemia[14]. Among Chinese postmenopausal women, a study revealed that AIP may be considered a strong indicator to reflect the risk of coronary artery disease[15]. This may reflect physiological variation in lipid metabolism and the accumulation of atherosclerotic risk factors with time. On the other hand, among male groups, there were no statistically significant differences, suggesting that other mediating factors may be involved Table 5. This direct association between the lipid levels and both sex and age might influence the levels of these parameters.

Numerous studies have revealed that AIP was related to atherosclerosis and severe cardiovascular stroke[16,17]. Additionally, several studies have referred to the associations between AIP and obesity, metabolic syndrome, and diabetes mellitus[18,19]. However, there is limited research on the association between sex, age, and AIP, with conflicting results. A study demonstrates that the association between AIP and hypertension differs by sex, with females having a significantly weaker relation than in males[20]. This study also revealed a significant association between atherogenic lipid parameters in males. Another study in Taiwan exhibits that the association between AIP and hypertension was stronger in males than in females[21]. The AIP was considered an important biomarker for plasma atherosclerosis and a diagnostic tool to suspect the risk of cardiovascular disease[22]. Moreover, several studies have shown an association between the AIP and the incidence of insulin-resistance-related metabolic diseases, as well as obesity[23,24]. This study demonstrates an association between higher AIP and old age in males and females. In human adipose tissue, TG is considered the most abundant lipid biomarker, which may contribute to the development of insulin resistance[25]. On the other hand, HDL-c is known to have anti-inflammatory properties in metabolic diseases due to its lipid and protein components[26]. AIP involves these two lipid biomarkers, TG and HDL-c, and consequently, it reflects dyslipidemia better than low HDL-c or high TG concentration alone.

These results highlight the crucial role of AIP as a strong biomarker for screening cardiovascular risk, especially in male and older populations. Routine investigations of AIP could enhance early detection and preventive strategies. Further studies should examine sex-specific associations with lipid metabolism, particularly among high-risk populations.

CONCLUSION

The findings of this study indicate that both age and sex are significant factors influencing the AIP. Males and older individuals tend to have higher AIP levels, which may contribute to a greater risk of developing cardiovascular diseases. AIP can be considered a simple, cost-effective tool for early risk assessment, particularly in preventive healthcare settings. Further longitudinal studies are recommended to confirm these associations and to explore additional influencing factors such as diet, physical activity, and overall health status.

Author's Contribution:

Concept & Design or acquisition of analysis or interpretation of data:	Rithab Ibrahim Al-Samawi
Drafting or Revising Critically:	Rithab Ibrahim Al-Samawi
Final Approval of version:	The above author
Agreement to accountable for all aspects of work:	The above author

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