Published in final edited form as:
Nutr Metab Cardiovasc Dis. 2012 March ; 22(3): 223–230. doi:10.1016/j.numecd.2010.07.007.

LIFESTYLE DETERMINANTS OF C-REACTIVE PROTEIN IN MIDDLE-AGED, URBAN CHINESE MEN

Raquel Villegas, Ph.D., **Yong-Bing Xiang**, **Hui Cai**, **Tom Elasy**, **Qiuyin Cai**, **Xianglan Zhang**, **Sergio Fazio**, **MacRae Linton**, **Honglan Li**, **Wang Hong Xu**, **Gong Yang**, **Wei Zheng**, and **Xiao-Ou Shu**

Abstract

Background—Increased levels of C-reactive protein (CRP), common in aging populations, are associated with higher risk for chronic diseases, including diabetes and coronary heart disease. The aim of this study was to investigate associations between lifestyle factors and high CRP among middleaged men living in Shanghai, China.

Keywords

CRP; lifestyle; middle-aged men

INTRODUCTION

Low grade, systemic inflammation is common in aging populations and may promote chronic disease (1). Identification of factors associated with high C-reactive protein (CRP) levels could help to prevent chronic diseases such as coronary heart disease and type 2 diabetes.

Data from some studies suggest that CRP levels are positively associated with lifestyle factors, including weight gain, obesity (2,3) and smoking (4,5). An inverse association between physical activity and CRP has been reported in some (6-8), but not all, studies (9,10). Associations between alcohol intake and CRP levels are less clear. Some studies have reported lower CRP levels among moderate and light drinkers compared with non drinkers (11,12). A J shape association (13) and an inverse association (14) between alcohol intake and CRP levels have also been reported Data on the association between tea intake and CRP are scarce(15). CRP levels have also been associated with dietary patterns in some populations (16-18). There are no reports on associations between dietary patterns in Chinese populations and CRP.

In 2002, we launched a population-based cohort study of 61 500 middle-aged men in Shanghai, China, the Shanghai Men's Health Study. In a sub-cohort of 3978 participants we measured levels of disease-related biomarkers, including CRP, providing us with a unique opportunity to address lifestyle determinants of CRP in a population with high tea intake, a high prevalence of smokers and with dietary patterns that differ from other populations.

Corresponding Author: Dr. Raquel Villegas Vanderbilt University Medical Center Nashville, Tennessee 37206 United States Phone: +1 615 936 1822 Fax: +1 615 936 8291 raquel.villegas@vanderbilt.edu.

The current study addresses an important issue, since Chinese people are facing a rapid lifestyle transition. Changes in diet and reduced physical activity in China have resulted in an increase in prevalence of obesity (19). The incidence of type 2 diabetes has also markedly increased over the past two decades in China (20). In this report we present a comprehensive evaluation of associations between lifestyle factors, including anthropometrics, physical activity, smoking, alcohol intake, tea intake and dietary patterns, and the prevalence of high levels of CRP in this population.

METHODS

The Shanghai Men's Health Study (SMHS)

The SMHS is a population-based cohort study of men (40 -74 years) living in urban Shanghai, China. Recruitment for the SMHS was conducted between 2002 and 2006. A total of 83 058 eligible male residents of eight communities in urban Shanghai were invited to participate and 61 500 men who had no prior history of cancer were enrolled in the study (response rate: 74.0%). The study protocols were approved by the Institutional Review Boards of all participating institutes, and all participants provided written informed consent. Information was collected on demographic characteristics, disease history and lifestyle factors by trained interviewers. Participants were measured for weight and waist and hip circumferences according to a standard protocol and were asked to provide biological samples, including a blood or cheek cell sample and a spot urine sample. In a sub-cohort of 3978 participants who had no history of diabetes at baseline and who had provide a fasting blood sample, we measured levels of disease-related biomarkers. After exclusion of participants who reported taking antibiotics at the time of the blood collection and participants with a CRP level >10 mg/L (21), a total of 3646 participants remained for the analyses.

Blood CRP and lipids measurement

At the time of the in-person interview, a 10 ml blood sample was drawn into an EDTA vacutainer tube. The samples were kept in a portable Styrofoam box with ice packs (0-4 °C) and were processed within 6 hours. High-sensitivity CRP measurements were performed on thawed samples using ACE® High Sensitivity C-Reactive Protein Reagent (ACI-22) on an ACE® Clinical Chemistry System (Alfa Wassermann, Inc, West Caldwell, NJ). The minimum detectable concentration of CRP was 0.1 mg/L. A second batch of samples was analyzed using a different reagent, because the company stopped producing the original reagent. Thus, we adjusted for batch in all analyses. Lipid profiles were measured by the Vanderbilt Clinical Nutrition Center using an ACE clinical chemistry system.

Physical Activity

Assessment of physical activity was obtained by using a validated physical activity questionnaire (PAQ) (22). The PAQ contained separate sections to collect information on physical activity related to exercise/sports, daily living activities and the commuting journey to/from work.

