LDL-C/HDL-C ratio: a strong metabolic risk factor of invasive breast cancer

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Research Article

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Abstract

Objective: Our study aims to evaluate whether low density lipoprotein cholesterol/high density lipoprotein cholesterol (LDL-C/HDL-C) can act as a metabolic risk factor of invasive breast cancer (BC) in females.

Methods: From January 2022 to December 2022, 505 females invasive BC and 505 age-matched controls were prospectively enrolled in our study. Data were obtained via medical records and questionnaires. We used Student’s *t*-test and Pearson’s *χ*² test to assess the baseline characteristics, and binary logistic regression was utilized to clarify the metabolic risk factors of invasive BC. Finally, stratified analyses were performed according to estrogen receptor (ER) status.

Results: LDL-C/HDL-C, waist circumference (WC), coronary heart disease and family history of cancer were independent risk factors of invasive BC. Among the metabolic factors, higher LDL-C/HDL-C ratio (OR, 25.19, 95% CI, 13.15-48.25) and WC (OR, 1.20, 95% CI, 1.15-1.24) were associated with higher BC risk (*P* < 0.05) after adjustment for the potential confounders. Stratified analyses according to ER state also demonstrated that LDL-C/HDL-C and WC were still independent risk factors regardless of whether ER status was positive or negative (*P* 0.05).

Conclusions: We find that LDL-C/HDL-C ratio is a strong metabolic risk factor of invasive BC regardless of whether ER status was positive or negative.

1 Introduction

The 2020 Global Cancer Burden report has ranked breast cancer (BC) as the most common newly diagnosed cancer across the globe. There were about 420,000 new cases of BC in Chinese women, ranking the first in the world, and the death toll that year was about 117,000, ranking the first in female cancer deaths (1). Therefore, more prevention of BC is an important issue. Interestingly, researchers have found that metabolic disorders can reflect a woman's susceptibility to BC (2–4). Compared to conventional risk elements such as family history, metabolic disorders are more treatable. Although the conclusions of these studies are not completely consistent, metabolically unhealthy is positively associated with total BC and invasive BC risk in most studies (5–6). Furthermore, although the results remained inconsistent, major scientific studies have verified the positive relevance involving low density lipoprotein cholesterol (LDL-C) and BC risk, and the reversed relevance involving high density lipoprotein cholesterol (HDL-C) and BC risk (7–10). However, the relevance between LDL-C/HDL-C and BC in women has not yet been thoroughly illustrated. LDL-C/HDL-C not only represents lipids ratio but also acts as a reliable indicator of insulin resistance (IR) (11), which interacts closely with the occurrence and prognosis of BC (12, 13). For the reasons mentioned above, we hypothesize that LDL-C/HDL-C could be firmly bound up with BC development. There is growing evidence on the close relationship between metabolic disorders and total BC risk. However, the research on metabolic disorders and invasive BC were limited. Accounting for the obvious effects of metabolic factors such as LDL-C and waist circumference (WC) in...
invasive BC, we enrolled the patients with invasive BC. In addition, we only incorporated the subjects with invasive ductal BC which has the highest incidence to minimize confounding effects derived from different pathological types.

2 Materials And Methods

2.1 Study population

We initiated a prospective case-control study involving 505 females with invasive BC confirmed by postoperative pathology in the first hospital of Qinhuangdao, China. Upon approval by the ethics committee, this study was conducted (permit number: 2022B002). We also performed the study basing on the declaration of Helsinki and local regulations. All patients were newly diagnosed with invasive ductal BC; those who had undergone surgery, chemotherapy, targeted therapy, or endocrine therapy were excluded. A total of 505 age-matched (±3 years) females with no BC as confirmed by breast ultrasound during the same period were selected as healthy controls. Suspected BC females and subjects with other concurrent cancer were excluded as well.

2.2 Data collection

Data were obtained via records of medical care and questionnaires. Metabolic indicators including LDL-C (mmol/l), HDL-C (mmol/l), fasting glucose (mmol/l), triglycerides (TG) (mmol/l), and uric acid (μmol/l) were documented using medical records. We tested the above indicators of the cases and controls through the standard methods using the same automatic analyzer (LABOSPECT 008, Tokyo, Japan). LDL-C/HDL-C ratios were calculated from LDL-C and HDL-C results.

