RESEARCH

Dietary fiber intake and mortality among survivors of myocardial infarction: prospective cohort study

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Abstract

Objective To evaluate the associations of dietary fiber after myocardial infarction (MI) and changes in dietary fiber intake from before to after MI with all cause and cardiovascular mortality.

Design Prospective cohort study.

Setting Two large prospective cohort studies of US women and men with repeated dietary measurements: the Nurses' Health Study and the Health Professionals Follow-Up Study.

Participants 2258 women and 1840 men who were free of cardiovascular disease, stroke, or cancer at enrollment, survived a first MI during follow-up, were free of stroke at the time of initial onset of MI, and provided food frequency questionnaires pre-MI and at least one post-MI.

Main outcome measures Associations of dietary fiber post-MI and changes from before to after MI with all cause and cardiovascular mortality using Cox proportional hazards models, adjusting for drug use, medical history, and lifestyle factors.

Results Higher post-MI fiber intake was significantly associated with lower all cause mortality (comparing extreme fifths, pooled hazard ratio 0.75, 95% confidence interval 0.58 to 0.97). Greater intake of cereal fiber was more strongly associated with all cause mortality (pooled hazard ratio 0.73, 0.58 to 0.91) than were other sources of dietary fiber. Increased fiber intake from before to after MI was significantly associated with lower all cause mortality (pooled hazard ratio 0.69, 0.55 to 0.87).

Conclusions In this prospective study of patients who survived MI, a greater intake of dietary fiber after MI, especially cereal fiber, was inversely associated with all cause mortality. In addition, increasing consumption of fiber from before to after MI was significantly associated with lower all cause and cardiovascular mortality.

Introduction

Diet plays an important role in the etiology of atherosclerosis and coronary heart disease,[1] yet secondary prevention guidelines generally emphasize pharmacological management owing to the lack of evidence to guide diet and lifestyle recommendations.[2-8] The need for better lifestyle guidelines for survivors of myocardial infarction (MI) is profound especially because a substantial drop in the case fatality rate has increased the number of survivors in the United States.[9] Compared with the general population, this growing patient population is at higher risk for mortality and may be more motivated to change their lifestyle habits. Evidence as to whether and to what extent dietary changes from before to after MI improve prognosis is, however, insufficient.

Greater intake of dietary fiber improves glycemic response and insulin sensitivity, increases the production of short chain fatty acids, and increases satiety to help control overall energy intake.[10 11] Dietary fiber is inversely associated with risk of dyslipidemia, hypertension, obesity, diabetes, peripheral vascular disease, coronary heart disease, and stroke.[12-17]

The Diet and Reinfarction Trial (DART), the only clinical trial of dietary fiber intake among 2033 male survivors of MI, did not show a lower rate of coronary and total deaths with increased fiber intake during two years of follow-up after MI.[18 19] However, the study was limited by the short duration of follow-up, poor compliance to the dietary intervention, and generalizability of

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the patient population. The DART trial was also conducted almost 30 years ago. With more sensitive diagnostic criteria for onset of MI and greater advances in clinical management, the population of survivors of MI now differs from those at that time. Thus, it is unknown what the long term impact of diet and lifestyle change may have in a contemporary post-MI population.

The Nurses' Health Study (NHS) and the Health Professional Follow-up Study (HPFS) are two large prospective cohort studies of US women and men with repeated dietary measurements both before and after MI. Using data from these two cohorts, we evaluated the association of dietary fiber intake during the post-MI period, pre-MI period, and changes from before to after MI on survival.

Methods

Study population

The Nurses' Health Study is a prospective cohort of 121 700 US registered female nurses, aged 30-55 years in 1976. The Health Professional Follow-up Study is a prospective cohort of 51 529 US male health professionals, aged 40-75 years in 1986. In both studies the participants received detailed biennial questionnaires on lifestyle and medical history.

