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Dietary behaviors influence inflammatory markers: results from the CoLaus study

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DIETARY BEHAVIOURS INFLUENCE INFLAMMATORY MARKERS: RESULTS FROM THE COLAUS STUDY.

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Abstract

Background: The effect of different dietary markers on inflammatory markers has seldom been assessed in a general population setting. We assessed the effect of single foods, nutrients, dietary patterns and scores on inflammatory markers (CRP, IL-6, TNF-α and leucocyte count).

Methods: Cross-sectional study including 4027 participants (46.5% men, 57.2±10.2 years) in Lausanne, Switzerland (CoLaus study). Dietary intake was collected between 2009-2012 using a semi-quantitative food frequency questionnaire. Besides single foods and nutrients, three naive (using principal components analysis - PCA) and four oriented (Mediterranean, Alternative Healthy Eating Index - AHEI) dietary scores were used.

Results: Three dietary patterns explaining 20% of total variance were obtained and named "Meat & chips" (positive loadings for meat and French fries); "Pastries & fat" (positive loadings for hard fats, pastries and sugar) and "Fruits & vegetables" (positive loadings for fruits & vegetables). After multivariate adjustment on total energy intake, gender and other socio-demographic factors, fruit intake, the "Fruits & vegetables" pattern, the Mediterranean and the AHEI scores were negatively associated with CRP levels (standardized regression scores: -0.043, -0.054, -0.043 and -0.067, respectively, all p<0.01). The "Fruits & vegetables" pattern was also negatively associated with leucocyte count (standardized regression score: -0.057, p<0.01). Conversely, no association between nutrients and inflammatory markers and between all dietary markers and IL-6 or TNF-α was found.

Conclusion: global dietary behaviours have a small but significant impact on inflammatory markers in the general population. The effect of individual nutrients or foods (fruits excepted) is of less clinical importance.

Keywords: dietary scores; inflammation; epidemiology; dietary patterns; nutrients

Introduction

Systemic low-grade inflammation has been linked to several chronic conditions such as cardiovascular disease (CVD)[1]. Moreover, chronically elevated rates of inflammatory markers such as C-reactive protein (CRP) and interleukin 6 (IL-6) could be predictors of CVD risk[2].

The already well known association between diet and CVD may partly be linked through these inflammatory markers[3]. Indeed , several epidemiological studies have identified negative associations between inflammatory levels and specific nutrients such as polyphenols[4] [5], polyunsaturated fatty acids[6], histidine[7] and branched-chain amino acids[8].

Besides specific nutrients, dietary scores based on the consumption of specific food items have also been linked with inflammatory levels. For example, hypothesis-oriented scores such as the Mediterranean-diet score[9] has been linked with lower platelet and white blood cell counts[10.]. Similarly, the Southern European Atlantic diet[11] and the Baltic Sea diet[12] have been associated with lower levels of CRP. Similarly, the Alternate Healthy Eating Index (AHEI) of McCullough and coll.[13] was negatively associated with IL-6 levels[14] [3]. Conversely, the traditional Inuit diet, based on sea mammals' meat rich in n-3 fatty acids and vitamin D, tended to increase CRP and YKL-40 levels, possibly due to the presence of organic pollutants in marine mammals[15].

Also, naïve-oriented scores, such as dietary patterns obtained through principal component analysis (PCA), have been shown to be associated with inflammatory levels. For example, "prudent"[16] or "health-aware"[17] patterns were negatively associated with CRP levels. Ozawa and coll. used reduced rank regression analysis and identified a "dietary inflammatory pattern" rich in red and processed meat, peas, legumes and fried food, and low in whole grains, which was positively associated with IL-6 levels and other inflammatory markers[18]. However, most studies assessed only a limited number of nutrients or foods, or even focused on a single dietary score or pattern, while studies comparing simultaneously the effect of different dietary parameters on inflammatory markers are scarce.

Hence, our study aimed at assessing the associations between a wide range of dietary parameters (macro- and micronutrients, single foods, dietary patterns and scores) and several inflammatory markers to find the most accurate indicator of an anti-or pro-inflammatory diet.

