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# The effect of a free mackerel-supplemented diet on plasma and lipoprotein lipid concentrations in normolipidemic subjects

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*Summary:* The effect of mackerel consumption on plasma and lipoprotein lipid concentrations was studied in a seven-day experiment in eight healthy, normolipidemic subjects. Participants ate about 100 g mackerel (corresponding to about 2.5–3 g ω3 fatty acids daily.

The mean triglyceride concentrations in total plasma, VLDL, and LDL were significantly reduced by 40, 46.7, and 38.5 % respectively after fish consumption. There was also a small (non-significant) reduction of plasma cholesterol and a (significant) increase of the ratio of HDL/total plasma cholesterol.

These data show that a moderately increased intake of ω-3 fatty acids by fish food can change lipid characteristics in healthy normolipidemic individuals within a short-time period, even on a free diet.

*Zusammenfassung:* In einem Kurzzeit-Experiment wurde an gesunden, normolipidämischen Probanden geprüft, ob durch einen mäßig hohen Fischverzehr der Gehalt an Plasma- und Lipoproteinlipiden gesenkt werden kann. 8 Teilnehmer aßen eine Woche lang täglich 100 g Makrele (entsprechend etwa 2,5–3 g ω-3-Fettsäuren).

Die Triglycerid-Konzentrationen im Plasma und in den VLDL und LDL waren nach der Fischdiät um 40, 46,7 und 38,5 % niedriger als zu Beginn des Experiments. Die Plasmacholesterol-Konzentration war nur geringfügig erniedrigt, das Verhältnis HDL/Gesamt-Cholesterol aber signifikant erhöht.

Die Studie zeigt, daß eine moderate Steigerung des Fischverzehrs bei gesunden, normolipidämischen Probanden innerhalb einer Woche – selbst auf der Basis einer nicht strikt kontrollierten Diät – die Lipidspiegel verändern kann.

*Key words:* cholesterol, triglycerides, lipoproteins, ω 3 fatty acids

*Schlüsselwörter:* Cholesterol, Triglyceride, Lipoproteine, ω-3-Fettsäuren

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*Abbreviations*

HDL: high density lipoproteins
LDL: low density lipoproteins
VLDL: very low density lipoproteins

## Introduction

Fish oil is rich in ω3 fatty acids, particularly in the long-chain 20:5 ω3 and 22:6 ω3 fatty aids. These ω3 fatty acids exert a beneficial change of several risk factors for cardiovascular disease. They do reduce blood pressure, lower platelet aggregability and thromboxane $A_2$ generation, and also lower plasma lipid concentrations (for a recent review see 1). Epidemiological data suggest that the incidence of coronary heart disease is lower in populations with a high fish intake (2).

It has been reported that ω3 fatty acids cause a pronounced reduction of plasma and VLDL triglyceride concentrations and of plasma cholesterol (1, 3–8). There was a stronger reduction of triglyceride but a similar reduction of cholesterol concentrations by the consumption of salmon oil as compared to the highly unsaturated safflower oil (3). ω3 fatty acids raised hepatic ketogenesis in the perfused liver (9) and decreased hepatic triglyceride synthesis and secretion in VLDL particles both in hepatocyte culture (10) and in the perfused organ (9), more so than ω6 fatty acids. As lipoprotein lipase activity was enhanced, turnover of secreted VLDL particles was accelerated (11) and LDL synthesis was reduced in these studies (3). Hepatic cholesterol synthesis was reduced in these studies (3). Hepatic cholesterol synthesis was also depressed by feeding fish oil as compared to safflower oil (9, 12) and ω3 fatty acids inhibited cholesterol ester formation in cultured rat hepatocytes at least more than oleic acid (13). There is not much knowledge on the effect of ω3 fatty acids on the LDL receptor. From one study a decrease of LDL receptor and an increase of HDL receptor activity was reported (14).

Fish consumption is rather low in most western societies and it is obvious that changes of food habits are difficult to achieve. Encapsulated fish oil preparations are available as a lipid lowering agent. However, according to the recommendations issued by many advisory panels, a change of diet is preferable to the intake of nutritional supplements. Moreover, fresh fish is probably less susceptible towards autoxidation than isolated and processed fish oil (14). The lipid content of fish is highly variable between and within species, depending on season, diet, temperature, and thus on fishing grounds (14).

Because of all these reasons it was of interest to see whether a moderate increase of fish intake would improve plasma and lipoprotein lipid characteristics of healthy individuals.

## Methods

The subjects in this study were two males and six females, healthy and non-obese; seven were between 20 and 28 years old and one male was 53 years old. Body mass index (BMI = weight/(height)$^2$ as kg × $10^4$/cm$^2$) was 21.95 ± 0.48. Participants were asked to consume 100 g mackerel per day for one week in exchange for other fatty food items. No other dietary advice was given. According to food tables this amount of mackerel is approximately equivalent to about 2.5–3 g of ω-3 fatty acids per day (1, 15).

