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Review Article

Prevalence of Hypercholesterolemia, High LDL, and Low HDL in Iran: A Systematic Review and Meta-Analysis

CME Article

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What's Known

- The components of lipid were investigated in a systematic review
- The prevalence of dyslipidemia with respect to gender is substantial in Iran.

What's New

- The prevalence of different types of dyslipidemia in Iran is substantial.
- Given the risk of complications (e.g. cardiovascular disease, control of different types of dyslipidemia) in Iranian people, it is important to reduce the burden of cardiovascular diseases.

Abstract

Background: Chronic and abnormal increase of different types of dyslipidemia leads to some important diseases, such as constriction and abstraction of vessels in various parts of the body, especially in the heart. High lipid profile, such as increased total cholesterol and LDL as well as decreased HDL are recognized as cardiovascular disease risk factors. The present study aimed to estimate the prevalence of different types of dyslipidemia in Iran by a meta-analysis method.

Methods: A literature search for studies published during 1998-2015 was carried out using both Persian and English databases (SID, Magiran, IranMedex, MedLib, PubMed, and Scopus). Keywords such as lipid, dyslipidemia, CVD, cardiovascular risk factors, hypercholesterolemia, high LDL-C, low HDL-C, and prevalence were used in the search. Random-effects model was used for the analysis using STATA (version 11.2).

Results: In total, 163 articles were identified of which 49 articles fulfilled the inclusion criteria. The estimated prevalence (95% confidence interval) of eligible articles for high cholesterol ≥200 mg/dl and ≥240 mg/dl was 42% (95% CI: 38-45) and 17% (95% CI: 14-20), respectively. Moreover, the prevalence (95% confidence interval) for high LDL-C ≥130 mg/dl and ≥160 mg/dl was 40% (95% CI: 32-48) and 19% (95% CI: 16-23), respectively. The pooled prevalence estimate for low HDL-C (<40 among males, <50 among females) was 43% (95% CI: 33-53) in both sexes of the Iranian people. All types of lipid component abnormalities (hypercholesterolemia, high LDL-C, and low HDL-C) were more prevalent in women.

Conclusion: The results indicate that the prevalence of different types of dyslipidemia in Iran is substantial. Given the risk of complications (e.g. cardiovascular disease and control of different types of dyslipidemia) in Iranian people, it is important to reduce the burden of cardiovascular diseases.

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Keywords ● Cardiovascular diseases ● Iran ● Dyslipidemias

Introduction

Cardiovascular diseases (CVD) are one of the major health problems in the world and its increasing prevalence is threatening the human health.[1,2] While there are many prevention programs

for CVD incidence, these disorders are the most common cause of mortality in several countries.[3] According to the findings of various studies, the cause of 40-45% of mortality is related to CVD. Based on the third report of the World Health Organization, CVD (e.g. heart failure, stroke, and sudden cardiac death) is the cause of 12 million annual deaths worldwide.[4] The prevalence of CVD in developing countries is higher than developed countries.[5]

CVD includes coronary diseases, brain artery diseases, and peripheral artery diseases.[3] In coronary diseases, vessels that provide blood to the heart are obstructed; a common CVD disorder. Coronary artery obstruction is usually caused by arteriosclerosis. The sediment of cholesterol, calcium, or other materials in the inner layer of the artery and connective tissue cause arteriosclerosis.[1] Arteriosclerosis causes ischemic coronary artery and finally death[6] in which 25% of patients die suddenly without any signs.[7] Chronic and abnormal increase of triglyceride (TG) and total cholesterol (TC) concentration leads to some important diseases, such as constriction and abstraction of vessels in various parts of the body, especially in the heart.[8] The role of hypercholesterolemia as a major risk factor for coronary artery disease (CAD) has been proven; however, the role of triglyceride is controversial.[9] HDL is a protective factor.[3]

Changes in lifestyle due to the industrialization have altered peoples' diet and reduced their physical activity, which in turn leads to increased hyperlipidemia. A positive relationship between TC level and the risk of CVD has been indicated. This relationship has been found in many populations, including younger and elderly, male and female, and patients with or without CVD.[10] In addition, the elevation of LDL-C level leads to arteriosclerosis.[3] Recent studies have shown that the main blood cholesterol is LDL-C. When the concentration of LDL-C elevates, it accumulates in the intima-media of the artery that feeds the brain and heart, and eventually, plaque is produced.[7] On the other hand, HDL is a protective factor in CVD. Low HDL level incorporated with high TG level may cause a higher incidence of CVD.[3]

Studies have reported that CVD is one of the most important health problems in the Mediterranean and Middle Eastern countries (e.g. Iran) with an increasing prevalence.[4] According to available reports, the prevalence of CVD is 19.4% in Iran.[2] Hence, a decline in coronary events would be possible by modifying the serum lipid levels. Assessment of a nationwide estimate of dyslipidemia prevalence, as a major CVD risk factor, is essential in order to conduct prevention programs efficiently. It will also enable health policy makers to apply the best treatment programs. Using a meta-analysis method, the present study aimed to assess the prevalence of lipid profile disorders (TC, LDL-C, and HDL-C) in Iran.

Materials and Methods

Search Method

A literature search for studies published from October 1998 until January 2016 was carried out using both Persian (IranMedex, Magiran, SID, Irandoc) and English (Scopus, ISI Web of Science, PubMed) databases. Keywords such as lipid, dyslipidemia, CVD, cardiovascular risk factors, hypercholesterolemia, high LDL-C, low HDL-C, prevalence, public health, and epidemiology were used in the search. Moreover, the references of the identified articles were searched for additional sources of information. As a complementary search tool, the references of the selected citations and non-published national surveys were also hand-searched and relevant articles were evaluated. All articles that contained the above-mentioned search keywords in their title or abstract were included. To reduce bias, two researchers (F. Sayehmiri and F. Kiani) independently performed the search, selection of articles, and data extraction.

Inclusion and Exclusion Criteria

The inclusion criteria were all types of population-based articles (i.e. local, sub-national, or national surveys) that were carried out on individuals aged ≥20 years without a history of CHD, hyperlipidemia, diabetes, or hypertension.

The exclusion criteria were languages other than Persian or English, meta-analysis, systematic review, and studies performed on individuals with a history of CHD, hyperlipidemia, diabetes, hypertension, obesity, overweight, or other diseases. Additionally, studies that were not population-based or included duplicate citations were excluded.

The STROBE (strengthening the reporting of observational studies in epidemiology) statement was used for the quality control of studies. The quality of studies was assessed according to variables related to the study objectives, characteristics of the study population, clear explanation of the inclusion/exclusion criteria, data collection method as well as validity, explicit findings, and appropriate data analysis methods. When necessary, the authors were contacted for additional information.

