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Lipid pattern in middle-aged inhabitants of the Lower Silesian region of Poland. The PURE Poland sub-study

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Abstract

Introduction. A decreased serum high density lipoprotein-cholesterol (HDL-C) is a strong predictor of cardiovascular risk. However, total HDL is a very dynamic, changeable fraction, and does not perform the function of atherosclerosis markers. In the presented study, the pattern of serum lipids, including HDL-C subclasses (HDL2- and HDL3-cholesterol), in a middle-aged Polish Lower Silesia population was defined.

Materials and method. A group of 746 males and 1,298 females, aged 35–70, were investigated. All subjects were participants in the PURE study. Mean serum lipid levels were determined for groups selected on the basis of gender, age, cigarette smoking, drinking alcohol and place of residence (urban/rural area). The data were analyzed using STATISTICA 6.0 PL.

Results. In multiple linear regression models, age was the most important independent and consistent predictor of total cholesterol (TC) and LDL cholesterol (LDL-C). The prevalence of low HDL-C (threshold 40 mg/dL in males, 50 mg/dL in females) was 16.5% for males and 22.6% for females. This gender-conditioned difference in the prevalence of low HDL-C was greater in rural (20.0% vs. 30.9%, respectively, in males and females) in comparison to urban (14.4% vs. 17.1%) areas. The lipid pattern was significantly worse in rural than in urban females. Female rural inhabitants showed higher triglycerides (TG) and lower HDL cholesterol (total and contained in subclasses HDL2 and HDL3). Simultaneously, a higher BMI, higher percent of smokers and drinkers and lower age of smoking female rural inhabitants in comparison to urban females were estimated. In the total population, cigarette smoking or drinking alcohol were associated with significant increases in TC, LDL-C and TG, also with decreased HDL-C (smoking) or HDL2-C (drinking). Two-way analysis of variance showed the existence of interaction between these risk factors in their influence on HDL-C and HDL3-C.

Conclusion. In the middle-aged population of the Lower Silesian region in Poland the place of residence (urban/rural area) had a significant impact on the lipid pattern. This pattern is more atherogenic in rural women than in urban women.

Key words

HDL cholesterol, HDL subfractions, urban, rural inhabitancy

INTRODUCTION

Cardiovascular disease (CVD) is still the most important cause of mortality in Europe, causing over 4.3 million deaths each year [1]. The mortality from CVD contributes to about 54% of total mortality in females, this being noticeably higher when compared to a male mortality of (43%) [2]. Epidemiological studies have shown that acute coronary incidences are the main cause of death among females in Northern Europe, whereas stroke is the main cause of death in females from Mediterranean countries [3]. There is, however, a relatively small amount of available data concerning women females from Eastern and Central Europe. This problem therefore needs to be addressed with a bigger effort by public health authorities in these European regions, to study and collect more reliable epidemiological information on CVD in their region.

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The role of atherogenic dyslipidemia (hypertriglyceridemia in a fasting or postprandial state co-existing with a decreased HDL cholesterol) is well documented. Plasma HDL cholesterol (HDL-C) values below 50 mg/dl in females, and below 40 mg/dl in males, occur in more than 40% of patients diagnosed with coronary heart disease (CHD), and is recognized as a more important risk factor for CHD than increased LDL cholesterol alone [4]. Similarly, decreased HDL-C in elderly patients is more significantly associated with stroke than high LDL cholesterol [5, 6]. On the other hand, it has been documented that even as little as a 1% increase in plasma HDL-cholesterol decreases CHD risk by 1%–3% [7, 8].

Therefore, total HDL definitely plays a pivotal role in protecting patients from developing atherosclerosis and its many complications. The action of HDL is pleiotropic and includes various mechanisms: reversal of cholesterol transport [9], anti-inflammatory [10, 11] and anti-oxidative [12, 13] effects, anti-aggregatory, anticoagulant and profibrinolytic potential [13, 14], influence on the vascular wall [15], inhibition of apoptosis [12] and anti-mitotic activity [16].

Measurement of total HDL does not fully correlate with its numerous perceived benefits. This is for the following reasons:

1) the HDL fraction is a dynamically changeable fraction that includes a sequence of sub-fractions and sub-types transforming from nascent to mature form;
2) the protective properties of various separated forms are not defined;
3) separate HDL subtypes may lose their protective properties, while some can even become pro-atherogenic;
4) the effects of HDL can change from protective to atherogenic, depending on co-existing factors, i.e. influenza infection [17]. Therefore, measurements of particular HDL subfractions and the determination of their role in cardiovascular risk would be necessary. HDL subclass $2_{(a,b,c)}$ including large, buoyant particles and HDL subclass $3_{(d,c,b,a)}$ including smaller, dense particles, are both considered to be a so-called 'good cholesterols'. Simultaneously, both of these HDL sub-classes serve as carriers for a wide range of proteins involved in lipid metabolism, inflammation processes, and thrombosis. These proteins are subject to dynamic changes in structure, thereby causing dynamic changes in HDL function. In this way, HDL functions depend on the size and structure of the HDL particles [18]. In fact, the loss of HDL antioxidant properties has been observed in various physiological and pathological conditions, such as the acute postprandial state, inflammatory processes [19], as well as in patients diagnosed with type 2 diabetes mellitus, or in patients undergoing haemodialysis [20]. When measuring total HDL it is essential to interpret not only the function of the separate factors, but that of the whole HDL system, taking into account its considerable activity and variability.

