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Fish consumption in relation to other foods in the diet

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Abstract

Our aim was to investigate whether fish consumption is associated with the consumption of other healthy foods. The study population consisted of 2605 men and 3199 women from the nationally representative Health 2000 survey and 114 professional fishermen and 114 fishermen's wives (the Fishermen substudy) in Finland. Dietary data were collected using a calibrated (i.e. determined to have relative validity) FFQ. Model-adjusted means for food consumption and *P* values for linear trend were calculated across fish consumption tertiles. Those with the highest fish consumption had the highest consumption of vegetables, fruit and berries, potatoes, oil and wine even after adjusting for other food groups. The consumption of red meat and sausages had a tendency to decrease across fish consumption tertiles but the associations were inconsistent in the study populations. In conclusion, fish consumption had a positive linear association with the consumption of some other healthy foods such as vegetables, fruit, berries, and oil both in the general population of Finland and in a population with high fish consumption. Additional adjustment for other food groups had a clear effect on some of the studied associations. Therefore, when evaluating the health effects of fish consumption, confounding by other foods characterising a healthy diet needs to be considered.

Key words: **Fish consumption: Foods: Healthy diet**

According to official nutrition recommendations, it is advisable to eat fish at least twice per week[1,2]. Fish consumption and long-chain PUFA (*n*-3 PUFA) intake are thought to be important for human health[3–5], and to protect especially from CVD[6,7], diabetes[8–10] and possibly some cancers[11,12] although the conclusions seem partly contradictory[13,14]. Despite the large body of evidence, it has been hypothesised that at least a part of the observed beneficial effects of fish consumption could be explained by an overall healthy diet, and fish consumption may even be a surrogate for healthy lifestyle in general[7,15]. This implies that the postulated health benefits of fish consumption would not be achieved by eating fish alone.

Many epidemiological studies on the associations between fish consumption and chronic diseases such as CVD[16–19] including cerebrovascular diseases[20–23] and cardiovascular mortality[24–27], diabetes[9] and cancer[28–32] have reported associations between fish and other foods as baseline characteristics to describe their study populations. These studies have provided descriptive data on, for example, the association between the consumption of fish and vegetables but have mostly not accounted for the effects of confounding factors such as lifestyle and other foods in the diet. To the best of our knowledge, the specific association between fish consumption and the overall diet has not been the main research question in previous studies, and has thus not gained the attention it deserves to provide strong evidence for dietary recommendations.

In the present study, we wanted to investigate whether fish consumption is associated with the consumption of some other foods, especially those that are considered healthy based on official nutrition recommendations. In other words, we wanted to explore if there are some common features in the diets of those who eat a lot of fish. The analyses were conducted in a unique population with high fish consumption where the effects of fish could be most easily seen. In addition, the analyses were repeated in a large sample of the general population of Finland.

Methods

Study populations

The nationally representative Health 2000 health examination survey (the Health 2000 survey) was conducted during 2001–2002 and coordinated by the National Institute for Health and

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Welfare in Finland (THL, merged from the former National Public Health Institute (KTL) and the National Research and Development Centre for Welfare and Health (STAKES))[33]. The main study was carried out in a population aged 30 years or over, and it included an interview, several questionnaires and a health examination. A total of 5998 participants completed an FFQ[34], and 2605 men and 3199 women had all the required data for the present study.

The Nutrition, Environment and Health study (the Fishermen study) was conducted during 2004–2005 and coordinated by THL. A total of 1427 professional fishermen, their wives and other family members answered a self-administered health questionnaire. Of those, 309 volunteers, aged 22–74 years, and living near Helsinki and Turku study centres participated in a health examination study (the Fishermen substudy) including, for example, blood sampling, basic measurements and an FFQ[35]. Of those, 114 professional fishermen and 114 fishermen's wives had all the required data for the present study. In our previous study, we showed that fish consumption among the fishermen and their wives was approximately 1·5-fold when compared with that of the general population[35], which attests our hypothesis of a population with high fish consumption.

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and the protocols of the Health 2000 survey and the Fishermen study were approved by the ethical committee of the Hospital District of Helsinki and Uusimaa. A written informed consent was obtained from all participants.

Dietary data

In both studies, diet was assessed by the same calibrated (i.e. determined to have relative validity) self-administered FFQ designed to cover the whole diet over the past 12 months[36,37]. The FFQ consisted of 128 commonly used and/or nutritionally important food items, mixed dishes and alcoholic beverages based on the national FINDIET study[38]. Serving sizes were specified by natural units (for example, serving, slice, glass, cup) or weight/volume measures, and the nine response options ranged from 'never or seldom' to 'six or more times per day' (for more information, see the Appendix in our earlier publication[39]). Daily consumption of foods (g/d) and the intake of energy (MJ/d) and nutrients were calculated by the national Fineli® Finnish Food Composition Database[40]. For the purpose of the present study, food items and mixed dishes were combined into twenty food groups based on culinary use, nutrient profile and nutritional relevance (see Supplementary Appendix; available online at http://www.journals.cambridge.org/bjn).

Other covariates

Age (years) was calculated at the time of sampling in the Health 2000 survey and at the time of the health examination in the Fishermen substudy.