Participants and methods

Sampling procedure

The CoLaus study is a population-based study assessing the clinical, biological and genetic determinants of cardiovascular disease in the city of Lausanne, Switzerland[19]. Recruitment began in June 2003 and ended in May 2006, enrolling 6733 participants who underwent an interview, a physical exam, and a blood analysis. The first follow-up was performed between April 2009 and September 2012, 5.5 years on average after baseline. We only consider data from the follow-up examination as dietary intake assessment was first introduced here.

Blood samples

Venous blood samples (50 mL) were drawn in the fasting state. Most biological assays were performed at the clinical laboratory of the Lausanne university hospital (CHUV) within 2 hours of blood collection on fresh samples. Supplementary samples were stored at -80°C.[20]

Dietary intake

Dietary intake was assessed using a validated self-administered, semi quantitative Food Frequency Questionnaire (FFQ) which also included portion size[21]. Briefly, this FFQ assesses the dietary intake of the previous 4 weeks and consists of 97 different food items accounting for more than 90% of the intake of calories, proteins, fat, carbohydrates, alcohol, cholesterol, vitamin D and retinol, and 85% of fibre, carotene and iron. For each item, consumption frequencies ranging from "less than once during the last 4 weeks" to "2 or more times per day" were provided, and the participants also indicated the average serving size (smaller, equal or bigger) compared to a reference size. Daily consumption of the different food items was computed based on frequency and portion size and expressed in mL (for drinks) or in grams (for other foods). Conversion into nutrients was performed based on the French CIQUAL food composition table[22] taking into account portion size.

Dietary scores

Three dietary scores were computed, two based on the Mediterranean diet, the third on a modification of the alternative healthy eating index (AHEI). The first Mediterranean dietary score (hereby designated as "Mediterranean score 1") was derived from Trichopoulou et al.[9], the score ranges between zero and eight. The second Mediterranean dietary score (hereby designated as "Mediterranean score 2") is adapted to the Swiss population and was computed according to Vormund et al.[23]. Contrary to the score from Trichopoulou et al, dairy products are considered as beneficial. The score thus ranges between zero and nine. The AHEI was adapted from McCullough et al.[13]. In our study, the amount of trans fat could not be assessed, and we considered all participants taking multivitamins as taking them for a duration ≥5 years. Thus, the modified AHEI score ranged between 2.5 and 77.5 instead of 2.5 and 87.5 for the original AHEI score[13]. For all three scores, higher values represented a healthier diet.

Dietary patterns

Prior to assessment of dietary patterns, the 97 items of the FFQ were grouped into 40 food and nutrient groups, including vitamin and food supplements (**supplementary table 1**) as previously reported[24] .

Dietary patterns were assessed by PCA with varimax rotation as done in previous studies[25] [26] [27] [28] . The Kaiser-Meyer-Olkin (KMO) and the Bartlett test for sphericity were applied to assess the appropriateness of applying PCA to the dataset. The Bartlett test compares the correlation matrix between the different items to be included in the PCA to the identity matrix. A non-significant Bartlett test indicates that the variables are highly correlated and that information compression using PCA is not useful. The KMO was 0.754, which was above the suggested minimum of 0.5[29] and comparable to values reported in the literature [25 30]. The Bartlett test for sphericity yielded a p-value of <0.0001. Hence, both KMO and the Bartlett tests indicated that the data were suitable for PCA.

The number of dietary patterns to be retained was calculated based on the same criteria as in other studies[31 26], namely: 1) analysis of the scree plot; 2) an eigenvalue higher than one and 3) the interpretability of the dietary pattern. For interpretation purposes, varimax rotation was performed. Items with absolute factor loading >0.30 were considered to characterize the dietary patterns [24], although all items were used to calculate dietary pattern scores. Dietary patterns were categorized into quintiles and the dietary intake of the highest was reported.