OBJECTIVE

The aim of the presented study was to evaluate the lipid pattern, including HDL_2 and HDL_3 cholesterol sub-fractions, in middle-aged females and males residing in the Lower Silesian region of Poland, as well as to relate lipid levels to age, gender, and selected environmental factors.

MATERIALS AND METHOD

Subjects. The study was performed between 2007 and 2009. The pattern of lipids was analysed in a sample group, representative for the middle-aged Lower Silesian population, consisting of 2,044 persons: 1,298 females aged 54.3 ± 10 and 746 males aged 54.7 ± 9.7. All studied subjects were of Polish descent, and all were volunteers who agreed to participate in the PURE study. There were 1,216 urban inhabitants and 828 rural inhabitants; among them 248 females (19.2%) and 175 males (24%) were tobacco smokers, and 39 females (3.2%) and 197 males (26.7%) reported increased alcohol consumption (more than one alcohol unit per day). The percent of smokers and alcohol drinkers was higher among rural residents, compared to urban residents. The mean age for males who smoked and/or drank was slightly lower in the rural population than in the urban population. In the rural areas, the mean age for female smokers was also lower than for urban females. The alcohol consumption by rural females was higher. Mean body mass index (BMI) of rural inhabitants was higher than in urban habitants (Tab. 1).

Table 1. Baseline characteristic of studied population. Age and body mass index (BMI) are presented as mean and standard deviation.

Gender	No.	Place of residence	age (years)	smokers (% and age)	drinkers (% and age)	BMI (kg/m²)
male	452	urban	54.1±9.7	19%; 53.3±8.5	25%; 53.3±9.8	28.0±4.1
	290	rural	54.6±10.5	32%; 52.7±8.3	30%; 51.6±10	29.6±5.8**
female	761	urban	54.6±8.9	16% 52.6±8.3	2%;50.6±9.6	27.5±5.3
	530	Rural	54.7±9.9	23%; 50.2±8.3*	5%;52.9±8.1	28.7±5.6**

*,**; difference statistically significant: *p<0.05; **p < 0.01 in comparison to male or female residents of urban areas

This study was approved by the Polish Ethics Committee: No. KB-443/2006.

Biochemical measurements. Venous blood was taken from subjects after a 12-hour fasting state, and centrifuged at 1,000g for 20 min. at 4°C. Each serum sample was divided among 3 tubes and stored at a temperature of -80°C. Plasma lipids were measured using standard methods. Total serum cholesterol (TC), triglycerides (TG), and HDL cholesterol (HDL-C) were measured using the enzymatic assay SPINREACT (Sant Esteve De Bas, Girona, Spain). LDL cholesterol (LDL-C) was estimated, among patients with a TG concentration lower than 400 mg/dL, as TC – HDL-C – TG/5 (Friedewald formula). The QUANTOLIP® HDL (Technoclone GmbH, Vienna, Austria) precipitation test was used to measure HDL_2 and HDL_3 cholesterol.

Statistical analysis. Statistical analysis was performed on the total group as well as on individual groups of subjects selected based on the following age ranges: 35–50 (n=586), 51–60 (n=815) and 61–70-years-old (n=508). In order to estimate a dependence between age and lipids, additional groups of patients below 35 years of age (n=62) and above 70 years (n=63) were taken into account. Normally distributed variables are presented as mean ± SD while (non-normally distributed *or* non-parametric) parameters were expressed as a median with 25th and 75th percentiles. A Kolomogorov-Smirnow test was used to evaluate normal distribution. *Post-hoc* comparison was performed using RIR Tukey test and the Mann-Whitney *U*-test, the latter when the variables did not adjust to normal distribution. ANOVA was used in analysis between the groups which were normally distributed, while the Kruskall-Wallis test in the absence of normal distribution. A Chi-square test was used in the analysis of association between qualitative variables. Multivariate analyses were adjusted for gender, place of residence (urban/village), tobacco use (smokers and non-smokers) and alcohol consumption (drinkers or non-drinkers).

The correlation between parameters was examined by calculated Spearman correlation coefficient. A $p<0.05$ was considered as statistically significant. All analyses were conducted using the STAT statistical package Version 6.0 (STATISTICA 6 PL. StatSoft).

RESULTS

The total studied population demonstrated a slightly increased plasma LDL (as well as total-) cholesterol level, what was found to be linearly associated with age (Fig. 1.)