Data Extraction

Data extraction included information such as primary author, publication year, region,

study type (local study or survey), sample size, age groups as well as the reported mean and prevalence of hypercholesterolemia, high LDL and low HDL in total, and gender. Two researchers independently reviewed the articles (abstract and full text) in order to collect the data according to the standard protocol. Disagreements were resolved by a discussion panel. Data were initially noted on collection forms and then entered into Microsoft Excel.

Data Synthesis and Analysis

The variance of prevalence was calculated using binomial distribution and the weighted mean was used for a combination of prevalence in different studies. Each article was assigned a weight based on 1/variance. I^2 statistics was used to measure heterogeneity. Since a significant variation was found between the findings of different studies, a random-effects model was used for the analysis. The findings were then presented in forest plots (point estimations and 95% CI). All statistical analysis was performed using STATA (version 11.2).

Results

Initially, 163 full-text articles were identified of which 91 were excluded after title and abstract evaluation. From the remaining 72 articles, after full-text evaluation, 23 were excluded (7 duplicates, 4 lacked data, and 12 did not report prevalence). Eventually, 49 cross-sectional studies[2,3,5,7,8,11-54] were selected for meta-analysis (figure 1). The extracted data from these studies are shown in table 1. Due to the severe heterogeneity of the reported prevalence (P<0.001), the meta-analysis was performed using a random-effects method.

Table 2 presents the pooled estimate of the mean of lipid components using a meta-analysis of the data extracted from population-based studies in Iran. From various cities in Iran, 26 studies reported the mean cholesterol level. Based on our meta-analysis, the pooled estimate of the mean cholesterol level in both sexes was 194.89 mg/dl (95% CI: 192.68-197.10).

Tables 3-5 show the pooled estimate of the prevalence of lipid components according to ATPIII cut-off, using a meta-analysis of the extracted data from population-based studies in Iran. The eligible studies for the prevalence estimation of hypercholesterolemia ≥200 mg/dl and ≥240 mg/dl were 31 and 23 articles, respectively. The estimated prevalence of cholesterol ≥200 mg/dl and ≥240 mg/dl in both sexes was 42% (95% CI: 38-45) and 17% (95% CI: 14-20), respectively. The prevalence of

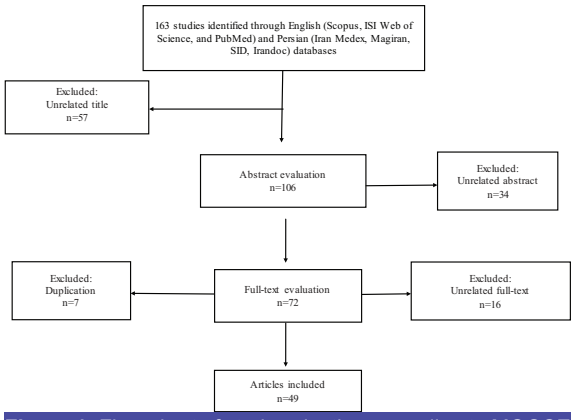

Figure 1: Flow chart of study selection according to MOOSE guidelines.

cholesterol ≥200 mg/dl is shown in figure 2.

For the assessment of the mean LDL-C level, 19 articles were analyzed. As shown in table 2, the estimated mean of LDL-C in both sexes was 117.46 mg/dl (95% CI: 111.94-122.99). Furthermore, the prevalence of high LDL-C level was found in 21 (≥130 mg/dl) and 23 (≥160 mg/dl) eligible studies. The pooled estimate of the prevalence of LDL-C ≥130 mg/dl and ≥160 mg/dl in both sexes was 40% (95% CI: 32-48) and 19% (95% CI: 16-23), respectively. The prevalence of LDL-C ≥130 mg/dl is shown in figure 3. As shown in table 2, the pooled estimate of the mean of HDL-C level from the 20 included studies was 44.22 mg/dl (95% CI: 42.13-46.32). From the 17 eligible studies that reported the prevalence of low HDL-C (<40 among males, <50 among females), the estimated prevalence of low HDL-C was 42% (95% CI: 35-530) (table 5). In addition, 19 eligible studies were included in the meta-analysis to assess the prevalence of low HDL-C (<35 mg/dl) for which the prevalence of 28% (95% CI: 19-37) was estimated. The prevalence of low HDL-C (<40 mg/dl) is shown in figure 4.

Mean and Prevalence of Total Cholesterol, LDL-C, and HDL-C Stratified by Gender

The estimated mean and the prevalence of each lipid component, according to sex, are shown in tables 2 and 3-5, respectively. Based on the results, the prevalence of hypercholesterolemia was higher among women. The value for the prevalence of cholesterol ≥200 mg/dl was 39% (95% CI: 30-48) in men and 44% (95% CI: 39-48) in women. The prevalence of cholesterol ≥240 mg/dl was 15% (95% CI: 12-18) in men and 20% (95% CI: 16-24) in women (table 3). Furthermore, the mean total cholesterol level in men and women was 191.05 mg/dl (95% CI: 187.39-194.72) and 197.49 mg/dl (95% CI: 193.87-201.11), respectively, which was higher

Table 1: Summary of the studies on the prevalence of hypercholesterolemia, low HDL-C and high LDL-C levels, mean TC, HDL-C, and LDL-C.

