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Original Article

Evaluation of Atherogenic Indices Among Women With Breast Cancer in Ile-Ife, Nigeria

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ABSTRACT

Introduction: Cardiovascular disease is the most common cause of death globally, and its risk among women with breast cancer (BC) is not fully assessed. This study aimed to evaluate the cardiovascular risk among women with BC using atherogenic indices.

Methods: Ninety women were recruited for this cross-sectional study and stratified into BC and controls. Anthropometric measurements were taken, followed by blood collection (5 mL) for lipid profile (TC, TG, LDL-c, and HDL-c) assay. Castelli risk index I and II (CRI-I and CRI-II), atherogenic index of plasma (AIP), atherogenic coefficient (AC), Cholindex (CI), and non–HDL-c (NHC) were calculated to estimate cardiovascular risks. Data were analyzed by SPSS 22 using the Student *t* test and the Pearson correlation and presented as mean ± SD. A *P* value of less than 0.05 was considered significant.

Results: Women with BC were significantly younger than controls (51.6 ± 10.3 vs 59.0 ± 12.7 y; $P = 0.003$) and had significantly lower mean waist circumference (90.5 ± 11.3 vs 96.3 ± 14.9 cm; $P = 0.036$). The mean serum TG and HDL-c (1.11 ± 0.4 vs 1.36 ± 0.5 mmol/L; $P = 0.015$ and 1.09 ± 0.4 vs 1.48 ± 0.3 mmol/L; $P = 0.000$) were significantly lower in the BC group. CRI-I, CRI-II, and AC were significantly higher in the BC group than in the controls (4.83 ± 2.0 vs 3.69 ± 0.9; $P = 0.001$ and 3.29 ± 1.8 vs 2.24 ± 0.8; $P = 0.001$ and 3.83 ± 2.0 vs 2.68 ± 0.9; $P = 0.000$), respectively. A higher proportion (80.4%, 38.3%, and 59.6%) of women with BC had a high risk of cardiovascular disease than controls (69.8%, 9.3%, and 27.9%), respectively, except for NHC.

Conclusions: In this study, women with BC had a high risk of cardiovascular disease. Estimating the atherogenic indices of women with BC may be beneficial. ***(Iranian Heart Journal 2026; 27(2): 27-37)***

KEYWORDS: breast cancer; cardiovascular risk; atherogenic indices

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Breast cancer (BC) is a global challenge affecting mostly women, and the prevalence of BC in Africa is high.[1] It is the most common cancer in women and the leading cancer mortality among females.[2] In Nigeria, the prevalence of BC is 22.7%,[3] with abnormalities in lipid and lipoprotein metabolism reported as comorbid

states among women with BC.[4-5] This may have an impact on the disease outcome because dyslipidemia is a risk factor for cardiovascular disease (CVD),[4,6] the major cause of death globally.[5] Although younger women are assumed to be protected from CVD due to hormonal influence on lipid metabolism, accumulating evidence suggests a relationship between BC and dyslipidemia, nullifying this assumption[4-5] and showing an increased risk of CVD in women with BC.

The altered lipid metabolism in BC is partly linked to the expression of receptors in the breast tissue for high-density lipoprotein-cholesterol (HDL-c), resulting in reduced HDL.[7] There are also reports of alterations involving other lipid biomarkers, including low-density lipoprotein-cholesterol (LDL-c) and triglycerides (TG). Nonetheless, these biochemical indicators are better expressed in assessing the cardiovascular risk using equations termed "atherogenic indices", such as atherogenic index of plasma (AIP), Castelli risk indices I and II (CRI-I and CRI II), atherogenic coefficient (AC), cholesterol index (CI), and non-HDL cholesterol (NHC).[8] These indices have better predictive ability than the traditional lipid markers for cardiovascular risk assessment. AIP has been suggested as an alternative screening tool to predict infarction, acute coronary events, atherosclerosis, and CVD, which is useful in women with BC.[5] On the other hand, in a prior study, AC and NHC were predictors of the coronary artery disease risk,[9] while CRI is considered the most independent predictor of coronary artery disease and future cardiovascular events.[10] While dyslipidemia is a biochemical modifiable risk factor for CVD, the nonbiochemical modifiable risk factors are unhealthy diet, obesity, sedentary lifestyle, low socioeconomic status, smoking, harmful use of alcohol, and chronic diseases (eg, diabetes mellitus and hypertension).[11] Previous studies have reported only data on an isolated single component of atherogenic indices: AIP among Nigerian women with BC, while the extensive ratios were studied in the general population. The combination of atherogenic indices among women with BC has not been reported. Accordingly, the assessment of atherogenic ratios (AIP, AC, CRI-I, CRI-II, NHC, and the ratio of total cholesterol to HDL) in treatment-naïve women with BC and comparing their cardiovascular risk with apparently healthy women screened negative for breast lesions on imaging will provide more information regarding this group of women. The aim of this study was to evaluate the cardiovascular risk among women with BC using atherogenic indices and compare the findings with those in controls.

