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Age-dependence of lipid parameters in the general population and vegetarians

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Altersabhängigkeit von Lipidparametern in der Allgemeinbevölkerung und bei Vegetariern

Summary Age-dependent changes of lipid metabolism may arise both as a result of mechanisms of biological ageing and factors influencing age-dependent changes. To study possible influences of nutrition and life-style of vegetarians on age-dependence of lipid parameters, subjects of general population were compared with vegetarians. In the frame of population-based lipid screening projects in the city of Leipzig/ Germany (Lipid Study Leipzig, LSL) 10 550 subjects (3 816 men and 6 734 women, age 18–99 years) of general population were compared with 417 vegetarians (vegans, lacto-vegetarians, lacto-ovo-vegetarians, 148 men and 269 women, age 18–93 years). Most of the vegetarians included in the study were members of the German Society of Vegetarians. The study program included capillary blood cholesterol measurements and the determination of high-density lipoprotein (HDL)-cholesterol, the measurement of other cardiovascular risk factors and the evaluation of dietary and life-style factors. Evaluation of cardiovascular risk profile within LSL was connected with individual consultation.

The mean total cholesterol and non-HDL-cholesterol level and the total: HDL-cholesterol ratio showed the expected age-dependence, with maximum values within the decade 60–70 years. Vegetarians showed lower total and non-HDL-cholesterol levels in comparison with the general population. Furthermore, the age-dependent increase of these parameters is less pronounced under the conditions of vegetarian nutrition and life-style. Especially in young adulthood a significant difference is observed. Thus, the results of the present study reveal the role of nutritional and life-style factors that determine the lipid profile on a population basis and suggest that the known age-dependent rise of the level of atherogenic plasma lipoproteins is partly preventable.

Key words Ageing – lipoproteins – cholesterol – general population – vegetarians

Zusammenfassung Altersabhängige Veränderungen im Lipidstoffwechsel können sowohl auf Mechanismen des biologischen Alterns zurückzuführen sein als auch auf Faktoren, welche diese beeinflussen. Um mögliche Effekte der Ernährung und des Lebensstils von Vegetariern auf die Altersabhängigkeit von Lipidparametern zu untersuchen, wurden

Personen der Allgemeinbevölkerung mit Vegetariern verglichen. Im Rahmen von Lipidscreening-Projekten auf Bevölkerungsebene in Leipzig (Lipid-Studie Leipzig, LSL) erfolgte der Vergleich von 10 550 Personen (3 816 Männer und 6734 Frauen im Alter von 18–99 Jahren) der Allgemeinbevölkerung mit 417 Vegetariern (Veganer, Lacto-Vegetarier, Lacto-ovo-Vegetarier, 148 Männer und 269 Frauen im Alter von 18–93 Jahren). Die in die Untersuchungen einbezogenen Vegetarier waren weitgehend Mitglieder des Deutschen Vegetarierbundes. Das Untersuchungsprogramm schloss die Cholesterolmessung aus Kapillarblut und die Bestimmung von High-density-Lipoprotein (HDL)-Cholesterol sowie die Messung weiterer kardiovaskulärer Risikofaktoren und die Evaluation von Ernährungs- und Lebensstilfaktoren sowie eine individuelle Beratung ein.

Die mittleren Spiegel von Gesamtcholesterol und Nicht-HDL-Cholesterol sowie die Relationen Gesamtcholesterol/HDL-Cholesterol zeigten die erwartete Altersabhängigkeit mit Maxima in der Altersdekade 60–70 Jahre. Vegetarier wiesen im Vergleich zur Allgemeinbevölkerung niedrigere Konzentrationen an Cholesterol und Nicht-HDL-Cholesterol auf. Weiterhin ist der altersabhängige Anstieg dieser Parameter unter den Bedingungen der vegetarischen Ernährungs- und Lebensweise weniger ausgeprägt. Ein signifikanter Unterschied besteht insbesondere bei jungen Erwachsenen. Der bei Vegetariern eingeschränkte altersabhängige Anstieg der für das atherogene Risiko relevanten Lipidparameter weist auf die determinierende Wirkung exogener Faktoren der Ernährungs- und Lebensweise zusätzlich zu den für die Altersabhängigkeit angenommenen endogenen Ursachen hin. Somit ist die altersabhängige Cholesterol-Erhöhung präventiv zu beeinflussen.