Reference	Year		Location and study design	Sample size	Age group	Cholesterol (mean±SD)
	Study	Publication				
Navaie[11]	1994	2000	Tehran; local study	T: 2.705 M: 1.296 F: 1.409	>30	T: 196±44.7 M: 188±41.1 F: 203±46.4
Fakhrzade[12]	1996-1997	2002	Bushehr; local study	T: 1.036 M: 370 F: 666	30-64	T: 199.6±47.8 M: 195±46.1 F: 204.2±49.5
Saeedi[13]	1997-1998	2003	Kermanshah; local study	T: 922 M: 329 F: 593	>20	T: 199.5±37.2 M: 196.2±32.5 F: 201.3±39.4
Sarrafzadegan[14]	1998	1998	Isfahan; local study	T: 2.200 M: 1.000 F: 1.200	19-70	T: 196.4±27.5 M: 193.1±28.8 F: 199.6±26.4
Karimi[8]	1999	2000	Bushehr; local study	T: 1.206 M: 410 F: 796	>20	T: 181.7±44.4 M: 179.6±43.5 F: 183.7±45.2
Azizi[15]	1999-2000	2003	Tehran; local study	T: 6.246 M: 2.339 F: 3.907	20-60	T: 210±47 M: 206±44 F: 213±48
Azizi[16]	1999-2000	2003	Tehran; local study	T: 1.766 M: 911 F: 855	>60	T: 222±46 M: 212±40 F: 244±47
Fakhrzade[17]	2000	2005	Qazvin; local study	T: 1.000 M: 499 F: 501	>25	
Yosefinia[18]	2000	2007	Arak; local study	T: 4.303 M: 2.082 F: 2.221	>30	
Kelishadi[19]	2000-2001	2008	Isfahan; local study	T: 3.694 M: 1.924 F: 1.770	>20	
Sadeghi[20]	2001	2005	Isfahan, Najafabad, Arak; local study	F: 6.391	>20	F: 203.83±53.3
Mohamadi fards[5]	2002	2003	Isfahan, Najafabad; local study	T: 6.175 M: 3.005 F: 3.169	>20	
Mohamadi fards[5]	2002	2003	Arak; local study	T: 6.339 M: 3.117 F: 3.222	>20	
Hajzade[21]	2002	2007	Mashhad; local study	T: 2.215 M: 785 F: 1.457	>40	
Mellati[22]	2002-2003	2009	Zanjan; local study	T: 2.768 M: 1.310 F: 1.458	21-75	T: 186.3±41.7 M: 182.1±39.4 F: 190.5±43.9
Sharifi[23]	2002-2003	2008	Zanjan; local study	T: 2.941 M: 1.396 F: 1.545	>20	T: 189.6±38.4 M: 182.5±35 F: 196.7±41.8
Amiri[24]	2003	2004	Boshehr; local study	T: 2.092 M: 992 F: 1.100	25-64	T: 209.2±52.5 M: 204.96±51.1 F: 213.33±53.89
Agheli[25]	2003	2005	Rasht; local study	T: 550 M: 285 F: 265	>30	
Agheli[25]	2003	2005	Ghazvin; local study	T: 550 M: 274 F: 276	>30	
Seyffarshad[26]	2003	2007	East Azerbaijan, local study	T: 3.031 M: 1.533 F: 1.498	20-64	T: 195.6±44.7 M: 190.6±40.7 F: 199.17±47.3

(Contd...)

Table 1: (*Continued*)

Reference	Year		Location and study design	Sample size	Age group	Cholesterol (mean±SD)
	Study	Publication				
Mahmoodi[27]	2003-2004	2006	Tehran; local study	T: 232 M: 120 F: 112	>55	T: 185.81±47.05 M: 185.71±49.1 F: 185.91±44.98
Esmaili-Nadimi[3]	2004	2004	Rafsanjan; local study	T: 491 M: 247 F: 244	>20	T: 198.2±47.4 M: 200.8±45.4 F: 195.5±49.2
Nabipour[28]	2004	2008	Persian Gulf (Bushehr, Genaveh, Deilam); local study	T: 3.723 M: 1.746 F: 1.977	25-64	T: 205.29±52.3 M: 201.53±52.2 F: 210.05±51.52
Namayande[29]	2004	2011	Yazd; local study	T: 2.000 M: 1.000 F: 1.000	20-74	
Aghasadeghi[30]	2004-2005	2008	Shiraz; local study	T: 198 M: 73 F: 125	21-80	
Chehrei[31]	2005	2007	Arak; national survey	T: 750 M: 170 F: 580	25-58	T: 175.5±45.6 M: 170.2±45.3 F: 180.9±45.9
Malek[32]	2005	2009	Semnan; local study	T: 3.799 M: 1.695 F: 2.104	30-70	
Alikhani[33]	2005	2009	Country; national survey	T: 65.781 M: 32.842 F: 32.932	25-64	T: 197.8±44.9 M: 195.1±40 F: 200.5±48.8
Ghiasvand[34]	2005	2006	Tehran; local study	T: 266	21-46	T: 182.92±37.46
Ghoddosi[35]	2005	2006	Tehran; local study	T: 6.932 M: 4.013 F: 5.619	>20	
Vaghari[36]	2005	2009	Golestan; local study	T: 1.995 M: 997 F: 998	25-65	T: 203.6±40.7 M: 196.7±39.5 F: 209.4±42.9
Hatami[37]	2006	2007	Tehran; local study	T: 3.000 M: 1.619 F: 1.381	>20	T: 220.64±55.34
Asgari[38]	2007	2007	Country; national survey	T: 19.017 M: 9.078 F: 9.939	25-64	T: 185.5±43.8 M: 181.4±40.8 F: 189.6±47.8
Delavari[39]	2007	2008	Country; national survey	T: 3.024	25-64	
Javadi[40]	2007	2009	Qazvin; local study	F: 400	>20	F: 173.5±32.6
Azabdaftari[41]	2007	2009	Ahvaz; local study	M: 91	>25	
Esteghamati[42]	2007	2009	Country; national survey	T: 3.397 M: 1.645 F: 1.752	20-64	T: 195.63±1.10
Saberi[43]	2007	2011	Kashan; local study	M: 429	21-73	
Bahonar[44]	2008-2009	2010	Isfahan; local study	T: 585	>20	T: 198±39
Nikparvar[45]	2008-2009	2015	Bandar Abbas; local study	T: 137 M: 42 F: 95	20-27	T: 167.08±33.68
Agajani Delavar[46]	2009	2009	Babol; local study	F: 984	30-50	
Asayi[47]	2009	2013	Gonabad; local study	T: 606 M: 205 F: 401	20-84	T: 200.13±41.20 M: 200.16±41.1 F: 199.99±41.3
Majdi[7]	2009-2010	2012	North Khorasan; local study	T: 11.704 M: 5.730 F: 5.974	>20	T: 193.7±41.3 M: 196.4±42.7 F: 190.9±39.8
Heydari[48]	2010	2010	Shiraz; local study	M: 341	20-54	

(Contd...)

