RESEARCH REPORT

High consumptions of grain, fish, dairy products and combinations of these are associated with a low prevalence of metabolic syndrome

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Objective: To analyse the relation between various food groups and the frequency of insulin resistance syndrome (IRS).
Design: A sample of 912 men aged 45–64 years was randomly selected. Questionnaires on risk factors and a three consecutive day food diary were completed. Height, weight, waist circumference, and blood pressure were measured. A fasting blood sample was analysed for lipid and glucose measurements. The NCEP-ATP-III definition was used to assess IRS. Data were analysed according to quintiles of food groups and medians of dairy products, fish, or cereal grains.
Results: The prevalence of IRS was 23.5%. It reached 29.0%, 28.1% and 28.1% when the intake was below the median for fish, dairy products, and grain, respectively. When consumptions of all three types of food were higher than the median, the prevalence reached 13.1%, and when they were lower, the prevalence was 37.9% ($p<0.001$). In logistic regression adjusted for confounders (centre, age, physical activities, education level, smoking, dieting, alcohol intake, treatments for hypertension and dyslipidaemia, energy intake, and diet quality index) the odds ratios for IRS (above median value *v* below) were 0.51 (95% confidence interval, 0.36 to 0.71) for fish, 0.67 (0.47 to 0.94) for dairy products, and 0.69 (0.47 to 1.01) for grain. When intakes of all three kinds of food were high, the OR was 0.22 (0.10 to 0.44).
Conclusions: A high consumption of dairy products, fish, or cereal grains is associated with a lower probability of IRS. The probability decreases when intakes of all three types of food were high.

It has been shown that in some populations consumption of dairy products is positively correlated with a low prevalence of insulin resistance syndrome (IRS)[1 2] and negatively with some components of IRS.[3] In a recent prospective study, dairy products were inversely linked with IRS.[4] Carbohydrate intake was correlated with a low prevalence of IRS,[1] and the prevalence of IRS was 38% and 33% lower in the highest quintile for grain fibre and whole grain intake, respectively, when compared with the lowest consumptions. A high dietary glycaemic index was positively associated with the metabolic syndrome.[5] Inverse correlations between fish intake and the risk of glucose intolerance have been demonstrated.[6 7] It has also been found that fish oil acts on some components of IRS, inducing a decrease in plasma triglyceride concentrations[8 9] and a modest lowering of blood pressure in both normal and mildly hypertensive individuals.[10] However, the meaning of these relations remains uncertain. Are the reported associations specific to the foods studied or specific to patterns of eating? Modification of one component of the diet is counterbalanced by a reciprocal modification of other components, and the connection between a food component and IRS could be considered a proxy of eating patterns. In this hypothesis, where dietary components are not independent, the relation between the combination of two dietary components and IRS could at most be very similar to that observed for each component studied separately. Conversely, if a food component is not an exclusive marker of eating patterns, the effects of food component combinations could differ.

Using data issued from a cross sectional population survey carried out in three areas in France, we investigated the relations between various food groups and distribution of IRS frequency separately and in a mutual and global combination.

METHODS

Population sampling

The design was a cross sectional, population based survey and the sample was randomly selected from the general population. Screening for cardiovascular risk factors and nutrition was carried out between 1995 and 1997 by the three French MONICA centres.[11] A sample of middle aged men (aged 45 to 64 years), living in three regions—Lille (northern France), Strasbourg (north-eastern France), and Toulouse (south-western France)—was randomly recruited.[12 13] Polling lists (nominal lists for French inhabitants aged over 18 years) available in each town hall of the survey areas were used to carry out a random selection in the general population. Participants were volunteers and received no financial compensation. The response rate reached 60% of the people contacted. Among a sample of 976 subjects who participated in the study, 912 with complete data for all the variables were analysed statistically. The study protocol was approved by an institutional review committee in agreement with the French law on human biomedical research. Informed consent to participation in the study was obtained from each subject.

