Dyslipidemia and Its Associated Factors in Women of the Bandare-Kong Cohort Study

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Research

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Abstract

**Background:** Dyslipidemia, a major risk factor for cardiovascular diseases, has become a global issue. Due to geographic and demographic variations in the prevalence of dyslipidemia, this study aimed to evaluate dyslipidemia and its associated factors in women of the Bandare-Kong Cohort Study (BKNCD).

**Methods:** This study was conducted on women from the population-based BKNCD, as part of the Prospective Epidemiological Research Studies in Iran (PERSIAN). Sociodemographic data, medical history, and anthropometric indices were collected. Diastolic blood pressure, systolic blood pressure, fasting plasma glucose, serum triglyceride (TG), total cholesterol (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were measured. Daily calorie intake and weekly metabolic equivalent of tasks were also recorded. Dyslipidemia was defined as any lipid abnormality based on the Adult Treatment Panel III criteria.

**Results:** From the 2223 women in this study (mean age: 48.28±9.26 years), dyslipidemia was observed in 1884 (84.8%). High TC was the most common lipid abnormality (53.9%) followed by low HDL (50.8%). Dyslipidemia was most prevalent among women aged 65-70 years, the widowed, illiterate, unemployed, and overweight, with very low socioeconomic status, diabetes, and high waist circumference, hypertension, those using hookah and living in urban areas. Logistic regression revealed that only women with high WHR were at increased risk of dyslipidemia (OR=2.48, 95% CI:1.75-3.53, P<0.001). Having a high school diploma (OR=0.57, 95% CI:0.37-0.89, P=0.015) and living in rural areas (OR=0.68 95% CI:0.49-0.96, P=0.028) were protective.

**Conclusions:** Dyslipidemia was highly prevalent in women of BKNCD. High WHR appears to be the only significant risk factor for dyslipidemia.

Introduction

Dyslipidemia, a disorder of lipid metabolism, is clinically defined as the presence of one of the following abnormalities: elevated plasma triglycerides (TG), elevated total cholesterol (TC), high levels of low-density lipoprotein (LDL), and decreased high-density lipoprotein (HDL) (1). With the increasing prevalence of dyslipidemia, mostly due to adverse changes in lifestyle including dietary changes, the more sedentary lifestyle, and reduced physical activity, it has become a global public health issue (2, 3). There is substantial evidence that dyslipidemia is associated with an increased risk of cardiovascular disease (CVD) (4). According to the World Health Organization (WHO) estimates, dyslipidemia, especially high TC, is responsible for 2.6 million deaths annually and 29.7 million disability-adjusted life years (DALYS) worldwide (5).

The prevalence of dyslipidemia varies in different regions, with hypercholesterolemia ranging from 22.6–54% across Africa, South East Asia, Europe, and America (5). Studies in Iran have also reported the prevalence of dyslipidemia: the prevalence of hypertriglyceridemia, hypercholesterolemia, high LDL, and low HDL ranged 14-40.6%, 14–61%, 13.4–45.5%, and 5–73%, respectively (6–9). In addition, it has been
demonstrated in many parts of the world including Iran, that dyslipidemia can be influenced by numerous factors including socio-economic status, level of fat intake, obesity, and gender (7, 10–13). Dyslipidemia is a modifiable risk factor for the development of type 2 diabetes, atherosclerosis, CVD, and stroke; early effective management of patients with dyslipidemia can decrease the incidence and burden of the above-mentioned conditions (14–19).

Metabolism in women can be affected by alterations in hormonal levels throughout their lives, in either the premenopausal or postmenopausal period (20). It has been reported that serum TC levels in women increases with age; however, this occurs more gradually compared to men (12). Yet, it increases at a higher rate after the age of 44 years, probably as a result of loss of estrogen in the postmenopausal period and decreased activity of LDL receptors (21).

With regard to regional differences in the prevalence of dyslipidemia and gender variations in this respect, and taken into consideration the modifiable nature of dyslipidemia for prevention and control of the disease burden, as well as specific hormonal effects in females, it would be extremely important to be aware of the prevalence and potential influencing factors of this condition in women. Thus, we aimed to evaluate dyslipidemia and its associated factors in women of the PERSIAN Bandare-Kong Cohort Study.

**Methods**

**Participants**

We evaluated the women of the PERSIAN Bandare Kong Cohort Study, a prospective, population-based cohort study in Bandare-Kong, Iran, which has been previously described in detail (22). This cohort study includes 2334 women aged 35–70 years, recruited between November 17, 2016 and November 22, 2018, from Hormozgan province, southern Iran, as part of the Prospective Epidemiological Research Studies in Iran (PERSIAN). Written informed consent was obtained from all the participants. After exclusion of pregnant women, those taking lipid-lowering medications, and incomplete records, 2223 women were included in the final analysis.