Exclusion criteria

Participants with the following characteristics were excluded: 1) No dietary data; 2) No socio-clinical data; 3) No inflammatory data; 4) Anti-inflammatory drugs; 5) Inflammation (CRP>20 mg/L); 6) Total energy intake (TEI) <850 or >4500 kcal/day.

Statistical analysis

Statistical analysis was performed using Stata version 14.1 for Windows (Stata Corp, College Station, Texas, USA). Participants characteristics were expressed as number (percentage) for categorical variables or as average ± standard deviation for continuous variables.

Bivariate associations were assessed using Spearman nonparametric rank correlation. Dietary markers significantly associated on bivariate analysis with inflammatory markers were further explored using multivariable analysis. Multivariable analysis was performed using linear regression adjusting for age (continuous), body mass index (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous). Results were expressed as standardized coefficients; standardized coefficients can be interpreted as multivariable-adjusted correlations. For multivariable analyses, inflammatory markers were log-transformed.

The importance of dietary scores and patterns relative to single foods was further addressed by entering simultaneously in each model one dietary pattern and the foods significantly associated with inflammatory markers. Statistical significance was considered for a two-sided test with $p<0.01$.

Results

Characteristics of the participants

Of the initial 5064 participants, 1037 (20.5%) were excluded. The reasons for exclusion are indicated in **figure 1** and the characteristics of excluded and included participants are summarized in **supplementary table 2**. Excluded participants were older, had a higher BMI, a lower education, and were prone to smoke, be sedentary and have diabetes.

Dietary patterns

The results of the PCA are summarized in **supplementary table 3**. The KMO was 0.754, indicating that the data were suitable for PCA. Two unhealthy and one healthy dietary patterns were identified, explaining 20% of the overall variance. The three patterns were named “Meat & chips” (unhealthy: positive loadings for all kinds of meat and French fries); “Pastries & fat” (unhealthy: positive loadings for hard fats, pastries and sugar) and “Fruits & vegetables” (healthy: positive loadings for fruits & vegetables).

Participants in the highest quintile of the “Meat & chips” and the “Pastries & fat” patterns showed a higher intake of total fat (expressed as percentage of total energy intake) and of saturated fat (expressed as percentage of total fat). Participants in the highest quintile of the “Meat & chips” pattern also showed a higher intake of protein while participants in the highest quintile of “Fruits & vegetables” pattern showed a higher intake of carbohydrates and fiber (**supplementary table 3**).

Associations of individual nutrients with inflammatory markers

On bivariate analysis, total fat was positively associated with IL-6, and carotene was negatively associated with CRP and leucocyte count (**table 1**). However, these relationships were no longer significant when adjusting for confounders (**table 2**).

Associations of single foods with inflammatory markers

On bivariate analysis, fruits, carrots and tofu were negatively associated with CRP and leucocyte count; green salad, bananas, apples and kiwis were negatively associated with leucocyte count, while vegetables showed a positive association with IL-6 levels (**table 1**). After multivariable adjustment, only the negative association between tofu and CRP levels remained (**table 2**).

Associations of dietary patterns and scores with inflammatory markers

On bivariate analysis, the “Meat & Chips” pattern was positively associated with CRP levels and leucocyte count; the “Pastries & Fat” pattern was negatively associated with leucocyte count, and the “Fruits & Vegetables” pattern was negatively associated with CRP levels and leucocyte count (**table 1**). After multivariable adjustment, only the negative associations between the “Fruits & Vegetables” pattern and CRP levels and leucocyte counts remained (**table 2**).

On bivariate analysis, both Mediterranean scores and the AHEI were negatively associated with CRP levels; the AHEI was also negatively associated with leucocyte count (**table 1**). After multivariable adjustment, only the negative associations between Trichopoulou’s Mediterranean score and the AHEI with CRP levels remained (**table 2**).

When entered simultaneously with fruit intake, the “Fruits & Vegetables” pattern, the Trichopoulou’s Mediterranean score and the AHEI tended to remain significantly and negatively associated with CRP levels, while the association with fruit intake was no longer significant (**supplementary table 4**).