Data on education, marital status and smoking were obtained from a structured interview in the Health 2000 survey and from the self-administered health questionnaire in the Fishermen substudy. With regard to education, two questions were used in the Health 2000 survey: 'What is your basic education?' with eight response options from 'less than elementary school' to 'high school' and 'What is your highest education after basic education?' with eleven response options from 'no vocational education' to 'doctoral degree'. In the Fishermen substudy, education level was determined by the question 'What is your education?' with eight response options from 'less than elementary school' to 'academic degree'. The final education variable was constructed similarly in both studies, and it consisted of three classes: basic, intermediate and high education. The final marital status consisted of three classes: married or cohabiting, unmarried, and divorced/separated or widowed. Regarding smoking, the following questions were asked: 'Have you ever smoked?', 'Have you smoked at least 100 times?', 'Have you ever smoked regularly (i.e. daily for at least 1 year)?' and 'When did you last smoke?'. The final smoking variable consisted of three classes: never, occasional or ex-, and daily smoker.

Data on physical activity were obtained from the self-administered health questionnaire both in the Health 2000 survey and in the Fishermen substudy. Free-time physical activity was determined by the question 'How often do you exercise in your free time so that the duration is at least half an hour and you get at least mildly out of breath?' with response options ranging from 'daily' to 'a couple of times per year or less often'. Physical activity while commuting was determined by the question 'How many minutes do you walk or cycle while going to work?' with response options ranging from 'not at all' to '2 hours per day or more'. The final physical activity variable consisted of three classes: sufficient, intermediate and sedentary.

Weight (kg) and height (cm) were measured during the health examination by trained research personnel. Weight in light clothing was measured to an accuracy of 0·1 kg using a bioimpedance device or digital scales in the Health 2000 survey, and digital scales in the Fishermen substudy. Height was recorded using a wall-mounted stadiometer to an accuracy of 0·5 cm.

Statistical analyses

Statistical analyses to produce Tables 1–3 were performed using the SAS statistical software package (version 9.2; SAS Institute Inc., Cary, NC, USA). SAS survey procedures were used to account for the sampling design of the Health 2000 survey data. In addition, a post-stratification weight was used to adjust for the oversampling of the 80-year-old and older individuals, and for the non-response to the FFQ[41]. For the Fishermen substudy, basic SAS procedures were used. For the categorical variables in Table 1, however, the SAS SURVEYFREQ procedure was used also for the Fishermen substudy since the basic SAS FREQ procedure does not yield 95 % CI for the multinomial proportions.

Table 1. Background data of the Health 2000 survey and the Fishermen substudy participants
(Mean values or percentages with 95 % confidence intervals)

	Health 2000 survey men (n 2605)			Health 2000 survey women (n 3199)			Fishermen (n 114)			Fishermen's wives (n 114)		
Variable	Mean	%	95 % CI	Mean	%	95 % CI	Mean	%	95 % CI	Mean	%	95 % CI
Age (years)	51		51, 52	54		53, 54	55		53, 56	54		52, 56
Energy intake (MJ/d)	10		9·9, 10	9·1		9·0, 9·3	9·8		9·3, 10	8·8		8·3, 9·3
Fish consumption (g/d)												
Arithmetic mean	46		44, 48	45		43, 46	86		74, 99	64		57, 72
Geometric mean	34		33, 36	33		32, 34	70		62, 79	53		47, 61
BMI (kg/m^2)	27		27, 27	27		27, 27	28		27, 29	28		27, 29
Education level												
Basic		37	35, 39		40	38, 42		54	44, 63		33	25, 42
Intermediate		38	36, 40		27	26, 29		37	28, 46		27	19, 35
High		25	24, 27		33	31, 35		9·6	4·1, 15		39	30, 49
Marital status												
Married or cohabiting		77	75, 78		65	63, 67		78	70, 86		90	85, 96
Unmarried		13	12, 14		9·9	8·8, 11		9·6	4·1, 15		0	–
Divorced/separated or widowed		10	9·4, 12		25	23, 27		12	6·1, 18		9·6	4·1, 15
Smoking												
Never smoker		37	35, 38		65	63, 67		44	35, 53		64	55, 73
Occasional or ex-smoker		36	35, 38		18	16, 19		37	28, 46		25	17, 33
Daily smoker		27	25, 29		17	16, 19		19	12, 27		11	5·5, 17
Physical activity												
Sufficient		30	28, 31		34	32, 36		33	25, 42		30	21, 38
Intermediate		30	28, 32		29	27, 31		19	12, 27		31	22, 39
Sedentary		40	38, 42		37	35, 38		47	38, 57		39	30, 49

The SAS GLM procedure was used to produce model-adjusted consumption of different food groups by fish consumption tertiles for Tables 2 and 3. We used three different adjustments: age and total energy intake (model 1); age, total energy intake and lifestyle factors (BMI, education, marital status, smoking and physical activity) (data not shown); and age, lifestyle factors and the consumption of eighteen other food groups (model 2). Total energy intake was omitted from model 2 due to multicollinearity caused by simultaneous inclusion of energy and all food groups. Energy and continuous food group variables were transformed according to natural logarithm $\log(x+1)$, which clearly improved normality of the variable distributions and fulfilled the model assumptions. Antilogarithms were taken from the arithmetic means of the log-transformed variables, and the resulting geometric means and their 95 % CI were reported. In addition, P values for linear trends across fish consumption tertiles were calculated. The coefficients for linear contrasts needed for the calculation of these P values were produced by SAS/IML software[42] because geometric means for the fish consumption tertiles were not equally spaced. All the results were reported separately for the sexes and the two studies. To check for multicollinearity, pairwise Pearson correlation coefficients and collinearity diagnostics, namely tolerance, variance inflation factor and condition index, were calculated.