Data collected

Extensive questionnaires were completed by the participants with the help of trained and certified medical staff who collected data on age, socioeconomic status, occupational activity, previous medical history, drug intake, and cardiovascular risk factors including smoking habits. Education level was

Abbreviations: IRS, insulin resistance syndrome; MONICA, MONItoring of trends and determinants in CArdiovascular disease; NCEP-ATP-III, National Cholesterol Education Programme Adult Treatment Panel III

Table 1 Characteristics of the study population (n = 912)

Variable	
Age (years)	55.1 (6.1)
Centre	
Lille (%)	38.7
Strasbourg (%)	25.1
Toulouse (%)	36.2
Living area	
Rural (%)	16.5
Semi-urban (%)	46.7
Urban (%)	36.8
Years of schooling	11.6 (3.8)
Occupational activity	
Blue collar (%)	45.4
Intermediate (%)	28.0
White collar (%)	26.6
Physical activity (%)*	33.2
Current cigarette smoker (%)	21.2
Drugs for	
Hypertension (%)	20.4
Dyslipidaemia (%)	16.3
Diabetes (%)	5.2
Dieting (%)	23.4
Alcohol consumption (g/d)	33.6 (30.9)
Body mass index (kg/m^2)	27.2 (4.0)
Waist circumference (mm)	972 (109)
Waist to hip ratio	0.96 (0.06)
Systolic blood pressure (mm Hg)	139.4 (19.2)
Diastolic blood pressure (mm Hg)	86.2 (11.7)
Heart rate (beats/min)	67.9 (10.1)
Blood glucose (mmol/l)	5.78 (1.30)
Total cholesterol (mmol/l)	5.98 (1.01)
High density lipoprotein (mmol/l)	1.33 (0.38)
Low density lipoprotein (mmol/l)	4.02 (0.95)
Triglycerides (mmol/l)	1.38 (0.75)
Insulin resistance syndrome (%)†	23.5
High blood pressure (%)	75.8
High waist girth (%)	29.5
High blood glucose (%)	21.5
High triglycerides (%)	24.0
Low HDLc (%)	21.9

Values are mean (SD) or percentages.
*Intense physical activity, 20 minutes, three times a week or more.
†Insulin resistance syndrome estimated from the NCEP definition and its components.
HDLc, high density lipoprotein cholesterol; NCEP, National Cholesterol Education Programme.

assessed by the report of the number of completed years of schooling. Frequency of physical activity was assessed and four levels of leisure time physical activity were defined.

Clinical measurements

Research nurses undertook clinical measurements.[14] Height, body weight, and waist and hip circumferences were taken using standardised procedures. Blood pressure was measured twice in the sitting position in the right arm with a standard mercury sphygmomanometer after a five minute rest. Measurements were rounded to the nearest 2 mm Hg. The average of the two measurements was used for the statistical analysis.

Biological analyses

Plasma glucose, triglycerides, total cholesterol, and high density lipoprotein (HDL) cholesterol were measured in blood samples drawn after an overnight fast (10 hours at least).[15] Low density lipoprotein (LDL) cholesterol was calculated according to Friedwald *et al*.[16]

Assessment of dietary and alcohol intakes

Food and alcohol intakes were assessed using a three day food record method as described extensively in a previous publication.[17] Each type of alcoholic drink (wine, beer, cider, aperitifs, and spirits) was recorded. Food data were translated into nutrient values using Renaud and Regal food composition tables.[18 19] A diet quality index based on nutritional recommendations[20 21] taking into account the traditional diet in France[22 23] was established, as described in a previous paper.[13]

Foods considered were: dairy products (milk and cheese), grains including bread and cereals, and fish including sea fish, river fish, and seafood. All types of food containing fish, cereal grains, or dairy products—including mixed dishes and recipes—were considered in order to calculate the respective contributions of the three products to the weight or energy content of the diet.[24]

The validity of energy intake records was assessed by calculating, for each subject, the ratio between the total daily energy intake recorded and the estimated basal metabolic rate.[25 26] The basal metabolic rate was estimated using Schofield's equations based on body weight, age, and sex.[27] All the analyses were carried out both on the whole sample and after exclusion of subjects with a ratio below 1.05.