For exercise/sports physical activity, participants were asked if they had engaged in regular exercise/sports during the preceding five years. Exercisers were asked to report details for up to three types of exercises/sports (i.e., type, hours/week, and years of participation in each activity). For daily living physical activity, participants were asked about walking, stair climbing, bicycling and household chore habits. For commuting-related physical activity, participants were asked whether they walked, bicycled, drove a vehicle or rode a bus to work.

Summary energy expenditure values (metabolic equivalent task [MET]-hr/day) for individual activities were estimated using a compendium of physical activity values (23). Summary energy expenditure values for exercise/sports participation were estimated as MET-hours/day/year by using the weighted average of energy expended in all exercise/ sports-related activities reported over the preceding 5 years. Summary energy expenditure values were also calculated for activities related to daily living and commuting. Finally, we calculated totals for physical activity related to exercise/sports participation, daily living and commuting, and an overall physical activity total (total METs), by combining all types of physical activities.

Body Size and Weight History

Anthropometric measurements of weight, height and waist and hip circumferences were taken twice, according to a standard protocol. If the difference between the first two measurements was larger than 1 cm for circumferences or 1 kg for weight, a third measurement was taken. The average of the two closest measurements was applied in the present study. From these measurements, the following variables were created: BMI, weight in kg divided by the square of height in meters and WHR, waist circumference divided by hip circumference. Standardized weight change was calculated as the difference between measured weight at baseline and self-reported weight at age 20 divided by the interval between study recruitment and age 20 (kg/yr) (data on weight at age 20 was available for 3407 participants). We present data as weight gained during 5-year intervals.

Smoking status

Participants were asked if they smoked regularly and how many cigarettes they smoked per day. Participants were then classified according to their current smoking status into one of five categories: never smokers (n=688; 18.34%), ex-smokers (n=226; 6.03%), >0-10 cigarettes/ day (n=809; 21.60%), >10-20 cigarettes/ day (n=1604 42.83%), >20 cigarettes/ day (n=418; 11.16%).

Dietary Variables

Tea consumption—Participants were asked if they drank tea regularly and the amount of tea they consumed per month. Participants were classified in four categories according to their tea drinking habits: never (n=1043; 27.85%), <250g/month (n=783; 20.91%), 250 g/ month (n=892; 23.82%), and >250 g/month (n=1027; 27.42%).

Alcohol consumption—Participants were asked if they drank alcohol regularly and the usual amount of alcohol they consumed (rice wine, grape wine, beer, or liquor). Participants who have given up drinking were classified as ex-drinkers. One drink was defined as 360 g of beer, 103 g of grape wine, 30 g of liquor (24), or 103 g of rice wine. Participants were classified into 6 categories: ex-drinkers (n=141, 3.77%), never drinkers (n=2190; 58.48%), occasional drinkers (< 0.5 units/day; n=62; 1.66%), light drinkers (0.5-0.99 units/ day; n=167; 4.46%), moderate drinkers (1.0-2.99 units/day; n=700; 18.69%), and heavy drinkers (>= 3 units/day; n=485; 12.95%) (25). Because occasional drinkers were a small group, we combined them with light drinkers. Ex-drinkers were not included in the analysis of alcohol consumption.

Dietary patterns

Usual dietary intake was assessed through an in-person interview using a validated food frequency questionnaire (FFQ) (26). Dietary patterns were derived using factor analysis, with 81 individual foods or food groups entered into the analysis as the absolute amount of intake in g/d. The PROC FACTOR procedure in SAS version 9.1 (SAS Institute, Cary, NC, USA) was applied to perform the analysis. This procedure uses factor analysis and orthogonal rotation (varimax option in SAS) to derive non-correlated factors and to render the results more easily interpretable. To determine which number of factors to retain, the scree plots and the factors themselves were examined to see which set of factors most meaningfully described distinct food patterns. Three factors were extracted. Factor loadings were calculated for each food or food group across the three factors The loadings can be considered as correlation coefficients between food groups and dietary patterns and take values between −1 and +1. A factor score was calculated for each participant for each of the three factors, in which the standardized intakes of each of the 81 foods or food groups were weighted by their factor loadings and summed. The sums were standardized again ((score – mean score)/standard deviation of score). Three dietary patterns were identified (27). Factor-loading matrices for the three dietary patterns are listed in the Appendix. Dietary pattern I was heavily loaded with vegetables, such as legumes and leafy vegetables, and was named the ‘vegetable diet’. Pattern II was mainly rich in fruits and was named the ‘fruit diet’. Pattern III had high loadings for meat and was named the ‘meat diet’. These three patterns explain 79% of the variance of food intake.

Other potential confounding factors—Information on socio-demographic factors such as age, occupation (professional, clerical, manual), education level, income level, and presence of CVD at baseline (yes/no) was collected by in-person interview.

Statistical analysis—Participants were categorised into two groups by CRP level: normal (<=3mg/L) and high (>3mg/L). Associations between CRP categories and lifestyle factors were investigated using unconditional logistic regression models.