Heparinized blood was taken from fasted individuals at 0900 hrs prior to and after one week of daily fish consumption. Cholesterol concentrations in plasma and lipoprotein were determined enzymatically using a cholesterol oxidase/iodide test

Table 1. Plasma and lipoprotein lipid concentrations before and after one week of a mackerel diet.

| | Cholesterol | | Triglycerides | |
|---|---|---|---|---|
| | before | after | before | after |
| | | mmol/l | | |
| Total | 4.52 ± 0.33 | 4.41 ± 0.35 | 1.13 ± 0.16 | 0.66 ± 0.09* |
| VLDL | 0.37 ± 0.08 | 0.33 ± 0.06 | 0.32 ± 0.06 | 0.17 ± 0.02* |
| LDL | 2.42 ± 0.28 | 2.57 ± 0.28 | 0.52 ± 0.07 | 0.32 ± 0.04* |
| HDL | 1.36 ± 0.11 | 1.44 ± 0.13 | 0.20 ± 0.03 | 0.16 ± 0.01 |

Values are the means ± SEM of eight subjects. * Significantly different from the respective value before mackerel diet using Wilcoxon rank order test ($p < 0.01$).

kit (Hoffmann-La Roche, Basel, Switzerland, Cat. No. 0710687) and triglycerides were determinbed according to Wahlefeld (16). Separation of VLDL was achieved by flotation at d 1.006 g/ml in an Airfuge (Beckman Instr.) using a modified method of Wieland and Seidel (17). HDL lipids were determined after precipitation of VLDL and LDL by adding 0.52 g/l dextrane sulfate and 0.052 mmol/l of $MgCl_2$ to whole plasma (18). LDL lipids were calculated by subtraction. Recovery of cholesterol and triglycerides in lipoprotein fractions was from 91.8 to 98.5 %.

All reagents were of reagent quality.

Means ± SEM are given throughout. Statistical calculations were done using Wilcoxon rank order text.

## Results

A significant decrease of triglycerides in total plasma, VLDL, and LDL and no change of HDL triglycerides occurred as a consequence of mackerel diet consumption (Table 1). Total plasma triglycerides were reduced by 40 %, VLDL by 46.7 %, and LDL triglycerides by 38.5 %.

There was a tendency towards lower concentrations of total plasma and VLDL cholesterol and a tendency towards higher concentrations of HDL cholesterol due to the mackerel diet (Table 1). But the ratio of HDL/total cholesterol was significantly increased from 0.31 ± 0.02 before to 0.34 ± 0.03 after the mackerel diet ($p < 0.05$).

## Discussion

In agreement with other studies (3–8) a significant reduction of both total plasma, VLDL, and LDL triglycerides was observed in this experiment. This occurred in young, normolipidemic subjects after a consumption of not more than about 2.5–3 g of ω3 fatty acids daily for one week. This effect might have been even stronger in hyperlipidemic patients, as it has been shown before that the effect of ω3 fatty acids is positively correlated with the baseline triglyceride levels (8).

There was only a tendency towards lower total and VLDL and towards higher HDL cholesterol concentrations with the mackerel diet. This is not surprising because of the low amount of ω3 fatty acids applied, the low baseline cholesterol concentrations, and the rather short experimental period. Nevertheless, the ratio of HDL/total cholesterol was significantly increased after one week of mackerel diet.

It is surprising to see that such a considerable reduction of triglyceride concentrations by about 45 % appeared within one week. About the same reduction was achieved in a longer-term experiment by giving 3 g of ω3 fatty acids per day (5). Popp et al. (5) maintain that supplementation above this amount does not lead to a further decrease of plasma triglyceride concentrations.

It has been reported before that an increased ratio of HDL/total cholesterol reduces the risk for coronary heart disease (19). It is much debated whether high triglyceride levels are an independent risk factor, too. There is only one study confirming this contention (20), but nevertheless triglycerides are associated with other high-risk indicators (21). There is also metabolic evidence emerging that remnants of triglyceride-rich lipoproteins are involved in the development of atherosclerosis (22, 23). This makes the reduction of plasma triglyceride concentrations a desirable change, particularly in hypertriglyceridemic people.

It was furthermore been shown in other studies that such relatively low doses as 2.8–3.5 g ω3 fatty acids per day increase the amount of ω3 fatty acids in plasma lipids (6, 24) and diminish other risk factors like blood viscosity and erythrocyte deformability (24), and platelet/vessel wall interaction (25) concomitantly with reduction of plasma triglyceride concentrations.

It is not reasonable to expect people to eat 100 g fish every day. But the consumption of a larger serving of fish two to three times per week over a longer time period may also lead to a comparable change of lipid characteristics. Fish consumption at this level could become a dietary habit for a large part of the general population.

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