We assessed diet and lifestyle characteristics among 2639 women and 2081 men who were free of cardiovascular disease, stroke, or cancer at enrollment (1976 for women and 1986 for men), survived a first MI during the follow-up through 2008, and were free of stroke at the time of initial onset of MI. The pre-MI period was defined as the time between the study enrollment and the return of the last food frequency questionnaire before the onset of MI. The post-MI period was the time from the date of the first food frequency questionnaire (FFQ) returned after the initial onset of MI until death or the end of the study period, whichever occurred first.

From the incident non-fatal MI events, we restricted our analysis to participants who provided both pre-MI exposure information and at least one post-MI food frequency questionnaire (2258 for women and 1840 for men). We excluded participants (381 for women and 241 for men; see supplementary table) who died before the return of the first post-MI food frequency questionnaire or whose post-MI dietary assessment was incomplete.

Exposure assessment

Dietary habits were assessed with a validated food frequency questionnaire every four years from 1976-2006 for the Nurses' Health Study and from 1986-2006 for the Health Professionals Follow-up Study. The food frequency questionnaire assesses average food intake over the previous year. Consumption of each food is based on a commonly used unit or portion size, with nine possible response categories of intake frequency, ranging from "never" to "6 or more times per day." Each category is assigned a weight representing the midpoint of that category. Estimates from the food frequency questionnaire adequately reflect long term average dietary fiber intake based on several weeks of formal diet records (r=0.68 for dietary fiber, r=0.79 for cold breakfast cereal, the major source of fiber in these two populations).[20-22]

We obtained the dietary fiber content of foods from the Harvard food composition database, which is a compilation of data from the United States Department of Agriculture, the published literature, food manufacturers, and outside consultation with experts. We calculated energy adjusted values for all nutrients including fiber to estimate the composition of dietary fiber in the diet, independent of the total quantity of food reported.[23]

Identification of incident MI

After participants self reported an incident MI, we sent them a computer generated personalized letter requesting permission to access their medical records. For non-respondents (<5% of all men and women reporting a non-fatal MI), a research nurse telephoned them to obtain further details on their diagnosis and to seek permission for their medical records to be reviewed. Study physicians reviewed the records blinded to the participants' exposure status. Myocardial infarction was confirmed according to symptoms plus either diagnostic electrocardiographic changes or increased levels of cardiac enzymes, including cardiac specific troponin.[24]

Outcome assessment

Our primary outcomes were all cause and cardiovascular mortality. We identified deaths occurring after the first non-fatal MI during follow-up from vital records, the national death index, and reports by the participant's next of kin, or the postal system.[25] Our outcome of cardiovascular mortality consisted of fatal MI, fatal stroke, and coronary heart disease, which were confirmed through a review of medical records or autopsy reports with the permission of the next of kin.

Covariate assessment

Covariates were chosen a priori based on previous studies. We considered dietary covariates, medication use, medical history, and lifestyles factors. Covariates were assessed from the questionnaire immediately preceding the initial onset of MI and updated with each subsequent questionnaire cycle. In the Health Professionals Follow-up Study, we also considered detailed clinical characteristics obtained through medical chart review, including ST segment elevation MI (yes or no), site of initial MI (anterior, inferior, and other), revascularization at the time of MI (primary angioplasty or thrombolytic therapy, versus none), left ventricular ejection fraction (≥40%, <40%, or missing), initial creatinine levels (continuous), and heart failure during hospital stay (yes or no).

We included known predictors of MI survival and potential confounders that changed the β coefficient by at least 10%. In the final model, covariates not included due to limited evidence of confounding were family history of MI, hypercholesterolemia, height, protein intake, polyunsaturated fat intake, multivitamin use, glycemic index, site of MI, ST elevation, and initial creatinine level.

Statistical analysis

We defined change of dietary fiber from before to after MI as the absolute difference between energy adjusted fiber intake from the first post-MI food frequency questionnaire and the most recent pre-MI food frequency questionnaire. We considered both simple updated and cumulative average of fiber intake as described elsewhere[26] and presented simple updated analyses because of similar results. For missing data in the exposure and covariates, we carried forward the value reported in the previous post-MI questionnaire cycle.