Statistical analysis

We used the working definition of IRS suggested by the NCEP expert panel.[28] Food intakes were grouped in quintiles except for fish intake which was grouped in tertiles because of the high percentage of non-fish-eaters.

First, the percentage of IRS was distributed according to quintiles of food groups, and the crude probability of presenting with an IRS was calculated. Then the adjusted probability was calculated controlling for confounding variables (age, centre, physical activity, level of education, smoking, alcohol intake, treatment for hypertension and dyslipidaemia, energy intake without alcohol, dieting, and diet quality index).

Second, analyses were carried out using the food groups that were inversely and significantly associated with IRS, which were fish, dairy products, and cereal grains. The relation with IRS was tested using a combination of these three food groups. Each food item was divided into two groups according to the median value of its distribution—33, 175, and 177 g/day for fish, dairy products, and grain, respectively. The association with IRS was tested using this categorisation for each food separately and using different combinations of food, two by two (dairy products–grain, dairy products–fish, and grain–fish), and for all the three types of food altogether (dairy products–grain–fish). A systematic adjustment was made for centre, age, level of education, leisure time physical activity, smoking status, drug treatment for hypertension and for dyslipidaemia, alcohol consumption, energy intake, dieting, and diet quality index. A multivariate logistic regression was undertaken to test the independent statistical association of IRS with quintiles of food group intakes and with the various combinations of dairy products, grain, and fish variables.

Statistical analysis was done using the SAS statistical software, release 8.2 (SAS Institute, Cary, North Carolina, USA).

RESULTS

Table 1 shows the major characteristics of the population studied. The prevalence of IRS was on average 23.5% in this population sample.

Table 2 shows that the proportions of IRS decreased along the quintiles for grain and dairy product consumption, and with tertiles for fish consumption. Quintiles of other food intakes were not significantly associated with IRS.

The probabilities of having IRS according to quintiles of consumption of various foods are given in table 3. The global trend of the associations between IRS and grain or dairy product intakes was negative, but the values of the odds ratio

Table 2 Proportions of IRS according to quintiles of consumption of several foods (g/d)

	Q1	Q2	Q3	Q4	Q5	p Value*
Eggs	23.6	29.1	20.7	27.3	17.2	0.12
Fish†	29.4	20.6	20.3	–	–	0.03
Meat	20.0	20.2	21.6	25.9	29.7	0.21
Cereal grains	27.8	32.8	21.9	16.6	18.2	0.009
Vegetables	22.2	24.0	27.2	21.2	22.6	0.71
Fruit	26.9	22.0	25.7	21.7	21.1	0.66
Potatoes	22.4	24.0	16.9	26.3	27.6	0.21
Dairy products	32.6	25.0	21.8	18.8	19.9	0.04
Alcohol	24.6	21.4	18.9	25.0	27.5	0.44

*Adjusted p values using the false discovery rate controlling method.
†For fish intake, distribution values were categorised in tertiles.
IRS, insulin resistance syndrome estimated from the National Cholesterol Education Programme definition.

tended to be higher in Q5 than in Q4. The negative trends remained significant after multivariate adjustment. However, for grain and dairy products, the fifth quintile increased and the statistical test comparing the fifth with the first quintile became non-significant. The negative association between IRS and tertiles for fish intake remained significant after multivariate adjustment. When meat intake increased, the risk of having IRS increased significantly. For other food categories no significant associations with IRS were reported.

Table 4 shows that systolic blood pressure was lower when the consumptions of fish, grains, and dairy products were above the median value than when the consumptions were below the median. A similar relation was observed for triglyceride concentrations. The proportions of high triglyceride concentration and low HDL cholesterol concentration (NCEP definitions) were about twofold lower when the consumption of fish, dairy products, and grain was above the median than when it was below the median. The number of years spent at school and the proportion of men practising physical activities were the highest in the group with a high consumption of fish, dairy products, and grain. Finally the proportion of men with IRS was about threefold lower when the consumption of all three food types (fish, dairy products, and grain) was above the median value than when it was below the median value.