As sensitivity analyses, we applied an additive model with thin-plate regression spline in the multiple generalised cross-validation package (mgcv) for R Statistical Software version 2.9.1[43,44]. An additive model is a non-parametric extension of a linear model for Gaussian response and allows the data to 'speak for themselves' because a smoothing function does not assume a rigid form for the dependence. It can be used to explore the relationships between the dependent variable and the independent variables, for example, to visually assess linearity of the studied associations. In the sensitivity analyses of the present study, each food group was treated as a response variable (at a time), continuous fish consumption as a smoothed predictor, and all other covariates (as in model 2) as parametric predictors. As a result of sensitivity analyses, scatter plots with regression curves and approximate 95 % CI were drawn, and the most important observed associations were visualised in Figs 1 and 2. In the figures, the plotted points are partial residuals, the solid curve is the additive model fit, and the dashed curves represent the approximate 95 % CI. The fit is named as s(log_fish, edf), where edf is the estimated degrees of freedom describing the wiggliness of the fit. When edf for the smooth is close to 1, the curve fits to a straight line. However, the CI typically becomes wider (and the uncertainty increases) towards the ends of the curve due to decreasing number of observations, and, therefore, only the central part of the curve is usually reliable.

Results

The fishermen were, on average, 4 years older and had a higher proportion of individuals having only basic education when compared with the general population men in the Health 2000 survey (Table 1). The proportion of daily smokers was lower among the fishermen and their wives than in the general population. The geometric mean for fish consumption was over twofold among the fishermen when compared with the general population men, and 1·6-fold among the fishermen's wives when compared with the general population women.

Table 2. Model-adjusted food consumption (g/d) by fish consumption tertiles (g/d) among the Health 2000 survey men and women (Geometric means and 95 % confidence intervals)

Fish consumption tertiles ...	Health 2000 survey men (*n* 2605)							Health 2000 survey women (*n* 3199)						
	1st tertile*		2nd tertile†		3rd tertile‡			1st tertile§		2nd tertile‖		3rd tertile¶		
	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend
Vegetables														
Model 1**	156	149, 163	198	190, 206	232	223, 241	<0·01	218	210, 227	254	245, 263	296	285, 306	<0·01
Model 2††	184	176, 192	197	190, 204	198	190, 206	0·01	248	240, 257	253	245, 262	261	252, 270	0·03
Fruit and berries														
Model 1	91	84, 99	109	102, 117	128	121, 136	<0·01	156	147, 165	171	162, 180	191	180, 202	<0·01
Model 2	99	91, 107	105	99, 112	124	116, 132	<0·01	163	154, 173	170	161, 178	183	173, 195	<0·01
Potatoes														
Model 1	147	142, 153	157	151, 163	158	151, 165	0·04	139	134, 145	147	142, 152	148	143, 153	<0·01
Model 2	147	141, 153	156	150, 162	159	152, 167	0·02	139	133, 144	145	141, 150	151	146, 156	<0·01
Wheat														
Model 1	83	80, 86	79	76, 81	74	71, 76	<0·01	72	70, 74	70	68, 72	65	63, 67	<0·01
Model 2	82	79, 85	78	75, 81	75	72, 78	<0·01	70	68, 73	70	68, 72	67	65, 69	0·01
Rye														
Model 1	42	40, 45	43	41, 46	41	38, 43	0·31	39	37, 42	41	39, 44	42	40, 44	0·09
Model 2	40	37, 43	43	41, 46	43	41, 46	0·11	38	36, 40	41	39, 43	44	42, 47	<0·01
Oil														
Model 1	7·1	6·9, 7·3	8·2	8·0, 8·4	9·5	9·2, 9·7	<0·01	6·6	6·5, 6·8	7·7	7·6, 7·9	8·8	8·6, 9·0	<0·01
Model 2	7·5	7·3, 7·7	8·1	7·9, 8·3	9·1	8·9, 9·3	<0·01	6·9	6·7, 7·1	7·6	7·5, 7·8	8·6	8·4, 8·8	<0·01
Margarine														
Model 1	4·6	4·1, 5·2	4·3	3·8, 4·8	4·4	3·9, 5·0	0·67	4·5	4·1, 4·9	4·6	4·2, 5·0	4·0	3·6, 4·4	0·13
Model 2	4·4	4·0, 4·9	4·3	3·8, 4·7	4·6	4·1, 5·1	0·60	4·1	3·8, 4·5	4·4	4·0, 4·8	4·6	4·2, 5·0	0·14
Butter														
Model 1	9·7	9·2, 10	9·7	9·3, 10	9·2	8·8, 9·6	0·11	8·4	8·0, 8·8	8·3	8·0, 8·6	8·6	8·2, 8·9	0·35
Model 2	9·3	8·8, 9·7	9·5	9·2, 9·9	9·8	9·4, 10	0·07	8·2	7·8, 8·5	8·3	8·0, 8·6	8·8	8·5, 9·2	<0·01
Poultry meat														
Model 1	10	9·2, 11	15	14, 16	19	18, 21	<0·01	13	12, 15	19	17, 20	22	20, 24	<0·01
Model 2	13	11, 14	15	14, 16	16	14, 17	<0·01	17	15, 18	18	17, 20	18	16, 19	0·42
Red meat														
Model 1	92	89, 96	100	97, 103	105	101, 109	<0·01	76	73, 79	82	79, 85	76	73, 80	0·70
Model 2	100	97, 103	99	96, 102	98	95, 102	0·53	79	76, 82	81	78, 84	74	71, 77	0·01
Sausages														
Model 1	36	34, 38	32	30, 34	28	26, 30	<0·01	21	20, 23	19	17, 20	15	14, 16	<0·01
Model 2	33	31, 35	32	30, 34	30	28, 33	0·07	19	18, 21	18	17, 19	17	16, 18	0·02
Liquid milk products														
Model 1	427	401, 454	377	356, 396	343	324, 363	<0·01	438	418, 460	403	385, 422	346	330, 363	<0·01
Model 2	387	363, 412	373	351, 395	382	360, 406	0·87	400	379, 422	402	385, 420	380	361, 399	0·12
Cheese														
Model 1	27	25, 29	26	25, 28	28	26, 30	0·24	28	27, 30	31	29, 33	33	31, 35	<0·01
Model 2	28	26, 30	26	24, 27	27	25, 29	0·61	29	28, 31	30	29, 32	32	30, 34	0·03
Sugar and confectionery														
Model 1	31	30, 33	31	29, 32	27	25, 28	<0·01	24	22, 25	25	24, 27	28	27, 29	<0·01
Model 2	30	29, 31	30	29, 31	29	27, 30	0·11	26	25, 28	26	25, 27	25	24, 26	0·06