We used a Cox proportional hazards model with time since return of the first post-MI food frequency questionnaire as the underlying time scale. Person months were calculated from the date of the first food frequency questionnaire returned after initial MI until death or the end of study period, whichever came

first. We also evaluated the association between pre-MI fiber intake with post-MI survival starting at the date of initial onset of MI. The proportional hazards assumption was tested by modeling multiplicative interaction terms between time and the primary exposure variable. For analyses of trends, we fit medians of each fifth as a continuous variable.

To evaluate potential survivor bias related to the requirement that each participant had to have at least one post-MI dietary assessment, we estimated the probability of not being missing, and then reweighted the study population by the inverse of this probability.[27]

For the association between post-MI dietary fiber and mortality, we tested for possible effect modification by body mass index (<25 or ≥25 kg/m²), physical activity level (highest two fifths versus lowest three fifths), and glycemic load (thirds) using the likelihood ratio test. Because previous studies suggest a potential interaction between fiber intake and lipid lowering medications,[28] we also explored interactions with aspirin use (yes, no) and use of lipid lowering medications (yes, no). We performed analyses in men and women separately and evaluated heterogeneity of results using the Cochrane Q statistics.[29] To pool results across the sexes, we used fixed effect models in the absence of significant heterogeneity, and random effect models otherwise.[30 31]

Dietary habits pre-MI (habitual diet) might affect post-MI survival. We tested the hypothesis of a "carry-over effect" of the pre-MI diet on post-MI mortality, adjusting for covariates from the period before MI. To examine the association between changes in dietary fiber in the period from before to after MI and survival, we also adjusted for changes in covariates during that period. For models with missing covariates, we tested three different methods (missing indicator, imputed with median, and assuming no change from before to after MI periods) with similar results, and therefore we present only the results using the missing indicator method. We also modeled fiber intake by nine subgroups of pre-MI (thirds) and post-MI fiber intake (thirds) and used the likelihood ratio test to examine the interaction between pre-MI and post-MI intake.

To ensure that the food frequency questionnaire only reflected post-MI intake, we conducted sensitivity analyses that only included participants whose first post-MI food frequency questionnaire was returned at least 12 months after initial MI. We additionally adjusted for β blocker use during the post-MI period. Because lack of physical activity may indicate frailty and severity of diseases, we also performed further sensitivity analyses adjusting for physical activity with a two year lag or excluding participants in the lowest fifth of physical activity. We performed all statistical analyses using the Statistical Analysis System 9.2 (SAS Institute).

Results

During 32 years of follow-up in women and 22 years in men, we documented 2258 women and 1840 men with incident MI and dietary assessments both before and after MI. Table 1⇓ summarizes the age standardized baseline characteristics of the study population by fifths of energy adjusted fiber intake, with baseline defined as the first questionnaire cycle post-MI.

The median follow-up post-MI was 8.7 years for women and 9.0 years for men. During the follow-up, we confirmed 682 total and 336 cardiovascular deaths for women, and 451 total and 222 cardiovascular deaths for men.

Higher post-MI fiber intake was significantly associated with lower all cause mortality in age adjusted models for both men

and women (table 2⇓). Further adjustment for lifestyle characteristics and dietary factors attenuated these associations, but the pooled hazard ratio remained significantly inverse (table 2). When we modeled fiber as a continuous variable, the pooled hazard ratio was 0.85 (95% confidence interval 0.74 to 0.97) for total mortality for a 10 g/day increment in intake. Our results were similar after using inverse probability weighting to account for potential selection bias (comparing extreme fifths, pooled hazard ratio 0.89, 0.74 to 1.07, P for heterogeneity=0.13). Further adjustment for pre-MI diet did not substantially alter associations for post-MI diet.