METHODS

A total of 90 women were enrolled for this cross-sectional, preliminary study involving women (n = 47) with suspicious breast lesions on imaging (ultrasound and mammography) and controls (n = 43). Women were recruited from the Radiology Department of Obafemi Awolowo University Teaching Hospital (OAUTH), Ile-Ife. Those with suspicious breast lesions on imaging were confirmed as BC on histology reports. Controls were healthy women with normal breast imaging reports. Ethical approval was obtained from the Ethics Committee of OAUTH, Ile-Ife (ERC/2022/07/04). To be included in the study, women had to be undergoing BC screening via breast imaging (mammography and breast ultrasound). All women enrolled in this study had no history of diabetes mellitus. Excluded from this study were women with BC having comorbid chronic illnesses, those on lipid-lowering drugs or hormone replacement therapy, and those diagnosed with BC already on treatment. Controls with chronic diseases, drug consumption, pregnancy, or any nonmalignant breast lesion on imaging were excluded. All participants were non-smokers. A semistructured

questionnaire was used to obtain information on sociodemographics and past medical history, followed by a measurement of weight and height using a weighing scale with meter rule in kilogram (kg) and meter (m) by Sica. The waist and hip circumferences were measured using a tape measure in centimeters (cm). Body mass index (BMI) was calculated using the Quittelet formula (weight/height), while the waist-to-hip ratio (WHR) (waist/hip circumference) was estimated using the measured anthropometry. Random venous blood specimens (5 mL) were collected from consenting women into plain bottles for lipid assay (TC, TG, and HDL-c) using Cobas c311 (Roche Diagnostics, Germany). The blood specimens were allowed to clot, retract, and centrifuged at 1500*g* for 10 minutes. The supernatant serum was harvested with a Pasteur pipette into an Eppendorf and analyzed immediately at the Postgraduate/Metabolic Research Unit Laboratory, Department of Chemical Pathology, OAUTH, Ile-Ife. Results for LDL-c were calculated using the Friedewald equation. Atherogenic indices, including AIP [Log (Serum TG/HDL-c)],[12] AC [(Serum TC–HDL-c)/HDL-c],[10] CRI-I [Serum TC/HDL-c],[13] CRI-II [Serum LDL-c/HDL-c],[13] NHC [Serum TC – HDL-c],[14] Cholindex (LDL-c-HDL-c),[15] and the ratio of HDL to TC [Serum HDL-c/TC] were calculated for each participant. The HDL-to-TC ratio is routinely used for reporting lipid results in the authors' local laboratory. AIP results were graded as low (-0.3–0.1), medium (0.1–0.21), and high (> 0.21) risks for CVD.[12] Moreover, AC and CRI-I exceeding 3.0 were considered high risk (abnormal),[16] while CRI-II greater than 3.3 and CI exceeding 2.07 were taken as abnormal and NHC below 130 mg/dL desirable. The ratios of HDL-c to TC were used to stratify the participants into 5 groups: dangerous risk (< 0.07), high risk (0.07–0.17), average risk (0.17–0.27), below average risk (0.27–0.45), and probably protective against CVD (> 0.45).

Data were entered into an Excel spreadsheet and analyzed using SPSS 22 via the Student *t* test for comparison between the BC and control groups, while the Pearson correlation was applied to determine the association among the variables. A *P* value of less than 0.05 was considered significant.