Daily energy intakes and selected nutrients according to different combinations of fish, dairy products, and grain

Table 3 Probability of having IRS according to quintiles for several types of food intake (g/d)

	Q1	Q2	Q3	Q4	Q5	p Value for trend
Eggs	1	1.33	0.85	1.22	0.67	0.15
		0.82 to 2.14	0.52 to 1.38	0.76 to 1.96	0.40 to 1.13	
	1	1.70	1.16	1.53	1.01	0.92
		1.02 to 2.86	0.67 to 2.00	0.90 to 2.60	0.56 to 1.82	
Fish†	1	0.63	0.61	–	–	0.008
		0.43 to 0.91	0.42 to 0.89			
	1	0.69	0.57	–	–	0.008
		0.45 to 1.03	0.38 to 0.86			
Meat	1	1.01	1.10	1.40	1.69	0.02
		0.61 to 1.69	0.66 to 1.82	0.86 to 2.29	1.04 to 2.73	
	1	0.96	1.10	1.70	2.29	0.0007
		0.56 to 1.64	0.64 to 1.88	0.99 to 2.90	1.30 to 4.02	
Cereal grains	1	1.27	0.73	0.52	0.58	0.0004
		0.81 to 1.98	0.45 to 1.18	0.31 to 0.86	0.35 to 0.95	
	1	1.24	0.79	0.55	0.76	0.05
		0.76 to 2.00	0.47 to 1.33	0.30 to 0.98	0.39 to 1.48	
Vegetables	1	1.11	1.31	0.94	1.02	0.83
		0.68 to 1.81	0.81 to 2.11	0.57 to 1.56	0.62 to 1.67	
	1	1.15	1.49	1.26	1.27	0.39
		0.69 to 1.92	0.89 to 2.48	0.72 to 2.21	0.72 to 2.24	
Fruit	1	0.77	0.94	0.72	0.72	0.22
		0.47 to 1.24	0.59 to 1.50	0.46 to 1.22	0.45 to 1.17	
	1	0.81	1.03	0.79	0.96	0.85
		0.49 to 1.36	0.62 to 1.70	0.46 to 1.34	0.56 to 1.65	
Potatoes	1	1.09	0.70	1.24	1.32	0.21
		0.67 to 1.77	0.41 to 1.19	0.76 to 2.00	0.81 to 2.15	
	1	1.11	0.74	1.22	1.54	0.16
		0.66 to 1.86	0.42 to 1.30	0.72 to 2.07	0.88 to 2.69	
Dairy products	1	0.69	0.58	0.46	0.51	0.002
		0.44 to 1.09	0.36 to 0.92	0.29 to 0.75	0.32 to 0.83	
	1	0.76	0.64	0.49	0.64	0.03
		0.46 to 1.23	0.39 to 1.07	0.28 to 0.83	0.37 to 1.09	
Alcohol	1	0.84	0.72	1.02	1.16	0.35
		0.51 to 1.36	0.44 to 1.18	0.64 to 1.65	0.73 to 1.86	
	1	0.80	0.67	0.95	1.18	0.46
		0.56 to 2.49	0.48 to 1.89	0.35 to 1.29	0.45 to 1.43	

†For fish intake, the distribution values were categorised in tertiles.
The first line displays crude odds ratios (OR) and 95% confidence intervals. In the second line OR were adjusted for age, centre, physical activity, level of education, smoking habits, alcohol intake, drugs for hypertension and dyslipidaemia, energy intake (without alcohol), dieting, and diet quality index.
IRS, insulin resistance syndrome estimated from the National Cholesterol Education Programme definition.