Discussion

This study is one of the few that compared the associations between different dietary parameters and inflammatory markers in the general population. Our results show that (un)healthy dietary behaviours have a small but significant impact on inflammatory markers, while individual nutrients or foods have a lower clinical importance.

Associations of individual nutrients with inflammatory markers

Only a limited number of macro- and micronutrients were associated with inflammatory markers on bivariate analysis, and no significant association remained after adjustment for confounders. These findings are in agreement with Scottish study[17], which also failed to find any significant association between several micronutrients (flavonoids and antioxidants) and inflammatory markers. Also, the lack of association between vitamin D intake and inflammatory markers matches an earlier study on Inuits, whose diet is known to be rich in this component[32]. Overall, our results suggest that most macro and micro-nutrients are not associated with inflammatory markers. Still, as no information was available regarding polyphenol intake, it was not possible to confirm or infirm the existing information on the anti-inflammatory properties of polyphenols[4 5].

Associations of single foods with inflammatory markers

Fruit intake was negatively associated with CRP levels, but not with IL-6, TNF-α or leucocyte count. The association with CRP remained after multivariate analysis, a finding in agreement with the literature[33]. A possible explanation is the high polyphenol content of fruits[34], which has been linked with a decrease in inflammation levels[4 5]. Our results thus stress the need of an adequate consumption of fruit to decrease inflammatory levels.

Associations of dietary patterns and scores with inflammatory markers

The Mediterranean diet score was negatively associated with CRP levels, and this association persisted after multivariate adjustment. These findings are in agreement with previous studies [10 35 36], suggesting that the beneficial effect of the Mediterranean diet on CVD might partly be linked to a decreased inflammatory status.

The AHEI was negatively associated with CRP levels. This finding is in agreement with some studies where the AHEI was inversely correlated with CRP [37] or IL-6 levels[3 14], but not with other studies which failed to find any association [38 39]. As the associations were rather weak, a possible explanation is the relatively small sample size (<1000 participants) of the studies that failed to find a significant association.

Of the three dietary patterns obtained, only the "Fruits & Vegetables" one retained its negative association with CRP and IL-6 after multivariable adjustment. These findings are partly in agreement with other studies which also assessed dietary patterns using PCA. Indeed, both the "health-aware" pattern from the Lothian Birth Cohort study[17] and the "prudent" pattern from the Aberdeen Prospective Osteoporosis Screening Study cohort[16], which scored high in fruits and vegetables, were negatively associated with CRP levels.

Interestingly, the "Fruits & Vegetables" pattern, the Trichopoulou's Mediterranean score and the AHEI showed stronger negative associations with CRP levels than single fruit intake, indicating that their effects were not only due to a higher fruit intake, but that other components might also intervene. Overall, our results suggest that a diet rich in fruits (but not only) is paramount for reducing inflammatory levels.

Importance for clinical practice

Many studies have focused on the associations between single nutrients or foods and inflammatory markers. Still, increasing or decreasing the consumption of specific nutrients or even of selected foods might be difficult to achieve in general practice. Our results indicate that dietary recommendations focused on the consumption of several food groups are more important than recommendations focused on specific foods or nutrients[40]. Hence, in clinical practice, generic recommendations could be provided, instead of focusing on specific foods or nutrients, which are difficult to identify and to integrate in a normal diet. This would facilitate dietary counselling by general practitioners, whose nutritional knowledge is usually low[41].

Similarly, from a public health perspective, simple messages aimed at a healthier eating and increased consumption of fruits and vegetables[42 43] could be delivered. The impact of such measures in the general population could then be monitored by any of the scores (AHEI, Mediterranean or "Fruits and vegetables") rather than by complex nutrient assessment.

Strengths and limitations

Our study has several strengths: firstly, it is one of the very few simultaneously comparing the effect of different dietary parameters on inflammatory markers. Secondly, it relied on a rather large sample size, thus allowing a relatively adequate statistical power. Indeed, only five studies assessing the association between diet and inflammatory markers had a larger sample size[4 11 44 10 18]. Finally, due to the population-based setting, our results can be transposed to other populations and practical recommendations can be used in public health and clinical practice.