Participants were categorised by BMI by using cut-points suggested for Asian populations (28), by WHR according to World Health Organization recommendations (14), by waist circumference recommended for Chinese men (29), and by standardized weight gain since age 20 years. Analyses between these factors and CRP level were adjusted for age, kcal/day, occupation, education, income, pre-existing CVD, assay batch, smoking, alcohol consumption, tea consumption and physical activity. In addition, the analysis of standardised weight gain since age 20 years was adjusted for weight at age 20 years.

Associations between physical activity categories and CRP levels were adjusted for age kcal/day, occupation, education, income, pre-existing CVD, assay batch, smoking, alcohol consumption and tea consumption.

Associations between CRP levels with smoking, alcohol, tea consumption were adjusted for age, kcal/day, occupation, education, income, physical activity, CVD, and assay batch; In addition the smoking analysis was adjusted for alcohol and tea consumption, the alcohol analysis was adjusted for smoking and tea consumption, and the tea consumption analysis was adjusted for smoking and alcohol consumption.

Analyses of dietary patterns and CRP level were adjusted for age kcal/day, occupation, education, income, pre-existing CVD, assay batch, smoking, alcohol consumption and tea consumption and physical activity All analyses were performed using SAS (version 9.1), and all tests of statistical significance were based on two-sided probability.

RESULTS

A total of 10.32% participants were in the high CRP category (Table 1). Participants in the high CRP category had higher BMI, WHR, and waist circumference than all other participants. Participants in the high CRP level had higher triglyceride levels, lower HDL-cholesterol levels and higher prevalence of cardiovascular disease than participants with normal CRP levels.

We found positive associations between high CRP with overall and central obesity (Table 2). Weight gain in adulthood was also associated with high CRP. Compared with men with no weight gain, men with a weight gain of 2.8 kg per 5-year interval had an OR of 11.80 (95%CI: 6.48-21.49) for high CRP.

We found an inverse association of marginal significance between daily living-related physical activity and high CRP, while no association was found between exercise/sports-related physical activity and CRP level or commuting-related physical activity (Table 3).Total physical activity was inversely related to the prevalence of high CRP. Compared with normal CRP level, the ORs for <=3, >3-6, >6-9, >9-12 and >12 METs were 1.00, 0.91, 0.84, 0.69 and 0.65 (P trend 0.01). When we repeated the analyses with further adjustment for BMI, the associations were attenuated (P trend =0.07).

Smoking cigarettes was associated with the prevalence of high CRP (Table 4). The ORs of having high CRP were 1.00, 1.43, 1.05, 1.36 and 1.51, respectively, for never smokers, ex-smokers, >0-10, >10-20 and >20 cigarettes per day. When we repeated the analyses with further adjustment for BMI, the association between smoking and high CRP was strengthened. Similarly alcohol consumption was associated with the prevalence of high CRP. Tea intake was not associated with CRP level. When we repeated the analyses with adjustment for BMI similar results were found.

A fruit-based pattern was inversely associated with high CRP (Table 5). A trend of marginal statistical significance was observed between the meat-based pattern and high CRP. No association between a vegetable-based pattern and high CRP was found. In analyses adjusted for BMI, we found similar results.

DISCUSSION

In this cross-sectional analysis, obesity, weight gain, smoking, and alcohol consumption were associated with the prevalence of high CRP, while physical activity and a fruit-based pattern were inversely associated with high CRP after accounting for a wide range of potentially confounding variables.

Other studies have reported similar associations of CRP level with body weight and weight gain (2,3). Adipose tissue, particularly visceral adipose tissue, is metabolically active, promoting an inflammatory state (30). Similarly a positive association between smoking and CRP level has been found, (4,5). Smoking may have an influence on compounds in the visceral adipose tissue and cause the release of interleukin-6, which results in higher CRP production in hepatic cells (31).

Inverse associations between physical activity level and CRP have been reported in some studies. North Americans who frequently engaged in physical activity had significantly lower CRP compared with those who were physically inactive (6). In a prospective study of British middle-aged and elderly men, an inverse association between physical activity and CRP was also observed (8). Exercise/sports-related physical activity was not associated with CRP level in this study. Two other studies also found no association between CRP and exercise/sports physical activity (9,10). In this population the participation in exercise/sports is low, while the participation on non exercise/sports physical activity activities related to commuting and daily living is high (32).The association between physical activity and CRP was attenuated after adjustment for BMI, similar to another study (7), suggesting that the association might be mediated by BMI.

Moderate and heavy alcohol consumption was associated with higher prevalence of high CRP. Other studies have found lower CRP levels among moderate and light drinkers compared with non-drinkers (11,12). Both J-shaped and inverse associations between alcohol consumption and CRP have been reported (13,14). In our study, 82.2% of those in the moderate alcohol consumption category were also current smokers. Thus, it is possible that any benefit gained from moderate alcohol consumption is counteracted by the adverse effects of smoking. Moderate alcohol consumption may impair interlurkin-6 production, a major regulator of CRP (33). The anti-inflammatory effects of moderate alcohol consumption have been proposed to explain why moderate alcohol intake lowers CHD risk (12).