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Table 2. *Continued*

Fish consumption tertiles …	Health 2000 survey men (*n* 2605)							Health 2000 survey women (*n* 3199)						
	1st tertile*		2nd tertile†		3rd tertile‡			1st tertile§		2nd tertile‖		3rd tertile¶		
	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend
Coffee														
Model 1	257	227, 290	283	256, 314	263	235, 293	0·90	218	197, 241	256	235, 278	221	199, 246	0·92
Model 2	243	214, 277	284	257, 314	277	246, 311	0·23	215	194, 239	249	230, 270	230	206, 256	0·55
Soft drinks and juices														
Model 1	124	112, 136	160	149, 173	155	142, 170	<0·01	120	109, 131	114	104, 124	125	115, 135	0·41
Model 2	126	113, 140	158	146, 172	155	140, 171	0·02	117	106, 128	113	103, 124	129	118, 142	0·13
Beer														
Model 1	25	21, 30	29	25, 33	31	27, 36	0·05	3·5	3·0, 4·1	4·8	4·2, 5·6	4·6	4·0, 5·2	0·03
Model 2	30	26, 35	28	24, 32	27	24, 31	0·31	4·2	3·7, 4·7	4·6	4·0, 5·2	4·1	3·5, 4·7	0·61
Wine														
Model 1	2·0	1·7, 2·4	3·6	3·2, 4·1	4·7	4·0, 5·4	<0·01	1·6	1·3, 1·8	2·9	2·5, 3·3	3·6	3·2, 4·1	<0·01
Model 2	2·7	2·4, 3·1	3·5	3·1, 4·0	3·7	3·2, 4·2	<0·01	2·1	1·9, 2·4	2·7	2·4, 3·1	2·9	2·6, 3·3	<0·01
Spirits														
Model 1	2·0	1·8, 2·3	2·3	2·0, 2·5	2·7	2·4, 3·0	<0·01	0·44	0·37, 0·51	0·56	0·49, 0·63	0·65	0·57, 0·73	<0·01
Model 2	2·1	1·9, 2·3	2·2	2·1, 2·4	2·6	2·3, 2·9	<0·01	0·49	0·42, 0·56	0·53	0·47, 0·59	0·62	0·54, 0·70	0·02

* *n* 868, geometric mean 14, range 0–29 g/d.
† *n* 868, geometric mean 38, range 30–48 g/d.
‡ *n* 869, geometric mean 75, range 49–557 g/d.
§ *n* 1065, geometric mean 13, range 0–29 g/d.
‖ *n* 1068, geometric mean 37, range 30–46 g/d.
¶ *n* 1066, geometric mean 72, range 46–561 g/d.
** Model 1: age and total energy intake.
†† Model 2: age, BMI, education, marital status, smoking, physical activity and other food groups.