To evaluate whether the association differed by fiber type, we jointly examined cereal fiber, fruit fiber, and vegetable fiber. Only intake of cereal fiber was strongly inversely associated with lower all cause and cardiovascular mortality: pooled hazard ratio 0.73 (0.58 to 0.91) for all cause mortality, 0.72 (0.52 to 0.99) for cardiovascular mortality (figure⇓).

No significant effect modification by body mass index, physical activity level, glycemic load, aspirin or lipid lowering medication use was observed. Results were also similar after excluding participants with food frequency questionnaires returned within 12 months of initial onset of MI, excluding participants in the lowest fifth of physical activity, using a two year lag for physical activity or additionally adjusting for β blocker use (data not shown).

Pre-MI dietary fiber was not associated with post-MI mortality (highest fifth versus lowest fifth, pooled hazard ratio 1.17, 0.92 to 1.48 for all cause mortality and 1.10, 0.77 to 1.55 for cardiovascular mortality).

We also examined associations for change in fiber intake from before to after MI. Participants on average increased their fiber intake from the before to after MI period (table 3⇓). Spearman correlations for fiber intake between pre-MI and the first post-MI were 0.48 for women and 0.53 for men. A greater increase in fiber intake was significantly associated with lower all cause and cardiovascular mortality in both sexes. Compared with participants who were in the lowest third of fiber intake in both pre-MI and post-MI periods, participants in the highest third in both periods had the lowest all cause mortality: hazard ratio 0.73 (95% confidence interval 0.54 to 0.99), P for interaction=0.01 for women, and 0.81 (0.58 to 1.13), P for interaction=0.16 for men.

Discussion

In this prospective study of dietary intake after myocardial infarction (MI), greater intake of dietary fiber, especially cereal fiber, was inversely associated with all cause mortality. Participants increased their average dietary fiber intake after MI, and the greater the increase, the lower was the risk of subsequent all cause and cardiovascular mortality. Overall, the benefits for increased fiber intake were strongest for fiber from cereal and grain sources.

Possible mechanisms for the beneficial effects of a high fiber diet on coronary heart disease risk and mortality include reductions in systemic inflammation, lower serum low density lipoprotein cholesterol level, reduced lipid peroxidation, improved insulin sensitivity, overall better glycemic control, and a beneficial gut microbiota environment.[32-34] Many biomarkers for these pathways have been studied in the prediction of incident coronary heart disease, but few with the exception of hyperlipidemia or inflammation have been examined in patients post-MI.[35-40] It is likely that these mechanisms would be similar in the post-MI environment, but

mechanisms to explain lower overall mortality have not been as thoroughly explored.

The benefits of fiber we observed were mainly from cereal and grain sources. In the general population, a 20-40% risk reduction in coronary heart disease has consistently been observed among those who consume fiber-rich whole grains regularly,[13] yet less than 5% of Americans consume the minimum recommended fiber intake of 25 g/day for women and 38 g/day for men.[41] In our study, the association with all cause mortality was stronger than with cardiovascular mortality. This may occur because patients who have experienced MI are initially and increasingly targeted for intensive medical and therapeutic management to reduce their risk of recurrent cardiovascular events, and less so for the many other causes of death. Because dietary fiber has broad effects on other causes of death, our results may reflect the success of secondary prevention in the past two decades.