RESULTS

This study found that women with BC were significantly younger than controls (51.6 ± 10.3 vs 59.0 ± 12.7 y; *P* = 0.003) and had lower values for all the measured anthropometric parameters. Nevertheless, statistically significant values were found for only the mean waist circumference, which was lower in the BC group (90.5 ± 11.3 cm vs 96.3 ± 14.9 cm; *P* = 0.036) (Table 1).

Lipid parameters in women with BC were lower than those in controls, with the exception being LDL-c. However, significant levels were found for only TG (1.11 ± 0.4 mmol/L vs 1.36 ± 0.5 mmol/L; *P* = 0.015) and HDL-c (1.09 ± 0.4 mmol/L vs 1.48 ± 0.3 mmol/L; *P* = 0.000) (Table 2). When compared with local reference limits, the mean serum TC (reference < 5.1 mmol/L) in the BC group was normal (4.78 + 1.1 mmol/L) but elevated in the controls (5.23 ± 1.1 mmol/L). Both groups had elevated mean serum LDL-c (< 2.2 mmol/L) and normal mean serum TG (< 1.7 mmol/L). Meanwhile, the mean serum HDL-c (reference > 1.1 mmol/L) was low in the BC group (1.09 ± 0.4 mmol/L) and normal in the controls (1.48 ± 0.3 mmol/L) (Table 2).

Women with BC had higher mean levels of atherogenic indices than controls, except for NHC and HDL:TC. Still, significant differences were found for CRI-1 (4.83 + 2.0 vs 3.69 + 0.9; *P* = 0.001), CRI-II (3.29 ± 1.8 vs 2.24 ± 0.8; *P* = 0.001), AC (3.83 + 2.0 vs 2.68 + 0.9; *P* = 0.001), and HDL: TC (0.24 ± 0.1 and 0.29 ± 0.1; *P* = 0.001) (Table 3).

Table 1. Comparison of age and anthropometry of women with BC and controls

	BC (No. = 47)	Controls (No.= 43)	*P*
Age (y)	51.6±10.3	59.0±12.7	0.003*
Weight (kg)	66.6±14.1	72.7±15.7	0.054
Height (m)	1.57±0.7	1.59±0.7	0.098
BMI (kg/m^2)	26.8±4.9	28.4±5.6	0.157
Waist (cm)	90.5±11.3	96.3±14.9	0.036*
Hip circumference (cm)	100.1±13.5	106.2±15.7	0.053
WHR	0.91+0.07	0.91+0.08	0.929

*$P < 0.05$

WHR: waist-to-hip ratio; BMI: body mass index; BC: breast cancer

Table 2. Lipid parameters among women with BC and controls

Biomarker (mmol/L)	BC (No. = 47)	Controls (No.= 43)	*P*
Total cholesterol	4.78±1.1	5.23±1.1	0.05
Triglyceride	1.11±0.4	1.37±0.5	0.015*
HDL-c	1.09±0.4	1.48±0.3	0.000*
LDL-c	3.18±0.9	3.16±0.9	0.940

*$P < 0.05$

BC: breast cancer; HDL-c: high-density lipoprotein-cholesterol; LDL-c: low-density lipoprotein-cholesterol

Based on the measured atherogenic indices (CRI-1, CRI-II, AC, AIP, and CI), more women with BC had higher risks of CVD than controls (80.4% vs 69.8%; 38.3% vs 9.3%; 59.6 vs 27.9%; 21.3% vs 11.6%; 42.6% vs 32.6%, respectively), with statistical significance noted for CRI-I (P = 0.002), CRI-II (P = 0.001), and AC (P = 0.003). Nonetheless, only NHC had a higher proportion in controls (60.5% vs 57.4%) at a high risk of CVD than in the BC group. Further stratification based on the HDL: TC ratio showed that more women with BC were at high risk of CVD than controls (11 [23.4%] vs 2 [4.7%]). Further, when stratified, none of them was likely protective against CVD, suggesting a higher risk of CVD among the BC group (Table 4).