Table 4 Cardiovascular risk factors in relation to combinations of dairy products, fish, and cereal grain intakes

Dairy products	< median				≥ median				
Fish	< median		≥ median		< median		≥ median		
Grain	< median	≥ median	< median	≥ median	< median	≥ median	< median	≥ median	
	n = 132	n = 91	n = 123	n = 110	n = 94	n = 122	n = 103	n = 137	p Value
Age (y)	55.8	55.4	55.4	54.5	56.0	54.3	54.5	55.0	0.28
School (y)	10.5	11.5	11.9	11.6	11.3	11.9	12.1	12.2	0.01
BMI (kg/m^2)	27.4	27.2	27.7	27.0	27.3	27.3	27.0	26.6	0.58
Waist to hip ratio	0.97	0.96	0.96	0.95	0.96	0.96	0.95	0.95	0.43
Waist circumference (mm)	989	976	988	963	975	970	963	953	0.11
Glycaemia (mmol/l)	5.74	5.56	5.96	5.74	5.92	5.80	5.72	5.78	0.48
Total cholesterol (mmol/l)	6.07	6.06	6.03	5.94	6.08	5.93	5.81	5.94	0.53
High density lipoprotein (mmol/l)	1.37	1.34	1.39	1.34	1.24	1.29	1.34	1.34	0.18
Low density lipoprotein (mmol/l)	4.00	4.08	3.98	4.00	4.12	4.05	3.90	4.03	0.85
Triglycerides (mmol/l)	1.53	1.39	1.44	1.32	1.57	1.29	1.26	1.27	0.02
Systolic blood pressure (mm Hg)	143.6	140.9	144.2	140.6	136.1	136.9	136.6	136.0	0.0004
Diastolic blood pressure (mm Hg)	88.4	86.5	88.5	86.6	84.4	85.4	84.1	84.8	0.02
Physical activity (%)	15.2	38.5	29.3	33.6	33.0	39.3	39.8	40.2	0.0002
Smoking (%)	28.0	23.1	23.6	20.0	22.3	16.4	14.6	20.4	0.26
Dieting (%)	21.1	22.0	27.6	24.6	26.6	14.8	24.3	26.3	0.33
Drugs for									
Hypertension (%)	24.2	19.8	33.3	14.6	26.6	11.5	17.5	16.1	0.0004
Dyslipidaemia (%)	23.5	8.8	18.7	19.1	20.2	6.6	19.4	13.9	0.005
Diabetes (%)	4.6	3.3	7.3	0	9.6	4.9	3.9	7.3	0.07
IRS (%)	37.9	29.7	26.0	17.3	28.7	18.9	17.5	13.1	<0.0001
High blood pressure (%)	82.6	79.1	80.5	76.4	75.3	72.9	68.9	70.1	0.14
Large waist girth (%)	37.9	34.1	35.0	27.3	27.7	25.4	27.2	21.9	0.08
High blood glucose (%)	25.0	18.7	24.4	20.0	22.3	21.3	17.5	21.2	0.87
High triglycerides (%)	28.8	26.4	28.5	22.7	34.0	18.9	21.4	14.6	0.02
Low HDLc (%)	26.5	26.4	18.7	19.1	36.2	18.0	16.5	17.5	0.007

χ^2 test for comparisons of percentages; one way analysis of variance or Kruskal–Wallis test for comparisons of means. Logarithmic transformation for triglycerides.
BMI, body mass index; HDLc, high density lipoprotein cholesterol; IRS, insulin resistance syndrome estimated from the National Cholesterol Education Programme definition and its components.