Schlüsselwörter Altern – Lipoproteine – Cholesterol – Allgemeinbevölkerung – Vegetarier

Introduction

Advancing age is a risk factor for atherosclerotic cardiovascular disease (CVD). This is due in large part to the cumulative damage of other cardiovascular risk factors on the arterial tree. Many of the contributing factors are related closely to life-style including atherogenic diets, sedentary life habits, overweight, and cigarette smoking. Nevertheless a growing body of evidence indicates that major vascular events can be reduced by risk factor management in older subjects. Furthermore, results of clinical trials have shown that lipid lowering therapy reduced coronary heart disease in elderly individuals [19]. It is well recognized that a favourable lipoprotein profile provides protection from atherosclerotic CVD. Cholesterol represents a primary cardiovascular risk factor. In general, serum cholesterol levels increase up to the age of 60–70 years in both men and women due to increases in low-density lipoprotein (LDL)-cholesterol. This age-dependent change is characteristic of elderly populations and has been observed in all epidemiologic cross-sectional studies [4, 11, 18]. However, reliable data on the longitudinal increase of lipid parameters with age are rare [2, 8, 22]. Furthermore, data with respect to the underlying causes of the age-dependence are scarce. Dietary and life-style factors may influence the age-dependence of lipid parameters.

Although no single dietary factor is universally associated with CVD, high caloric diets rich in saturated fatty acids are generally positively correlated with hypercholesterolemia and coronary artery disease. A diet consisting largely of low-caloric vegetables and fruit markedly reduces risk factors for atherosclerosis. Epidemiological studies have shown a decreased risk for CVD among vegetarians [9]. Furthermore, data from prospective studies raise the possibility that the life-style pattern that includes a very low meat intake is associated with greater longevity [20]. Vegetarians and general population differ both with respect to nutrition and other life-style factors. These factors may have implications for lipoprotein metabolism [10, 12]. Studies on population basis among residents of Leipzig/Germany showed significant differences in total cholesterol, ratios of cholesterol:high-density lipoprotein (HDL)-cholesterol, mean body-mass-index and various life-style factors between the general population and vegetarians [13].

Both animal experiments and clinical trials, as well as cross-sectional and longitudinal studies have shown age-associated changes in lipoprotein metabolism [11]. These age-dependent changes may arise both as a result of intrinsic mechanisms of biological ageing and environmental factors influencing age-dependent changes including dietary habits. To clarify possible influences of nutrition and life-style of vegetarians on age-dependence of lipid parameters, in the

frame of Leipzig lipid screening projects the general population was compared with vegetarians.

Study design and measurements

Subjects

With the aim of evaluating the lipid and risk factor profile on a population basis a cross-sectional study (Lipid Study Leipzig – LSL) was initiated in the city of Leipzig, Germany. LSL was carried out at community centres, work sites and at the University. To study the possible influence of nutrition and life-style of vegetarians on age-dependence of lipid parameters, 10550 subjects (3816 men and 6734 women, age 18–99 years) of the general population were compared with 417 vegetarians (vegans, lacto-vegetarians, lacto-ovo-vegetarians, 148 men and 269 women, age 18–93 years). Recruitment of vegetarians was carried out mainly during meetings of the German Society of Vegetarians (Deutscher Vegetarierbund e.V.).

Study program

The study program included capillary blood cholesterol measurements and the determination of HDL-cholesterol using the dry-chemistry Reflotron Systems (Roche Diagnostics GmbH, Mannheim). The subjects were compared with respect to the following parameters:

- Total cholesterol, which reflects the sum of cholesterol carried by all of the lipoprotein subspecies and ratio of total cholesterol to HDL-cholesterol (Cholesterol carried by vasoprotective HDL particles).
- Non-HDL-cholesterol [1, 6], difference between total and HDL-cholesterol, which reflects the sum of cholesterol carried by all of the potentially atherogenic lipoprotein subspecies (low-density lipoproteins, very-low-density lipoproteins).

Furthermore, the study program included measurement of weight and height (body-mass-index), waist and hip circumfance (waist-to-hip ratio), and blood pressure. The participants were questioned on their own and their family history regarding cardiovascular diseases, risk factors, and metabolic disorders. Furthermore, life-style and dietary factors (smoking behaviour, physical activity and dietary habits) were evaluated. The examinations included an interview and a health habits and food frequency questionnaire. Risk evaluation was connected with individual consultation.

Statistics

The association between age and total cholesterol as well as age and non-HDL-cholesterol were evaluated using regression analyses for male and female subjects, respectively. Linear regression models were performed for three age groups separately. To analyse the impact of nutrition (vegetarians vs. general population), an indicator variable and an interaction term were included in the models. Slopes with 95% confidential interval were presented.