**Study design**

The BKNCD cohort study is part of the PERSIAN (Prospective Epidemiological Research Studies in Iran) Cohort. Sociodemographic data were collected using a face-to-face interview by trained interviewers. Age, education, marital status, place of residence, and hookah use were recorded. Data regarding occupation, type of residence ownership, home size/area, trips, and other possessions including cars, computers, dishwasher, etc. were used to determine socioeconomic status (SES) by means of principal component analysis. Daily calorie intake was calculated using daily ingested foods reported by the participants and their calorie content. Daily and weekly energy expenditure were determined using the metabolic equivalent of tasks (METs).
Weight was measured with a digital scale (measurement accuracy of 0.5 kg), with subjects in minimum clothing and without shoes. Height was measured with subjects standing shoeless and with their shoulders set normally. Waist circumference (WC) was measured twice for each participant and the average was recorded. WC was measured at the end of several consecutive natural breaths, at a level parallel to the floor, the midpoint between the top of the iliac crest and the inferior margin of the last palpable rib in the midaxillary line. Hip circumference (HC) was measured at the largest circumference of the buttocks, at a parallel level to the floor. All measurements were done with the same stretch-resistant tape to the nearest 0.5 cm. Subjects were standing upright during the measurements, with arms relaxed at the side, feet evenly spread apart and body weight evenly distributed (23). Waist-to-hip ratio (WHR) was calculated as WC divided by HC to the nearest 0.01. WHO cut-off for substantially increased risk of metabolic complications in women are: WC > 88 cm and WHR ≥ 0.85 (23). According to the study by Azizi et al. the cut-off value of WC for the Iranian population is WC ≥ 95 cm for both men and women (24). No WHR cut-off has been established for the Iranian population; therefore, the WHO cut-off for WHR was used.

BMI was calculated as weight in kilograms divided by the square of the person’s height in meters to the nearest 0.01. According to the WHO guidelines, BMI < 18.5 kg/m2 was considered as underweight, 18.5 ≤ BMI < 25 as normal, 25 ≤ BMI < 30 as overweight, and BMI ≥ 30 as obese (25).

Blood pressure (BP) was measured using a standard mercury sphygmomanometer after 5 minutes of rest with an appropriate cuff size for the upper-arm circumference, in the seated position, with feet on the floor, and arm supported at heart level. The average of two measurements made at least 5 min apart was used for analysis. Hypertension was defined as sustained blood pressure ≥ 140/90 mmHg (26) or treatment with anti-hypertensive medications. Elevated values (≥ 140/90 mmHg) were confirmed on a separate day.

Venous blood samples were collected following overnight 8-hour fasting and fasting plasma glucose (FPG) was measured. Plasma glucose measurements were done using the glucose oxidase method. According to the American Diabetes Association (ADA) criteria, diabetes was defined as an FPG ≥ 126 mg/dl, confirmed in a repeat test, or treatment with glucose-lowering agents (27). Venous blood samples were collected on another day following overnight 12-hour fasting and TC, TG, LDL, and HDL were measured for each participant using the enzymatic method. LDL < 100 mg/dl was considered optimal, 100–129 mg/dl near or above optimal, 130–159 borderline high, 160–189 high, and ≥ 190 very high. TC < 200 mg/dl was considered desirable, 200–239 borderline high, and ≥ 240 high. Low HDL was defined as HDL < 50 mg/dl in women and HDL ≥ 60 mg/dl was considered high. TG < 150 mg/dl was considered normal, 150–199 borderline high, 200–499 high, and ≥ 500 very high. Based on the Adult Treatment Panel (ATP III) criteria (28), dyslipidemia was defined as the presence of one or more of the following disorders:

1. TC ≥ 200 mg/dl
2. TG ≥ 150 mg/dl
3. LDL ≥ 130 mg/dl
4. HDL < 50 mg/dl (in women)

Data analysis

Statistical Package for the Social Sciences (SPSS) software (version 25.0, Armonk, NY: IBM Corp.) was used for data analysis. Mean, standard deviation, frequency, and percentages were used to describe the results. Logistic regression model was used to examine the correlation of dyslipidemia and its components with associated factors. Linear regression was used to determine the predictive power of associated factors on lipid profile components. P-values of equal to or less than 0.05 were regarded as statistically significant.

Results

From the 2223 women evaluated in this study (with mean age of 48.28 ± 9.26), dyslipidemia was observed in 1884 (84.8%). Mean values of TC, TG, HDL, and LDL were 204.72 ± 42.39 mg/dl, 127.19 ± 68.73 mg/dl, 50.37 ± 10.83 mg/dl, and 129.16 ± 35.52 mg/dl, respectively. High TC was the most common lipid abnormality (53.9%) followed by low HDL (50.8%), high LDL (48%), and high TG (26.2%). One, two, three, and four abnormal lipid components were observed in 26.6%, 30.2%, 19.9%, and 8.1%, respectively. High TG (individually, with other components being normal), high TC, low HDL, and high LDL were exclusively seen in 1.2%, 4.3%, 20.8%, and 0.3%, respectively. In general, most participants were aged 35–44 years (22.3%). They were mostly married (83.1%), and illiterate (55.1%). Most of them lived in urban areas (84.3%), had very low socioeconomic status (23.3%), and were unemployed (84.8%). Moreover, 13.5% used hookah. With regard to medical history and anthropometric indices, 20.9% had diabetes, 30% had hypertension, most participants were overweight (39%), 87.4% had high WHR, 76.4% had high WC based on WHO cut-off, and 53.6% based on Iranian-specific cut-off.