Table 5 Energy, nutrients, and index quality score in relation to combinations of dairy products, fish, and grain intakes

Dairy products	< median				≥ median				
Fish	< median		≥ median		< median		≥ median		
Grain	< median	≥ median	< median	≥ median	< median	≥ median	< median	≥ median	
	n = 132	n = 91	n = 123	n = 110	n = 94	n = 122	n = 103	n = 137	p Value
Energy without alcohol (kcal)	1784	2377	1872	2380	2085	2616	1982	2535	<0.0001
Energy supplied by									
Protein (%)	17.4	15.8	18.7	17.0	16.9	15.8	18.9	17.5	<0.0001
Carbohydrate (%)	39.8	43.6	38.4	44.6	41.2	45.1	40.2	43.3	<0.0001
Fat (%)	42.8	40.6	42.9	38.4	41.9	39.1	40.9	39.2	<0.0001
P:S ratio	0.42	0.48	0.49	0.51	0.40	0.41	0.42	0.47	0.002
Saturated fat (g/d)	33.9	41.3	34.1	39.1	40.3	47.0	36.7	44.0	<0.0001
Monounsaturated fat (g/d)	31.1	38.6	32.6	37.0	35.2	40.7	32.9	39.6	<0.0001
Polyunsaturated fat (g/d)	13.4	18.9	15.6	18.5	14.7	17.7	14.7	19.1	<0.0001
Alcohol (g/d)	35.5	30.2	36.8	31.1	26.0	20.8	25.4	25.5	<0.0001
Index quality score	5.9	6.6	7.1	7.5	6.3	6.9	7.9	7.8	<0.0001

One way analysis of variance or Kruskal–Wallis test for comparisons of means.
P:S ratio, ratio of polyunsaturated to saturated fat.

intakes are shown in table 5. The greatest consumption of polyunsaturated fat was observed in a group of men with a high consumption of fish, dairy products and grain, and the highest energy intake was observed in men with a high consumption of grain and dairy products whatever the fish intake. Similarly, the quality index score was the highest when consumptions of fish and dairy products were above the median value whatever the grain intake.

Table 6 shows the odds ratios of the associations between IRS and intakes of fish, dairy products, and grain. The associations were analysed for each food item separately, for combinations of foods, two by two, and for combinations with the three types of food together. The proportion of IRS was much higher when food intake was below the median value (29.0%, 28.1%, and 28.1% for fish, dairy products, and grain consumers, respectively) than when it was above the median (18.4%, 18.9%, and 18.9%, respectively). In a given subject, when fish, dairy products, and grain consumptions were all simultaneously higher than the median value, the IRS proportion was 13.1%. When the consumptions of the three types of food were simultaneously below the median value, the IRS percentage was 37.9%.

Each interaction between types of food with IRS (fish*grain, fish*dairy products, dairy products*grain, and fish*grain*dairy products) was tested for each corresponding multivariate logistic model and was not statistically significant. The decrease of odds ratio was significant when the fish intake was above the median value (in comparison with a low consumption) in subjects with a higher consumption of dairy products ($p = 0.02$) or grain ($p = 0.006$), but not statistically significant when the consumption of dairy products and grain were high simultaneously ($p = 0.07$).

When statistical analyses were done after the exclusion of subjects with high levels of physical activity, the negative associations remained statistically significant. Similar results were obtained when subjects treated for hypertension, subjects treated for dyslipidaemia, or current smokers were excluded from the analyses.

DISCUSSION

This study shows an inverse relation between IRS frequency and consumption of fish, dairy products, and grain. The strength of the relation increased when the consumptions of these types of food were simultaneously high. The probability of having an IRS was approximately five times lower when the consumption was above the median cut off point for fish, dairy products, and grain together, in comparison with a low consumption of all three types of food. The potential protective effect against IRS seems to be more effective for fish intake than for dairy products or grain consumption. However, an additive effect was present with a combination of these food groups. Comparative to fish intake, when the consumption of dairy products and grain increased (fifth quintile) the risk of developing an IRS tended to increase also, suggesting that a high consumption of these foods could have an opposite effect on insulin resistance. The negative association could be confounded by intakes of other foods and by healthy profiles. After adjustment for confounders, the inverse association between food and IRS remained significant. The lack of significant interaction between these food items and IRS may imply that the relation between food and IRS is not dependent either on the other two types of food studied in this population or on the amount consumed in particular. Moreover, when the consumption of fish increased, the probability of having IRS decreased significantly in subjects with the highest consumption of dairy products or grain, thus demonstrating an additive effect.