Among women with BC, body weight had strong positive correlations with BMI (r = 0.908; P = 0.000), waist circumference (r = 0.645, P = 0.000), and hip circumference (r = 0.586; P = 0.000). However, in the control group, body weight correlated weakly with height (r = 0.448; P = 0.003), and strongly with BMI (r = 0.919; P = 0.000), waist circumference (r = 0.765; P = 0.000), and hip circumference (r = 0.654; P = 0.000). Height was found to have a weak positive correlation only with waist circumference (r = 0.323; P = 0.027) in the BC group but correlated weakly in the control group with both waist circumference (r = 0.387; P = 0.010) and hip circumference (r = 0.351; P = 0.021). In both BC and control groups, BMI moderately correlated with waist circumference (r = 0.584; P = 0.000 and 0.698; P = 0.000, respectively) and hip circumference (r = 0.542; P = 0.000 and r = 0.590; P = 0.000, respectively). WHR was the only anthropometric parameter with a significantly weak positive correlation with TG only in the BC group (r = 0.291; P = 0.027) (Table 5).

Correlations were also observed between lipid parameters and atherogenic indices in the BC and control groups: TC had weak positive correlations with TG (r = 0.352; P = 0.015) and HDL-c (r = 0.290; P = 0.048) in the BC group, whereas the control group showed a weak positive correlation with only TG (r = 0.318, P = 0.038). Both the BC and control groups showed strong positive

correlations with LDL-c (r = 0.932; P = 0.000 vs r = 0.949, P = 0.000, respectively). Similarly, TC had weak positive correlations with CRI-I (r = 0.357; P = 0.014), CRI-II (r = 0.391; P = 0.007), and AC (r = 0.357; P = 0.014), as well as strong positive correlations with CI (r = 0.746, P = 0.000) and NHC (r = 0.932; P = 0.000) in the BC group. Nevertheless, the control group showed moderate positive correlations with CRI-I (r = 0.595; P = 0.000), CRI-II (r = 0.684; P = 0.000), and AC (r = 0.595; P = 0.000), as well as strong positive correlations with CI (r = 0.946, P = 0.000) and NHC (r = 0.823; P = 0.000) (Table 5).

In women with BC, TG weakly correlated positively with LDL-c (r = 0.290, P = 0.048), CRI-I (r = 0.421, P = 0.003), CRI-II (r = 0.320, P = 0.028), AC (r = 0.421, P = 0.003), CI (r = 0.354, P = 0.015), and NHC (r = 0.457, P = 0.001) but strongly with AIP (r = 0.810, P = 0.000). Still, the control group had a weak negative correlation with HDL-c (r = −0.401, P = 0.000); weak positive correlations with CRI-II (r = 0.454, P = 0.002), CI (r = 0.357, P = 0.019), and NHC (r = 0.455, P = 0.002); moderate positive correlations with CRI-I (r = 0.628, P = 0.000) and AC (r = 0.628, P = 0.000); but a strong positive correlation with AIP (r = 0.904, P = 0.000) (Table 5).

Serum HDL-c in the BC and control groups had significant negative correlations with atherogenic indices except for NHC: weakly with CI (r = −0.403, P = 0.005 and r = −0.343, P = 0.024), moderately with CRI-I (r = −0.694, P = 0.000 and r = −0.641, P = 0.000), moderately with CRI-II (r = −0.658, P = 0.000 and r = −0.540, P = 0.000), moderately with AC (r = −0.694, P = 0.000 and r = −0.641, P = 0.000), and strongly with AIP (r = −0.726, P = 0.000 and r = −0.722, P = 0.000) (Table 5).

In women with BC, LDL-c correlated positively with all measured atherogenic indices: moderately with CRI-I (r = 0.598, P = 0.000), moderately with CRI-II (r = 0.641, P = 0.000), moderately with AC (r = 0.598, P = 0.000), and strongly with CI (r = 0.928, P = 0.000) and NHC (r = 0.984, P = 0.000) except for AIP. However, the control group showed strong positive correlations (CRI-I [r = 0.702, P = 0.000], CRI-II [r = 0.822, P = 0.000], AC [r = 0.702, P = 0.000], CI [r = 0.941, P = 0.000], and NHC [r = 0.963, P = 0.000]) with all the indices except for AIP (Table 5).