This study also has several limitations. First, and as alredy indicated, no information regarding polyphenols was available. Hence, it was not possible to confirm previous findings[5 4]. Future studies should rely either on an extensive food composition database or on the direct measurement of polyphenols in serum or urine. Second, the Mediterranean-diet score is based on a Greek population's food consumption, and the scores obtained cannot be directly transposed to a Swiss population. Finally, we could not calculate the Dietary Inflammatory Index (DII), which is composed by a list of 45 items, mainly specific nutrients and spices[45] and is often used in recent literature on CVD and inflammation, showing decreased CRP levels with high DII scores[46]. However, this score is based on food items [45] that are rarely collected in epidemiological studies and are dependent on the food composition table. Hence, its interest for public health or clinical practice is limited.

Conclusion

Our results show that healthy dietary behaviours have a small but significant impact on inflammatory markers in the general population. The effect of individual nutrients or foods appears to be of less clinical importance.

Conflict of interest

The authors report no conflict of interest.

Ethical statement

The institutional Ethics Committee of the University of Lausanne, which afterwards became the Ethics Commission of Canton Vaud (www.cer-vd.ch) approved the baseline CoLaus study (reference 16/03, decisions of 13th January and 10th February 2003); the approval was renewed for the first (reference 33/09, decision of 23rd February 2009) and the second (reference 26/14, decision of 11th March 2014) follow-up. The full decisions of the CER-VD can be obtained from the authors upon request. The study was performed in agreement with the Helsinki declaration and its former amendments, and in accordance with the applicable Swiss legislation. All participants gave their signed informed consent before entering the study.

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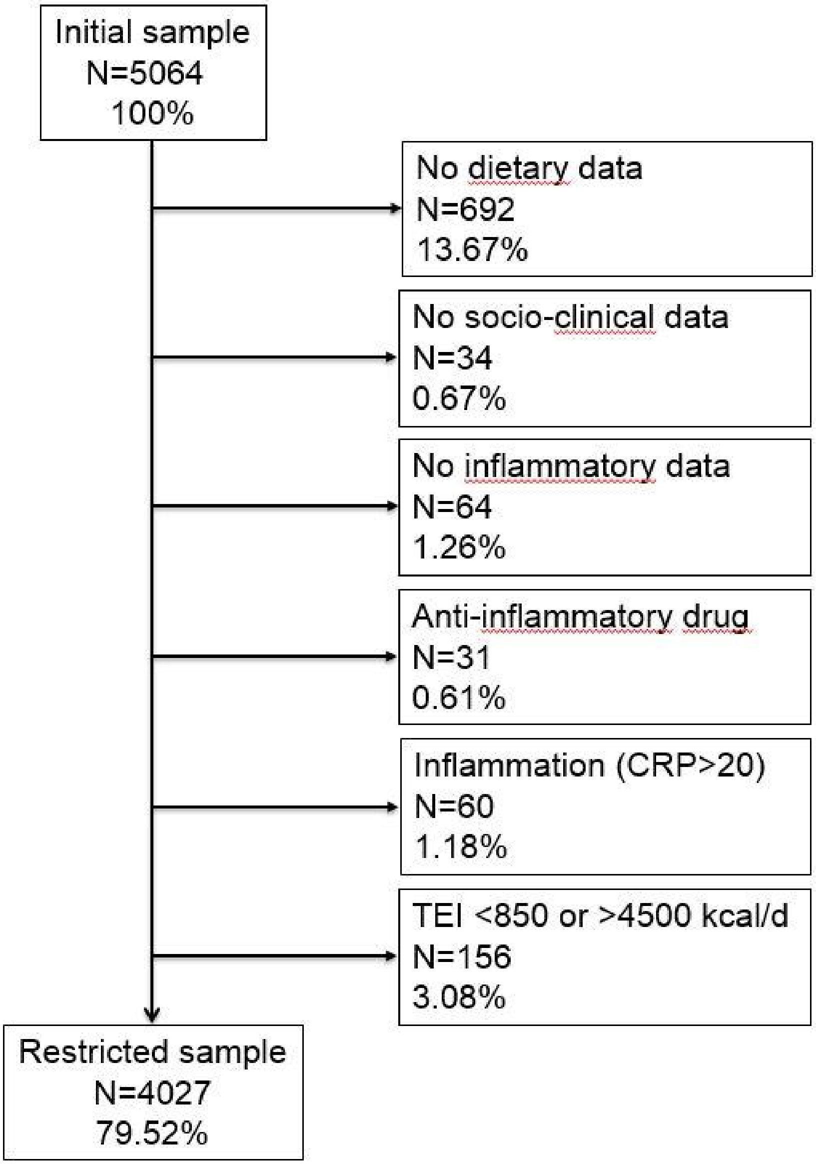
Figure legends