Prevalence of dyslipidemia and individual lipid abnormalities are demonstrated in Table 1. The prevalence of dyslipidemia was the highest in women aged 65–70 years, while high TC and high LDL were most prevalent in 60–64 age group. On the other hand, high TG and low HDL were most prevalent in 50–54, and 40–44 age groups, respectively. Except for low HDL which was more prevalent among married women, dyslipidemia and all other lipid abnormalities were highest in widowed participants. Aside from low HDL, which was the highest in those with an associate's degree, illiterate participants had the highest rate of dyslipidemia and lipid abnormalities. Apart from high TG, most prevalent in those living in rural areas, dyslipidemia and other lipid abnormalities were most prevalent in those living in urban areas. Details of lipid abnormalities are shown in Table 2.

Logistic regression revealed that high WHR was consistently correlated with dyslipidemia and all of its components. Women living in rural areas were at increased risk of dyslipidemia compared to those living in urban areas, while having a high school diploma was protective against dyslipidemia. Age of 50–54 years, overweight, obesity, diabetes, and were associated with high TG. Women aged 45–64 years were at
increased risk of having high TC; however, surprisingly diabetes and hookah were protective in this regard. On the contrary, hookah, as well as diabetes and 50–64 years of age were risk factors for low HDL, while high or very high socioeconomic status and living in rural areas were protective. Women aged 45–64 years were also at increased risk of having high LDL. High WC based on WHO cutoff was another risk factor for high LDL. Nevertheless, living in rural areas and diabetes were negatively correlated with high LDL (Table 3).

Linear regression ("enter" method) showed that every 1 kg/m² increase in BMI led to 2.51, 1.56, and 0.94 mg/dl increase in TG, TC, and LDL, respectively. Every 1 mg/dl increase in FPG and every 1 mmHg increase in systolic blood pressure (SBP) led to 0.22 and 0.41 mg/dl increase in TG, respectively. Every 1 year advance in age and 1 mmHg elevation in diastolic blood pressure (DBP) led to 0.59 and 0.31 mg/dl increase in TC, respectively. Weight, HC, and WHR were negatively correlated with HDL. Age was also positively associated with LDL. Besides, altogether age, years of education, weight, WC, HC, WHR, BMI, FPG, SBP, DBP, daily calorie intake, and weekly METs could predict 14%, 6%, 7%, and 3% of the variance of TG, TC, HDL, and LDL, respectively (Table 4).
| Variable          | Total | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|-------------------|-------|--------------|---------|---------|---------|----------|
|                   | N (%) | %            | %       | %       | %       | %        |
| Age groups (years)|       |              |         |         |         |          |
| 35–39             | 496 (22.3) | 79.6 | 16.9 | 41.5 | 53.0 | 38.5 |
| 40–44             | 410 (18.4) | 81.5 | 23.2 | 44.9 | 56.8 | 40.2 |
| 45–49             | 384 (17.3) | 87.5 | 26.3 | 58.1 | 53.9 | 49.7 |
| 50–54             | 327 (14.7) | 89.0 | 34.6 | 61.8 | 47.4 | 55.4 |
| 55–59             | 293 (13.2) | 85.3 | 32.8 | 63.5 | 42.3 | 54.6 |
| 60–64             | 179 (8.1) | 87.2 | 27.9 | 67.6 | 44.1 | 63.1 |
| 65–70             | 134 (6.0) | 91.0 | 32.1 | 56.7 | 50.7 | 50.0 |
| Marital status    |       |              |         |         |         |          |
| Single            | 72 (3.2) | 76.4 | 22.2 | 47.2 | 41.7 | 38.9 |
| Married           | 1848 (83.1) | 84.8 | 25.6 | 52.9 | 51.4 | 47.3 |
| Widowed           | 241 (10.8) | 87.6 | 32.4 | 62.2 | 50.2 | 57.3 |
| Divorced          | 62 (2.8) | 80.6 | 22.6 | 58.1 | 46.8 | 43.5 |
| Education         |       |              |         |         |         |          |
| Illiterate        | 1225 (55.1) | 87.6 | 28.8 | 59.3 | 48.7 | 52.3 |
| Elementary school | 506 (22.8) | 85.2 | 25.7 | 49.2 | 57.3 | 45.7 |
| Middle school     | 175 (7.9) | 79.4 | 23.4 | 48.6 | 53.1 | 41.7 |
| High school diploma | 199 (9.0) | 75.9 | 20.1 | 44.7 | 46.2 | 37.2 |
| Associate's degree | 29 (1.3) | 82.8 | 17.2 | 44.8 | 58.6 | 44.8 |
| Bachelor's degree | 74 (3.3) | 77.0 | 14.9 | 40.5 | 47.3 | 41.9 |