For the measured atherogenic indices, CRI-I had a strong positive correlation with CRI-II (r = 0.991, P = 0.000 vs r = 0.996, P = 0.000), AC (r =1.000, P = 0.000 vs r = 1.000, P = 0.000), AIP (r = 0.750, P = 0.000 vs r = 0.731, P = 0.000), and CI (r = 0.806, P = 0.000 vs r = 0.877, P = 0.000) in both the BC and control groups, respectively. Nonetheless, CRI-I showed a moderate correlation with NHC in the BC group (r = 0.634, P = 0.000) and a strong correlation in the control group (r = 0.814, P = 0.000) (Table 5).

Table 3. Comparison of mean atherogenic indices among women with BC and controls

Atherogenic Index	BC (No. = 47)	Controls (No.= 43)	*P*
CRI	4.83±2.0	3.69±0.9	0.001*
CRII	3.29±1.8	2.24±0.8	0.001*
AC	3.83±2.0	2.68±0.9	0.001*
AIP	0.0015±0.2	-0.05±0.2	0.278
CI	2.08±1.0	1.68±1.0	0.076
NHC	3.68±1.0	3.75±1.0	0.747
HDL:TC	0.24±0.1	0.29±0.1	0.001*

*P < 0.05

BC: breast cancer; CRI: Castelli risk index; AIP: atherogenic index of plasma; AC: atherogenic coefficient; CI: Cholindex; HDL: high-density lipoprotein; NHC: non–HDL-c; TC: triglycerides

Table 4. Proportion/grading of women into cardiovascular risks using atherogenic indices

Atherogenic Index	BC (No. = 47)	Controls (No.= 43)	Total	*P*
	Frequency (%)	Frequency (%)		
CRI-1				0.002*
Low risk (<3.0)	5 (10.6)	13 (30.2)	18	
High risk (>3.0)	42 (80.4)	30 (69.8)	72	
Total	47 (100)	43 (100)	90	
CRI-2				0.001*
Low risk (<3.3)	29 (61.7)	39 (90.7)	68	
High risk (>3.3)	18 (38.3)	4 (9.3)	22	
Total	47 (100)	43 (100)	90	
AC				0.003*
Low risk (<3.0)	19 (40.4)	31 (72.1)	50	
High risk (>3.0)	28 (59.6)	12 (27.9)	40	
Total	47 (100)	43 (100)	90	
AIP				0.471
Low risk (<0.11)	32 (68.1)	33 (76.7)	65	
Intermediate risk (0.11–0.21)	5 (10.6)	5 (11.6)	10	
High risk (>0.21)	10 (21.3)	5 (11.6)	15	
Total	47 (100)	43 (100)	90	
NHC				0.771
Low risk (<130 mg/dL)	20 (42.6)	17	37	
High risk (>130 mg/dL)	27 (57.4)	26	53	
Total	47 (100)	43	90	
CI				0.329
Low risk (>2.06)	27 (57.4)	29 (67.4)	53	
High risk (>2.06)	20 (42.6)	14 (32.6)	34	
Total	47 (100)	43 (100)	90	
Cardiovascular Risk Grading (HDL:TC)				
	BC (n=47)	Controls (n=43)		
	Frequency (%)	Frequency (%)		
Dangerous risk	0 (0)	0 (0)		
Below average risk	11 (23.4)	2 (4.7)		
Average risk	20 (42.6)	20 (46.5)		
Above average risk	16 (34.0)	20 (46.5)		
Probably protective	0 (0)	1 (2.3)		

*$P < 0.05$

BC: breast cancer; CRI: Castelli risk index; AIP: atherogenic index of plasma; AC: atherogenic coefficient; CI: Cholindex; HDL: high-density lipoprotein; NHC: non–HDL-c; TC: triglycerides

Table 5. Correlations of anthropometry, biochemical, and atherogenic indices among women with BC and controls