Table 6 Probability of presenting with an insulin resistance syndrome in relation to different combinations of fish, dairy product, and grain intakes (n = 912)

	OR	95% CI	p Value
Grain above *v* below median value	0.69	0.47 to 1.01	0.06
Dairy above *v* below median value	0.67	0.47 to 0.94	0.02
Fish above *v* below median value	0.51	0.36 to 0.71	0.0001
Fish and dairy combination			
Fish below and dairy below median (reference)	1		
Fish below and dairy above median	0.63	0.40 to 0.99	0.05
Fish above and dairy below median	0.46	0.31 to 0.75	0.002
Fish above and dairy above median	0.33	0.20 to 0.54	0.0001
Grain and dairy combination			
Grain below and dairy below median (reference)	1		
Grain below and dairy above median	0.66	0.42 to 1.04	0.07
Grain above and dairy below median	0.68	0.42 to 1.10	0.12
Grain above and dairy above median	0.44	0.26 to 0.75	0.003
Fish and grain combination			
Fish below and grain below median (reference)	1		
Fish below and grain above median	0.70	0.42 to 1.14	0.16
Fish above and grain below median	0.51	0.33 to 0.81	0.004
Fish above and grain above median	0.34	0.20 to 0.58	0.0001
Fish, grain and dairy combination			
Fish below, grain below and dairy below median (reference)	1		
Fish below, grain below and dairy above median	0.62	0.33 to 1.14	0.13
Fish below, grain above and dairy below median	0.69	0.36 to 1.32	0.26
Fish below, grain above and dairy above median	0.41	0.20 to 0.82	0.02
Fish above, grain below and dairy below median	0.49	0.27 to 0.87	0.02
Fish above, grain below and dairy above median	0.33	0.17 to 0.65	0.002
Fish above, grain above and dairy below median	0.31	0.16 to 0.62	0.0009
Fish above, grain above and dairy above median	0.22	0.10 to 0.44	0.0001

All models were adjusted for age, centre, physical activity, level of education, smoking habits, alcohol intake, drugs for hypertension and dyslipidaemia, energy intake (without alcohol), dieting, and diet quality index.
Median intake values were 177, 175, and 33 g/day for grain, dairy products, and fish, respectively.
CI, confidence interval; OR, odds ratio.

The three consecutive day food record method has some limitations, in particular the seasonal availability of some types of food. This was not the case for the food items analysed here, which are regularly available and eaten throughout the year in the three regions investigated. Further adjustment for season did not change the results significantly. Subjects under-reporting a low energy intake may have biased the relation between food intake and IRS. When these subjects were not considered in the statistical analyses the results were not significantly altered.

In our population sample, the highest dairy product and grain consumption was associated with a more healthy profile, whereas such differences were not observed between subjects with the highest consumption of fish or with the lowest consumption. Thus the negative association between IRS and food components could be confounded by healthy profiles. After adjustment for healthy behaviours the inverse association between food intakes and IRS remained significant. Moreover, when the statistical analyses were done again after excluding subjects with high levels of physical activity, not only did the negative associations remain statistically significant but the strength of the relations tended to increase as well. Similar results were obtained when current smokers or subjects treated for hypertension or dyslipidaemia were excluded from the analyses.

Although statistical models had been adjusted for various environmental factors and potential confounders, with their corresponding records excluded from the analyses, the possibility of residual confounding by unmeasured factors cannot be entirely excluded. Moreover, the main limitation of our study is its observational design.

We observed an inverse relation between dairy product intake and IRS as mentioned in previous reports of observational studies.[1 2 4] Our results showing a negative association between a diet rich in grain and the risk of IRS are less convincing than other reports.[1 5]

The negative association between fish and IRS is consistent with the results obtained in Alaska native population[7] or in elderly people.[6] However, the inverse association had not been reported in another French male population recruited from the social security system and not directly selected at random from the general population.[1] Moreover, subjects had been selected from other geographical regions and the dietary methodology was different (food frequency questionnaire). However, inverse relations between IRS and dairy products or grain were similar.