Abbreviations: N, number; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.
| Variable                        | Total   | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|--------------------------------|---------|--------------|---------|---------|---------|----------|
| Master's degree                | 14 (0.6)| 64.3         | 14.3    | 42.9    | 42.9    | 35.7     |
| PhD                            | 1 (0.0) | 0.0          | 0.0     | 0.0     | 0.0     | 0.0      |
| Place of residence             |         |              |         |         |         |          |
| Urban                          | 1874 (84.3) | 85.0       | 25.9    | 54.1    | 52.9    | 48.6     |
| Rural                          | 349 (15.7) | 83.4        | 27.5    | 53.0    | 39.5    | 45.0     |
| SES                            |         |              |         |         |         |          |
| Very low                       | 517 (23.3) | 85.7        | 27.9    | 51.6    | 55.7    | 46.6     |
| Low                            | 461 (20.7) | 84.2        | 26.9    | 56.2    | 50.3    | 50.8     |
| Average                        | 445 (20.0) | 85.4        | 24.7    | 54.8    | 51.9    | 49.0     |
| High                           | 444 (20.0) | 84.7        | 25.9    | 53.2    | 48.6    | 47.1     |
| Very high                      | 356 (16.0) | 83.4        | 25.0    | 53.9    | 45.5    | 46.6     |
| Occupation                     |         |              |         |         |         |          |
| Unemployed                     | 1884 (84.8) | 85.6        | 27.0    | 55.3    | 50.7    | 49.2     |
| Employed                       | 339 (15.2) | 80.2        | 21.5    | 46.3    | 51.0    | 41.9     |
| Hookah                         |         |              |         |         |         |          |
| No                             | 1922 (86.5) | 84.6        | 26.2    | 55.0    | 49.5    | 48.5     |
| Yes                            | 301 (13.5) | 85.7        | 25.9    | 46.8    | 58.8    | 44.9     |
| Diabetes                       |         |              |         |         |         |          |
| No                             | 1759 (79.1) | 83.6        | 21.6    | 53.3    | 49.9    | 48.0     |
| Yes                            | 464 (20.9) | 89.2        | 43.5    | 56.0    | 54.1    | 48.1     |
| Hypertension                   |         |              |         |         |         |          |
| No                             | 1556 (70.0) | 83.5        | 21.8    | 50.6    | 51.9    | 45.8     |
| Yes                            | 667 (30.0) | 87.7        | 36.4    | 61.6    | 48.3    | 53.4     |
| BMI                            |         |              |         |         |         |          |
| Underweight                    | 47 (2.1) | 63.8        | 2.1     | 42.6    | 31.9    | 34.0     |

Abbreviations: N, number; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.
| Variable        | Total | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|-----------------|-------|--------------|---------|---------|---------|----------|
| Normal          | 630 (28.3) | 80.2 | 16.8 | 50.2 | 45.1 | 44.8 |
| Overweight      | 867 (39.0) | 87.2 | 29.5 | 56.2 | 54.2 | 50.6 |
| Obese           | 679 (30.5) | 87.3 | 32.3 | 55.2 | 53.0 | 48.7 |
| WHO WC          | Normal | 525 (23.6) | 75.8 | 13.3 | 46.5 | 42.9 | 38.7 |
|                 | High   | 1698 (76.4) | 87.5 | 30.2 | 56.2 | 53.2 | 50.9 |
| Iranian WC      | Normal | 1031 (46.4) | 80.9 | 18.0 | 51.6 | 46.8 | 46.0 |
|                 | High   | 1192 (53.6) | 88.1 | 33.2 | 55.9 | 54.3 | 49.8 |
| WHO WHR         | Normal | 279 (12.6) | 67.4 | 7.2  | 39.8 | 38.4 | 32.6 |
|                 | High   | 1944 (87.4) | 87.2 | 28.9 | 55.9 | 52.6 | 50.3 |

Abbreviations: N, number; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.
Table 2
Details of lipid abnormalities based on ATP III cut-offs

| Variable | Range       | N    | %   |
|----------|-------------|------|-----|
| TG       | < 150 mg/dl | Normal | 1641 | 73.8 |
|          | 150–199 mg/dl | Borderline high | 336 | 15.1 |
|          | 200–499 mg/dl | High | 240 | 10.8 |
|          | ≥ 500 mg/dl | Very high | 6 | 0.3 |
| TC       | < 200 mg/dl | Desirable | 1025 | 46.1 |
|          | 200–239 mg/dl | Borderline high | 787 | 35.4 |
|          | ≥ 240 mg/dl | High | 411 | 18.5 |
| HDL      | < 50 mg/dl | Low | 1129 | 50.8 |
|          | 50–59 mg/dl | Normal | 653 | 29.4 |
|          | ≥ 60 mg/dl | High | 441 | 19.8 |
| LDL      | < 100 mg/dl | Optimal | 467 | 21.0 |
|          | 100–129 mg/dl | Near or above optimal | 688 | 30.9 |
|          | 130–159 mg/dl | Borderline high | 674 | 30.3 |
|          | 160–189 mg/dl | High | 272 | 12.2 |
|          | ≥ 190 mg/dl | Very high | 122 | 5.5 |