A fruit-based pattern was inversely associated with a high CRP level while no association between a vegetable-based pattern and CRP was observed. A prudent dietary pattern with high intake of fruit, vegetables has been associated with lower CRP levels in some (16,17), but not all, studies (34). Similarly, a pattern with high intake of soy, fish, and fruit in Japanese women (18) was also associated with lower CRP levels. However, a ‘fruit pattern’ was not associated with CRP level in another study (35), Although dietary patterns high in vegetable intake have been associated with lower inflammation in some studies (16,17), in our population, participants with chronic disease were more likely to have the vegetable-based diet (27).

We observed a positive trend of marginal statistical significance between the meat-based pattern and high CRP in our population. The meat-based pattern in our population had the strongest correlation with intake of fat and protein, a negative correlation with fiber, and a weak correlation with vitamins and minerals compared with the other two patterns. (27). The meat-based pattern had similarities with a Western dietary pattern that has been associated with higher CRP in some studies (16,17). In a study conducted in Japan, no dietary pattern associated with high CRP was found(18).To our knowledge, no other study has reported associations between dietary patterns and CRP levels in China.

Our study has some limitations. The study had a cross-sectional design, and therefore, causal relationships cannot be inferred. Another limitation of the study is that it did not include women, thus, our results may not be applicable to women in urban Shanghai. We excluded men with a prior history of cancer from the SMHS. Therefore, our results may not be directly generalized to men with a previous history of cancer. In addition, study participants of this subcohort study were more likely to be younger, to smoke, to consume alcohol, to have a professional job and to have a higher level of education and were less likely to exercise compared to the whole SMHS cohort. Thus, the results of this study may not represent the entire cohort. The fruit-based pattern was more common among men with higher income higher level of education, who were less likely to smoke or consume alcohol and were more physically active, while participants with a meat-based pattern were more likely to smoke and consume alcohol (27). Thus, although we adjusted for those variables, residual confounding is still possible.

Strengths of this study are its population-based design and the extensive information on confounders, including a validated physical activity questionnaire with information on exercise/sports-related, daily living-related and commuting-related physical activity. In addition, this population has a high prevalence of smokers, which allowed us to investigate associations between smoking and CRP comprehensively.

In conclusion, components of an adverse lifestyle were associated with high CRP. The implications of this study are that promotion of an active lifestyle and a healthy diet to maintain weight and an emphasis on reducing smoking and alcohol consumption could reduce levels of CRP and translate into the reduction of type 2 diabetes and coronary heart disease. This should be a high public health priority.

Acknowledgments

RV performed statistical analyses and prepared the manuscript; YBX supervised data collection and provided critical review of the manuscript; HC provided assistance with statistical analysis; TE provided critical review of the manuscript; QC provided critical review of the manuscript; XZ provided critical review of the manuscript; SF provided critical review of the manuscript; MRL provided critical review of the manuscript; HLL provided critical assistance with data collection and provided critical review of the manuscript; WHX provided critical review of the manuscript; GY supervised data collection and provided critical review of the manuscript; WZ designed the study and provided critical review of the manuscript; and XOS designed the study, provided significant advice and critical review of the manuscript.

We thank the participants and research staff of the Shanghai Men's Health Study for their contributions to the study and Ms. Bethanie Hull for technical assistance in the preparation of this manuscript. This work was supported by an NIH grant (R01 CA82729, Shu) and a pilot and feasibility grant originating from a Diabetes Center grant (2 P60 DK020593-29 Powers)

Appendix

Factor loading for three major dietary patterns at baseline, SMHS*

Food or food group	Factor I (vegetable)	Factor II (fruit)	Factor III (meat)
Rice	7	−5	−4
Noodles, steamed bread, dumplings and other wheat foodstuffs	4	−6	17
All kinds of desserts	−5	25	9
Bread	−2	31 *	6
Pork chops	0	8	24
Pork ribs	5	9	31 *
Pig's feet	2	−1	36 *
Pig's hamhock	−1	−1	32 *
Fresh pork (fat)	0	−7	14
Fresh pork (lean)	10	8	27
Fresh pork (mixture)	5	−2	34 *
Pig liver	2	−1	27
Organ meat (heart, brain, tongue, tripe, intestine)	3	−4	33 *
Beef, lamb	9	4	35 *
Eggs, duck eggs	7	18	19
Chicken	6	18	40 *
Duck, goose	8	15	36 *
Salt water fish	19	14	31 *
Fresh water fish	19	19	20
Rice field eel or river eel	6	8	32 *
Shrimp, crab, etc.	16	26	30
Conch, etc.	10	5	24
Fresh milk	0	34 *	−1
Soya milk, powdered soya milk	6	6	6
Bean curd	24	3	23