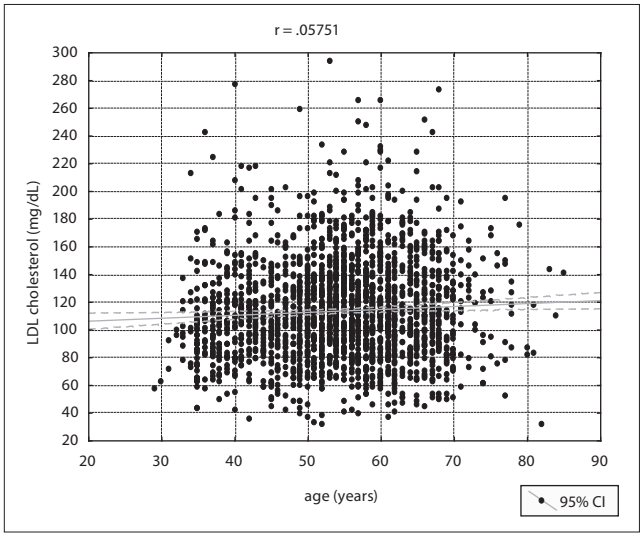

Figure 1. Linear dependence between age and plasma LDL cholesterol concentration

The linear correlation coefficient between age and LDL cholesterol was found to be statistically significant in the group of females (p<0.001), and in males, the linear correlation between age and total cholesterol was found to have a p<0.03. In multiple linear regression models, age was the most important independent and consistent predictor of total cholesterol (R=0.07302018 R2=0.00533195, R^2=0.00484148, F(1.2028)=10,871 p<0.0009) and LDL cholesterol (R=0.05751059 R2=0.00330747, R^2=0.00281430 F(1.2021)=6.7066 p<0.0097). Similar results were obtained in analyses adjusted to BMI, for cigarette smoking, alcohol intake and place of residence (city or rural area).

Analysis of LDL-C values performed in particular groups of subjects, selected depending on the range of age, showed the highest LDL cholesterol levels in females in the 50–60-years-of-age group, and in males in the 35–50-years-of-age group. It was found that in older subjects, the LDL cholesterol actually decreased slightly, up to the age of about 70 years, and tended to rise again above this age (Fig. 2). Two-way analysis of variance did not confirm any significant dependence between age and LDL cholesterol values in the group above 70-years-of-age (F(1.563)=.36684, p=0.54498).

In all middle-aged groups selected based on their tobacco smoking, alcohol consumption, or place of residence (urban or village), plasma TG, total HDL-, HDL_2- and HDL_3- cholesterol concentrations remained independent of age, except for the dependence found between age and triglycerides, which appeared in the group of teetotalers (Tab. 2).

The mean LDL cholesterol in the total studied population did not exceed 88.4 mg/dl in 25% of persons, and was not found to be higher than 134.5 mg/dl in 75% of subjects. According to the National Cholesterol Education Programme Adult Treatment Panel III criteria, the mean triglycerides level in nearly 75% of the studied subjects was found to be lower than 150 mg/dL (Tab. 3). The prevalence of low HDL-C (threshold 40 mg/dL in males, 50 mg/dL in females) was

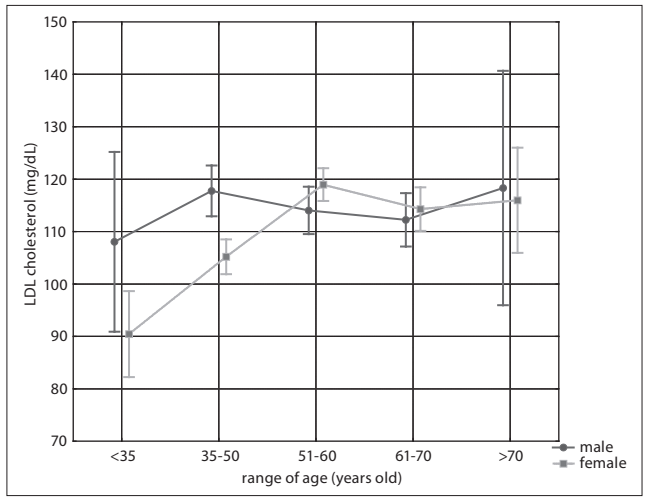

Figure 2. LDL cholesterol level (mean and 95.% confidential coefficient) in studied males and females in various ranges of age.

Table 2. Correlations between lipid concentrations and age in smokers and non-smokers, alcohol drinking and non-drinkers, inhabitants of urban and rural areas in the Lower Silesian region.

