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# Gender disparities, hyperglycemia and their association with atherogenic biomarkers

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## ABSTRACT

Atherogenic index (AI) and coronary risk index (CRI) are potential biomarkers reflecting atherosclerosis which is a main aetiology of ischemic heart disease. Dyslipidemia is an important risk factor for atherosclerosis causing endothelial injury which is the initiation of athrogenesis. Cardiovascular disese (CVD) risk is significant associated with high AI in which coronary artery events were documented. Predictive values of AIP for CVD risk is more pronounced in the presence of any components of metabolic syndrome such as hyperglycemia and in male gender when compared to females. This study associate the atherogenic index (AI) and coronary risk index (CRI) between status of genders and the hyperglycemia.. It was a laboratory based study and a hundred volunteer adult subjects participated after giving informed consent. General proforma was used to collect subjects' demographic data. Blood samples (5.0 mL) was collected in plain tubes from the subjects after overnight fast. Serum was isolated into dry plain plastic screw-capped containers and stored frozen-20°C prior to analyses. Serum total cholesterol (TC), triglycerides (Tg), high-density lipoprotein-cholesterol (HDL-C) and low-density lipoprotein-cholesterol (LDL-C) and fasting glucose concentrations were determined by chemical analyser. Atherogenic index is calculated as log (TG/HDL–C) and the Coronary risk index calculated as CRI=TC/HDL-C. There were 52 (51.5%) males and 48 (48.5%) females in this study. For the AI,

**Keywords:** *Cardiovascular disease (CVD) risk, Dyslipidemia, Atherogenic index, Coronary risk index, Gender disparit*

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there were statistically significant mean differences between genders (p-value < 0.001) and diabetes status (p-value = 0.039). As for CRI, only gender (p-value < 0.001) showed a statistically significant mean difference. Hence, we conclude that there is a significant mean difference between males and females for both AI and CRI. As for the other health status, only the status of diabetes mellitus was found to have a significant mean difference for AI. In conclusion, this study demonstrates that both AI and CRI differ significantly by gender, with males showing higher values, while diabetes status was independently associated with AI. These findings emphasize the relevance of gender- and diabetes-specific consideration in evaluating coronary artery disease risk.

## INTRODUCTION

Coronary artery disease (CAD) is one of the most prominent noncommunicable diseases and the cause of one-third of deaths worldwide (Zeinali-Nezhad et al., 2024) It is commonly associated with components of metabolic syndrome (MS), a condition having abdominal obesity, hypertriglyceridemia, low level of high density lipoprotein (HDL), hypertension and fasting hyperglycemia. Abnormalities in serum lipid levels, dyslipidemia, and obesity can lead to atherosclerosis and cardiovascular complications. High serum cholesterol and elevated triglyceride are common risk factors for atherosclerosis associated coronary artery disease. Single time- atherogenic index of plasma is positively correlated with cardiovascular morbidity (Huang et al, 2024). Low density lipoprotein (LDL-C) is considered a primary lipid assessment to predict risk of coronary artery disease (Jung et al., 2022, Casula et al., 2021). Atherogenic index which is a lipid biomarker is reported to be associated with cardiovascular diseases (Assempoor et al., 2025) and is considered an optimal indicator for the cardiovascular risk and subclinical atherosclerosis (Lee, 2024). Male gender is associated with higher risk of cardiovascular incidence which can be explained by effects of Ychromosome-linked genes. These male specific cardiovascular phenotype leading to high LDL levels potentiated by smoking habit in males contribute to higher risk in male gender (Moosazadeh et al, 2024). Coronary risk index calculated as CRI= TC/HDL-C is closely correlated with total cholesterol and LDL levels and it reflects coronary plaque formation in young adults. This study aimed to determine gender disparity in the atherogenic index (AI) and coronary risk index (CRI) and the status of metabolic syndrome such as diabetes mellitus.

## MATERIALS AND METHODS

This cross sectional study was conducted in Kota Kinabalu and 100 adults participated. Written consent was obtained before the commencement of the study. A proforma was used to collect subjects' information such as age, gender and history of diabetes and hypertension. The blood pressure and anthropometrics weight and height, waist circumference of the participants were measured using weighing scale and measuring tape, respectively. Body mass index (BMI) expressed as kg/m2 was calculated and obesity is defined as BMI = 30 kg/m2. Blood samples (5.0 mL) was obtained from the subjects between the hours of 08.00-10.00 after overnight fast. Serum separation was done after blood collection and stored at temperature of -20°C for collective analysis in a batch of 20 samples. Serum total cholesterol (TC), triglycerides (Tg), high-density lipoprotein-cholesterol (HDL-C) and low-density lipoprotein-cholesterol (LDL-C) and fasting glucose concentrations were determined by chemical analyser. Atherogenic index is calculated by the equation log (TG/HDL–C) and coronary risk index was calculated as CRI=TC/HDL-C.