Food or food group	Factor I (vegetable)	Factor II (fruit)	Factor III (meat)
Fried bean curd, vegetarian chicken, bean curd cake and other kinds of bean products excluding fresh bean curd	27	1	30
Dried soyabeans	11	8	13
Mung bean, red beans and other dried beans	10	20	7
Soyabean sprouts	22	−1	29
Mung bean sprouts	21	0	27
Greens, Chinese greens	31 *	7	−1
Spinach	32 *	1	17
Green cabbage	31 *	6	3
Chinese cabbage, bok choi cabbage	35 *	3	7
Cauliflower	35 *	8	7
Chinese celery	39 *	6	5
Snow pea shoots	29	11	11
Eggplant	37 *	2	1
Wild rice stems	39 *	6	8
Asparagus lettuce	34 *	0	12
Potatoes	37 *	9	8
Wax gourd	41 *	13	0
Cucumber	40 *	19	2
Luffa	33 *	8	2
Fresh mushrooms, fresh xianggu mushrooms	32 *	20	11
Fresh red and green peppers	34 *	−3	15
Tomatoes	40 *	26	1
Bamboo shoots	31 *	14	13
Lotus roots	26	13	3
Head of garlic	21	3	10
Garlic and garlic shoots	36 *	−8	15
Onions	30	7	8
Chinese chives	38 *	−6	14
Green onions	21	6	18
White turnips	34 *	12	2
Carrots	25	16	−2
Baby soya beans	37 *	9	8
Fresh peas	29	14	9
Fresh broad beans	22	9	5
Yard long bean	45 *	5	1
Green beans (four-season beans)	47 *	11	2
Hyacinth beans/snow peas (Dutch peas)	35 *	9	9
Garland chrysamthemum	35 *	6	6
Shepherd’s purse	31 *	10	12
Clover	33 *	3	13

Food or food group	Factor I (vegetable)	Factor II (fruit)	Factor III (meat)
Amaranth	39 *	5	4
Apples	14	48 *	−3
Pears	15	42 *	0
Tangerines, oranges, grapefruits	14	50 *	0
Bananas	8	35 *	−2
Grapes	13	39 *	3
Watermelon	14	45 *	0
Peaches	12	36 *	1
Other fruits (e.g., strawberries, cantaloupe)	14	35 *	1
Black and white edible tree fungi	5	9	1
Dried xianggu mushrooms	12	14	4
Sea tangle	19	7	10
Sea laver	11	9	9
Milk powder	1	6	0
Preserved fruits	−2	20	7
Peanuts	11	10	13

* Factor loadings>30; factor loadings are multiplied by 100 and rounded to the nearest integer

Reference List

(1). Gurven M, Kaplan H, Winking J, Finch C, Crimmins EM. Aging and inflammation in two epidemiological worlds. J Gerontol A Biol Sci Med Sci. Feb; 2008 63(2):196–9. [PubMed: 18314457]

(2). Pou KM, Massaro JM, Hoffmann U, Vasan RS, Maurovich-Horvat P, Larson MG, et al. Visceral and subcutaneous adipose tissue volumes are cross-sectionally related to markers of inflammation and oxidative stress: the Framingham Heart Study. Circulation. Sep 11; 2007 116(11):1234–41. [PubMed: 17709633]

(3). Fogarty AW, Glancy C, Jones S, Lewis SA, McKeever TM, Britton JR. A prospective study of weight change and systemic inflammation over 9 y. Am J Clin Nutr. Jan; 2008 87(1):30–5. [PubMed: 18175734]

(4). Lao XQ, Jiang CQ, Zhang WS, Adab P, Lam TH, Cheng KK, et al. Smoking, smoking cessation and inflammatory markers in older Chinese men: The Guangzhou Biobank Cohort Study. Atherosclerosis. Mar; 2009 203(1):304–10. [PubMed: 18692847]

(5). Ryu SY, Lee YS, Park J, Kang MG, Kim KS. Relations of plasma high-sensitivity C-reactive protein to various cardiovascular risk factors. J Korean Med Sci. Jun; 2005 20(3):379–83. [PubMed: 15953856]

(6). Abramson JL, Vaccarino V. Relationship between physical activity and inflammation among apparently healthy middle-aged and older US adults. Arch Intern Med. Jun 10; 2002 162(11): 1286–92. [PubMed: 12038947]

(7). Geffken DF, Cushman M, Burke GL, Polak JF, Sakkinen PA, Tracy RP. Association between physical activity and markers of inflammation in a healthy elderly population. Am J Epidemiol. Feb 1; 2001 153(3):242–50. [PubMed: 11157411]

(8). Wannamethee SG, Lowe GD, Whincup PH, Rumley A, Walker M, Lennon L. Physical activity and hemostatic and inflammatory variables in elderly men. Circulation. Apr 16; 2002 105(15): 1785–90. [PubMed: 11956120]

(9). Verdaet D, Dendale P, De BD, Delanghe J, Block P, De BG. Association between leisure time physical activity and markers of chronic inflammation related to coronary heart disease. Atherosclerosis. Oct; 2004 176(2):303–10. [PubMed: 15380453]