Based on pathological findings, estrogen receptor (ER ) status was determined. The questionnaire included history of type 2 diabetes mellitus T2DM, coronary heart disease (CHD), smoking, alcohol consumption, age at menarche (years), age at first pregnancy (years), breastfeeding longer than 1 year, and family history of cancer. We also measured the height (cm), weight (kg) and WC (cm) for all subjects and gained body mass index (BMI) by calculating through the formula, weight/height^2 (kg/cm^2).

2.3 Statistical analysis

The statistical analysis was conducted through SPSS 23.0 software. The normal distribution test was utilized. The quantitative data were all normally distributed, so they were presented as means±standard. Additionally, the quantitative data were assessed by Student’s t-test. The categorical data were presented as cases and rate(%) and were assessed by Pearson’s χ2-test. Next, we applied multivariate logistic regression to identify the independent risk factors from a set of variables by entering candidates based on a P-value of 0.05 in Table1. In order to compare the metabolic risk factors including LDL-C, LDL-C/HDL-C, WC and TG, we initiated univariate logistic regression analysis to build Model 1, and multivariate logistic regression to build Model 2. Finally, we initiated stratified analyses basing on ER
state(ER-positive or ER-negative). A $P$-value of 0.05 was considered to represent a statistically significant result for all tests.

3 Results

3.1 Baseline characteristics

505 females invasive BC with an average age of 54.31 and 505 controls with an average age of 54.00 were prospectively enrolled in our study. The normal distribution test was utilized. All statistics fit the normal distribution. There were significant differences in BMI, WC, T2DM, CHD, age at first pregnancy, family history of cancer, LDL-C, LDL-C/HDL-C, TG and uric acid between the invasive BC group and the controls ($P<0.05$).(Table 1).

3.2 LDL-C/HDL-C is a strong metabolic risk factor of BC

The aforementioned different characteristics were incorporated into a binary logistic regression equation, and multivariate logistic regression analysis revealed the following: family history, CHD, LDL-C/HDL-C, and WC were independent risk factors for invasive BC (Table2).

We compared LDL,LDL-C/HDL-C,WC and TG in Model1 and Model2. In Model 1, univariate logistic regression analysis verified the following: LDL-C, LDL-C/HDL-C, WC, and TG were all risks of all invasive BC($P<0.05$). In Model 2, BMI, Type 2 Diabetes, CHD, age at first pregnancy, family history of cancer, uric acid, LDL, LDL/HDL, WC and TG were all added into the regression equation, and the results proved that LDL-C(OR,0.55,95%CI,0.35-0.87) and TG(OR,0.49,95%CI,0.34-0.70) were no longer independent risk factors for invasive BC ($P 0.05$). After adjusting all the confounders, a higher LDL-C/HDL-C(OR,25.19,95%CI,13.15-48.25) ratio and WC(OR,1.20,95%CI,1.15-1.24) were still bound up with higher likelihood of developing BC independently($P 0.05$). (Table 3).

Stratified analysis according to ER status yielded the consistent conclusions. In Model1, univariate logistic regression analysis demonstrated that LDL-C, LDL-C/HDL-C, WC, and TG were all risks of ER-positive BC and ER-negative BC($P <0.05$). In Model 2, after adjustment for all potential confounders, LDL-C/HDL-C remained independent risk factors for ER-positive BC(OR,26.70,95%CI,12.83-55.59) and ER-negative BC (OR,20.33,95%CI,8.41-49.15); WC remained independent risk factors for ER-positive BC (OR,1.18,95%CI,1.13-1.23) and ER-negative BC (OR,1.25,95%CI,1.19-1.32). (Table 4).

4 Discussion

Compared to inherent BC risks such as reproduction and family history, metabolic disorders are actually treatable. Despite this, they are frequently overlooked. It is noteworthy that the prevalence of BC and its progression have been intimately linked to IR and metabolic diseases(14, 15 16). The use of metabolic indicators is also practical, feasible, and cost-effective, which are essential for BC prediction and
prevention, not least for those with family history and other risk factors. Thus, we aimed to find the optimal metabolic risk factors of BC.

Previous studies on metabolic factors and BC risk mostly focused on the overall BC population. There is little research on invasive BC and metabolism. Given the high incidence of invasive ductal BC, we enrolled the patients with invasive ductal BC to reduce the confounding effects caused by different pathological types. Moreover, LDL-C is a predictor of invasive BC and induces BC proliferation and invasion (15). In addition, central obesity can promote the transformation from ductal BC to invasive BC through adipose microenvironment (16). The above factors indicate that the metabolic factors such as LDL-C and WC are closely related to invasive BC risk, therefore, the invasive BC females were included in our study as the case group.