Abbreviations: N, number; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Table 3
Logistic regression analysis of dyslipidemia and individual lipid abnormalities

| Variable          | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|-------------------|--------------|---------|---------|---------|----------|
|                   | OR (95% CI)  | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Age groups (years)|              |         |         |         |          |
| 35–39*            | 1.00         | 1.00    | 1.00    | 1.00    | 1.00     |
| 40–44             | 0.82 (0.58–1.18) | 1.26 (0.89–1.78) | 1.04 (0.79–1.37) | 1.00 (0.76–1.33) | 0.96 (0.73–1.28) |
| 45–49             | 1.11 (0.73–1.70) | 1.22 (0.85–1.76) | 1.65 (1.22–2.23)** | 0.86 (0.63–1.16) | 1.35 (1.00–1.82)** |
| 50–54             | 1.25 (0.78–1.98) | 1.71 (1.18–2.49)** | 1.91 (1.39–2.64)** | 0.63 (0.46–0.87)** | 1.70 (1.23–2.34)** |
| 55–59             | 0.82 (0.51–1.33) | 1.35 (0.90–2.02) | 2.03 (1.43–2.87)** | 0.50 (0.35–0.71)** | 1.64 (1.16–2.32)** |
| 60–64             | 0.92 (0.51–1.64) | 1.05 (0.65–1.70) | 2.39 (1.57–3.63)** | 0.52 (0.35–0.79)** | 2.24 (1.48–3.39)** |
| 65–70             | 1.42 (0.68–2.92) | 1.20 (0.71–2.03) | 1.43 (0.91–2.27) | 0.71 (0.45–1.13) | 1.26 (0.80–1.99) |
| Marital status    |              |         |         |         |          |
| Single*           | 1.00         | 1.00    | 1.00    | 1.00    | 1.00     |
| Married           | 1.13 (0.61–2.07) | 0.76 (0.41–1.40) | 0.86 (0.52–1.42) | 1.38 (0.83–2.28) | 1.04 (0.62–1.73) |
| Widowed           | 1.17 (0.56–2.45) | 0.96 (0.48–1.92) | 1.12 (0.63–1.99) | 1.33 (0.74–2.36) | 1.36 (0.76–2.44) |
| Divorced          | 0.82 (0.34–2.00) | 0.71 (0.29–1.70) | 1.17 (0.57–2.39) | 0.99 (0.48–2.04) | 0.90 (0.44–1.86) |
| Education         |              |         |         |         |          |
| Illiterate*       | 1.00         | 1.00    | 1.00    | 1.00    | 1.00     |

Abbreviations: OR, odds ratio; CI, confidence interval; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.

*Reference categories.

**Statistically significant (P-value < 0.05).
| Variable                  | Dyslipidemia | High TG   | High TC   | Low HDL  | High LDL  |
|---------------------------|--------------|-----------|-----------|----------|-----------|
|                           |              | (0.63–1.25) | (0.84–1.44) | (0.67–1.08) | (0.95–1.53) | (0.75–1.20) |
| Elementary school         | 0.88         | 1.10      | 0.86      | 1.20     | 0.95      |
|                           | (0.63–1.25)  | (0.84–1.44) | (0.67–1.08) | (0.95–1.53) | (0.75–1.20) |
| Middle school             | 0.67         | 1.20      | 0.98      | 1.00     | 0.90      |
|                           | (0.42–1.06)  | (0.79–1.83) | (0.69–1.40) | (0.70–1.43) | (0.63–1.28) |
| High school diploma       | 0.57         | 1.11      | 0.83      | 0.82     | 0.77      |
|                           | (0.37–0.89)**| (0.72–1.70) | (0.59–1.18) | (0.58–1.16) | (0.54–1.10) |
| Associate's degree        | 1.00         | 1.02      | 0.87      | 1.53     | 1.13      |
|                           | (0.35–2.85)  | (0.36–2.88) | (0.39–1.90) | (0.69–3.40) | (0.51–2.49) |
| Bachelor's degree         | 0.69         | 0.87      | 0.76      | 0.98     | 1.09      |
|                           | (0.35–1.37)  | (0.42–1.82) | (0.44–1.32) | (0.57–1.69) | (0.63–1.89) |
| Master's degree           | 0.34         | 0.70      | 0.80      | 0.83     | 0.81      |
|                           | (0.10–1.14)  | (0.13–3.53) | (0.26–2.47) | (0.27–2.55) | (0.25–2.56) |
| PhD                       | 0.00         | 0.00      | 0.00      | 0.00     | 0.00      |
| Place of residence        | Urban*       | 1.00      | 1.00      | 1.00     | 1.00      |
|                           |              | 1.00      | 1.00      | 1.00     | 1.00      |
|                           | Rural        | 0.68      | 0.94      | 0.84     | 0.54      |
|                           | (0.49–0.96)**| (0.71–1.24)| (0.66–1.08)| (0.42–0.69)**| (0.59–0.97)**|
| SES                       | Very low*    | 1.00      | 1.00      | 1.00     | 1.00      |
|                           |              | 1.00      | 1.00      | 1.00     | 1.00      |
|                           | Low          | 0.90      | 0.92      | 1.21     | 0.80      |
|                           | (0.62–1.29)  | (0.68–1.24)| (0.93–1.57)| (0.61–1.04)| (0.93–1.57) |
|                           | Average      | 1.06      | 0.85      | 1.21     | 0.85      |
|                           | (0.72–1.56)  | (0.62–1.16)| (0.92–1.58)| (0.65–1.11)| (0.90–1.54) |
|                           | High         | 0.96      | 0.86      | 1.09     | 0.72      |
|                           | (0.65–1.41)  | (0.63–1.17)| (0.83–1.43)| (0.55–0.95)**| (0.79–1.36) |