(10). Rawson ES, Freedson PS, Osganian SK, Matthews CE, Reed G, Ockene IS. Body mass index, but not physical activity, is associated with C-reactive protein. Med Sci Sports Exerc. Jul; 2003 35(7):1160–6. [PubMed: 12840637]

(11). Albert MA, Glynn RJ, Ridker PM. Alcohol consumption and plasma concentration of C-reactive protein. Circulation. Jan 28; 2003 107(3):443–7. [PubMed: 12551869]

(12). Imhof A, Woodward M, Doering A, Helbecque N, Loewel H, Amouyel P, et al. Overall alcohol intake, beer, wine, and systemic markers of inflammation in western Europe: results from three MONICA samples (Augsburg, Glasgow, Lille). Eur Heart J. Dec; 2004 25(23):2092–100. [PubMed: 15571824]

(13). Volpato S, Pahor M, Ferrucci L, Simonsick EM, Guralnik JM, Kritchevsky SB, et al. Relationship of alcohol intake with inflammatory markers and plasminogen activator inhibitor-1 in well-functioning older adults: the Health, Aging, and Body Composition study. Circulation. Feb 10; 2004 109(5):607–12. [PubMed: 14769682]

(14). Levitan EB, Ridker PM, Manson JE, Stampfer MJ, Buring JE, Cook NR, et al. Association between consumption of beer, wine, and liquor and plasma concentration of high-sensitivity C-reactive protein in women aged 39 to 89 years. Am J Cardiol. Jul 1; 2005 96(1):83–8. [PubMed: 15979440]

(15). De BD, Clays E, Delanghe J, De BG. Epidemiological evidence for an association between habitual tea consumption and markers of chronic inflammation. Atherosclerosis. Dec; 2006 189(2):428–35. [PubMed: 16442546]

(16). Esmaillzadeh A, Kimiagar M, Mehrabi Y, Azadbakht L, Hu FB, Willett WC. Dietary patterns and markers of systemic inflammation among Iranian women. J Nutr. Apr; 2007 137(4):992–8. [PubMed: 17374666]

(17). Lopez-Garcia E, Schulze MB, Fung TT, Meigs JB, Rifai N, Manson JE, et al. Major dietary patterns are related to plasma concentrations of markers of inflammation and endothelial dysfunction. Am J Clin Nutr. Oct; 2004 80(4):1029–35. [PubMed: 15447916]

(18). Nanri A, Yoshida D, Yamaji T, Mizoue T, Takayanagi R, Kono S. Dietary patterns and C-reactive protein in Japanese men and women. Am J Clin Nutr. May; 2008 87(5):1488–96. [PubMed: 18469275]

(19). Yang G, Kong L, Zhao W, Wan X, Zhai Y, Chen LC, et al. Emergence of chronic non-communicable diseases in China. Lancet. Nov 8; 2008 372(9650):1697–705. [PubMed: 18930526]

(20). Gu D, Reynolds K, Duan X, Xin X, Chen J, Wu X, et al. Prevalence of diabetes and impaired fasting glucose in the Chinese adult population: International Collaborative Study of Cardiovascular Disease in Asia (InterASIA). Diabetologia. 2003; 46(9):1190–8. [PubMed: 12879248]

(21). Pearson TA, Mensah GA, Hong Y, Smith SC Jr. CDC/AHA Workshop on Markers of Inflammation and Cardiovascular Disease: Application to Clinical and Public Health Practice: overview. Circulation. Dec 21; 2004 110(25):e543–e544. [PubMed: 15611378]

(22). Jurj AL, Wen W, Xiang YB, Matthews CE, Liu D, Zheng W, et al. Reproducibility and validity of the Shanghai Men's Health Study physical activity questionnaire. Am J Epidemiol. May 15; 2007 165(10):1124–33. [PubMed: 17351289]

(23). Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. Sep; 2000 32(9 Suppl):S498–S504. [PubMed: 10993420]

(24). Shu XO, Hatch MC, Mills J, Clemens J, Susser M. Maternal smoking, alcohol drinking, caffeine consumption, and fetal growth: results from a prospective study. Epidemiology. Mar; 1995 6(2): 115–20. [PubMed: 7742395]

(25). Management of Mental Disorders. World Health Organization Collaborating Centre for Mental Health and Substance Abuse; London: 1999.