	Correlation with age	
	in group of smokers (n = 423)	**in group of non-smokers (n = 1595)**
Total cholesterol (mg/dl)	0.1213; 0.05	0.0806; 0.05
TG (mg/dl)	ns	ns
HDL cholesterol (mg/dl)	ns	ns
HDL_3-cholesterol (mg/dl)	ns	ns
HDL_2-cholesterol (mg/dl)	ns	ns
LDL-cholesterol (mg/dl)	0.1395; 0.05	0.0557; 0.05
	in group of drinkers (n = 235)	**in group of non-drinkers** (n = 1792)
Total cholesterol (mg/dl)	ns	0.0961; 0.001
TG (mg/dl)	ns	0.05139; 0.05
HDL cholesterol (mg/dl)	ns	ns
HDL_3-cholesterol (mg/dl)	ns	ns
HDL_2-cholesterol (mg/dl)	ns	ns
LDL-cholesterol (mg/dl)	ns	0.0791; 0.001
	in residents of urban area (n = 1211)	**in residents of rural area** (n = 826)
Total cholesterol (mg/dl)	0.0922; 0.001	ns
TG (mg/dl)	ns	ns
HDL cholesterol (mg/dl)	ns	ns
HDL_3-cholesterol (mg/dl)	ns	ns
HDL_2-cholesterol (mg/dl)	ns	ns
LDL-cholesterol (mg/dl)	0.0580; 0.05	ns

Values are expressed as correlation coefficient; p – value; ns, not significant

shown to be 16.5% for males and 22.6% for females. The difference between the prevalence of low HDL-C in males and females was greater in rural areas (20.0% *vs.* 30.9%, respectively), in comparison to urban areas (14.4% *vs.* 17.1%).

In comparison to males, the plasma TG concentration in females was lower (p<0.001), total HDL and its sub-fractions were higher (p<0.001), whereas total and LDL cholesterol were similar for both genders (p=0.139 and p=0.423, respectively) (Tab. 4). Analysis of variance confirmed the

Table 3. Lipid pattern in total studied population (SD - standard deviation).

Variable	Mean	N	Median	25.0 per-centile	75.0 per-centile	SD	Sum
Total-C (mg/dl)	198.1	2034	193.7	170.8	222.8	40.21	403538.3
TG (mg/dl)	129.5	2033	108.8	79.45	156.4	81.57	263230.3
HDL-C (mg/dl)	58.8	2033	57.1	47.20	67.95	15.85	119507.3
HDL_3-C (mg/dl)	42.9	2027	41.7	35.40	49.50	10.75	87112.0
HDL_2-C (mg/dl)	15.8	2027	14.6	11.00	19.40	7.019	32010.8
LDL-C (mg/dl)	113.6	2030	110.3	88.36	134.5	36.34	230715.9

significant (p<0.001) impact of gender on TG, HDL-C, as well as on the HDL_2-C and HDL_3-C levels.

In smokers (21% of the population; 19% of females and 24% of males) total cholesterol, LDL cholesterol, as well as TG concentrations were higher (p<0,001; p<0.05; p<0.05, respectively), whereas total HDL cholesterol was lower (p<0.05) in comparison to non-smokers. Only 11.6% of all subjects reported regular alcohol consumption, at least once per week. Alcohol drinking was associated with increased levels of TG, TC, LDL-C (similar to smoking), as well as with a significantly decreased HDL_2 cholesterol sub-fraction. In the studied population, 75 persons (3.7%) reported long-term smoking, with simultaneous heavy or binge drinking. When comparing this group to non-smokers and non-drinkers, only higher TC and TG levels were observed (Tab. 5).

Two-way analysis of variance confirmed as significant the effect of tobacco smoking (p<0.05) or alcohol drinking (p<0.001) on measured lipids. Furthermore, the existence of interactions between these risk factors and HDL-C (p<0.05), and HDL_3-C (p<0.05) levels were shown (Fig. 3); however, no significant interactions were demonstrated (p>0.05) with others lipids.

With regard to comparisons made based on subjects' place of residence, rural inhabitants displayed higher levels of total cholesterol (p<0.01), LDL-C (p<0.05) and TG (p<0.001), compared to urban inhabitants. Simultaneously, lower levels (p<0.05) of HDL-C, HDL_2-C and HDL_3-C were observed in rural habitants. These observed differences in lipid patterns between urban and rural habitants were caused predominantly by a more atherogenic lipid pattern in rural women, in comparison to women resident in urban areas (Tab. 4).

Comparisons performed in the groups of subjects selected based on age ranges: 35–50, 51–60, and 61–70 years, demonstrated increased TG and decreased HDL cholesterol levels in all groups of rural women in comparison to urban women (Tab. 7). Decreased HDL cholesterol was a