Abbreviations: OR, odds ratio; CI, confidence interval; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.

*Reference categories.

**Statistically significant (P-value < 0.05).
| Variable       | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|---------------|--------------|---------|---------|---------|----------|
|               | Very high    | 0.97 (0.64–1.46) | 0.90 (0.64–1.27) | 1.16 (0.87–1.56) | 0.65 (0.48–0.87) | 1.04 (0.77–1.39) |
| Occupation    | Unemployed*  | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |
|               | Employed     | 0.85 (0.61–1.20) | 0.95 (0.69–1.31) | 0.83 (0.64–1.07) | 0.94 (0.72–1.22) | 0.84 (0.65–1.09) |
| Hookah        | No*          | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |
|               | Yes          | 0.92 (0.64–1.33) | 0.81 (0.60–1.10) | 0.63 (0.49–0.82) | 1.37 (1.05–1.77) | 0.78 (0.60–1.01) |
| Diabetes      | No*          | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |
|               | Yes          | 1.23 (0.86–1.74) | 2.12 (1.67–2.69) | 0.78 (0.62–0.98) | 1.31 (1.04–1.65) | 0.73 (0.58–0.92) |
| Hypertension  | No*          | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |
|               | Yes          | 0.91 (0.66–1.24) | 1.35 (1.06–1.70) | 1.20 (0.96–1.49) | 0.86 (0.70–1.07) | 1.07 (0.87–1.33) |
| BMI           | Normal & underweight* | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
|               | Overweight   | 1.39 (0.95–2.03) | 1.59 (1.13–2.25) | 1.23 (0.93–1.64) | 1.15 (0.87–1.52) | 1.10 (0.83–1.45) |
|               | Obese        | 1.35 (0.84–2.18) | 1.65 (1.10–2.48) | 1.29 (0.91–1.82) | 0.97 (0.69–1.37) | 1.07 (0.76–1.51) |
| WHO WC        | Normal*      | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |
|               | High         | 1.19 (0.80–1.77) | 1.09 (0.74–1.61) | 1.12 (0.82–1.51) | 1.19 (0.88–1.62) | 1.50 (1.11–2.03) |
| Iranian WC    | Normal*      | 1.00     | 1.00    | 1.00    | 1.00     | 1.00     |

Abbreviations: OR, odds ratio; CI, confidence interval; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.

*Reference categories.

**Statistically significant (P-value < 0.05).
| Variable | Dyslipidemia | High TG | High TC | Low HDL | High LDL |
|----------|-------------|---------|---------|---------|----------|
| High     | 0.96 (0.66–1.41) | 1.21 (0.89–1.63) | 0.80 (0.62–1.04) | 1.18 (0.91–1.53) | 0.78 (0.60–1.02) |
| WHO WHR  | Normal*     | 1.00    | 1.00    | 1.00    | 1.00     |
|          | High        | 2.48 (1.75–3.53)** | 3.01 (1.87–5.15)** | 1.52 (1.12–2.06)** | 1.72 (1.27–2.34)** | 1.61 (1.18–2.20)** |

Abbreviations: OR, odds ratio; CI, confidence interval; TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SES, socioeconomic status; BMI, body mass index; WHO, World Health Organization; WC, waist circumference; WHR, waist-to-hip ratio.

*Reference categories.

**Statistically significant (P-value < 0.05).
Table 4
Multiple regression analysis of predictors of lipid profile components

| Dependent variable | Predictors              | B         | P-value | Adjusted R² |
|--------------------|-------------------------|-----------|---------|-------------|
| TG                 | Age                     | 0.269     | 0.182   | 0.137       |
|                    | Years of education      | 0.244     | 0.510   |             |
|                    | Weight                  | 1.113     | < 0.001 |             |
|                    | WC                      | -2.905    | 0.127   |             |
|                    | HC                      | 0.623     | 0.737   |             |
|                    | WHR                     | 382.448   | 0.053   |             |
|                    | BMI                     | 2.511     | 0.002   |             |
|                    | FPG                     | 0.228     | < 0.001 |             |
|                    | SBP                     | 0.416     | 0.003   |             |
|                    | DBP                     | -0.041    | 0.856   |             |
|                    | Daily calorie intake    | 0.004     | 0.024   |             |
|                    | Weekly METs             | -0.058    | 0.182   |             |