For statistical analysis, descriptive analysis, and an independent t-test were performed using SPSS version 29 to answer the objective of this study. All categorical variables are presented with frequency and percentage,

whereas numerical variables are presented with mean and standard deviation. As for the independent t-test, the level of significance was set at 0.05, in which, if the p-value is less than 0.05 indicates that the result is significant.

**Table 1:** Participants' demographics

| Variables | Mean (SD) | n (%) |
|---|---|---|
| Age (n = 96) | 35.3 (11.9) | |
| Gender<br>Male<br>Female | | <br>51 (51)<br>49 (49) |
| Smoking status (n=93)<br>Yes<br>No | | <br>82 (88.2)<br>11 (11.8) |
| Diabetes status (n=94)<br>Yes<br>No | | <br>90 (95.7)<br>4 (4.3) |
| Hypertension status (n = 94)<br>Yes<br>No | | <br>83 (88.3)<br>11 (11.7) |
| BMI (n = 96) | 27.9 (5.1) | |
| LDL/HDL ratio<br>Normal<br>High | | <br>92 (92)<br>8 (8) |
| TG/HDL ratio<br>Normal<br>High<br>Very high | | <br>87 (87)<br>12 (12)<br>1 (1) |
| Atherogenic index | 2.2 (0.9) | |
| Coronary risk index | 1.2 (1.2) | |

## RESULTS

A total of 100 participants were recruited for this study, where most of the participants were males (51%) and smokers (82%) with a mean (sd) age of 35.3 (11.9) as shown in table 1. Most of the participants were also diabetic (95.7%) and hypertensive (88.3%), with a mean (sd) of BMI was 27.9 (5.1). As for the LDL/HDL ratio, most of the participants are in a normal ratio (92%), and also in a normal ratio of TG/HDL ratio (87%), with a mean (sd) of ATI and CRI were 2.2 (0.9) and 1.2 (1.2), respectively.

From the independent t-test, we found that there is a significant mean difference of both AI (p-value < 0.001) and CRI (p-value < 0.001) between males and females, as shown in Table 3. Whereby, only the mean of AI (p-value = 0.039) was found to be significantly different between diabetic and non-diabetic participants, as shown in Table 4.

**Table 2:** Comparison of AI between different BMI level

| BMI | Mean (SD) | *P*-value* |
|---|---|---|
| Under weight and Normal | 1.7 (0.7) | <0.001 |
| Overweight | 2.4 (0.9) | |
| Obese | 2.6 (0.8) | |

**Table 3:** Independent t-test for gender

| Variable | Mean (SD) | | Mean diff. (95% CI) | *t*-statistics (df) | *p*-value* |
|---|---|---|---|---|---|
| | Male (51) | Female (49) | | | |
| Atherogenic Index (AI) | 2.74 (0.83) | 1.78 (0.60) | 0.96 (0.67, 1.25) | 6.57 (98) | <0.001 |
| Coronary Risk Index (CRI) | 1.73 (1.49) | 0.74 (0.53) | 0.99 (0.55, 1.44) | 4.41 (98) | <0.001 |

**Table 4: Independent t-test for diabetic status**

| Variable | Mean (SD) | | Mean diff. (95% CI) | *t*-statistics (df) | *p*-value* |
|---|---|---|---|---|---|
| | Diabetic (4) | FNon-diabetic (96) | | | |
| Athero-genic Index (AI) | 1.36 (0.50) | 2.26 (0.86) | -0.91 (-1.77, -0.04) | -2.09 (92) | 0.039 |

## DISCUSSION

Athrogenic index (AI) is a biomarker of plasma atherosclerosis and it is considered as a possible predictor of coronary artery disease (CAD). AI is significantly and positively correlated with narrowing of carotid lumen as assessed by carotid intima-media thicknesses (Huang et al., 2023). Studies reported a higher prevalence of obesity associated with high level of AI (Zhai et al., 2024). In this study, subjects with higher athrogenic index (AI) levels had higher BMI especially with obesity (2.6+/-0.8).

High BMI and obesity has an association with coronary risk index (CRI). High BMI of ≥30 appears to be a risk factor for early development of coronary artery disease (Pham et al., 2024). In this study, overweight or obese subjects have high CRI value with the p value of 0.001. BMI especially with obesity (2.6 (0.8)) and the association is significant with p valve of <0.001.