Table 5. Mean lipid concentrations depending on the tobacco smoking or the alcohol consumption

	no-smokers (n = 1613)	smokers (n = 423)
Total-C (mg/dl)	196 ± 38	205 ± 44***
TG (mg/dl)	126 ± 76	142 ± 99**
HDL-C (mg/dl)	59.0 ± 15.4	57.9 ± 17.4*
HDL_3-C (mg/dl)	43.0 ± 10.5	42.7 ± 11.6
HDL_2-C (mg/dl)	15.9 ± 6.8	15.2 ± 7.5
LDL-C (mg/dl)	112 ± 35	118 ± 40*
	no-drinkers (n = 1784)	drinkers (n = 235)
Total-C (mg/dl)	197 ± 39	206 ± 43*
TG (mg/dl)	127 ± 80	149 ± 89**
HDL-C (mg/dl)	59.0 ± 15.8	57.2 ± 16.0
HDL_3-C (mg/dl)	43.1 ± 10.7	42.6 ± 10.6
HDL_2-C (mg/dl)	16.0 ± 7.0	14.6 ± 6.8*
LDL-C (mg/dl)	113 ± 36	119 ± 38*
	no-smokers and no-drinkers (n = 1439)	smokers and abuse drinkers (n = 75)
Total-C (mg/dl)	196 ± 38	213.3 ± 47.2*
TG (mg/dl)	125 ± 76	161.5 ± 108*
HDL-C (mg/dl)	59.3 ± 15.4	59.2 ± 18.2
HDL_3-C (mg/dl)	43.2 ± 10.6	44.1 ± 12.1
HDL_2-C (mg/dl)	16.1 ± 6.8	15.1 ± 7.1
LDL-C (mg/dl)	112 ± 34	122 ± 42*

*,**,*** difference statistically significant in comparison to group of no-smokers (or no-drinkers or no-smokers and no-drinkers); * p<0.05; ** p<0.01; *** p < 0.001

Figure 3. Interaction between smoking and alcohol drinking on their influence on HDL cholesterol (p < 0.05) (a) and HDL_3 cholesterol (p < 0.05) (b).

Table 4. Mean lipid concentrations in women and in men totally and in particular ranges of age. Results are presented as mean ± SD, number of persons in brackets.

	women (1290)	men (741)	women 35-50 (359)	men 35-50 (224)	women 51-60 (537)	men 51-60 (276)	women 61-70 (305)	men 61-70 (199)
TC	199±39	196±42	187±36[a]	195±40	207±39[a]	195±41	204±40	192±43
TG	122±73[c]	143±93	102±59[c]	145±89	128±77	150±100	134±74	131±90
HDL-C	62.4±15.6[c]	52.5±14.	62.7±14.8[c]	52.7±14.	62.5±16.2[c]	51.7±14.	62.5±15.7[c]	53.2±14.
HDL_3-C	45.2±10.8[c]	39.1±9.5	45.7±10.2[c]	39.6±9.4	45.0±11.1[c]	38.7±9.6	45.3±10.9[c]	39.0±9.6
HDL_2-C	17.2±7.1[c]	13.4±6.1	16.9±6.7[c]	13.2±6.1	17.5±7.6[c]	13.1±6.3	17.2±6.7[c]	14.0±5.8
LDL-C	113±36	115±37	105±32[b]	118±37	119±37	114±38	112±36	112±36

[a, b, c] difference statistically significant in comparison to group of men; [a] p < 0.05; [b] p < 0.01; [c] p<0.001

Table 6. Mean lipid concentrations depending on the sex and on the inhabitancy (city/ rural area)

Inhabitancy	Total-C (mg/dl)	TG (mg/dl)	HDL-C (mg/dl)	HDL_3-C (mg/dl)	HDL_2-C (mg/dl)	LDL-C (mg/dl)
All						
City area (n=1211)	196±39	123±77	59.6±15.1	43.5± 10.4	16.1±6.7	112±35
Rural area (n=826)	201±42**	139± 87***	57.7±16.9*	42.2± 11.2*	15.4±7.4*	116±38**
Women						
City area (n=759)	198±39	114±70	64.1±14.8	46.3±10.4	17.7±6.8	112±35
Rural area (n=531)	201±39	132±76**	60.1± 16.4***	43.6± 11.1***	16.4± 7.4**	115±36
Men						
City area (n=452)	192±37	138±86	52.0±12.1	38.8±8.5	13.3±5.5	112±34
Rural area (n=289)	201±46	150±103	53.2±16.8	39.6±10.9	13.6±6.9	118±42

*, **, *** difference statistically significant in comparison to group of city area population; * p<0.05; ** p<0.01; *** p < 0.001

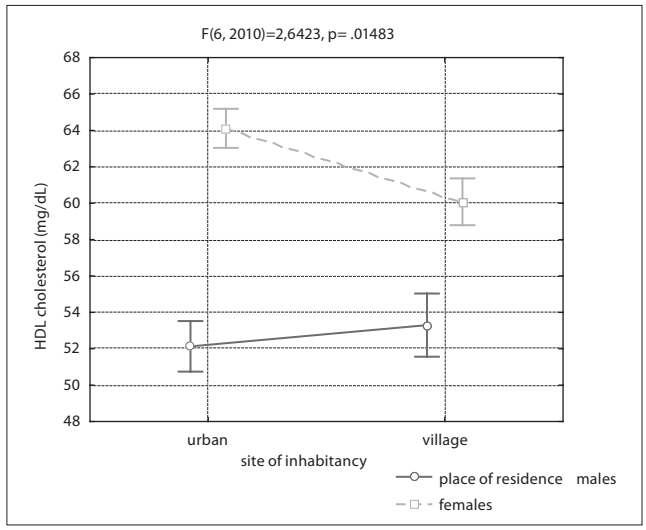

Figure 4. Impact of gender and site of inhabitancy on HDL cholesterol level. Vertical bars represent 0.95% confidence coefficient.

consequence of lower (on average by 7.4%) HDL_2 and lower (by 5.8%) HDL_3 cholesterol sub-fraction levels. In contrast to females, rural males displayed TG and HDL cholesterol levels similar to their urban male counterparts. Young rural men (aged 35–50 years) were the only exception, showing higher TG levels than their urban peers.