Table 1: (*Continued*)

Reference	Year		Location and study design	Sample size	Age group	Cholesterol (mean±SD)
	Study	Publication				
Hatmi[49]	2011	2011	Tehran; local study	T: 27.203 M: 26.785 F: 418	>30	
Saberi[50]	2011	2011	Rasht; local study	T: 103 M: 24 F: 79	>20	T: 152.9±37 M: 149.2±31.1 F: 154±40.1
Marjani[51]	2011	2012	Golestan; local study	F: 160	20-40	F: 182.03±56.33
Sharifi[52]	2011-2012	2015	Zanjan; local study	M: 120	>30	
Ansari[53]	2012	2012	Isfahan, Markazi; local study	M: 1.914	>20	
Hasankhani[2]	2012	2012	Kermanshah; local study	T: 400	>20	
Javadi[54]	2012	2014	Qazvin; local study	T: 996 M: 478 F: 518	>24	

Reference	Prevalence of high cholesterol (%)		LDL-C (mean±SD)	Prevalence of high LDL-C (%)		HDL-C (mean±SD)	Prevalence of low HDL-C (%)	
	≥200	≥240		≥130	≥160		≤40	≤35
Navaie[11]	T: 42.6	T: 15.4	T: 124±37.4 M: 118±35 F: 129±38.6	T: 40.7	T: 15.5	T: 36.6±8.9 M: 34.9±8.2 F: 38.3±9.2	T: 44.4	
Fakhrzade[12]	T: 47.6 M: 43.9 F: 50.3							
Saeedi[13]	T: 37.5 M: 34.8 F: 39.1		T: 122.4±43.3 M: 117.3±30 F: 125.3±48.9			T: 37.9±8.6 M: 37.4±4 F: 38.1±10.3		T: 14
Sarrafzadegan[14]		T: 5.6 M: 4.5 F: 6.7	T: 123.7±24 M: 120±25.8 F: 127.3±22.2		T: 32 M: 23.5 F: 40.5	T: 40.3±5.2 M: 40.2±5.5 F: 40.4±4.9		T: 52.3 M: 57.6 F: 47
Karimi[8]	T: 34.1 M: 29.9 F: 36.2	T: 9.5	M: 99.3±41.6 F: 108.8±63.8	T: 24.5 M: 20 F: 26.8	T: 9.2	M: 46.3±16.8 F: 49.2±16.7		T: 16.1 M: 20.7 F: 13.8
Azizi[15]	T: 55 M: 53 F: 56	T: 24 M: 20 F: 26	T: 133±40 M: 129±38 F: 135±40	T: 58 M: 55 F: 60	T: 23 M: 20 F: 24	T: 43±11 M: 39±9 F: 45±11		T: 19 M: 30 F: 13
Azizi[16]	T: 72.6 M: 61.2 F: 84.7	T: 39.7 M: 25 F: 55	T: 150±40 M: 140±36 F: 161±41	T: 68.2 M: 59 F: 78.3	T: 37.8 M: 26.9 F: 46.9	T: 43±11 M: 40±10 F: 47±11		T: 20.1 M: 3.9 F: 14.8
Fakhrzade[17]	T: 31.7			T: 24.7	T: 10.8		T: 53.9	
Yosefinia[18]		T: 20.9 M: 18.4 F: 23.4			T: 18.1 M: 15.7 F: 20.2		T: 33.1 M: 60.1 F: 46.6	
Kelishadi[19]		T: 25.2 M: 21.31 F: 29.1			T: 18.23 M: 14.82 F: 21.63		T: 24.4 M: 26.93 F: 21.87	
Sadeghi[20]		F: 21.5	F: 123.67±42.01		F: 17.5			
Mohamadi fards[5]		T: 20.3 M: 17.7 F: 23			T: 34.19 M: 33.5 F: 34.8		T: 28.5 M: 38.6 F: 18.25	
Mohamadi fards[5]		T: 17.3 M: 15.1 F: 19.4			T: 36.35 M: 33.7 F: 39		T: 29.38 M: 31.15 F: 27.6	
Hajzade[21]	T: 61.2 M: 59.4 F: 63							

(Contd...)

Table 1: (*Continued*)

Reference	Prevalence of high cholesterol (%)		LDL-C (mean±SD)	Prevalence of high LDL-C (%)		HDL-C (mean±SD)	Prevalence of low HDL-C (%)	
	≥200	≥240		≥130	≥160		≤40	≤35
Mellati[22]	T: 35.7 M: 31.3 F: 40		T: 116.7±38.3 M: 112.2±36.7 F: 121.2±39.8	T: 53.2 M: 49.7 F: 56.6		T: 39±6.7 M: 38±6.4 F: 39.9±6.9	T: 78.5 M: 63.9 F: 93.1	
Sharifi[23]	T: 47.3 M: 38.6 F: 54.8	T: 11.9 M: 7.9 F: 15.1	T: 116.33±35.6 M: 111.45±34.1 F: 121.2±37	T: 35 M: 30.3 F: 39.3	T: 13.8 M: 10.8 F: 16.7	T: 42.6±5.1 M: 39.5±4.4 F: 45.7±5.7	T: 55.7 M: 63 F: 52.9	T: 23.7 M: 27.7 F: 20.1
Amiri[24]	T: 55.1 M: 51.2 F: 58.7	T: 24 M: 21 F: 26.7	T: 131.5±66.7 M: 129.34±57.47 F: 133.72±75.78	T: 50.4 M: 46.7 F: 53.6	T: 22.3 M: 20.4 F: 24	T: 42.9±53.5 M: 39.21±41.2 F: 46.6±62.92	T: 61 M: 28 F: 52	
Agheli[25]	T: 27.5 M: 20.7 F: 34.3	T: 14.7 M: 6.3 F: 23			T: 18.5 M: 12.1 F: 24.9		T: 46.45 M: 60.2 F: 32.5	
Agheli[25]	T: 25.9 M: 29 F: 22.8	T: 14.3 M: 17.8 F: 10.7			T: 16.5 M: 13.9 F: 19.1		T: 10.1 M: 15.1 F: 5.1	
Seyffarshad[26]		T: 10.9 M: 9 F: 12.8						
Mahmoodi[27]	T: 29.7 M: 30.8 F: 28.6		T: 95.98±36.16 M: 95.20±27.34 F: 96.76±44.98		T: 10.3 M: 10 F: 10.7	T: 56.9±15.52 M: 53.48±14.63 F: 50.3±14.4	T: 12.9 M: 16.7 F: 8.9	
Esmaili-Nadimi[3]	T: 44.4	T: 20.6	T: 113.6±37.7 M: 115.2±37.5 F: 111.95±37.9	T: 32.6	T: 10.8	T: 48.9±12.7 M: 47.5±10.7 F: 50.3±14.4		T: 8.4
Nabipour[28]	T: 52 M: 48.5 F: 55.4	T: 21.8 M: 18.7 F: 24.8	T: 126±57.5 M: 122.93±51.42 F: 129.46±63.53	T: 45.6 M: 42.9 F: 48.2	T: 19.7 M: 17.3 F: 22	T: 45.2±46.1 M: 42.14±44.53 F: 48.11±47.60	T: 48.5 M: 58.5 F: 38.5	
Namayande[29]	T: 35.4	T: 12.2 M: 10.63 F: 13.25		T: 26.7	T: 5.7			T: 24.2
Aghasadeghi[30]	T: 29.3	T: 7.1		T: 27.8	T: 6.3		T: 38.9	
Chehrei[31]	T: 28.5 M: 30.2 F: 22.9		T: 104.2±41.9 M: 98.3±40.7 F: 110±43	T: 25.5 M: 19.9 F: 27.3		T: 46.21±12 M: 44.3±11.4 F: 47.7±12.5	T: 31.7 M: 41.6 F: 29.4	
Malek[32]							T: 30.7 M: 8.7 F: 48.5	
Alikhani[33]	T: 45.1 M: 42.7 F: 47.5							
Ghiasvand[34]	T: 50.8		T: 110.80±30.15	T: 25.4		T: 52.29±22.68	T: 60.6	
Ghoddosi[35]		T: 24 M: 19.7 F: 26.9			T: 22.2 M: 20.3 F: 25.1			T: 20.7 M: 31.4 F: 13
Vaghari[36]	T: 50 M: 44.7 F: 57							
Hatami[37]	T: 61		T: 128.15±41.74	T: 45.5		T: 41.68±13.24		T: 5.4
Asgari[38]	T: 40.2 M: 35.1 F: 45.3	T: 7.3 M: 5.6 F: 8.9				T: 42.94±8 M: 40.83±7.23 F: 45.10±8.81	T: 60.4 M: 49.7 F: 70.2	
Delavari[39]	T: 43.5 M: 41.6 F: 45.3			T: 80.1 M: 78.7 F: 81.5			T: 79.9 M: 75.5 F: 84	
Javadi[40]		F: 4.1	F: 101.2±29		F: 4.1	F: 43.6±8		F: 14.7
Azabdaftari[41]	T: 42.9			M: 33			M: 44	
Esteghamati[42]	T: 42.9 M: 40.4 F: 45.4	T: 14.1 M: 11 F: 17.3						
Saberi[43]							T: 51.3	