Atherogenic index is higher in individuals with diabetes mellitus (Du et al., 2024). The cut off value for glucose was taken at 7 mmol/L and AI levels are variable in these two categories, below 7 mmol/L and above 7mmol/L. The association between hyperglycemia and AI and CRI is weaker than lipid ratio. Known diabetics who are taking anti-lipid therapy may have improved levels of lipid compared to those who are not taking drugs. Undiagnosed hyperglycemia or hidden metabolic syndrome may have more tendensity to have higher lipid profile results. The difference in AI among diabetic and non-diabetics was significant ie. p value of 0.039. However, the AI was greater among non-diabetic. Limitation of this study is that only four diabetic participants participated and a larger sample size is needed for further detailed investigations.

This study revealed both the atherogenic index (AI) and coronary risk index (CRI) are significantly higher in males than in females, and it was consistent with previous epidemiological studies. A population-based study in Iran reported that men had significantly higher AI and CRI values compared to women, largely due to elevated triglyceride levels and lower HDL-C concentrations in males (Assempoor et al., 2025). We also observed the ratio of triglyceride and high density lipoprotein (TG/HDL) is associated with high AI and coronary risk index. This observation parallels broader cardiovascular research, which shows that men are at greater risk of developing cardiovascular disease at a younger age, a difference partly attributed to the protective role of oestrogen in premenopausal women (Maas & Appelman, 2010).

Mechanistically, gender disparities in AI and CRI may be explained by differences in lipid metabolism as a contribution of Y chromosome-linked genes and hormonal influences. Testosterone appears to increase inflammatory cell infiltration and cytokine secretion, promoting the development of atherosclerotic lesions and augment the coronary risk. Female hormone oestrogen reduces the expression of adhesion molecules and control vascular inflammation thereby slowing the progression of atherosclerosis (Kim, 2024). Higher triglycerides and lower HDL-C in men contribute to elevated AI, while lower HDL-C also results in higher CRI. In contrast, premenopausal women benefit from higher HDL-C and oestrogen's vascular protection. However, this advantage diminishes in post-menopause as studies have shown increases in TC, LDL-C, TG, and AI in postmenopausal women (Anagnostis et al., 2015; Johansson et al., 2023; Inaraja et al., 2020).

Further evidence comes from a study in Chinese patients, which found that AI was independently associated with coronary heart disease only in men (odds ratio 4.44), but not in women (Huang et al., 2024; Wang et al., 2025). Similarly, in patients with type 2 diabetes, elevated AI correlated strongly with CAD severity in males but not females, suggesting that gender differences in HDL functionality, inflammatory markers, or menopausal status may influence these associations (Huang et al., 2024).

Taken together, our results and the existing literature highlight that males tend to have a more adverse atherogenic and coronary risk profile, as reflected by both AI and CRI. This supports the use of gender-specific considerations when applying lipid ratios in cardiovascular risk stratification.

## CONCLUSION

We conclude that there is a significant mean difference between males and females for both AI and CRI. As for the other health status, only the diabetes status was found to have a significant mean difference for AI. Actively controlling AI levels can help in management of high risk groups to reduce the risk of CAD. Early detection and control of blood lipid levels are of great significance for the prevention of

cardiovascular events.

## CONFLICT OF INTEREST

Authors do not declare any conflict of interest.

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## REFERENCES

Anagnostis, P., Stevenson, J., C., Crook, D., Johnston, D.,G., Godsland, I.,F. (2015). Menopause and cardiometabolic disease: The evidence for hormone replacement therapy. Hormones, 14(4), 507–521.

Assempoor, R., Daneshvar, M.S., Taghvaei, A., Abroy, A., S., Azimi, A., Nelson, J., R., Hosseini, K. (2025). Atherogenic index of plasma and coronary artery disease: a systematic review and meta-analysis of observational studies. Cardiovasc Diabetol 24, 35; https://doi.org/10.1186/s12933-025-02582-2.

Cai, G., Liu, W., L, S., Wang, X., Guo, Y., Yan, Z., Du, Y., Zhou. Y. (2019). Gender-specific associations between atherogenic index of plasma and the presence and severity of acute coronary syndrome in very young adults: a hospital-based observational study. Lipids Health Dis. ;13;18(1):99. doi: 10.1186/s12944-019-1043-2. PMID: 30987629; PMCID: PMC6466804.

Casula, M., Colpani, O., Xie, S., Alberico. L., Baragetti, A. (2021). HDL in Atherosclerotic Cardiovascular Disease: In Search of a Role. Cells.;10:1869. doi: 10.3390/cells10081869.