Our study substantiates for the first time that LDL-C/HDL-C can be used as an independent risk factor for invasive BC in females. LDL-C/HDL-C has already been proven to be a strong indicator of the risks of both atherosclerotic cardiovascular and cerebrovascular diseases (17). However, it has rarely been mentioned in cancer development studies. Indeed, there have been few studies involving the relationship between LDL-C/HDL-C and cancer, especially BC risk. In our study, LDL-C/HDL-C was a forceful risk factor of invasive BC (OR, 25.19, 95% CI, 13.15–48.25). Although LDL-C was a risk factor for invasive BC in the univariate regression analysis, it was no longer an independent risk factor after adjusting for other confounders such as LDL-C/HDL-C.

Even though no complete consensus were achieved, major large studies and scientific trials have found a positive link between LDL-C and BC risk, and a reversed link between HDL-C and BC risk (7–10). A number of previous studies focused on the role of LDL-C on BC development. Increased LDL receptor expression observed in BC tissues can enhance circulating LDL-C absorption because proliferating cancer cells require extra cholesterol to maintain malignance (18). Dos Santos CR et al. also disclosed that LDL-C signaling promoted BC cell survival and induced BC cell proliferation and invasion (15). In addition, the recent meta-analysis has highlighted the reversed correlation between HDL-C and BC occurrence (19).

Experimental studies have also revealed that HDL-C contributes significantly in inhibiting the oxidative cascade of LDL-C oxidation and in alleviating inflammation stress, which may affect carcinogenesis (20, 21). HDL-C has beneficial biological properties, including antioxidant and anti-inflammatory properties (20), which could lead to a lower risk of BC. Additionally, HDL can inhibit the oxidation of native LDL and reduce lipoprotein-related peroxides through inverse cholesterol transport, thereby reducing the likelihood of inflammation associated with LDL (21).

Thus, LDL-C and HDL-C are closely linked and react with each other. The opposite effects of LDL-C and HDL-C on BC risk may explain the higher risk of LDL-C/HDL-C in a sense. The ratio may therefore be more indicative for BC development than either LDL-C or HDL-C alone. Our study also showed that LDL-C/HDL-C embraced greater risk for invasive BC than LDL-C alone. Akilzhanova et al. also observed that the LDL-C/HDL-C of the BC population surpassed the normal controls in their study (22). Even though His M et al. found no correlation between LDL-C/HDL-C and BC risk, they did find that the ratio was associated with
prostate cancer and the overall cancer risk of prostate cancer and BC(23). Liu YL et al. found that elevated LDL-C levels and an increased LDL-C/HDL-C might favour development of lymph node metastasis and that LDL-C/HDL-C might be a more effective biomarker for identifying advanced N2 stage than LDL-C levels alone in males with colorectal cancer(24). However, two studies from Sweden and France did not conclude association involving LDL-C/HDL-C and BC risk(7, 10). This discrepancy may be due to ethnic differences and other various confounding characteristics of the study populations.

Moreover, LDL-C/HDL-C not only represents the lipid ratio but is also a reliable proxy for IR (11). In this way, this metric allows physicians to identify both IR and dyslipidemia simultaneously. The prevalence and progress of BC are closely linked with IR(12, 13). Insulin could facilitate the progress of BC through interacting with epithelial tissues directly. Besides, it could also affect the tumor development through the other indirect ways, such as elevating the levels and activity of insulin-like growth factor, sex hormones, and adipokines (25). Moreover, dietary modifications to reduce insulinemic potential may reduce the risk of BC(26).

Obesity and dyslipidemias have been considered triggering conditions of the neoplastic pathology of BC, contributing to the increase in mortality rate(27). Furberg et al. (28) conducted a cross-sectional study including 206 healthy females aging 25 to 35 years and classified them basing on both BMI and LDL-C/HDL-C ratio. Their conclusions disclosed that the group with elevated BMI and LDL-C/HDL-C experienced higher free estradiol levels compared to other females, which is known to have a critical effect on the pathogenesis of BC. Finally, as an indicator of obesity for BC risk, WC is more authoritative than BMI(5). Consequently, this supports our results in some sense.