	Height	BMI	Waist	Hip	WHR	TC	TG	HDL	LDL	CRI-1	CRI-II	AC	AIP	CI	NHC
Weight BC r	.500	.908	.645	.586	.041	.043	.172	.009	.050	.030	.006	.030	.106	.005	.042
P	.300	.000*	.000*	.000*	.785	.772	.248	.950	.948	.843	.971	.843	.480	.972	.781
Cont r	.448	.939	.765	.654	.247	.080	-.058	.046	.075	.017	.042	.017	-.075	.055	.066
P	.003*	.000*	.000*	.000*	.110	.609	.714	.768	.631	.913	.759	.913	.631	.725	.674
Height BC r		-.097	.323	.271	.054	-.187	-.141	-.045	-.200	-.035	-.035	-.535	-.061	-.200	-.212
P		.517	.027*	.065	.720	.209	.344	.762	.178	.815	.815	.575	.683	.178	.153
Cont r		.121	.387	.351	.095	-.055	-.107	-.049	-.035	-.036	-.045	-.036	-.059	-.016	-.040
P		.440	.010*	.021*	.546	.724	.493	.755	.825	.819	.775	.819	.705	.919	.799
BMI BC r			.584	.542	.018	.136	.265	-.002	.100	.038	.010	.038	.145	.092	.143

P			.000*	.000*	.903	.361	.072	.988	.507	.800	.948	.800	.331	.537	.338
Cont r P			.698 .000*	.590 .000*	.235 .130	.119 .447	-.022 .887	.066 .673	.108 .492	.042 .752	.074 .639	.042 .787	-.057 .714	.079 .617	.099 .529
Waist BC r P				-.821 .000*	.191 .197	.225 .129	.173 .246	-.119 .425	.265 .072	.214 .149	.216 .144	.214 .149	.173 .244	.287 .050	.279 .057
Cont r P				.792 .000*	.452 .002*	.019 .901	.085 .586	-.177 .256	.044 .781	.135 .387	.116 .459	.135 .357	.113 .472	.101 .519	.078 .617
Hip BC r p					-.393 .006*	.066 .658	.033 .823	-.087 .560	.116 .436	.095 .527	.111 .458	.095 .527	.003 .956	.139 .351	.102 .495
Cont r P					-.176 .258	-.015 .924	-.055 .725	-.094 .550	.021 .893	.055 .727	.062 .695	.055 .727	-.056 .721	.052 .743	.016 .919
WHR BC r P						.203 .171	.291 .047*	-.030 .842	.180 .225	.145 .330	.122 .412	.145 .330	.234 .114	.176 .236	.223 .133
Cont r P						.030 .846	.205 .188	-.163 .292	.020 .897	.122 .437	.079 .612	.122 .437	.259 .094	.074 .635	.055 .588
TC BC r P							.352 .015*	.290 .048*	.932 .000*	.357 .014*	.391 .007*	.357 .014*	.108 .469	.746 .000*	.932 .000*
Cont r P							.318 .038*	.202 .194	.949 .000*	.595 .000*	.684 .000*	.595 .000*	.133 .395	.946 .000*	.823 .000*
TG BC r P								-.238 .107	.290 .048*	.421 .003*	.320 .028*	.421 .003*	.810 .000*	.354 .015*	.457 .001*
Cont r P								-401 .008*	.235 .130	.628 .000*	.454 .002*	.628 .000*	.904 .000*	.357 .019*	.455 .002*
HDL BC r P									-.034 .822	-.694 .000*	-.658 .000*	-.694 .000*	-.726 .000*	-.403 .005*	-.076 .612
Cont r P									-.004 .980	-.641 .000*	-.540 .000*	-.641 .000*	-.722 .000*	-.343 .024*	-.127 .419
LDL BC r P										.598 .000*	.641 .000*	.598 .000*	.253 .086	.928 .000*	.984 .000*
Cont r P										.702 .000*	.822 .000*	.702 .000*	.160 .305	.941 .000*	.963 .000*
CRI BC r P											.991 .000*	1.000 .000*	.750 .000*	.806 .000*	.634 .000*
Cont r P											.966 .000*	1.000 .000*	.731 .000*	.877 .000*	.814 .000*
CRI-2 BC r P												.991 .000*	.668 .000*	.832 .000*	.656 .000*
Cont r P												.966 .000*	.560 .000*	.955 .000*	.871 .000*
AC BC r P													.750 .000*	.806 .000*	.634 .000*
Cont r P													.731 .000*	.877 .000*	.814 .000*
AIP BC r P														.502 .000*	.387 .007*
Cont r P														.397 .018*	.376 .013*
CI BC r P															.929 .000*
Cont r P															.948 .000*