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Table 3. Model-adjusted food consumption (g/d) by fish consumption tertiles (g/d) among the fishermen and the fishermen's wives

(Geometric means and 95 % confidence intervals)

Fish consumption tertiles…	Fishermen (*n* 114)							Fishermen's wives (*n* 114)						
	1st tertile*		2nd tertile†		3rd tertile‡			1st tertile§		2nd tertile‖		3rd tertile¶		
	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend
Vegetables														
Model 1**	184	155, 219	183	154, 218	187	157, 223	0·89	232	196, 274	279	236, 329	286	241, 340	0·12
Model 2††	185	156, 220	171	146, 201	199	168, 237	0·45	261	221, 309	260	223, 302	272	231, 320	0·74
Fruit and berries														
Model 1	118	85, 163	134	96, 185	115	82, 160	0·81	147	111, 194	193	146, 254	215	161, 286	0·09
Model 2	104	75, 145	140	103, 192	123	88, 172	0·67	143	103, 197	188	140, 253	227	166, 311	0·07
Potatoes														
Model 1	154	131, 180	188	160, 221	190	161, 223	0·11	155	135, 179	144	126, 166	166	144, 192	0·42
Model 2	159	131, 194	193	161, 232	178	146, 218	0·60	148	124, 176	147	126, 172	172	146, 203	0·22
Wheat														
Model 1	75	66, 85	78	69, 89	76	67, 87	0·92	71	62, 83	59	51, 68	63	55, 74	0·38
Model 2	78	67, 91	73	63, 85	78	67, 91	0·89	64	54, 75	58	50, 67	72	61, 83	0·26
Rye														
Model 1	49	38, 62	43	34, 55	40	31, 51	0·29	30	24, 38	41	33, 51	49	38, 62	0·01
Model 2	44	33, 58	43	33, 56	44	33, 59	0·95	32	24, 43	44	34, 57	42	32, 55	0·27
Oil														
Model 1	7·0	6·3, 7·7	8·2	7·5, 9·1	9·1	8·2, 10	< 0·01	7·0	6·4, 7·7	8·2	7·5, 9·0	7·9	7·2, 8·7	0·13
Model 2	7·2	6·5, 7·9	8·0	7·3, 8·8	9·0	8·2, 9·9	< 0·01	6·9	6·2, 7·7	7·9	7·2, 8·7	8·3	7·5, 9·2	0·03
Margarine														
Model 1	6·2	3·6, 10	3·4	1·8, 6·0	5·2	2·9, 8·8	0·86	7·4	4·6, 11	4·2	2·5, 6·7	2·0	0·99, 3·5	< 0·01
Model 2	5·1	3·0, 8·2	4·3	2·6, 6·8	5·2	3·1, 8·5	0·86	4·6	2·6, 7·5	5·3	3·3, 8·2	2·7	1·5, 4·6	0·17
Butter														
Model 1	6·3	5·0, 8·0	7·4	5·8, 9·3	7·7	6·0, 9·7	0·31	5·6	4·4, 7·1	6·6	5·2, 8·3	7·5	5·9, 9·5	0·12
Model 2	7·2	5·7, 9·0	6·8	5·5, 8·4	7·3	5·8, 9·2	0·85	5·9	4·6, 7·5	6·9	5·5, 8·6	6·9	5·4, 8·6	0·46
Poultry meat														
Model 1	18	12, 26	17	11, 25	11	7·5, 17	0·09	18	12, 25	21	15, 30	19	13, 27	0·89
Model 2	18	12, 27	17	12, 25	11	7·1, 16	0·05	19	12, 28	17	12, 25	21	14, 31	0·63
Red meat														
Model 1	94	81, 109	91	79, 106	83	71, 96	0·21	90	77, 104	78	67, 90	72	62, 84	0·07
Model 2	99	85, 116	92	79, 107	78	66, 91	0·04	86	73, 101	75	65, 87	78	67, 92	0·55
Sausages														
Model 1	31	23, 41	26	19, 35	30	22, 40	0·98	23	16, 31	17	12, 23	11	7·5, 15	< 0·01
Model 2	29	21, 40	26	19, 35	31	22, 43	0·74	20	15, 28	16	12, 21	12	8·9, 16	0·03
Liquid milk products														
Model 1	429	331, 555	304	234, 395	298	229, 387	0·09	417	321, 541	313	242, 404	278	212, 364	0·05
Model 2	432	315, 593	289	214, 390	311	225, 430	0·29	394	286, 542	306	229, 408	301	221, 409	0·31
Cheese														
Model 1	24	18, 34	23	16, 32	17	12, 23	0·09	27	21, 36	35	27, 45	32	25, 42	0·50
Model 2	27	19, 38	21	15, 29	16	11, 23	0·07	32	23, 44	34	25, 45	29	21, 40	0·65
Sugar and confectionery														
Model 1	28	23, 35	28	23, 35	22	18, 28	0·11	28	23, 35	24	19, 29	18	15, 23	0·01
Model 2	28	22, 36	27	21, 35	23	18, 30	0·31	23	18, 30	25	20, 31	21	17, 27	0·63