Abdominal visceral fat is considered to be the pivotal pathological mechanism of obesity-related metabolic and hormonal changes leading to the occurrence and development of BC(29), and it has also been suggested that higher visceral adiposity may increase BC risk through the systemic pathway, in addition to local imbalances in hormonal, inflammatory and non-coding RNA profiles (30). In addition, abdominal obesity has been closely linked to a more aggressive tumour characteristics(31). As a marker of abdominal obesity, WC is strongly associated with visceral adiposity as well(32), and our study has also found that WC (OR, 1.20, 95%CI, 1.15–1.24) is still an independent risk factor of invasive BC even after the adjustment of the potential confounding factors. Park et al. expounded that in postmenopausal women, despite having normal BMIs, women with abdominal obesity had a higher risk of invasive BC (5). Our results also highlighted the crucial role of abdominal obesity in invasive BC risk, and all of these results point to WC being a better indicator of obesity for invasive BC risk than BMI.

Given that previous studies of metabolism and BC risk yielded different results due to different ER status, we performed stratified analyses according to different ER status. After adjusting for all the confounders, the OR of LDL-C/HDL-C was 26.70(95%CI 12.83–55.59) for ER-positive BC and 20.33(95%CI: 8.41–49.15) for ER-negative BC. To the best of our knowledge, there is no stratified analyses according to ER status on the relevance between LDL-C/HDL-C and the likelihood of developing BC. For the first time, our results showed that for LDL-C/HDL-C was a strong metabolic risk factor regardless of ER state.
Moreover, the previous studies on LDL-C, WC and BC risk in different ER status have inconsistent conclusions. Cedó L et al. observed that LDL-C mainly accelerated the development of BC in ER-negative cells, but this was not obvious in ER-positive cells (18). However, a Mendelian randomization found that genetically elevated LDL-C was associated with higher BC risk (OR, 1.09, 95% CI 1.02–1.18) and ER-positive BC risk (OR, 1.14, 95% CI 1.05–1.24) (8). Wang TN et al. showed that visceral obesity pathway were closely associated with the progress of ER-positive BC (33). Meanwhile, an increasing number of studies demonstrated that central obesity, may increase triple negative BC risk (34). Further research are needed to clarify the association of ER status with LDL-C/HDL-C and WC.

BC is a tumor with a relatively lengthy median survival time as well as non-tumor mortality risk, and CHD is the main cause of death for long-term survivors (35). This may be due to the fact that multiple risk factors for CHD, such as obesity and LDL-C/HDL-C as mentioned in this paper, are also risk factors for BC. Additionally, cardiovascular health as defined by the American Heart Association is very important for CHD and cancer prevention (35). Kimbung S also pointed out that statins, as a common drug for treating CHD, were capable of reducing the proliferation and recurrence of BC (36). At present, a number of clinical studies have revealed that higher LDL-C/HDL-C is both a risk factor for CHD and a sensitive index for predicting the occurrence and development of CHD (37). Due to its important role in CHD and BC, we speculate that this ratio may mediate the association between CHD and BC. Hence, larger studies are needed to validate these findings and clarify the causal link between CHD and BC.

What is not entirely consistent with previous studies is that conventional factors such as age at menarche, age at first pregnancy and breastfeeding time were not found to be invasive BC risk factors, which is contrary to the results of existing studies on BC risk factors (38, 39). Different factors, such as recall bias, the various confounding factors used in specific research, and individual investigators’ chosen bias may account for this, however.

There are also some limitations to our study. For instance, we did not measure the metabolic index of insulin level. Given the limited sample size, the relationship between metabolic risks and specific molecular subtypes was not investigated in our study either. Future research should therefore disclose whether the high LDL-C/HDL-C ratio is still closely bound up with specific molecular subtypes and their subsequent prognoses.

5 Conclusions

In summary, for the first time, our study demonstrates that LDL-C/HDL-C can be utilized as a strong metabolic risk factor for invasive BC in females. Apart from the inherent risk factors such as WC, at-risk women should initiate the active supervision and monitoring of their LDL-C/HDL-C ratios. To help formulate a proactive defense against BC, future studies should aim to elucidate the pathogenic mechanisms, and explore the novel anti-tumor value of conventional and novel drugs that act as modulators of LDL-C and HDL-C.
**Abbreviations**

BC breast cancer  
LDL-C low density lipoprotein cholesterol  
HDL-C high density lipoprotein cholesterol  
IR insulin resistance  
WC waist circumference  
TG triglycerides  
ER estrogen receptor  
T2DM type 2 diabetes mellitus  
CHD coronary heart disease  
BMI body mass index

**Declarations**

**Ethics approval and consent to participate**

The study was approved by the ethics committee of the First Hospital of Qinhuangdao (permit number:2022B002).