Analysis of variance confirmed the significant (p<0.001) impact of place of residence on the levels of particular lipids. It also confirmed the existence of interactions between gender and place of residence (p<0.01) in their effect on lipid levels (i.e. on HDL cholesterol (Fig. 4).

Multivariate analysis of variance showed a significant impact of not only gender (p<0.001) or alcohol drinking (p<0.001), but also place of residence (p<0.05), and both alcohol drinking/place of residence (p<0.01) on lipid levels.

A negative linear correlation between TG and total HDL was demonstrated in the entire studied population (Fig. 5.), including the sub-groups selected according to gender, place of residence, and smoking, and drinking habits. Furthermore, a negative linear correlation was demonstrated between TG and HDL_2 levels, as well as between TG and HDL_3 cholesterol (Tab. 8). In all analyzed cases, the calculated correlation coefficient was higher for the TG-HDL_3 relationship than for the estimated TG-HDL_2 dependence.

Moreover, an inverse linear correlation between body mass index and serum HDL cholesterol concentration, as well as a positive linear correlation between BMI and TG level, were demonstrated in all studied groups (Tab. 8).

Table 7. Lipid pattern in middle-aged residents of urban/rural area depending on age

	Total-C (mg/dl)	TG (mg/dl)	HDL-C (mg/dl)	HDL_3-C (mg/dl)	HDL_2-C (mg/dl)	LDL-C (mg/dl)
Women/age						
35-50 years old						
City area (n=190)	184±38	93±60	64.9±14.3	47.2±9.4	17.7±6.6	103±31
Rural area (n=169)	191±35	113±57**	60.2± 15.2**	44.1±10.9**	16.0±6.8*	108±32
51-60 years old						
City area (n=352)	204±37	120±73	63.7±15.2	45.8±10.8	18.0±7.3	116±36
Rural area (n=185)	212± 41*	145±82***	60.2±17.9*	43.6±11.5*	16.6±8.1*	124±37*
61-70 years old						
City area (n=195)	204±39	124±63	64.3±14.6	46.7±10.5	17.6±6.1	115±35
Rural area (n=110)	202±42	150±90**	59.4± 17.0**	42.7±11.0**	16.6±7.6	113±41
Men/age						
35-50 years old						
City area (n=130)	196±40	131±71	52.4±10.8	39.5±7.8	12.8±4.7	118±37
Rural area (n=95)	204±40	164±107**	53.2±17.7	39.6±11.3	13.6±7.7	118±37
51-60 years old						
City area (n=177)	194±39	154±107	51.0±12.8	37.9±8.9	13.1±6.3	113±34
Rural area (n=99)	198±46	142±88	53.2±16.1	40.1±10.8	13.0±6.3	117±44
61-70 years old						
City area (n=131)	186±33	123±65	53.2±12.5	39.3±8.9	13.9±5.3	108±27
Rural area (n=69)	202±57*	146±124	53.1±17.5	38.5±11.0	14.1±6.6	120±41*

*, **, *** difference statistically significant in comparison to group of cityarea population; * p<0.05; ** p<0.01; *** p < 0.001

Table 8. Correlation between TG and HDL cholesterol: total-, HDL_3- and HDL_2- and correlation between BMI and lipids in studied subgroups. All coefficients are statistically significant.

Correlation with TG								
	men (n = 746)	women (n = 1298)	no-smokers (n = 1595)	smokers (n = 423)	no-drinkers (n = 1792)	drinkers (n = 235)	urban (n = 1211)	village (n = 826)
HDL-C	- 0.3675	- 0.4238	- 0.4262	- 0.3716	- 0.4176	- 0.3548	- 0.4273	- 0.3869
HDL_3-C	- 0.3773	- 0.4138	- 0.4191	- 0.3835	- 0.4165	- 0.3529	- 0.4173	- 0.3923
HDL_2-C	- 0.2657	- 0. 3090	- 0.3192	- 0.2736	- 0.3065	- 0.2850	- 0.3073	- 0.3002
Correlation with BMI								
TG	0.1758	0.2858	0.2900	0.1412	0.2511	0.1672	0.2315	0.2384
HDL-C	- 0.2426	-0.2931	-0.2916	-0.2621	-0.2904	-0.2040	-0.2966	-0.2541
HDL_3-C	- 0.2434	-0.2826	-0.2821	-0.2610	-0.2814	-0.2236	-0.2904	-0.2475
HDL_2-C	- 0.1880	-0.2197	-0.2257	-0.2048	-0.2267	-0.1317	-0.2104	-0.2164