Figure 1 : selection procedure



Tables

Table 1: bivariate associations between inflammatory and dietary markers CoLaus study, Lausanne, Switzerland, 2009-2012.

	CRP (log)	IL-6 (log)	TNF-α (log)	Leucocytes
Total energy intake	-0.006	**0.057**	0.016	0.012
Macronutrients				
Total protein	-0.003	0.046	0.017	0.027
Vegetable protein	-0.043	0.041	0.000	-0.030
Animal protein	0.019	0.034	0.022	0.050
Total carbohydrates	-0.034	0.037	0.012	-0.008
Monosaccharides	-0.038	0.018	0.004	-0.011
Polysaccharides	-0.020	0.038	0.012	-0.007
Total fat	0.001	**0.054**	0.016	0.019
Saturated	0.007	0.039	0.028	0.021
Monounsaturated	-0.007	**0.057**	0.010	0.017
Polyunsaturated	0.033	**0.065**	0.007	0.047
Fiber	-0.052	0.028	0.002	**-0.056**
Cholesterol	-0.010	0.025	-0.005	0.010
Alcohol	-0.022	0.030	0.015	0.011
Micronutrients				
Calcium	-0.014	0.022	0.020	-0.032
Iron	-0.024	0.051	0.005	-0.012
Retinol	0.015	0.013	0.005	0.015
Carotene	**-0.061**	0.031	-0.008	**-0.081**
Vitamin D	-0.025	0.032	0.002	-0.019
Vitamin A	-0.021	0.028	-0.009	-0.025
Food Items				

Fruits	**-0.055**	0.000	-0.021	**-0.061**
Vegetables	-0.045	**0.059**	-0.002	-0.038
Fish	-0.037	0.023	-0.001	-0.016
Haricots verts	-0.022	0.010	0.004	0.006
Chou-fleur	-0.029	0.036	0.000	-0.019
Tomatoes	0.017	0.005	0.006	0.015
Carrots	**-0.064**	0.024	-0.001	**-0.098**
Green salad	-0.040	0.014	-0.020	**-0.061**
Thick vegetables soup	-0.033	0.040	-0.005	0.007
Tomato sauce	-0.028	0.006	-0.032	0.019
Tofu	**-0.091**	0.013	-0.026	**-0.086**
Bananas, apples	-0.035	-0.004	0.007	**-0.059**
Oranges, tangerines	-0.023	-0.005	-0.027	-0.021
Peaches, nectarines	0.030	-0.036	0.044	0.027
Strawberries, blackcurrants	0.034	-0.041	-0.002	-0.011
Kiwis	-0.034	0.012	0.028	**-0.077**
Fresh fruit juice	-0.043	-0.031	-0.031	-0.002
Patterns				
Meat & Chips	**0.072**	0.030	0.029	**0.094**
Fruits & Vegetables	**-0.090**	0.030	-0.022	**-0.131**
Pastries & Fat	-0.048	-0.007	-0.017	**-0.095**
Dietary scores				
Mediterranean (Trichopoulou)	**-0.076**	0.046	-0.022	-0.032
Mediterranean (Vormund)	**-0.054**	0.027	-0.018	-0.038
AHEI [1]	**-0.111**	0.033	-0.016	**-0.072**

AHEI, alternate healthy eating index. Data from 4027 participants. Results are expressed as Spearman correlations. Significant ($p<0.01$) correlations are indicated in bold.