Deng, S., Huang, W., Liao, J., Liu, Y., Song, Y., Fu, G., Xu, M. (2025). Association between atherogenic index of plasma and depression in premenopausal and postmenopausal women: A cross-sectional study. PLOS ONE 20(7): e0327103. https://doi.org/10.1371/journal.pone.0327103

Du, W., Wang, Y., Song, C., Tian, Z., Liu, Y., Shen, W. (2024). Diabetes Mellitus Mediates the Relationship Between Atherogenic Index of Plasma and Gallstones: A Population-Based Cross-Sectional Study. Diabetes Metab Syndr Obes; 23;17:317-332. doi: 10.2147/DMSO.S449562. PMID: 38288340; PMCID: PMC10822765.

Huang, Q., Liu, Z., Wei, M., Huang, Q., Feng, J., Liu, Z., Xia, J. (2023). The atherogenic index of plasma and carotid atherosclerosis in a community population: a population-based cohort study in China. Cardiovasc Diabetol.; 27;22(1):125. doi: 10.1186/s12933-023-01839-y.

Huang, X., Wen, S., Huang, Y., Huang Z. (2024). Gender differences in the association between changes in the atherogenic index of plasma and cardiometabolic diseases: a cohort study. Lipids Health Dis 23, 135 (2024). https://doi.org/10.1186/s12944-024-02117-w

Inaraja, V., Thuissard, I., Andreu-Vazquez, C., Jodar, E. (2020). Lipid profile changes during the menopausal transition. Menopause;27(7):780-787. doi: 10.1097/GME.0000000000001532. PMID: 32187130.

Johansson, T., Karlsson, T., Bliuc, D., Schmitz, D., Ek, W., Skalkidou, A., Center, J., R., Johansson, A. (2023). Contemporary menopausal hormone therapy and risk of cardiovascular disease: Swedish nationwide register based emulated target trial. BMJ 2024; 387 doi: https://doi.org/10.1136/bmj-2023-078784

Jung, E., Kong, S.,Y., Ro, Y.,S., Ryu, H.,H., Shin, S.,D. (2022). Serum Cholesterol Levels and Risk of Cardiovascular Death: A Systematic Review and a Dose-Response Meta-Analysis of Prospective Cohort Studies. Int J Environ Res Public Health.; 6;19(14):8272. doi: 10.3390/ijerph19148272.

Kim, H. (2024). Sex differences in coronary atherogenesis: a narrative review. Ewha Med J

Volume 47(2); 2024. DOI: https://doi.org/10.12771/emj.2024.e15

Lee, D.,Y. (2024). Emerging Circulating Biomarkers for Enhanced Cardiovascular Risk Prediction. J Lipid Atheroscler;13(3):262-279. https://doi.org/10.12997/jla.2024.13.3.262

Maas, A. H., & Appelman, Y. E. (2010). Gender differences in coronary heart disease. Netherlands Heart Journal, 18(12), 598–602.

Moosazadeh, M., Ebrahimnejad, P., Kheradmand, M., Modanloo, M., Mardanshah, F., Mahboobi, S., Rostamian, M., Safajoo, A., Dehghanzadegan, M., Kianmehr, F. (2024). Association Between Smoking and Lipid Profile in Men Aged 35 to 70 Years: Dose-Response Analysis. Am J Mens Health. 2024 May-Jun;18(3):15579883241249655. doi: 10.1177/15579883241249655. PMID: 38742733; PMCID: PMC11095195.

Pham, M., H., X., Christensen, D., M., Kristensen A., T., Middelfart, C., Sindet-Pedersen, C.,

Gislason, G., Olsen, N., T. (2024). Association of overweight and obesity with coronary risk factors and the presence of multivessel disease in patients with obstructive coronary artery disease – A nationwide registry study. International Journal of Cardiology Cardiovascular Risk and Prevention; 1-8. https://doi.org/10.1016/j.ijcrp.2024.200299

Wang, Y., Cui, J., Gao, J., Liang, S., Cai, G., Chen, X. (2025). Gender disparities in the association between atherogenic index of plasma and chronic kidney disease. BMC Public Health.; 1;25(1):825. doi: 10.1186/s12889-025-22087-7. PMID: 40025582; PMCID: PMC11871803.

Zeinali-Nezhad, N., Najafipour, H., Shadkam, M., Pourhamidi, R. (2024) Prevalence and trend of multiple coronary artery disease risk factors and their 5-year incidence rate among adult population of Kerman: results from KERCADR study. BMC Public Health 24, 25; https://doi.org/10.1186/s12889-023-17504-8

Zhai, L., Huo, R., R. & Zuo, Y., L. (2024). Atherogenic index of plasma and obesity-related risk of stroke in middle-aged and older Chinese adults: a national prospective cohort study. Diabetol Metab Syndr 16, 245. https://doi.org/10.1186/s13098-024-01481-y