Our results differ from the original DART trial, which is the only existing study on dietary fiber in secondary prevention. The DART trial showed that a high cereal fiber diet post-MI did not reduce mortality among men only.[18 19] In that study, 2033 survivors of MI under age 70 (mean age 56.5 years) were randomly assigned to dietary interventions that consisted of counseling to consume either a low fat diet with a high polyunsaturated to saturated fat ratio, a high fatty fish diet, or a diet with a target of 18 g/day of cereal fiber and 30 g/day of total dietary fiber.[19] After two years of follow-up, self reported compliance was good, but no objective measure of fiber intake was assessed.[18] Based on the reported average intake from dietary questionnaires at six months, only 50% of the population achieved the target of 18 g/day of cereal fiber,[18 19] and even fewer reached the fiber target. Interestingly, when recontacted approximately 10 years later, the 50% of DART participants still alive reported noticeably reduced intake of cereal fiber (6.2 g/day in the intervention arm and 5.0 g/day in the control arm), and there was no difference in mortality between the two groups.[42] Thus it is likely that compliance was a major challenge in this trial. Finally, participants were excluded at baseline if they were already on a high cereal fiber diet or had the intention to change to such a diet, leaving a study population of participants less likely to comply. Thus, with short follow-up, modest compliance, and a highly selective population, it is difficult to generalize the null results from DART trial to our free-living population with almost a decade of follow-up, a broader age range, and no restraints on baseline diet at enrollment. The PREDIMED (Prevencion con Dieta Mediterranea) study provided convincing evidence for the beneficial effects of the Mediterranean diet, high in monounsaturated fats from nuts and extra virgin olive oil and rich in fruits, vegetables, legumes, and non-refined grains, on cardiovascular risk reduction.[43 44] Although it is not possible to identify the specific aspects of the PREDIMED diets that reduced cardiovascular disease, increasing fiber intake may have contributed.

Limitations of this study

Our study has several limitations. Firstly, our food frequency questionnaire is a reliable measure for assessing dietary intake in the previous year,[20-46] but its validity is not known for measuring intake within the same person before and after MI. The time interval for the food frequency questionnaires covering the period between before and after MI could be up to eight years. However, our results were similar after sensitivity analyses excluding patients with missing information on the first post-MI food frequency questionnaire.

Our results may be confounded by beneficial factors related to fiber intake; foods that are high in fiber, such as whole grains, fruits, and vegetables, also contain vitamins, minerals, antioxidants, and phytochemicals, which may also be beneficial for health. Medication use and severity of the initial MI are also potential unmeasured confounders. Patients who consumed a high fiber diet or changed to a high fiber diet after MI may also have changed to many other healthy lifestyle factors post-MI, which lowered subsequent mortality rates. We adjusted for major confounders in our analyses, such as medication use, other dietary factors, and physical activity using data from questionnaires administered at the same time as the post-MI food frequency questionnaire. Despite the adjustment in our pooled analysis, a higher fiber diet post-MI was associated with long term reduced mortality. We also had a relatively homogeneous population of health professionals, thus further reducing potential residual confounding by unmeasured factors associated with socioeconomic status. For changes in fiber from before MI to after MI analyses, we cannot fully adjust for all known or unknown healthy lifestyle changes, and results may still be subject to modest residual and unmeasured confounding. We conducted sensitivity analyses using medication non-compliance as a potential unknown residual confounder (see web extra appendix). We found that the relative risk was only meaningfully attenuated in extreme conditions where the association of medication non-compliance and fiber intake is strong (40-45% difference in adherence prevalence) and where the association with non-compliance and mortality is strong (relative risk 2-3). We believe this is unlikely to occur because these strong associations would need to be independent of known covariates already in our model. Unfortunately, few large studies of clinical populations include the detailed dietary information necessary for confirmation of our findings.

This study was limited to participants who had at least one before MI and one after MI food frequency questionnaire. Participants who died before the return of the first post-MI questionnaire or did not return a post-MI one were not included in the study. This could introduce a selection bias by excluding patients who may be least sensitive to the benefits of dietary modification. We used the inverse probability weighting method to assess the impact of this bias and found that the results were essentially unchanged.

Even with two of the largest long term prospective cohorts of post-MI, we still had limited power to examine cause specific mortality. We also were not able to examine optimal timing for change in diet or potential interactions between dietary fiber and post-MI medications. Future research on lifestyle changes post-MI should focus on a combination of lifestyle changes and how they may further reduce mortality rates beyond what is achievable by medical management alone.