(Contd...)

Table 1: (*Continued*)

Reference	Prevalence of high cholesterol (%)		LDL-C (mean±SD)	Prevalence of high LDL-C (%)		HDL-C (mean±SD)	Prevalence of low HDL-C (%)	
	≥200	≥240		≥130	≥160		≤40	≤35
Bahonar[44]	F: 48.2		T: 117±28	T: 33.3		T: 46±11	T: 26.4	
Nikparvar[45]	T: 21.2 M: 14.3 F: 24.2		T: 102.47±29.95		T: 19 M: 19 F: 18.9	T: 47.64±9.49	T: 46.7 M: 36.7 F: 51.6	
Agajani Delavar[46]	F: 38.6	F: 11.4		F: 24.1	F: 7.5		F: 17	
Asayi[47]	T: 45.6 M: 47.1 F: 44.9	T: 16.6 M: 17.5 F: 15.8	T: 133.05±36.97 M: 133.32±38.65 F: 132.91±36.12	T: 49.6 M: 47.6 F: 50.6	T: 22.1 M: 22.3 F: 21.9	T: 40.37±6.92 M: 39.26±6.72 F: 40.95±6.96		T: 13.5 M: 17.5 F: 11.6
Majdi[7]	T: 34.5 M: 35.3 F: 33.7		T: 109.3±3.7 M: 107.7±3.9 F: 110.9±3.4	T: 58.4 M: 56.6 F: 60.3		T: 48.4±1.2 M: 46.8±1.3 F: 50±1.2	T: 40.9 M: 54.3 F: 27.4	
Heydari[48]	T: 33.4						T: 49.3	
Hatmi[49]	T: 34.8			T: 25.7			T: 31.1	
Saberi[50]	T: 9.7 M: 4.2 F: 11.4		T: 84.1±34 M: 83.2±28.4 F: 84.4±35.7	T: 10.7 M: 11.1 F: 12.7		T: 44.1±10.7 M: 44.1±10.5 F: 46.6±10.8		T: 30.1 M: 33.3 F: 29.1
Marjani[51]			F: 116.21±39.51			F: 44±13.39	F: 29.37	
Sharifi[52]							M: 24.2	
Ansari[53]	M: 28.7				M: 13.1			M: 11.3
Hasankhani[2]		T: 18.8			T: 22.8			T: 26.3
Javadi[54]						T: 66.6 M: 61.3 F: 71.6		

T: Total; M: Male; F: Female

Table 2: The pooled estimate of the mean of lipid components based on gender using random effect meta-analysis of data extracted from population-based studies in Iran

Variable	Number of study	Total	95% CI	I^2 (%)
T-C	T: 26 M: 21 F: 24	T: 194.89 M: 191. 05 F: 197.49	T: 192.68-197.10 M: 187.39-194.72 F: 193.87-201.11	T: 99.4 M: 99.5 F: 99.7
Mean LDL-C	T: 19 M: 16 F: 19	T: 117.46 M: 114.99 F: 120.27	T: 111.94-122.99 M: 109.40-120.59 F: 114.31-126.22	T: 99.7 M: 99.3 F: 99.6
Mean HDL-C	T: 20 M: 17 F: 19	T: 44.22 M: 41.87 F: 45.45	T: 42.13-46.32 M: 39.45-44.29 F: 43.24-47.67	T: 99.9 M: 99.9 F: 99.9

T: Total; M: Male; F: Female

in women compared to men (table 2).

The prevalence of high LDL-C and mean LDL-C levels were higher among women. The prevalence of LDL-C (≥130 mg/dl) in men was 41% (95% CI: 33-48) and 46% (95% CI: 38-55) in women. The prevalence of LDL-C (≥160 mg/dl) was 19% (95% CI: 16-23) in men and 23% (95% CI: 19-28) in women (table 3). In addition, the mean LDL-C level in men was 114.99 mg/dl (95% CI: 109.40-120.59) and 120.27 mg/dl (95% CI: 114.31-126.22) in women (table 2).

The mean HDL-C level was higher among women, 41.87 mg/dl (95% CI: 39.45-44.29) in men and 45.45 mg/dl (95% CI: 43.24-47.67) in women. The prevalence of low HDL-C level in women (≤50 mg/dl) was 41% (95% CI: 33-49) and in men (≤40 mg/dl) was 40% (95% CI: 32-49).