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Table 3. *Continued*

Fish consumption tertiles...	Fishermen (*n* 114)							Fishermen's wives (*n* 114)						
	1st tertile*		2nd tertile†		3rd tertile‡			1st tertile§		2nd tertile‖		3rd tertile¶		
	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend	Geometric mean	95 % CI	Geometric mean	95 % CI	Geometric mean	95 % CI	*P* for linear trend
Coffee														
Model 1	317	195, 517	343	210, 561	247	150, 405	0·41	347	200, 600	197	115, 339	210	119, 369	0·28
Model 2	289	163, 513	330	193, 565	281	158, 501	0·89	363	194, 681	180	102, 316	220	119, 404	0·38
Soft drinks and juices														
Model 1	78	50, 122	104	66, 163	80	51, 125	0·90	61	39, 96	107	69, 166	77	48, 122	0·65
Model 2	74	43, 126	88	53, 146	99	57, 169	0·51	48	28, 82	114	70, 185	93	54, 157	0·18
Beer														
Model 1	55	30, 98	69	38, 123	58	32, 105	0·97	3·0	1·2, 6·5	12	5·8, 22	5·9	2·6, 12	0·41
Model 2	44	25, 78	74	43, 126	67	37, 118	0·46	2·7	0·97, 6·1	11	5·8, 20	6·7	3·1, 14	0·25
Wine														
Model 1	4·1	2·0, 7·7	7·2	3·8, 13	9·4	5·1, 17	0·08	3·2	1·6, 5·8	8·7	5·0, 15	6·4	3·5, 11	0·20
Model 2	4·9	2·4, 9·2	6·2	3·2, 11	9·3	4·9, 17	0·18	4·5	2·1, 8·7	7·6	4·2, 13	5·3	2·7, 10	0·85
Spirits														
Model 1	6·1	4·0, 9·2	3·7	2·3, 5·8	4·4	2·8, 6·8	0·43	0·94	0·43, 1·6	1·3	0·69, 2·1	1·1	0·57, 1·9	0·72
Model 2	6·3	4·0, 9·7	3·5	2·2, 5·5	4·4	2·7, 7·0	0·46	1·4	0·69, 2·3	0·79	0·32, 1·4	1·2	0·61, 2·1	0·94

* *n* 38, geometric mean 36, range 10–49 g/d.
† *n* 38, geometric mean 69, range 50–93 g/d.
‡ *n* 38, geometric mean 137, range 94–463 g/d.
§ *n* 38, geometric mean 27, range 0–42 g/d.
‖ *n* 38, geometric mean 55, range 43–72 g/d.
¶ *n* 38, geometric mean 102, range 74–282 g/d.
** Model 1: age and total energy intake.
†† Model 2: age, BMI, education, marital status, smoking, physical activity and other food groups.

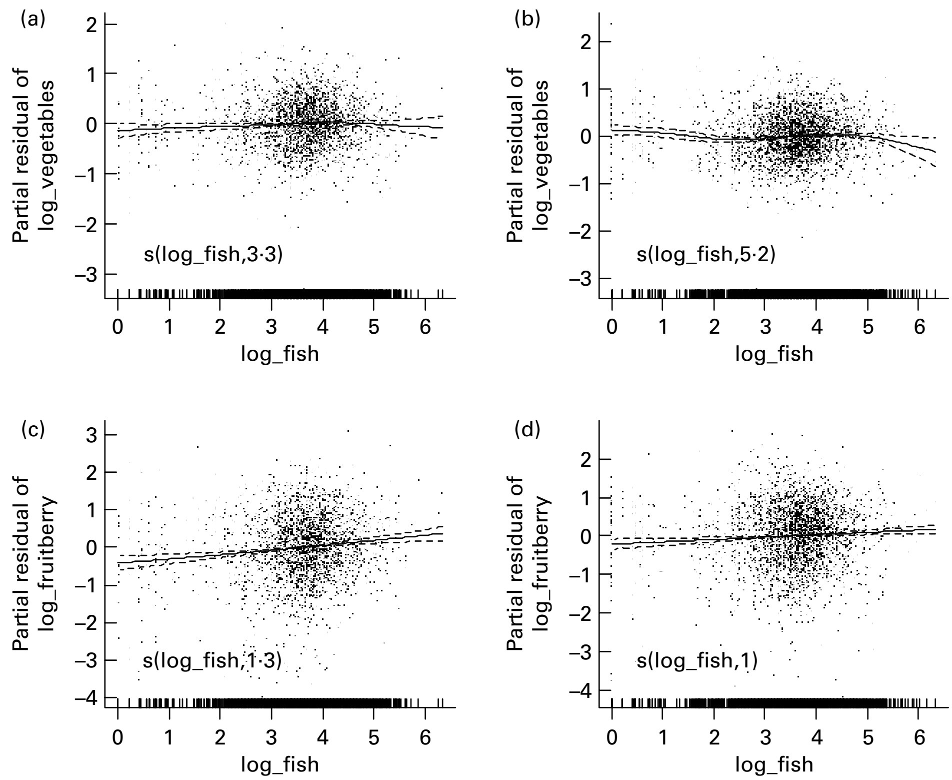

Fig. 1. Adjusted smoothed associations between fish consumption and the consumption of selected foods (vegetables, (a) and (b); fruit and berries, (c) and (d)) among the Health 2000 survey men (*n* 2605; (a) and (c)) and women (*n* 3199; (b) and (d)). Associations were adjusted for age, BMI, education, marital status, smoking, physical activity and other food groups, and were produced by an additive model with a thin-plate regression spline. All the FFQ variables were transformed according to $\log(x+1)$. The solid curve is the additive model fit and the dashed curves represent the approximate 95 % CI. The fit is named as s(log_fish, edf), where edf is the estimated degrees of freedom describing the wiggliness of the fit. The plotted points are partial residuals.