**Consent for publication**

Not applicable

**Availability of data and materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Competing interests**

The authors declare no conflict of interest.

**Funding**

Not applicable
Authors’ contributions All authors carried out the study measurements. Fuzai Yin was responsible for: study conception and design, data interpretation, and revision and critique of the manuscript. Kexin Fan was responsible for: drafting and revising the manuscript, statistical analysis, and data interpretation. Tengfei Sun was responsible for: data collection and critique of the statistical analysis.

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References


### Tables

**TABLE 1** Comparison of baseline characteristics in the two groups

<table>
<thead>
<tr>
<th></th>
<th>Controls n=505</th>
<th>Cases n=505</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54.00±15.39</td>
<td>54.31±16.01</td>
<td>0.752</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>22.76±3.76</td>
<td>23.42±4.26</td>
<td>0.010</td>
</tr>
<tr>
<td>WC(cm)</td>
<td>80.0±9.5</td>
<td>92.0±10.7</td>
<td>0.001</td>
</tr>
<tr>
<td>Type 2 Diabetes , %</td>
<td>11(2.4)</td>
<td>55 (11.3)</td>
<td>0.001</td>
</tr>
<tr>
<td>CHD, %</td>
<td>15(3.0)</td>
<td>30(6.2)</td>
<td>0.016</td>
</tr>
<tr>
<td>Smoking, %</td>
<td>13.26</td>
<td>15.30</td>
<td>0.701</td>
</tr>
<tr>
<td>Alcohol consumption, %</td>
<td>16.32</td>
<td>13.26</td>
<td>0.572</td>
</tr>
<tr>
<td>Age at menarche years</td>
<td>14.68±1.43</td>
<td>14.63±1.61</td>
<td>0.608</td>
</tr>
<tr>
<td>Age at first pregnancy, years</td>
<td>25.91±2.98</td>
<td>26.48±2.58</td>
<td>0.002</td>
</tr>
<tr>
<td>Breastfeeding ≥1 year, %</td>
<td>238 50.5</td>
<td>228 48.6</td>
<td>0.557</td>
</tr>
<tr>
<td>Family history of cancer, %</td>
<td>15 3.0</td>
<td>50 10.4</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL-C mmol/l</td>
<td>2.27±0.62</td>
<td>3.24±1.00</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL-C/HDL-C</td>
<td>1.61±0.53</td>
<td>2.87±1.01</td>
<td>0.001</td>
</tr>
<tr>
<td>TG mmol/l</td>
<td>1.13±0.61</td>
<td>1.56±0.82</td>
<td>0.001</td>
</tr>
<tr>
<td>Fasting glucose mmol/l</td>
<td>5.37±1.17</td>
<td>5.52±1.88</td>
<td>0.115</td>
</tr>
<tr>
<td>Uric acid μmol/l</td>
<td>272.85±66.99</td>
<td>302.32±84.87</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; WC, waist circumference; CHD, coronary heart disease; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; TG, triglyceride;
For categorical variables n (%) was presented; for quantitative variables mean (SD) was presented.

**Table 2** Multivariate logistic regression analysis of the risk factors

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Beta</th>
<th>SE</th>
<th>OR (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI kg/m²</td>
<td>-0.44</td>
<td>0.05</td>
<td>0.64 (0.58-0.71)</td>
<td>0.001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>0.18</td>
<td>0.02</td>
<td>1.20 (1.15-1.24)</td>
<td>0.001</td>
</tr>
<tr>
<td>Type 2 Diabetes, %</td>
<td>0.64</td>
<td>0.57</td>
<td>1.90 (0.62-5.80)</td>
<td>0.260</td>
</tr>
<tr>
<td>CHD, %</td>
<td>1.43</td>
<td>0.51</td>
<td>4.16 (1.55-11.20)</td>
<td>0.005</td>
</tr>
<tr>
<td>Age at first pregnancy, years</td>
<td>0.04</td>
<td>0.04</td>
<td>1.04 (0.96-1.13)</td>
<td>0.314</td>
</tr>
<tr>
<td>Family history of cancer, %</td>
<td>1.62</td>
<td>0.46</td>
<td>5.06 (2.04-12.51)</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL-C mmol/l</td>
<td>-0.59</td>
<td>0.23</td>
<td>0.55 (0.35-0.87)</td>
<td>0.010</td>
</tr>
<tr>
<td>LDL-C/HDL-C</td>
<td>3.23</td>
<td>0.33</td>
<td>25.19 (13.15-48.25)</td>
<td>0.001</td>
</tr>
<tr>
<td>TG mmol/l</td>
<td>-0.72</td>
<td>0.19</td>
<td>0.49 (0.34-0.70)</td>
<td>0.001</td>
</tr>
<tr>
<td>Uric acid μmol/l</td>
<td>-0.01</td>
<td>0.002</td>
<td>0.995 (0.992-0.999)</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; WC, waist circumference; CHD, coronary heart disease; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; TG, triglyceride; SE, standard error; OR, odds ratio; CI, confidence interval.