Subgroup Analysis for the Year of Publication

The year of publication of each study may also represent a source of heterogeneity. In an attempt to explain heterogeneity within this subgroup, a subgroup analysis was performed. The analysis showed that the prevalence of hypercholesterolemia (≥200 mg/dl and ≥240 mg/dl) was lower (39% and 15%, respectively) in studies published during 2005-2015 than those during 1994-2004 (43% and 18%, respectively). The same trend was obtained for the prevalence of LDL-C (≥130 mg/dl and ≥160 mg/dl), which showed high LDL-C to be less prevalent in studies published during 2005-2015 (38% and 18%, respectively) than those during 1994-2004 (42% and 20%, respectively). However, the reverse was true for the prevalence of low

Table 3: The pooled estimate of the prevalence of lipid components according to ATPIII cut-off, based on gender using random effect meta-analysis of data extracted from population-based studies in Iran (1994-2004)

Variable	Cut-off point (mg/dl)	Number of studies	Prevalence (%)	95% CI	I^2 (%)
High cholesterol	≥200	T: 17 M: 12 F: 12	T: 43 M: 45 F: 48	T: 38-49 M: 38-52 F: 40-56	T: 99.1 M: 98.2 F: 99.0
	≥240	T: 16 M: 14 F: 15	T: 18 M: 15 F: 22	T: 15-22 M: 12-18 F: 18-26	T: 99.1 M: 98.0 F: 98.8
High LDL-C	≥130	T: 11 M: 7 F: 7	T: 42 M: 43 F: 52	T: 34-50 M: 34-53 F: 41-62	T: 99.5 M: 98.8 F: 99.7
	≥160	T: 18 M: 13 F: 14	T: 20 M: 20 F: 26	T: 15-24 M: 15-24 F: 21-31	T: 99.4 M: 98.4 F: 98.8
Low HDL-C	M: ≤ 40 F: ≤50	T: 8 M: 9 F: 9	T: 40 M: 40 F: 40	T: 29-50 M: 30-50 F: 29-51	T: 99.7 M: 99.4 F: 99.6

T: Total, M: Male, F: Female

Table 4: The pooled estimate of the prevalence of lipid components according to ATPIII cut-off, based on gender using random effect meta-analysis of data extracted from population-based studies in Iran (2005-2015)

Variable	Cut-off point (mg/dl)	Number of studies	Prevalence (%)	95% CI	I^2 (%)
High cholesterol	≥200	T: 16 M: 9 F: 9	T: 39 M: 31 F: 38	T: 35-44 M: 15-46 F: 33-43	T: 99.3 M: 99.9 F: 98.8
	≥240	T: 6 M: 4 F: 6	T: 15 M: 13 F: 14	T: 7-22 M: 5-21 F: 7-22	T: 99.6 M: 99.4 F: 99.2
High LDL-C	≥130	T: 10 M: 4 F: 5	T: 38 M: 34 F: 37	T: 24-52 M: 13-56 F: 14-60	T: 99.9 M: 98.4 F: 99.4
	≥160	T: 5 M: 4 F: 5	T: 18 M: 18 F: 15	T: 12-24 M: 13-24 F: 5-26	T: 95.1 M: 94.5 F: 99.2
Low HDL-C	M: ≤40 F: ≤50	T: 9 M: 8 F: 6	T: 45 M: 41 F: 42	T: 34-55 M: 25-57 F: 29-55	T: 99.8 M: 99.8 F: 99.7

T: Total; M: Male; F: Female

HDL-C, which showed a significantly higher (15.2%) prevalence in studies published during 2005-2015 (45%) than those during 1994-2004 (40%) (table 2).

Discussion

In the present study, we considered the components of lipid in our systematic search. The findings indicated that the prevalence of dyslipidemia with respect to sex differences was considerable in Iran. The overall prevalence of high TC ≥200 mg/dl and TC ≥240 mg/dl levels was 42% (38-45) and 17% (14-20), respectively, among adults aged ≥20 years in Iran. This was according to the population-based studies on both sexes in different cities of Iran. In another meta-analysis in Iran, the prevalence of high TC (≥200 mg/dl) in 14 eligible studies was 41.6% (36.1-47.0), which is similar to our findings.[55] Thus, the prevalence of hypercholesterolemia in Iran is expected to be high. However, compared with other studies, the results show that hypercholesterolemia in Iran is lower than the Western European countries. In a systemic review,[56] the prevalence of high TC ≥200 mg/dl and TC ≥240 mg/dl was 56.7% and 31.7%, respectively, in adults aged 30-70 in Portugal. According to a report by the American Heart Association in 2013, the prevalence of TC ≥200 mg/dl and TC ≥240 mg/dl was 43.2 % and 28%, respectively, among non-Hispanic white people aged ≥20 years in the United States.[57] The prevalence of TC ≥200 mg/dl was 48% in the UK adults aged 19-64 years[58] and TC ≥240 mg/dl was 35.2% in some European countries such as England.[59] However, the findings of the present study reveal that the

Table 5: The pooled estimate of the prevalence of lipid components according to ATPIII cut-off, based on gender using random effect meta-analysis of data extracted from population-based studies in Iran (1994-2015)

Variable	Cut-off point (mg/dl)	Number of studies	Prevalence (%)	95% CI	I^2 (%)
High cholesterol	≥200	T: 31 M: 26 F: 24	T: 42 M: 39 F: 44	T: 38-45 M: 30-48 F: 39-48	T: 99.3 M: 99.7 F: 99.1
	≥240	T: 23 M: 18 F: 21	T: 17 M: 15 F: 20	T: 14-20 M: 12-18 F: 16-24	T: 99.4 M: 98.9 F: 99.2
High LDL-C	≥130	T: 21 M: 11 F: 11	T: 40 M: 41 F: 46	T: 32-48 M: 33-48 F: 38-55	T: 99.8 M: 98.8 F: 99.3
	≥160	T: 23 M: 17 F: 23	T: 19 M: 19 F: 23	T: 16-23 M: 16-23 F: 19-28	T: 99.3 M: 98.1 F: 99.0
Low HDL-C	M: ≤ 40 F: ≤50	T: 17 M: 18 F: 18	T: 42 M: 40 F: 41	T: 35-50 M: 32-49 F: 33-49	T: 99.8 M: 99.7 F: 99.6