Both in the general population and among the fishermen and their wives, those with the highest fish consumption had the highest consumption of vegetables, fruit and berries, potatoes, oil and wine (Tables 2 and 3). All these associations were relatively consistent regardless of adjustments. Red meat and sausage consumption had a tendency to decrease across fish consumption tertiles. The inverse association between fish and red meat was more evident among the fishermen and their wives, whereas the inverse association between fish and sausages was more evident among the women in both studies. In general, adjustment for lifestyle factors in addition to age and total energy intake (data not shown) had only a minor effect on the results. An additional adjustment for other food groups attenuated the observed associations. For example, when adjusted only for age, total energy intake and lifestyle factors, those with the highest fish consumption also had the highest consumption of poultry and the lowest consumption of liquid milk products, and sugar and confectionery, but these associations practically disappeared after adjusting for other food groups.

The regression curves produced by the additive model gave reassurance that a linear trend test could be applied for the studied associations. In addition, the shapes of the curves supported the conclusions made based on the model-adjusted means. For example, the regression curves showed a clear positive association between smoothed fish consumption and the consumption of fruit and berries (Fig. 1), and a clear negative association between smoothed fish consumption and the consumption of sausages (Fig. 2). On the other hand, the regression curves showing the association between smoothed fish consumption and red meat consumption (Fig. 2) were relatively flat, and the 95 % CI appeared to include zero. The regression curves for the fishermen and their wives are not shown due to the small number of observations.

Discussion

In the present study, those with the highest fish consumption had the highest consumption of vegetables, fruit and berries, potatoes, oil and wine. These trends were essentially the same regardless of adjustments and study population. Red meat consumption had a tendency to decrease across fish consumption tertiles, especially among the fishermen and their wives, whereas sausage consumption decreased across fish consumption tertiles especially among the women in the general population and the fishermen's wives. When adjusted for lifestyle, those with the highest fish consumption had the lowest consumption of liquid milk products and sugar and confectionery in both studies but these associations practically disappeared after adjusting for other food groups.

We used a calibrated FFQ[36,37] on the whole diet, which is a primary method to measure usual long-term food consumption[45]. Although absolute food consumption was reported in the present study, it should be noted that an FFQ is

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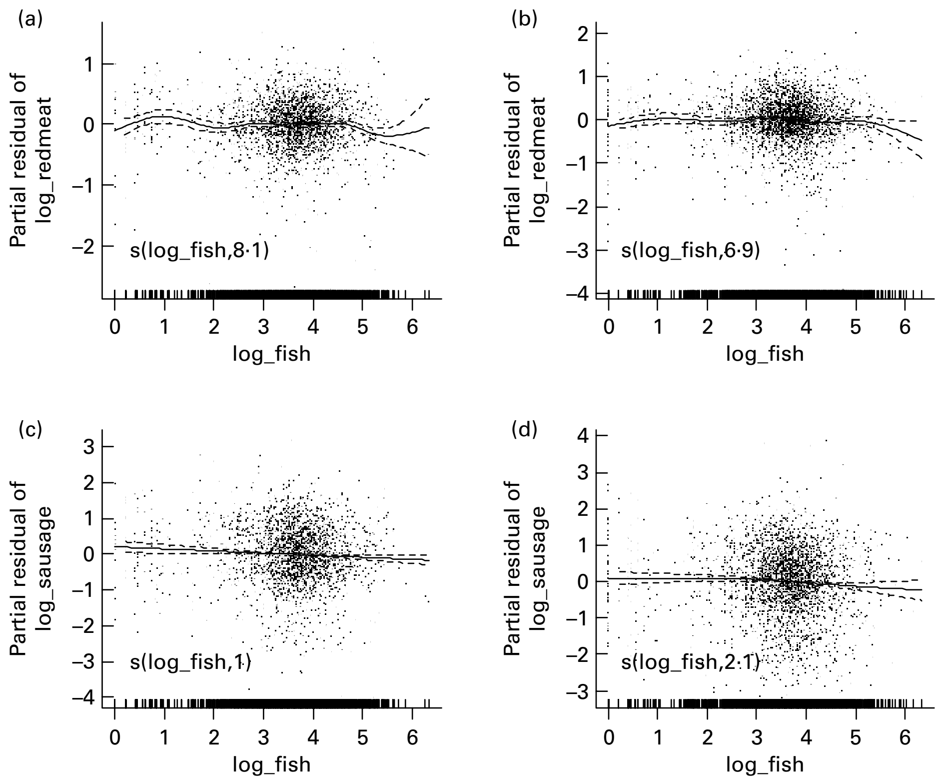