(26). Villegas R, Yang G, Liu D, Xiang YB, Cai H, Zheng W, et al. Validity and reproducibility of the food-frequency questionnaire used in the Shanghai Men's Health Study. Br J Nutr. Mar 7.2007 97:993–1000. [PubMed: 17381986]

(27). Cai H, Zheng W, Xiang YB, Xu WH, Yang G, Li H, et al. Dietary patterns and their correlates among middle-aged and elderly Chinese men: a report from the Shanghai Men's Health Study. Br J Nutr. Nov; 2007 98(5):1006–13. [PubMed: 17524168]

(28). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. Jan 10; 2004 363(9403):157–63. [PubMed: 14726171]

(29). Alberti KG, Zimmet P, Shaw J. The metabolic syndrome--a new worldwide definition. Lancet. Sep 24; 2005 366(9491):1059–62. [PubMed: 16182882]

(30). Visser M, Bouter LM, McQuillan GM, Wener MH, Harris TB. Elevated C-reactive protein levels in overweight and obese adults. Jama. Dec 8; 1999 282(22):2131–5. [PubMed: 10591334]

(31). Fried SK, Bunkin DA, Greenberg AS. Omental and subcutaneous adipose tissues of obese subjects release interleukin-6: depot difference and regulation by glucocorticoid. J Clin Endocrinol Metab. Mar; 1998 83(3):847–50. [PubMed: 9506738]

(32). Lee SA, Xu WH, Zheng W, Li H, Ya NG, Xiang YB, et al. Physical activity patterns and their correlates among Chinese men in Shanghai. Med Sci Sports Exerc. Oct; 2007 39(10):1700–7. [PubMed: 17909395]

(33). McCarty MF. Interleukin-6 as a central mediator of cardiovascular risk associated with chronic inflammation, smoking, diabetes, and visceral obesity: down-regulation with essential fatty acids, ethanol and pentoxifylline. Med Hypotheses. May; 1999 52(5):465–77. [PubMed: 10416955]

(34). Fung TT, Rimm EB, Spiegelman D, Rifai N, Tofler GH, Willett WC, et al. Association between dietary patterns and plasma biomarkers of obesity and cardiovascular disease risk. Am J Clin Nutr. 2001; 73(1):61–7. [PubMed: 11124751]

(35). Nettleton JA, Steffen LM, Mayer-Davis EJ, Jenny NS, Jiang R, Herrington DM, et al. Dietary patterns are associated with biochemical markers of inflammation and endothelial activation in the Multi-Ethnic Study of Atherosclerosis (MESA). Am J Clin Nutr. Jun; 2006 83(6):1369–79. [PubMed: 16762949]

Table 1

Participant characteristics by CRP categories

	All Participants	<=3 mg/L Normal CRP	>3 mg/L High CRP	*P trend*[+]
	N=3646	N=3267	N=376	
Age (years) mean	48	48	50	*<0.001*
Energy Intake (kcal/day) mean	1931.2	1932.1	1923.0	*0.74*
BMI[*] (Kg/m2) mean	23.3	23.1	24.9	<0.001
WHR[**] mean	0.89	0.89	0.91	<0.001
Waist circumference (cm) mean	83.7	83.2	88.5	<0.001
HDL cholesterol mmol/l	1.26	1.28	1.16	<0.001
Triglycerides mmol/l	1.90	1.80	2.69	<0.001
Current smoker (%)	75.5	75.7	75.5	0.94
Current alcohol drinker (%)	37.7	37.3	41.2	0.13
Tea consumption (%)	72.6	70.5	68.6	0.45
Exercise participation (%)	21.5	21.3	23.4	0.34
Education (%)				
None	3.1	19.2	20.0	0.16
Elementary	38.4	41.7	44.4	
High School	40.8	29.3	29.4	
College	17.7	9.7	6.1	
Income Level (%)				
<10000 Yuan/year	19.3	19.2	3.5	0.14
10000-19999 Yuan/year	42.0	41.7	43.1	
20000-29999 Yuan/year	29.3	29.3	35.6	
>30000Yuan/year	9.3	9.7	17.8	
Occupation (%)				
Professional	20.1	19.8	22.7	<0.001
Clerical	22.6	22.5	24.0	
Manual workers	57.3	57.7	53.3	
CVD[***] **(%)**	4.0	3.6	8.0	

[*] BMI: body mass index

[**] WHR: waist to hip ratio

[***] CVD cardiovascular disease.

[+] P trend calculated by chi square test for the prevalences of population characteristics, by ANOVA test for continuous variables and by Kruskal Wallis test for age (as age was not normally distributed).

Table 2

Logistic regression analysis with high CRP^+ a as the dependent variable and anthropometric measurements as the independent variables

	OR1	(95% CI)	P trend
BMI [*]			*<0.001*
BMI<23	1.00		
23-27.5	2.17	1.72-2.74	
>27.5	4.37	2.55-7.51	
High WHR [*]			*<0.001*
WHR<0.85	1.00		
WHR>=0.85	2.73	1.92-3.88	
High waist circumference [*]			
Waist<0.90	1.00		
Waist>=0.90	2.49	1.98-3.13	*<0.001*
Weight gain [**]			
<=0 kg/ 5 yr	1.00		*<0.001*
0-0.6kg/ 5 yr	2.27	1.26-4.09	
0.6-1.7 kg/ 5 yr	4.24	2.40-7.47	
1.7-2.8 kg/5 yr	5.88	3.28-10.55	
>2.8 kg/5 yr	11.80	6.48-21.49	

[+] The reference category is <=3mg/L

[*] Adjusted for age, kcal/day, alcohol consumption, smoking, tea consumption, physical activity, occupation, education, income, established CVD, and assay batch.