The χ^2 test was used to test statistical significance in the prevalence values. Differences were considered statistically significant at $p < 0.05$. All statistical analysis were performed using the Statistical Package of Social Sciences (SPSS 11.5.1, Chicago Ill, USA).

Results

The lipid parameters total and non-HDL-cholesterol of both men and women of the general population showed the expected age-dependent increase up to the age 60–70 years. This is in agreement with earlier results from the Lipid Study Leipzig [14, 15]. According to the present study except in the age below 30 years, both male and female vegetarians showed lower total cholesterol levels in comparison with the general population. The age-dependence of total cholesterol is seen in the general population as well as among vegetarians. However, the age-dependent increase of the cholesterol level is less pronounced under the conditions of vegetarian nutrition and life-style (Fig. 1).

The cholesterol : HDL-cholesterol ratio showed an age-dependent increase. The ratios in 18–30 year old male subjects of the general population and vegetarians were 3.9 ± 1.4 and 3.7 ± 0.9, respectively. In 51–70 year old subjects the total cholesterol : HDL-cholesterol ratios were 5.6 ± 2.0 and 4.7 ± 1.5, respectively. Thus, a more pronounced elevation in the general population was found.

Non-HDL-cholesterol may be very useful in predicting cardiovascular risk [1, 6]. In comparison with the general population, vegetarians show both lower mean plasma levels of non-HDL-cholesterol and a less pronounced increase with respect to age (Fig. 2).

Both for cholesterol and non-HDL-cholesterol separate regression models for different age intervals were fitted. In the age-group 18–30 years, a signifi-

Fig. 1 Total cholesterol levels of the general population (—, n = 10 550; 3 816 men, 6 734 women) and vegetarians (****, n = 417; 148 men, 269 women) with respect to age

Fig. 2 Non-HDL-cholesterol levels of the general population (—, n = 10 550; 3 816 men, 6 734 women) and vegetarians (**** , n = 417; 148 men, 269 women) with respect to age

cant difference between the slopes was found. Regression coefficients were lower in vegetarians in comparison with the general population. In higher age groups no statistically significant difference between the general population and vegetarians regarding the age-dependent change of lipid parameters was observed (Table 1).

A decreased prevalence of the prognostic favourable non-HDL-cholesterol class < 3.9 mmol/l is seen with respect to age. Interestingly, higher percentages of this non-HDL-cholesterol class were found in elderly vegetarians in comparison with subjects of the general population (Fig. 3).

Discussion

Certain fundamental parameters of ageing such as life-span and several age-related diseases can be modified by diet [16]. Vegetarian diets have been associated with low rates of CVD and mortality [9]. It may be difficult to determine which of the many changes of ageing are innate or genetically determined rather than the result of permanent environmental factors such as nutrition. To study possible influences of nutrition and life-style of vegetarians on age-dependence of lipid parameters, subjects of the general population were compared with vegetarians.

An elevation of the plasma concentration of atherogenic lipoproteins and of the ratio atherogenic lipoproteins : vasoprotective lipoproteins is a primary

Table 1 Regression coefficients with 95% confidential intervals (CI); p-value: difference of the slopes between the general population and vegetarians, *n* number of subjects of general population and vegetarians respectively

Parameter	Sex	Age	General population [95% CI]	Vegetarian [95% CI]	p-values
Cholesterol	male	18–30 years (n = 456/32)	3.7 [2.4; 5.0]	–1.8 [–6.6; 3.0]	0.030
		31–50 years (n = 568/38)	1.9 [1.3; 2.5]	2.2 [0.2; 4.2]	0.814
		51–70 years (n = 2102/54)	0.3 [–0.1; 0.6]	0.4 [–1.8; 2.6]	0.886
	female	18–30 years (n = 594/93)	2.1 [1.1; 3.1]	–0.9 [–3.7; 1.8]	0.036
		31–50 years (n = 1079/61)	1.9 [1.5; 2.3]	0.7 [–0.9; 2.3]	0.209
		51–70 years (n = 3728/91)	1.2 [1.0: 1.5]	0.3 [–1.6; 2.1]	0.278
Non-HDL-cholesterol	male	18–30 years (n = 455/30)	3.5 [2.1; 4.8]	–0.9 [–5.4; 3.6]	0.095
		31–50 years (n = 566/36)	1.9 [1.2; 2.6]	1.5 [–0.6; 3.7]	0.798
		51–70 yeras (n = 2100/52)	0.2 [–0.1; 0.6]	0.6 [–1.5; 2.6]	0.764
	female	18–30 years (n = 593/92)	1.8 [0.8; 2.8]	0.4 [–2.1; 2.9]	0.317
		31–50 years (n = 1077/60)	1.8 [1.3; 2.2]	0.9 [–0.7; 2.5]	0.361
		51–70 years (n = 3728/91)	1.5 [1.2; 1.7]	0.2 [–1.8; 2.1]	0.177