Fig. 2. Adjusted smoothed associations between fish consumption and the consumption of selected foods (red meat, (a) and (b); sausages, (c) and (d)) among the Health 2000 survey men (*n* 2605; (a) and (c)) and women (*n* 3199; (b) and (d)). Associations were adjusted for age, BMI, education, marital status, smoking, physical activity and other food groups, and were produced by an additive model with a thin-plate regression spline. All the FFQ variables were transformed according to log($x + 1$). The solid curve is the additive model fit and the dashed curves represent the approximate 95 % CI. The fit is named as s(log_fish, edf), where edf is the estimated degrees of freedom describing the wiggliness of the fit. The plotted points are partial residuals.

designed only to rank participants according to their dietary intake. With regard to multivariate modelling, a high number of covariates in a regression model may cause instability in the estimates. In the present study, however, the correlations between the covariates were relatively low, and collinearity seemed not to be a problem. To increase the validity of the results, the analyses were performed in two study populations: in a large nationally representative population with an exceptionally high response rate and in a unique population with high fish consumption.

In the present study, fish consumption seemed to have a strong positive linear association with vegetable, fruit and berry consumption even after adjusting for other food groups. This association was seen also among the fishermen, despite the fact that among them, high fish consumption has been thought to be an occupational characteristic and to derive from tradition and easy availability of fish. Similar positive linear associations have also been seen in all the previous studies that reported age-adjusted or unadjusted means as baseline characteristics[9,16–21,23–32]. Additionally, fish typically loads to a prudent dietary pattern together with vegetables and fruit in dietary pattern analyses[46–48].

Consuming more of one protein source usually means consuming less of some other source of protein. In the majority of previous studies, those with the highest fish consumption had the lowest meat consumption[16,19,21,23,24,32], but in some studies the direction of the association was the opposite[17,28–31], possibly due to combining all types of meat (red and white) in one variable. In the present study, a negative association between fish and red meat consumption was observed but it was more distinguishable among the fishermen and their wives than in the general population. The explanation for this might be that fishermen and their wives have fish consumption high enough to replace other sources of protein in their diet. Further, there was an inverse association between fish and sausage consumption in the general population and among the fishermen's wives. Overall, this association was more distinctive among the women than among the men, which may be due to the fact that women are typically more health conscious than men, and they may prefer fish over sausages. In addition, energy intake and the total amount of food consumed are usually smaller among women and therefore fish may be able to partially replace other types of meats in their diet. With regard to poultry consumption in previous studies, those who had the highest fish consumption had the highest consumption of poultry[17,23,27,29,49]. In the present study, this association was seen only in the general population, although the positive linear association practically disappeared especially among the women after adjusting for other food groups.

In some previous studies, those with the highest fish consumption had the lowest consumption of dairy products[16,27,32], but in some studies, the direction of the association was the opposite[17,23]. In only one previous study, the consumption of sweets was reported by fish consumption groups, and the association seemed to be negative[16]. In the present study, there was a negative linear association between fish consumption and the consumption of liquid milk products and sugar and confectionery when adjusted only for lifestyle factors but the association practically disappeared after adjusting for other food groups.

Alcohol consumption was typically the highest among those who had the highest fish consumption in some[9,26,30,32] but not all[18,19] previous studies. The positive linear association was especially evident among the Italian men[26]. Similarly, in the present study, the more the general population consumed fish, the higher was their wine and spirit consumption. A positive linear association between fish and wine consumption was also seen among the fishermen and their wives. This may be seen, together with vegetable and fruit consumption, as an indication of the Mediterranean-style diet[50] also among the Finnish fish consumers. Additionally, oil consumption was positively associated with fish consumption, which is also concordant with the Mediterranean-style diet.

The above referenced epidemiological studies reported associations between fish and other foods as either age-adjusted[16,21,24,25,27,30] or crude[9,17–20,23,26,28,29,31,32]. This is understandable since they reported food consumption means across fish consumption groups as baseline characteristics of their study populations. The aim of the present study was specifically to study the associations between fish and other foods, and, therefore, adjustments were essential. Adjusting for total energy intake is needed since, at least for some food groups, the more an individual eats one food, the more he or she tends to eat other foods too. Adjusting for lifestyle and all other food groups enables us to see the independent remaining effect after the confounding effect of lifestyle and the other food groups has been removed. In the present study, adjusting for other food groups attenuated the observed associations but the majority of them remained distinguishable even after the diet adjustment. This persistence can be seen as an indication of relatively strong and consistent associations. For the most part, our observations were parallel with the observations of the above referenced studies, suggesting that the present results are generalisable to other populations. Overall, diet associated with fish consumption appears to be relatively universal across populations regardless of differences in social and cultural circumstances[51] and dietary habits.

In summary, fish consumption seemed to have a positive linear association with the consumption of some other healthy foods such as vegetables, fruit, berries and oil both in the general population of Finland and in the population with high fish consumption. Additional adjustment for other food groups had a clear effect on some of the studied associations. Therefore, when evaluating the health effects of fish consumption, confounding by other foods characterising a healthy diet needs to be considered.

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A. W. T., S. M., A. L. S. and P. K. V. were responsible for conception and design, and acquisition of the data. A. W. T. and P. T. analysed and interpreted the data. A. W. T. drafted the manuscript. All authors were involved in reviewing the manuscript critically for important and intellectual content and gave final approval.

There are no conflicts of interest to declare.

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