**Table 3** Comparison of LDL-C, LDL-C/HDL-C, WC and TG in different models

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Model 1</th>
<th>P-value</th>
<th>Model 2</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDL-C (mmol/l)</td>
<td>4.84</td>
<td>3.88-6.05</td>
<td>0.001</td>
<td>0.55</td>
</tr>
<tr>
<td>LDL-C/HDL-C</td>
<td>9.85</td>
<td>7.39-13.12</td>
<td>0.001</td>
<td>25.19</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>1.12</td>
<td>1.10-1.14</td>
<td>0.001</td>
<td>1.20</td>
</tr>
<tr>
<td>TG mmol/l</td>
<td>2.61</td>
<td>2.08-3.26</td>
<td>0.001</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Abbreviations: LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; WC, waist circumference; TG, triglyceride OR, odds ratio; CI, confidence interval. Model 1: univariate logistic regression analysis of LDL-C, LDL-C/HDL-C,
WC and TG respectively; Model 2, BMI, Type 2 Diabetes, CHD, age at first pregnancy, family history of cancer, uric acid, LDL,

LDL/HDL, WC and TG were all added into the regression equation.

**TABLE 4** Stratified analyses of LDL-C, LDL-C/HDL-C, WC and TG in different models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ER+ n=334</td>
<td>ER- n=171</td>
<td>ER+ n=334</td>
<td>ER- n=171</td>
</tr>
<tr>
<td></td>
<td>OR(95% CI)</td>
<td>P-value</td>
<td>OR(95% CI)</td>
<td>P-value</td>
</tr>
<tr>
<td>LDL-C (mmol/l)</td>
<td>4.66 (3.67-5.93)</td>
<td>0.001</td>
<td>5.18 (3.83-7.03)</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL-C/HDL-C</td>
<td>9.33 (6.86-12.68)</td>
<td>0.001</td>
<td>9.24 (6.43-13.26)</td>
<td>0.001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>1.12 (1.10-1.14)</td>
<td>0.001</td>
<td>1.125 (1.10-1.15)</td>
<td>0.001</td>
</tr>
<tr>
<td>TG (mmol/l)</td>
<td>2.60 (2.06-3.28)</td>
<td>0.001</td>
<td>2.04 (1.56-2.67)</td>
<td>0.001</td>
</tr>
<tr>
<td>LDL-C (mmol/l)</td>
<td>0.52 (0.31-0.87)</td>
<td>0.012</td>
<td>0.67 (0.35-1.28)</td>
<td>0.222</td>
</tr>
<tr>
<td>LDL-C/HDL-C</td>
<td>26.70 (12.83-55.59)</td>
<td>0.001</td>
<td>20.33 (8.41-49.15)</td>
<td>0.001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>1.18 (1.13-1.23)</td>
<td>0.001</td>
<td>1.25 (1.19-1.32)</td>
<td>0.001</td>
</tr>
<tr>
<td>TG (mmol/l)</td>
<td>0.49 (0.33-0.73)</td>
<td>0.001</td>
<td>0.45 (0.26-0.79)</td>
<td>0.448</td>
</tr>
</tbody>
</table>

Abbreviations: LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; WC, waist circumference;

TG, triglyceride; ER+, estrogen receptor positive; ER-, estrogen receptor negative; OR, odds ratio; CI, confidence interval.

Model 1: univariate logistic regression analysis of LDL-C, LDL-C/HDL-C, WC and TG respectively; Model 2, BMI, Type 2 Diabetes, CHD, age at first pregnancy, family history of cancer, uric acid, LDL, LDL/HDL, WC and TG were all added into the regression equation.