| TC                 | Age                     | 0.598     | < 0.001 | 0.059       |
|                    | Years of education      | 0.001     | 0.998   |             |
|                    | Weight                  | -0.425    | 0.039   |             |
|                    | WC                      | 0.083     | 0.946   |             |
|                    | HC                      | -0.135    | 0.910   |             |
|                    | WHR                     | -0.935    | 0.994   |             |
|                    | BMI                     | 1.564     | 0.003   |             |
|                    | FPG                     | 0.035     | 0.084   |             |
|                    | SBP                     | 0.079     | 0.381   |             |
|                    | DBP                     | 0.318     | 0.030   |             |
|                    | Daily calorie intake    | 0.001     | 0.236   |             |
|                    | Weekly METs             | 0.086     | 0.002   |             |

Abbreviations: TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; BMI, body mass index; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; MET, metabolic equivalent of task.
| Dependent variable | Predictors            | B      | P-value   | Adjusted $R^2$ |
|--------------------|-----------------------|--------|-----------|---------------|
| HDL                | Age                   | 0.171  | <0.001    | 0.072         |
|                    | Years of education    | 0.117  | 0.054     |               |
|                    | Weight                | -0.300 | <0.001    |               |
|                    | WC                    | 1.294  | <0.001    |               |
|                    | HC                    | -0.883 | 0.004     |               |
|                    | WHR                   | -148.504| <0.001    |               |
|                    | BMI                   | 0.022  | 0.870     |               |
|                    | FPG                   | 0.011  | 0.034     |               |
|                    | SBP                   | -0.013 | 0.559     |               |
|                    | DBP                   | 0.055  | 0.138     |               |
|                    | Daily calorie intake  | <0.001 | 0.794     |               |
|                    | Weekly METs           | 0.018  | 0.010     |               |
| LDL                | Age                   | 0.358  | 0.001     | 0.031         |
|                    | Years of education    | -0.179 | 0.379     | (P-value < 0.001) |
|                    | Weight                | -0.310 | 0.076     |               |
|                    | WC                    | -0.742 | 0.476     |               |
|                    | HC                    | 0.720  | 0.479     |               |
|                    | WHR                   | 83.109 | 0.442     |               |
|                    | BMI                   | 0.945  | 0.033     |               |
|                    | FPG                   | -0.014 | 0.414     |               |
|                    | SBP                   | 0.045  | 0.552     |               |
|                    | DBP                   | 0.230  | 0.064     |               |
|                    | Daily calorie intake  | 0.001  | 0.480     |               |
|                    | Weekly METs           | 0.080  | 0.001     |               |

Abbreviations: TG, triglyceride; TC, total cholesterol; HDL, high-density lipoprotein; LDL, low-density lipoprotein; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip ratio; BMI, body mass index; FPG, fasting plasma glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; MET, metabolic equivalent of task.

**Discussion**
The primary finding of the current study was the very high prevalence of dyslipidemia in women aged 35–70 years of the PERSIAN Bandare Kong Cohort Study, with 84.8% of the study population having at least one type of lipid abnormality based on ATP III criteria. High TC was the most common (53.9%) followed by low HDL (50.8%), high LDL (48%), and high TG (26.2%).

Prevalence of dyslipidemia in women was 87.7% in Najafipour et al.’s study (29), 61.3% in the study by Ebrahimi et al. (30), 85.1% in Latifi et al.’s study (31), 80.4% in a study on Turkish adults (32), and 37.6% among Chinese women (2). In a systematic review and meta-analysis conducted by Tabatabei et al. on the prevalence of dyslipidemia in published articles until September 2011, hypercholesterolemia, low HDL, and high LDL were more prevalent in women compared to men (13). Esteghamati et al. showed that the prevalence of hypertriglyceridemia and hypercholesterolemia were 33.2% and 45.4% among females (33). The corresponding percentages were 41% and 23% in Japanese women aged 25–64 years (34), 25% and 37.2% in Turkish adults (35), 24.1% and 30.6% in Najafipour et al.’s study (29), and 65.1% and 47.5% in Latifi et al.’s study (31). The variety of the prevalence of dyslipidemia and its individual components across different studies can be explained by demographic, socioeconomic, and anthropometric features of study populations which will be discussed in details later on.

The results of this study showed that the prevalence of dyslipidemia steadily increased with age in women up to the age of 54, with an abrupt but slight decrease in the 55–59 age group, but it increased again thereafter probably due to hormonal changes during menopause. A similar trend was observed in Ebrahimi et al.’s study (30). Nonetheless, we found no significant increase in the odds of dyslipidemia with age based on the logistic regression analysis. Yet, other studies in different parts of the world have shown that the risk of different types of dyslipidemia increases with age in both men and women (35–37).

We found no correlation between marital status and dyslipidemia or any of its components, which was in line with the findings of Ebrahimi et al. (30). Whereas, aside from low HDL, other lipid abnormalities were higher in married and widowed individuals compared to singles in the study by Erem et al. (35).