[**] As above plus weight at age 20 yrs

Table 3

Logistic regression analysis* with high CRP+ as the dependent variable and physical activity as the independent variable

	OR1	(95% CI)	P trend	OR2	(95% CI)	P trend
Exercise/sports-related METs						
None	1.00		*0.42*	1.00		*0.67*
<3	1.04	0.77-1.40		1.03	0.76-1.40	
3-6	0.83	0.45-1.53		0.82	0.44-1.54	
>6	0.73	0.30-1.74		0.91	0.38-2.21	
Daily living-related METs						
<3	1.00		*0.09*	1.00		*0.29*
3-6	0.94	0.70-1.26		1.01	0.7-1.36	
>6-9	0.79	0.56-1.11		0.89	0.63-1.25	
>9-12	0.85	0.57-1.27		1.00	0.66-1.50	
>12	0.70	0.44-1.11		0.79	0.49-1.26	
Commuting--related METs						
None	1.00		*0.29*	1.00		*0.35*
<3	1.08	0.80-1.46		1.10	0.81-1.49	
>=3	0.86	0.67-1.12		0.88	0.68-1.15	
Total METs						
<3	1.00		*0.01*	1.00		*0.07*
3-6	0.91	0.63-1.30		0.99	0.69-1.43	
>6-9	0.84	0.8-1.21		0.95	0.66-1.39	
>9-12	0.69	0.46-1.0		0.78	0.51-1.18	
>12	0.65	0.43-0.99		0.78	0.51-1.20	

+The reference category is <=3mg/L

OR1 Adjusted for age, kcal/day, alcohol consumption, smoking, tea consumption, occupation, education, income, CVD, and assay batch.

OR2 As above plus BMI

Table 4

Logistic regression analysis with high CRP+ as the dependent variable and smoking, alcohol intake and tea intake as the independent variables

	OR1	(95% CI)	OR2	(95% CI)
Smoking				
Never smoker	1.00		1.00	
Ex smoker	1.43	0.89-2.32	1.31	0.81-2.15
>0-10 cig/day	1.05	0.71-1.55	1.19	0.80-1.78
>10-20	1.36	0.96-1.91	1.61	1.13-2.28
>20	1.51	0.98-2.33	1.69	1.08-2.63
Alcohol intake				
Never drinkers	1.00		1.00	
Occasional/light	0.93	0.57-1.53	0.95	0.58-1.58
Moderate	1.33	1.00-1.77	1.34	1.00-1.79
Heavy	1.40	1.00-1.95	1.37	0.97-1.92
Tea intake				
Never	1.00		1.00	
<250 g/month	0.74	0.53-1.04	0.69	0.49-0.98
250 g/month	0.95	0.70-1.30	0.92	0.67-1.28
>250 g/month	1.12	0.83-1.51	1.05	0.78-1.43

+The reference category is <=3mg/L

OR1 Adjusted for age, kcal/day, occupation, education, income, physical activity, CVD, and assay batch; In addition the smoking analysis was adjusted for alcohol and tea consumption, the alcohol analysis was adjusted for smoking and tea consumption, and the tea consumption analysis was adjusted for smoking and alcohol consumption.

OR2 As above plus BMI

Table 5

Logistic regression analysis* with high CRP+ as the dependent variable and dietary patterns as the independent variables

	OR1	(95% CI)	P trend	OR2	(95% CI)	P trend
Vegetable-based pattern			*0.39*			*0.94*
Quintile 1	1.00			1.00		
Quintile 2	1.01	0.71-1.44		0.94	0.66-1.35	
Quintile 3	1.29	0.92-1.82		1.11	0.78-1.57	
Quintile 4	1.08	0.76-1.55		0.98	0.68-1.41	
Quintile 5	1.16	0.81-1.66		0.97	0.67-1.40	
Fruit-based pattern						
Quintile 1	1.00		*0.03*	1.00		*0.04*
Quintile 2	0.71	0.51-0.99		0.72	0.51-1.01	
Quintile 3	0.69	0.49-0.97		0.70	0.50-1.00	
Quintile 4	0.66	0.47-0.94		0.66	0.46-0.95	
Quintile 5	0.67	0.46-0.97		0.68	0.46-0.99	
Meat-based pattern						
Quintile 1	1.00		*0.06*	1.00		*0.06*
Quintile 2	0.88	0.62-1.25		0.93	0.65-1.34	
Quintile 3	0.94	0.66-1.35		0.98	0.68-1.42	
Quintile 4	1.23	0.86-1.75		1.25	0.87-1.80	
Quintile 5	1.30	0.89-1.91		1.34	0.91-1.99	

+The reference category is <=3mg/L

OR1 Adjusted for age, kcal/day, education, income, occupation, physical activity, smoking, alcohol consumption, tea consumption, CVD, and assay batch.

OR2 As above plus BMI