T: Total; M: Male; F: Female

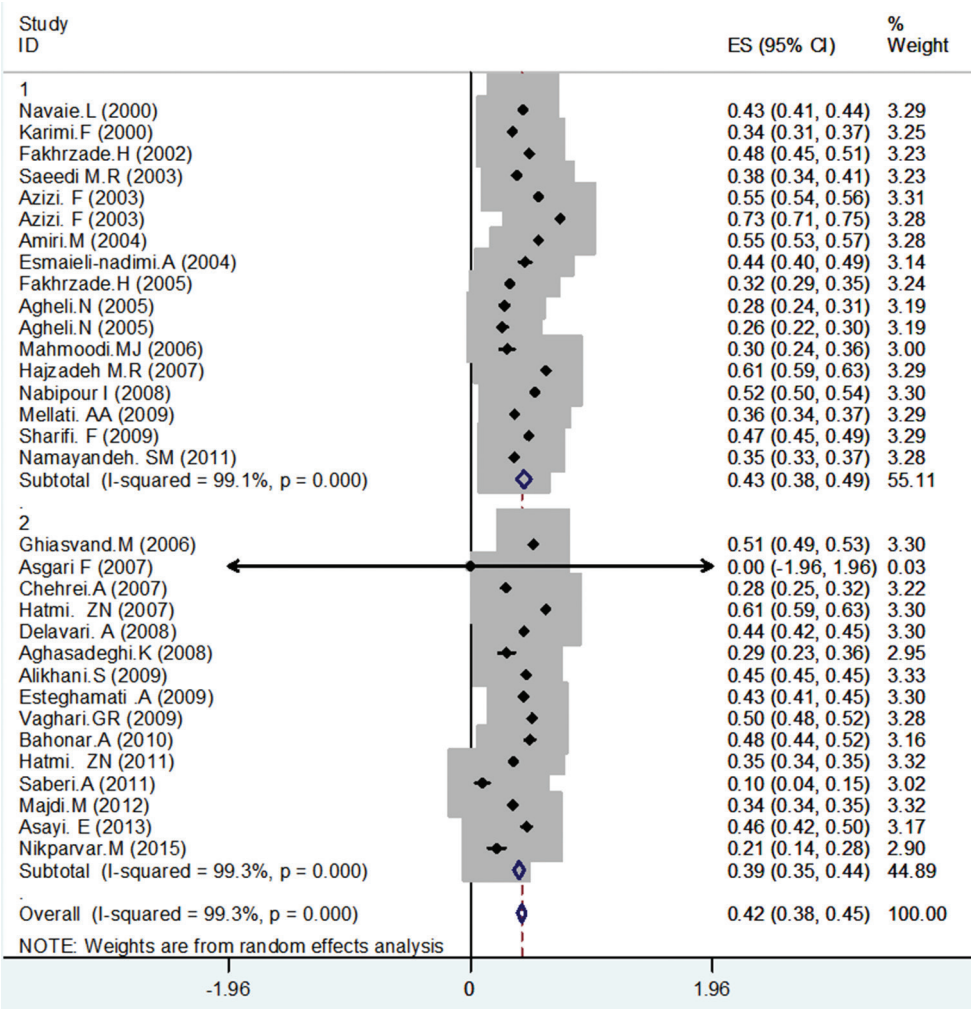

Figure 2: Meta-analysis of the prevalence of hypercholesterolemia (≥200 mg/dl). The square represents the effect of the estimate of individual studies (95 % confidence intervals) with the size of squares proportional to the weight assigned to the study in the meta-analysis. In this chart, studies are stored in order of the publication year and author's names, based on a random effects model. Rhombic mark shows the prevalence in Iran extracted from all studies.

prevalence of hypercholesterolemia in Iran is higher compared to other Asian countries. The corresponding figure for TC ≥200 mg/dl was approximately 34.5% in Oman,[60] 36.9% of Lebanese aged 18-65 years,[61] 41.6% in Iraq,[62] 20% in Pakistan,[63] 37.5% in Turkish people

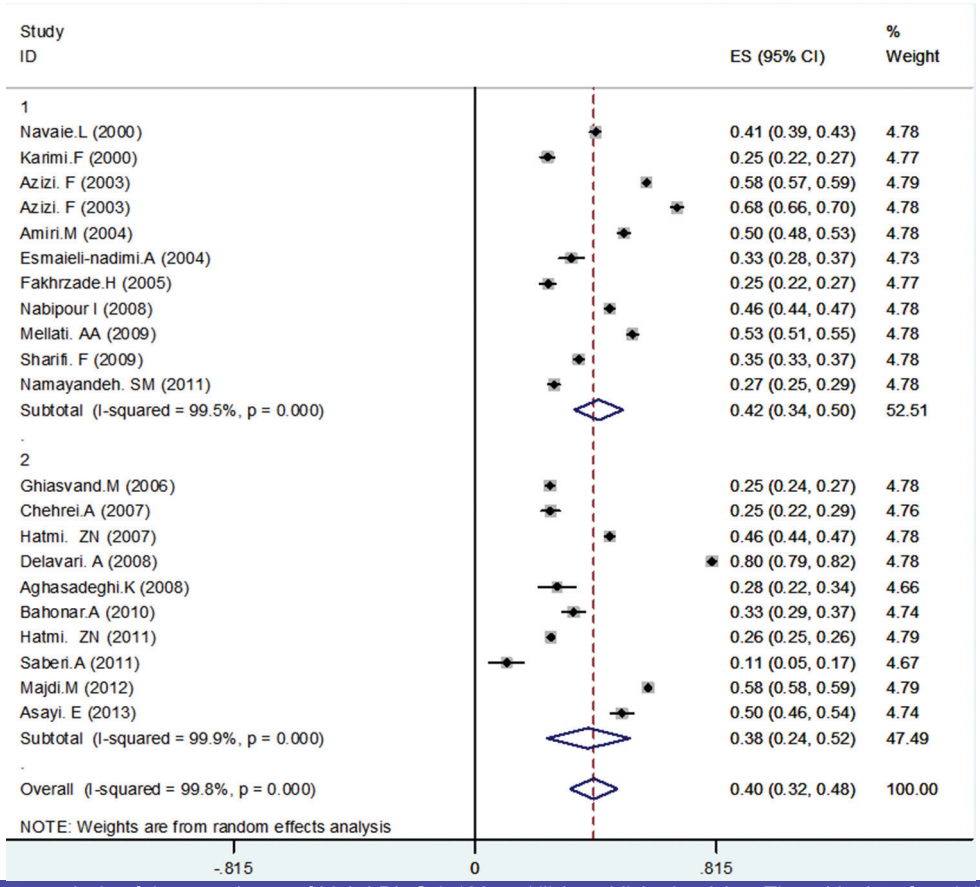

Figure 3: Meta-analysis of the prevalence of high LDL-C (≥130 mg/dl) in published articles. The midpoint of each line segment represents the estimated prevalence in the study. Rhombic mark shows the prevalence in Iran extracted from all studies.