*$P < 0.05$

BC: breast cancer; BMI: body mass index; WHR: waist-to-hip ratio; CRI: Castelli risk index; AIP: atherogenic index of plasma; AC: atherogenic coefficient; CI: Cholindex; HDL: high-density lipoprotein; NHC: non–HDL-c; TC: triglycerides

DISCUSSION

The mean age of women with BC in this study is similar to 52.1 ± 12.0 years reported by a previous study in Ibadan, southwestern Nigeria.[5] Lower mean ages of 47.17 ± 8.97 years and 49.1 ± 14.6 years were reported by studies in Ghana and Iraq, respectively.[6, 17]

BMI, waist circumference, and WHR were observed to be lower among women with BC, although only WHR was significant. This observation may be attributed to the wasting nature of the malignant disease, which may be worsened by cachexia from poor feeding and increased cell turnover characteristic of malignancy. This finding supports a previous report in which much lower BMI values were reported for the newly diagnosed (22.49 + 2.81 kg/m^2) and Tamoxifen treatment-exposed (22.06 + 2.66 kg/m^2) patients with BC compared with controls (23.41 + 2.15 kg/m^2).[18] In contrast, patients with BC recruited in a study conducted in Ghana had a significantly higher mean BMI value than controls.[6] A study from Iran reported that patients suffering from BC had higher BMI than controls.[17] This difference may be due to a lower mean age of women recruited in those studies and that the patients with BC were on treatment. Other anthropometric parameters measured in this study were not reported in those previous studies. It would be expected that women with BC being younger (mean = 51 y) than controls should have appreciably weight and BMI differences from pre- or perimenopausal women (age at menopause: 45–55 y).[19] Still, the reduced weight in them may further explain the effect of the malignant state.

Women with BC had lower mean serum levels of lipid parameters than controls, consistent with a report from Iraq, in which patients with BC had lower TC, TG, and LDL-c but higher HDL-c.[17] In contrast, a report from Ghana found higher TC, TG, and LDL-c in patients suffering from BC, while the lower HDL-c is consistent with the of the present study.[5] Other studies have found significantly higher mean TG but lower HDL-c among patients with BC.[4, 20] Lower HDL-c levels have been linked to an increased uptake of this lipoprotein by malignant breast cells, and changes in estrogen levels may also alter HDL-c.[7] Lipid values for women with BC in this study are considered to be within the local reference intervals except for HDL-c and LDL-c. Although this may be nutritional and attributed to the disease state, this picture could be misleading if further estimations were not done to assess the cardiovascular risk. Earlier studies have reported alterations in serum lipoprotein concentrations in BC.[5-6] The elevated LDL-c in both BC and control groups may suggest a local variant of LDL-c within the local population. This may suggest alterations in LDL metabolism, as it relates to LDL receptors. It should be noted that different polymorphic forms of E receptors have been reported. With the effective LDL receptor being E2/E2, a sizable portion of individuals have E2 in different combinations with E3 and E4 receptors. The latter ones exert an impact on LDL-c clearance and lipid excursion. Similarly, Apo B, resident on the LDL-c molecule, may influence its clearance from the circulation and lead to an elevated LDL-c level. Exploring the effects of LDL receptors and Apo B on lipid patterns among patients with BC may explain the genetic impact. This is, however, beyond the objective of this study.

The within-reference TC and TG may be considered low risk for CVD in the BC group. Nevertheless, upon further estimations, atherogenic indices yielded contrasting results. This buttresses the report on limitations of lipid profile results in cardiovascular risk assessment.[5] This is consistent with previous reports,[6] as the BC group in this study showed that its derived

atherogenic indices were not comparable with those of controls. In prior studies, AIP was elevated in patients with BC, especially the newly diagnosed, before treatment.[6,18] Nonetheless, a study reported lower AIP in patients with BC.[17] A study in Nigeria reported significantly higher atherogenic ratios (AIP, CRI-I, CRI-II, and AC) in women with BC.[20] The elevated atherogenic indices among patients with BC as compared with controls suggest a risk of CVD among them. The results of atherogenic estimates showed that a higher proportion of women with BC were at risk of CVD than controls. This was seen with CRI-1, CRI-2, AI, AIP, and CI. However, only NHC was higher in the control group with a higher CVD risk than in the BC group. Upon stratification based on the ratio of HDL to TC (HDL: TC), it was found that more women with BC were placed in the "below average" risk of CVD risk, suggesting a higher risk among them compared with controls. None of the women with BC was placed in the "probably protective" stage for CVD.