Table 2: multivariate associations between selected inflammatory and dietary markers CoLaus study, Lausanne, Switzerland, 2009-2012.

	CRP (log)	**IL-6 (log)**	**Leucocytes**
Macronutrients			
Total fat	-	0.001	-
Monounsaturated	-	0.006	-
Polyunsaturated	-	0.005	-
Fiber	-	-	-0.028
Micronutrients			
Carotene	-0.037	-	-0.047
Food Items			
Fruits	**-0.043**	-	-0.026
Vegetables	-	0.025	-
Carrots	-0.037	-	-0.041
Green salad	-	-	-0.043
Tofu	-0.024	-	-0.013
Bananas, apples	-	-	-0.010
Kiwis	-	-	-0.016
Dietary patterns			
Meat & Chips	0.011	**-**	0.045
Fruits & Vegetables	**-0.054**	**-**	**-0.057**
Pastries & Fat	-	-	-0.021
Dietary scores			
Mediterranean (Trichopoulou)	**-0.043**	-	-
Mediterranean (Vormund)	-0.039	-	-
AHEI [1]	**-0.067**	-	-0.041

AHEI, alternate healthy eating index; -, not assessed. Data from 4027 participants. Results are expressed as standardized regression coefficients adjusted for age (continuous), body mass index (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous). Significant ($p<0.01$) associations are indicated in bold.

Supplementary files

Supplementary table 1: food groups and subgroups used to derive dietary patterns.

Main group	**Subgroup**	**Examples**
Dairy products	Plain	Milk, yogurt
	Low fat	Cottage cheese, 0% fat; yogurt, light
	Cheese	Emmental, Gruyère, fondue, feta, tomme, parmesan
Bread & cereals	White bread	
	Wholemeal bread	
	Breakfast cereals	Puffed rice, corn flakes, muesli, porridge
	Toasts, crackers	
Meat	Red meat	Beef, horsemeat, veal, spareribs, lamb chops
	White meat	Poultry
	Processed meat	Sausage, salami, cured ham, cervelas, pâté, terrine
	Liver	Liver (veal, pork, poultry)
Fish	Oily fish	Salmon (fresh or smoked)
	Canned or fried fish	
	Lean fish & seafood	Cod, pollock, trout, shrimp
Vegetables	Vegetables	Spinach, green beans, tomatoes, broccoli, carrots, vegetable soup
Potatoes	Boiled	
	French fries	
Sauces	Sauces	Mayonnaise, vinaigrette, tomato
Other	Cafeteria	Ravioli, tortellini, cannelloni, pizza, quiche
	Starch	Rice, pasta, semolina
Eggs	Eggs	
Tofu	Tofu	
Fruit	Fresh fruit	Banana, pear, apple, plum, grapes, berries, orange, tangerine, melon, apricot, peach, nectarine, kiwi
	Canned fruit	
	Fresh fruit juice	
	Bottled fruit juice	
Fats & oils	Low-fat products	
	Hard fats	Butter, margarine
	Olive oil	
	Other vegetable oils	Sunflower seed, peanut
Sugar & sweets	Bakery	Croissant, chocolate bread, cream cake, English cake, biscuits, cookies, fruit pie
	Chocolate	Chocolate, jam, honey, ice-cream
	Sweeteners	Aspartame
	Sugar	
Supplements	Vitamins	Single or multivitamins
	Other supplements	Fibre, bran, garlic pills

Drinks	Sodas	
	Tea & coffee	
	Water	
	Alcoholic	Beer, wine, champagne, spirits, aperitifs

Supplementary table 2: Comparison between excluded and included participants, CoLaus study, Lausanne, Switzerland, 2009-2012.