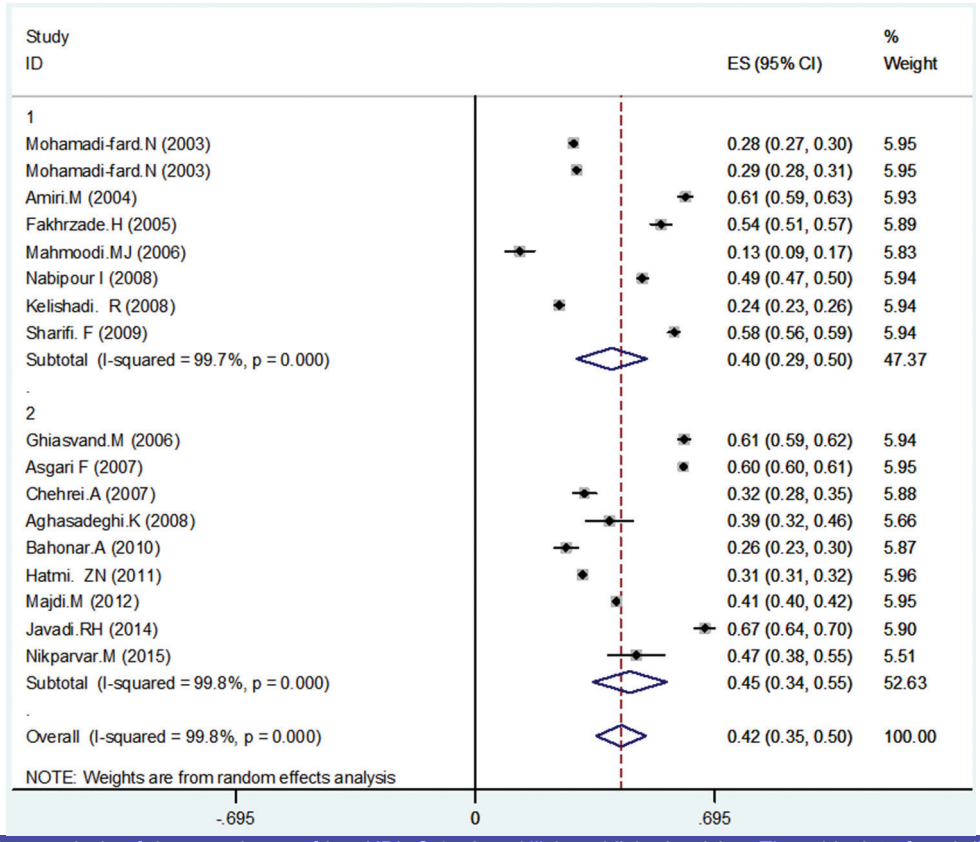

Figure 4: Meta-analysis of the prevalence of low HDL-C (≤40 mg/dl) in published articles. The midpoint of each line segment represents the estimated prevalence in the study. Rhombic mark shows the prevalence in Iran extracted from all studies.

aged ≥20 years,[64] 17.2% in Nepal,[65] 23.2% in Eastern India,[66] and 15.38% for TC ≥240 mg/dl in individuals aged ≥30 in a Chinese study.[67] The present study shows that similar to most other studies, hypercholesterolemia was more prevalent in Iranian women. The results of a study on people aged ≥20 years in the United States were similar to our results and they reported a higher prevalence of hypercholesterolemia in women.[68] In this regard, other studies in Pakistan,[63] China,[67] Arab countries, and others[69-71] were also similar to our findings.

In the present study, the reported prevalence of high LDL-C ≥130 mg/dl and ≥160 mg/dl levels in adults of both sexes was 40% (32-48) and 19% (16-23), respectively. In Asia, the prevalence of high LDL-C varies from 24.8% in China,[72] 32.1% in Lebanon,[61] to 44.5% in Turkey,[64] 46.9% among Indians aged ≥20 years,[66] and 57.8% in Iraq.[62] The prevalence of high LDL-C in Iran was higher relative to most other western countries. The corresponding figure was 29.7% in adult non-Hispanic white people in the United States[57] and 20.8% in Switzerland.[73]

We found a higher prevalence of hypercholesterolemia and high LDL-C in Iranian women, similar to findings in most other countries. In various studies, TC and LDL-C are similar between men and women in the first two decades of life, but then, the amount of these variables slightly increases in men and has an ascending trend in women. Women aged over 50 years (after menopause) have higher total cholesterol and decreased estrogen plays a role in these changes. Nowadays, estrogen-replacement therapy is recommended to reduce cardiovascular risk after menopause.[8,74]

The prevalence of low HDL-C level (<40 in males, <50 in females) was 42% (35-50) among adults of both sexes in our study. The reported prevalence of low HDL-C level in the meta-analysis of Tabatabaei et al.[55] in Iran (11 eligible studies) was 43.9% (33.4-54.4), which is similar to the findings of the present study. The prevalence of low HDL-C in Asian countries was 67.2% in India,[75] 56.7% in Nepal,[65] 54.75% in Taiwan,[76] 49.9% in Iraq,[62] 49.3% in Lebanon,[61] 37.2% in Malaysia,[77] 21.1% in Turkey,[64] 33.4% in Korea,[78] 19.2% in China,[72] and 75.4% in Oman.[60] The prevalence of low HDL-C was reported as 33.1% and 12.4% in adult American men and women,[57] respectively, and 53.4% in Switzerland.[73] In the present study, this figure was higher among females than males. Although ethnic diversity, differences in dietary habits, lifestyle of people in different regions, and time of study can lead to various findings, in general, women of all ages have higher HDL-C levels than men and the mean HDL-C level in men is lower than women of all ages.[10] Other studies have observed that HDL-C increases with aging in women and the difference in HDL-C levels is greater after the second decade between the two genders.[79] Data of Framingham study showed that 0.96 mg/dl decrease in HDL-C level had led to the increased risk of CVD in men and women by 2% and 3%, respectively.[80]

Sex-related differences in lipid disorders commonly have been observed in western societies, which have high incidences of CVD. However, it has not been seen in communities where the prevalence of CVD is low.[81] Such difference is justified in Iran because of the high incidence of CVD.[14] One reason for the diversity of findings among different studies might be due to the genetic differences. Other reasons might be insulin resistant, high-fat diet, smoking, and increased BMI.[82-85] Age and sex are the two other factors that influence blood lipids.[10] There is a positive and strong association between age and increased cholesterol level and CVD.[86,87] In recent decades, various changes in lifestyle and rapid socioeconomic changes in many countries have considerably led to increased risk of CVD.[4]

Conclusion

Many population-based studies have been performed in Iran to determine the prevalence of lipid profile abnormalities. A number of these studies had some heterogeneities in the data. However, the present study indicated that abnormalities in lipid components were considerable in Iran. Moreover, we found that abnormalities in lipid components were more prevalent in Iranian women. Since each plan for the control of these risk factors would have a positive effect on public health, healthcare organizations in Iran should execute well-defined programs to control dyslipidemia in the general population, especially in women. Besides lifestyle and dietary modifications, which have a considerable effect on dyslipidemia, long-term planning to reduce these risk factors must be applied by educating people.

Conflict of Interest: None declared.

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