It is important to note that cardiovascular risks based on atherogenic ratios among the control group are consistent with previous reports from Iran.[7] Women without BC were recruited in that study and had 70.4%, 36.2%, 20.4%, 77%, and 7.2% of their population at high risk of CVD based on AIP, AC, CI, CRI-1, and CRI-2, respectively. Nonetheless, the proportion of controls having a high risk of CVD based on NHC in this study is higher (60.5% vs 44.7%).[5] This study observed that while TC, LDL-c, and TG correlated positively with some atherogenic indices in both BC and control groups, HDL-c had an inverse relationship with all atherogenic estimates apart from NHC. This finding supports previous studies[6] and suggests that any component of lipid profile may be used either singly or in combination for isolated or combined atherogenic estimates. However, TG and HDL-c lipid parameters appear to be more consistent for the derivation of atherogenic ratios.

From the differences observed in atherogenic indices between the BC and control groups, as well as the correlations, CRI (I and II) and AC may be superior estimates to other indices. By way of example, CRI-I is considered an independent risk factor for coronary artery disease and a good predictor of future cardiovascular events.[5]

These atherogenic indices are more favorable predictive tools in the assessment of CVD risk either in the general population or in patients with BC.[5-6, 15] The estimation of atherogenic indices is not a routine clinical or laboratory practice because the results of lipid assays are reported based on some general criteria on their values to assess CVD. Consequently, lipid values within reference limits are assumed optimal, thus, cardioprotective. For instance, in the authors' local laboratory, lipid results are reported using absolute cutoff values for different parameters either as normal, borderline, or high. Further estimates using HDL:TC is used to grade patients into cardiovascular risks, but the distinct stratification into high or low risk is often not ascertained. However, from this study, the limitation of this practice is obvious, suggesting the need for the assessment of other tools for stratification. This is because having normal lipid values may not necessarily suggest a low or no risk of CVD. Estimating the atherogenic indices is, therefore, beneficial as it may be supportive in the management of BC.

Furthermore, the demonstration of higher mean scores for CRI-1, CRI-II, and AC among women with BC as they had a higher proportion of CVD risks in this study suggests an unknown cardiovascular burden in women with breast malignancy. A

previous report from Iraq concluded that patients with BC were vulnerable to CVD.[18] These reported results further necessitate more exploratory studies in this regard.

The observed correlation between WHR and TG only in BC is important for clinical utility as a simple measurement for a rough estimate. Similarly, serum TG being the only consistent lipid with correlations with all atherogenic indices may suggest a singular most useful biochemical lipid marker for CVD risk assessment among patients with BC. A previous study suggested that TG could be utilized as a marker of BC on the strength of a significant odds ratio.[5] However, it is worthy of note that the mean serum concentrations of TG were within limits in both control and BC groups in this study. In addition, blood specimens for the lipid assay were randomly collected, and the results were not elevated. Nevertheless, atherogenic estimates were abnormal, indicating that normal TG results should be reported with caution.

Limitations: Apo B and other cardiovascular risk factors were not determined in the current study. Additionally, lipid parameters were not compared in the different stages of BC.

CONCLUSIONS

The derived atherogenic indices showed that women with BC had higher cardiovascular risks. This finding suggests the limitation of routine lipid profile results for cardiovascular risk assessment, hence the importance of other atherogenic indices. Therefore, further estimates of atherogenic indices using the lipid results are beneficial for cardiovascular risk assessment in women with BC. Atherogenic tools, including CRI-I, CRI-II, and AC, may have stronger predictive values than lipid results. This should be beneficial in both laboratory and clinical practice, especially among patients with BC.

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