According to the findings of the current study, having a high school diploma was protective against dyslipidemia; however, there was no significant association between the level of education and individual components of dyslipidemia. Quite similarly, dyslipidemia was not influenced by level of education in a study conducted in India (10). In addition, this was partially consistent with the results of Ebrahimi et al.’s study, in which no relationship was found between the risk of developing different types of dyslipidemia and the level of education (30). On the contrary, Erem et al. in their study to estimate the prevalence of dyslipidemia and associated factors among Turkish adults, demonstrated that the risk of dyslipidemia was higher in those with lower education level. They justified their findings by higher exposure to risk factors such as poor eating habits and working conditions, difficulty to access health services, and stress in those with low level of education (35). Of note, the findings of the above-mentioned studies were with respect to both men and women. Results can be different when only women are concerned.
We found that women living in rural areas were at significant decreased risk of developing dyslipidemia, low HDL, and high LDL. The odds of hypertriglyceridemia and hypercholesterolemia, although insignificant, was also lower in women living in rural areas. Conversely, Cui et al. demonstrated that the prevalence of hypercholesterolemia was higher in rural areas compared to urban areas for women (34). Similarly Tripathy et al. demonstrated that living in rural areas increased the risk of dyslipidemia and high TC (38). The reason for these inconsistencies may be the consumption of fat-rich foods such as high-fat dairy by individuals living in rural areas in the two studies.

Over the past decade, there has been a decline in consumption of traditional foods, while use of high-fat, high-calorie, low-fiber, and processed foods has increased. This unhealthy diet together with insufficient physical activity, are risk factors for obesity and hypertriglyceridemia (39–41). Among the participants of the current study, 39% were overweight and 30.5% were obese. Overweight and obesity were only significantly correlated with hypertriglyceridemia but not dyslipidemia or other lipid abnormalities. Among the anthropometric indices, high WHR was the best predictor of dyslipidemia and all of its components. Obesity has been reported to be associated with hypertriglyceridemia in many studies (9, 10, 35–37, 42, 43). It should be noted that contrary to our findings, obesity has been proposed as a risk for hypercholesterolemia in some studies (9, 10, 35, 42).

The odds of hypertriglyceridemia was significantly higher in women with hypertension in our study, while neither dyslipidemia nor any other components were associated with hypertension. This was in agreement with the findings of Ebrahimi et al.; however, they also reported a significant correlation between high blood pressure and dyslipidemia (30). Tabrizi et al. reported similar results (44). Despite comparable findings regarding the association between hypertension and hypertriglyceridemia in a study in India, dyslipidemia and other lipid abnormalities were also significantly correlated in this study (38).

One limitation of the current study was that although, lipid-lowering medications were taken into account, some women with diabetes may have failed to indicate that they were taking these agents, which resulted in contradictory findings regarding the relationship between dyslipidemia or its components with diabetes. Another limitation was the assessment of physical activity which was reported in METs. The positive effect of physical activity on serum lipids, plasma glucose, and many other CVD risk factors has been previously established; therefore, the increase in TC and LDL with higher weekly METs observed in the current study can in part be due to inaccurate evaluation of physical activity. One more limitation was the daily calorie intake that was not subdivided based on specific foods. Calorie content of fat-rich foods would have been more valuable in the assessment of the correlation between lipid abnormalities and daily calorie intake.

**Conclusions**

Dyslipidemia was highly prevalent in women of the PERSIAN Bandare Kong Cohort Study. High TC was the most common, and high TG the least common lipid abnormalities in this population. High WHR put women aged 35–70 years at high risk of dyslipidemia and all of its components and appears to be the
best predictive anthropometric index with regard to lipid abnormalities. Women aged 50–54 years were at highest risk of developing lipid abnormalities compared to other age groups. Living in rural areas positively influenced the lipid profile of women, while marital status and employment had no effect on it. Except for the positive effect of having a high school diploma on dyslipidemia, level of education did not affect lipid abnormalities. Although the odds of high TG was higher in those with hypertension. The significance of hookah use and diabetes for lipid abnormalities was paradoxical. These findings should be taken into consideration in the preparation of future management and prevention guidelines designated for this specific population.

**Declarations**

**Abbreviations**

- ADA
- American Diabetes Association
- ATP III
- Adult Treatment Panel III
- BMI
- body mass index
- BP
- blood pressure
- CI
- confidence interval
- CVD
- cardiovascular disease
- DALYS
- disability-adjusted life years
- DBP
- diastolic blood pressure
- FPG
- fasting plasma glucose
- HC
- hip circumference
- HDL
- high-density lipoprotein
- LDL
- low-density lipoprotein
- MET
- metabolic equivalent of task
- OR
- odds ratio
Declarations

Ethics approval and consent to participate

The cohort study was given ethical approval by the Ethics Committee of Hormozgan University of Medical Sciences.

Availability of data and materials

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

Competing interests

The authors declare that they have no competing interests.

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MN designed the study and was a major contributor in writing the manuscript. MK was consulted on the possible associated factors to be taken into account and wrote the manuscript. HY performed the statistical analysis. MK interpreted the analyzed data. All authors read and approved the final manuscript.

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