Our study identified an eating pattern composed of a combination of high levels of fish, dairy products, and grain which was associated with very low frequency of IRS (13.1%) and a low risk of having the condition (odds ratio = 0.21 (95% confidence interval, 0.10 to 0.44)). This risk was even lower when the consumption was high for only one component of the three types of food. Some epidemiological studies have examined the relation between food patterns and IRS using

What is already known on this subject

- Consumption of dairy products, grain, and fish has each been shown to be inversely associated with insulin resistance syndrome.

What this study adds

- Diet patterns characterised by a high consumption of dairy products, fish, or grain were associated with a lower probability of presenting with an insulin resistance syndrome.
- The combination of these food intakes tended to be more favourable than the consumption of each one separately and dramatically decreased the risk of having a metabolic syndrome.

cluster or principal components analysis. Such multivariate techniques make comparisons with other studies difficult because distinct food clusters or food components identified are dependent on the population studied. However, it has been shown in a UK cohort study that component 1 of a principal component analysis—characterised by the frequent intake of salad vegetables, fruits, fish, pasta, and rice and a low intake of fried foods, sausages, fried fish, and potatoes—appeared to be protective from the metabolic syndrome.[29] In another population, the multi-ethnic Insulin Resistance Atherosclerosis Study cohort, the ''dark bread pattern'' (high fibre breads, rice, pasta, and vegetables) was associated with the best level of insulin sensitivity.[30] Though fish and some carbohydrates were also found to be negatively associated with IRS, in the present study vegetable and fruit consumptions were not linked to IRS, as was reported in the Framingham Offspring Study with fibre from vegetable and fruit.[5] The specific effect of fruit, vegetable, or fibre on IRS frequency could not be shown, probably because of the high level of consumption of these food components in our study population, whatever the other eating patterns. Conversely, meat consumption was positively associated with IRS in our study, as reported previously. The association remained significant after multivariate adjustment.

Three of the five components of the metabolic syndrome (blood pressure, triglycerides, and HDL cholesterol) seem to be the preferential target of the nutritional pattern characterised by a high intake of dairy products, grain, and fish.

Several studies have demonstrated a significant and negative relation between dairy product intake and blood pressure. About 70% of the calcium intake is supplied by dairy products in Western countries.[3 31–33] It has been shown that dietary calcium, acting through a decrease in 1,25-$(OH)_2$-vitamin D production, reduces the stimulus of cell calcium influx and thus induces a hypotensive effect.[34] Moreover, it has been suggested that an antihypertensive action could be exerted by milk bioactive proteins inhibiting angiotensin converting enzyme.[35] In addition, calcium provided by food or in supplements causes a decrease in triglyceride levels[36] and an increase in HDL cholesterol levels,[37] though other studies have reported no such effect.

Diets including fish and with a 30% fat content reduce triglycerides and total and LDL cholesterol and increase HDL2 cholesterol.[8] In patients with an increased risk of coronary heart disease, a high fish oil intake favourably affects VLDL and HDL cholesterol.[38] In an elderly population, a low consumption of fish may protect against the development of impaired glucose tolerance and diabetes mellitus.[6] A lower prevalence of impaired glucose tolerance and diabetes is associated with daily seal oil or salmon consumption in Alaskan natives.[7]

A role of carbohydrates with a high or low glycaemic index in insulin resistance has not been demonstrated clearly and the available data are controversial.[39]

Conclusions

Our study shows that patterns characterised by a high consumption of dairy products, fish, or grain are associated with a lower probability of presenting with an IRS. The combination of these food intakes tends to be more favourable than the consumption of each food type separately, and dramatically decreased the risk of having a metabolic syndrome.

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