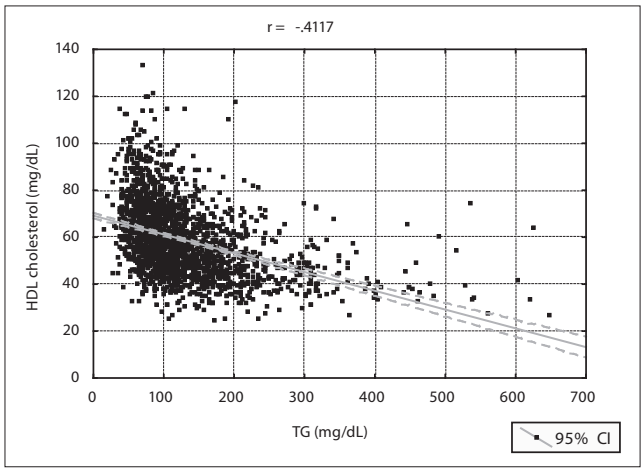

Figure 5. Correlation between TG and HDL cholesterol (p<0.001) in studied population of the Lower Silesian region.

DISCUSSION

In the presented cross-sectional study of a middle-aged Lower Silesian population, the prevalence of undesirable blood cholesterol levels (above 200 mg/dL) was similar in females and males, according to the MONICA study performed in Eastern European countries [21]. The total cholesterol (TC) and LDL-cholesterol increased moderately together with age, but were irrespective of the body mass index (BMI). HDL cholesterol and triglycerides remained similar in the younger, as well as in the older subjects. It has been demonstrated in longitudinal studies conducted on Western populations aged 20–30 that the level of serum cholesterol also increased with age, and this increase was only marginally related to changes in BMI [22]. In turn, in a prospective study described by Ferrara et al., age was not an independent predictor of lipid changes, whereas a weight change was demonstrated to be the most important variable responsible for changes in TC and LDL-C, progressive with age [23]. However, the study was performed in an elderly population, whereas in the presented study the range of age was from 35–70. The age-related differences in lipids observed in the presented study are similar to the changes in lipoprotein levels, as measured by Nuclear Magnetic Resonance Spectroscopy in the Framingham Study [24]. In both studies, LDL-C was more strongly associated with age among females than among males.

Furthermore, some differences in TC and LDL-C levels were observed between males and females under the age of 60. At the age range 35–50, TC and LDL-C levels were lower in females compared to males, whereas at the age range 51–60, the values of TC and LDL-C in females were somewhat higher than in males. This observation is consistent with other studies [24, 25], as well as with National Cholesterol Education Programme report, ATP III: 'prior to the age of menopause, females have lower total cholesterol levels than males of the same age. After menopause, however, female LDL levels tend to rise' [26].

Apart from the significant impact of age on the serum TC (p<0.001) and LDL-C (p<0.01) levels, analysis of variance showed the significant (p<0.001) impact of gender on TG and HDL (total-, HDL_2- and HDL_3-) cholesterol. The fasting HDL-C concentrations were higher in females in comparison to males, but they were generally stable with age for both genders. This correlates with the Framingham Study, where HDL-cholesterol concentrations were also weakly associated with age (r=–0.07 for males; –0.03 for females) [24], although in other studies, such as the Large French Population [27] or SYMFONIE [28], a moderate increase of HDL-C concentration together with age was observed. In the Rancho-Bernardo study, HDL-C levels increased in males above the age of 50, but did not increase in females in the same age range [23].

In the presented study, only the tendency for HDL-C concentrations to rise in males above the age of 60 was demonstrated. However, we observed a little increase of HDL_2 cholesterol in females between the ages of 51–60 (on average about 0.6 mg/dL in comparison to 35–50-year-old women) and in males between the ages of 61–70 (by about 0.8 mg/dL in comparison to 35–50-year-old men). A similar distribution of large HDL particles concentrations was shown on the graph presenting the relationship of HDL sub-classes with age in the Framingham Study [24]. Although concomitant changes in HDL_3 cholesterol concentrations were not observe, even a small isolated increase of HDL_2 cholesterol can be associated with a reduced risk of coronary heart disease. Ostlund et al. showed that HDL_2 levels are inversely correlated with truncal fat, plasma insulin levels and glucose intolerance, and are not independently associated with gender or total body fat [29]. In the presented study, HDL_2-C (also total HDL-C and HDL_3-C) was inversely correlated with TG, and positively with BMI. The linear correlation between TG and HDL-C levels has been described before [30, 31, 32]. This relationship is so strong that serum TG concentrations were recognized

as good predictors of the lipid compositions of HDL [32]. Furthermore, linear dependences between BMI and TG, and between BMI and HDL-C were observed [33].