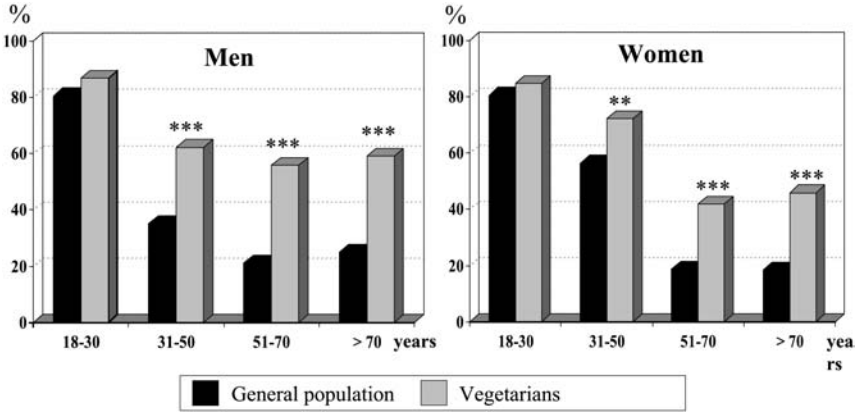

Fig. 3 Prevalence of the non-HDL-cholesterol class < 3.9 mmol/l of the general population and vegetarians with respect to age (*** $p < 0.001$, ** $p < 0.01$ (general population/vegetarians))

risk factor for CVD. High levels of non-HDL- and LDL-cholesterol and low levels of HDL-cholesterol are predictors of vascular risk. Populations that have very low levels of atherogenic lipoproteins generally have low rates of CVD even when other risk factors for atherosclerosis are present [21].

Age-dependent changes in plasma lipoproteins have been extensively studied in man and experimental animals [11]. Although the available data are frequently inconsistent, in the majority of studies, an age-dependent decrease of catabolic rates of lipids and lipoproteins is seen, resulting in elevated blood levels of atherogenic lipoproteins [5, 11]. The total plasma cholesterol and non-HDL-cholesterol level as well as the level of triglycerides increase with age in populations of most industrialized countries [5, 14, 15, 18]. However, the pathophysiology of this progressive increase up to the age of 70 years is not clear, and many explanations have been put forward. Several results indicate that older subjects have re-

duced lipoprotein lipase activity and delayed clearance of triglyceride-rich lipoproteins [11]. LDL receptor activity plays an important role in regulating LDL metabolism. There is a decrease in the fractional rate of catabolism of LDL with increasing age which may be associated with a diminished LDL receptor activity [7]. However, it was proposed that the apparent decline in LDL receptor activity noted with age is actually related to dietary factors. A high fat consumption suppresses LDL receptor activity [3]. Based on these observations, it should be evident that a low total fat diet according to the eating pattern of vegetarians would be helpful in reducing the age-dependent increase of atherogenic lipoproteins.

In the present study both in the general population and vegetarians an age-dependent increase of atherogenic lipoproteins has been found. However, the age-dependence of total cholesterol, non-HDL-cholesterol, and the ratio cholesterol : HDL-cholesterol is less pronounced under the conditions of a vegetarian nutrition and life-style. Especially in young adulthood a significant difference between the slopes of subjects of general population and vegetarians is observed. Thus, the results suggest that the age-dependence of lipoprotein parameters may arise both as a consequence of intrinsic mechanisms and environmental factors. The less pronounced age-dependence of plasma lipids of vegetarians is in agreement with other epidemiological studies in populations with low intakes of saturated fat and cholesterol and with a high degree in physical activity. In Ethiopia, an age-dependence of total and LDL-cholesterol was seen. However, in comparison with industrialized countries lower lipid levels were found in all age groups. Furthermore, in Ethiopia higher lipid values were found in blood serum of urban persons in comparison with rural subjects, which may be a reflection of different life-styles [17]. In summary, the results of the present study reveal the primary role of nutritional and life-style factors that determine the lipid profile on population basis and suggest that the known age-dependent rise of atherogenetic plasma lipoproteins is partly preventable.

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