	Included	Excluded	P-value
Sample size	4027	1037	
Gender (male)	46.51%	46.67%	0.926
Age (years)	57.2 ± 10.2	60.0 ± 11.3	<0.001
Education			<0.001
High	23.09%	14.44%	
Middle	26.89%	21.61%	
Low	50.01%	63.95%	
BMI (kg/m^2)	26.0 ± 4.5	27.0 ± 5.1	<0.001
BMI categories			<0.001
Normal	45.10%	37.45%	
Overweight	38.99%	40.12%	
Obese	15.92%	22.43%	
Smoking status			<0.001
Current	20.34%	27.55%	
Former	37.94%	36.22%	
Never	41.72%	36.22%	
Sedentary	56.41%	65.79%	<0.001
Diabetes	9.56%	15.13%	<0.001

BMI, body mass index. Results are expressed as percentage or as average standard deviation. Between group comparisons using chi-square for categorical variables or student's t-test for continuous variables.

Supplementary table 3: factor loadings, percentage of total variance explained, and nutritional intake of the highest quintile for the three dietary patterns identified, CoLaus study, Lausanne, Switzerland, 2009-2012.

		Meat & chips	Fruits & vegetables	Pastries & fat
Bread & cereals	White bread			0.307
Meat	Red meat	0.419		
	White meat	0.403		
	Processed meat	0.417		
	Liver, kidneys	0.421		
Vegetables	Vegetables		0.342	
Potatoes	French fries	0.334		
Fruit	Fresh fruit		0.346	
Fats & oils	Hard fats			0.373
Sugar & sweets	Bakery			0.346
	Chocolate			0.327
	Sugar			0.314
% of variance explained §		8%	7%	5%
Total energy intake (kcal)		2267 [1849 - 2755]	2160 [1788 - 2655]	2466 [2121 - 2948]
Macronutrients (% TEI)				
Protein		16.3 [14.6 - 18.3]	14.9 [13.2 - 17.1]	13.9 [12.4 - 15.6]
Carbohydrates		42.9 [37.4 - 48.3]	48.1 [42.7 - 54.2]	47.4 [41.4 - 53.2]
Fat		35.6 [31.4 - 40.2]	34.1 [29.3 - 38.9]	35.0 [30.5 - 39.5]
Alcohol		2.6 [0.6 - 6.7]	1.1 [0.2 - 2.9]	1.7 [0.4 - 4.6]
Fatty acids (% fat)				
Saturated		36.6 [32.7 - 40.0]	33.8 [29.8 - 37.8]	39.5 [35.5 - 43.4]
Monounsaturated		40.1 [37.5 - 42.7]	40.4 [37.4 - 44.2]	38.2 [35.7 - 41.1]
Polyunsaturated		14.3 [12.3 - 17.0]	14.9 [12.7 - 17.5]	13.2 [10.9 - 16.0]
Fibre (g/day)		15.6 [11.4 - 21.3]	24.0 [17.6 - 32.2]	17.4 [13.1 - 23.4]

Only items with absolute factor loading >0.300 are shown. Results for energy and nutrient intake are expressed as median and [interquartile range]. TEI, total energy intake. §, by the rotated components using varimax procedure.

Supplementary table 4: multivariate associations between selected dietary patterns or scores with C-reactive protein levels, further adjusted for fruit intake, CoLaus study, Lausanne, Switzerland, 2009-2012.

	Fruits & Vegetables	Mediterranean diet	AHEI
Fruit intake	-0.017 (0.399)	-0.032 (0.063)	-0.015 (0.399)
Selected score/pattern	-0.045 (0.021)	-0.035 (0.027)	-0.061 (<0.001)

AHEI, alternate healthy eating index. Data from 4027 participants. Results are expressed as standardized regression coefficients adjusted for age (continuous), body mass index (continuous), gender, smoking (never, former, current), educational level (high, middle, low), physical activity, diabetes (yes/no) and total caloric intake (continuous) and (p-value).