Among other cardiovascular risk factors undergoing modification, active smoking has been one of the most important causes of cardiovascular mortality [34]. In Eastern European countries, in comparison to western countries, the prevalence of smoking remains at lower levels and is much lower in females than in men. The latter difference is marked in adults and less marked in youth [2]. In the presented study, the prevalence of smoking was typically lower in females than in males. Moreover, the mean age of smoking females was somewhat lower in comparison to males. A different prevalence of smoking (and drinking alcohol) based on place of residence was also observed; a markedly higher percentage of smokers (and drinkers) was attributed to the rural population, as compared to urban inhabitants. This can be partially explained by the economic growth and improvement in the socio-economic conditions of Polish rural areas during the last 20 years. Among rural inhabitants, the false view that smoking and drinking are signs of prosperity is popular and has its consequences.

The presented study confirmed the adverse effect of smoking as a cardiovascular risk factor, leading to an increase in TC, LDL-C and TG, as well as decrease in HDL cholesterol. Such changes were also observed in epidemiological studies performed on populations from various regions of the world, i.e. India [35] and China [36]. Similarly, alcohol drinking was associated with increased TG, TC and LDL-C levels, and likewise with significantly decreased HDL_2 cholesterol concentrations (Tab. 5). However, interestingly, in groups of individuals reporting simultaneously long-term smoking and alcohol abuse, only increased concentrations of TC and TG were observed. This can be explained by the existence of an interaction between smoking and alcohol drinking, in their influence on HDL cholesterol. This interaction was confirmed by two-way analysis of variance (Fig. 2).

It is already known that alcohol consumption is associated with ischemic heart disease. Drinking patterns may contribute to the disproportions in the CHD incidence observed between different regions. Heavy or binge drinking is associated with an increased risk of CHD in comparison to regular drinking [37]. Regular and moderate alcohol consumption is known to be associated with increased HDL cholesterol levels, and through a combination of an increase in both HDL_2 and HDL_3 cholesterol, this results in a decreased risk of developing atherosclerosis [37, 38, 39]. The increased antioxidant potential of HDL or alcohol-induced increased reverse cholesterol transport mediated by HDL_2 [39] are suggested as being responsible for the anti-atherogenic mechanisms linked to alcohol consumption. In the presented study, reported intake of alcohol was associated with significantly ($p<0.05$) lower cholesterol in the HDL_2 subclass in comparison to non-drinkers, without associated changes in HDL_3 cholesterol. As described earlier, HDL_2-C increases with alcohol consumption up to about 450 ml per day, after which serum HDL_2 cholesterol begins to decrease, whereas HDL_3-C does not show any statistically significant changes [38]. This is possible because the actual alcohol intake was likely to have been much more than that reported; the observed changes in the HDL cholesterol subclasses in the presented study were due to alcohol-induced liver impairment.

A new and interesting aspect of the presented study is the demonstrated significant impact of place of residence (urban/rural area) on lipid pattern. The lipid pattern in the rural population was found to be significantly worse than in urban residents. Ths difference in lipid levels was especially strong among females. In comparison to females living in urban areas, female residents in the rural areas displayed higher TG and lower HDL cholesterol concentrations. Lower HDL cholesterol levels were caused by a decrease in both HDL_2 and HDL_3 cholesterol sub-classes. This more atherogenic lipid pattern was associated with a worryingly high percentage of females with low HDL-C. The prevalence of low HDL-C defined by NCEP-ATP III in rural women was 31% and was nearly twice as high as in urban females. Lipid distribution in rural females, suggesting the possibility of progression to atherogenic dyslipidemia, was associated with a higher ($p<0.01$) BMI in comparison to the BMI in urban women (this difference, however, was demonstrated in females well as in males) (Tab. 1). The inverse linear correlation between BMI and serum HDL-C, and the positive correlation between BMI and TG (Tab. 8) (typical for metabolic syndrome) confirm the known thesis that excessive body weight worsens the degree of dyslipidemia in white females [33]. Apart from a higher BMI, this more atherogenic lipid pattern in rural females could also be the result of a markedly higher percent of smokers and drinkers, as well as a lower age of forming smoking habit is rural women, in comparison to female urban inhabitants (Tab. 1).

In European countries, cardiovascular diseases are still the most important cause of death. The presented results contribute to the broadening of knowledge pertaining to cardiovascular disease risk factors among the population of Lower Silesian region of Poland by demonstrating the more artherogenic lipid pattern in rural women as compared to urban females. Other prospective studies are recommended to better define the causes and consequences of the lipid changes observed in the inhabitants of this region.

CONCLUSION

Among the middle-aged population of the Lower Silesian region of Poland, place of residence (urban/rural area) was found to have a significant impact on observed lipid patterns. The lipid pattern in female rural inhabitants was found to be more atherogenic than in their urban counterparts.

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