Our analyses should be viewed in the context of recent concerns about unrealistic findings in nutritional epidemiology.[47] Randomized trials of specific dietary factors could be problematic and are subject to serious difficulties and bias due to non-compliance and attrition and can rarely test all hypothesis based research questions. As a result, our findings, in conjunction with feeding studies, other observational data, and the success of nutritional interventions in post-MI care suggested by the Lyon Heart Study, provide robust evidence of the benefits of fiber for the large population of survivors of MI.

Strengths of this study

The strengths of our study include the large sample size and long duration of follow-up from two prospective cohort studies,

with follow-up rates in excess of 90% in each two year cycle. Our study measured dietary intake repeatedly in both before MI and after MI periods to reduce measurement error, and used validated lifestyle questionnaires to assess other important risk factors for survival.

Conclusion

Greater intake of dietary fiber after MI, especially cereal fiber, was inversely associated with all cause and cardiovascular mortality. In addition, participants who increased their dietary fiber intake after MI had lower long term rates of all cause and cardiovascular mortality.

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What is already known on this topic

Dietary fiber is associated with lower risk of coronary heart disease in healthy populations

It is unclear whether higher consumption of dietary fiber after myocardial infarction (MI) is associated with lower mortality

What this study adds

In this prospective study of survivors after MI, a greater intake of dietary fiber, especially cereal fiber, after MI was inversely associated with all cause mortality

In addition, increasing consumption of fiber from the period before to after MI was significantly associated with a 31% lower all cause mortality and 35% lower cardiovascular mortality

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Tables

Table 1| Age standardized baseline characteristics of 2258 women in the Nurses' Health Study and 1840 men in the Health Professional Follow-up Study by fifths of fiber intake after initial myocardial infarction (MI). Values are percentages unless stated otherwise

Characteristics	Women			Men		
	Lowest fifth	Third fifth	Highest fifth	Lowest fifth	Third fifth	Highest fifth
No of participants	433	437	457	367	373	358
Mean (SD) post-MI fiber intake*	12.4 (2.0)	19.2 (0.8)	28.7 (4.4)	16.0 (2.4)	24.4 (1.0)	37.0 (5.8)
Mean (SD) pre-MI fiber intake†	14.0 (4.6)	17.5 (4.6)	22.2 (6.6)	17.3 (4.9)	22.3 (5.6)	27.8 (8.3)
Mean (SD) change from before to after MI‡	–1.6 (4.5)	1.7 (4.5)	6.5 (6.7)	–1.3 (4.6)	2.1 (5.6)	9.2 (9.0)
Mean (SD) age at diagnosis (years)§	64.5 (8.8)	64.9 (8.5)	65.1 (8.2)	65.8 (9.5)	66.1 (8.9)	66.1 (8.9)
Mean (SD) body mass index (kg/m²)	26.3 (5.4)	27.6 (6.2)	26.3 (5.2)	26.4 (3.7)	26.1 (3.6)	25.6 (3.7)
Mean (SD) physical activity (MET h/wk)	9.4 (13.5)	13.4(18.4)	20.1 (20.8)	25.9 (33.6)	37.0 (54.0)	40.4 (35.0)
Smoking status:						
Never smoker	25	30	38	28	36	41
Former smoker	51	61	58	54	52	47
Current smoker	24	9	4	9	4	1
Married	64	69	69	85	90	88
Diabetes	19	27	24	13	13	15
High blood pressure	67	74	70	59	58	50
Increased cholesterol level	71	80	79	68	63	64
Aspirin use	61	62	64	78	82	81
Lipid lowering drug use	42	50	55	48	57	50
CABGS	53	53	63	70	76	74
Reproductive factors:						
Premenopause	5	4	4	Not applicable	Not applicable	Not applicable
Past PMH user	29	29	28	Not applicable	Not applicable	Not applicable
Current PMH user	57	57	64	Not applicable	Not applicable	Not applicable
Dietary intake:						
Mean (SD) total energy (kcal/d)	1619 (538)	1637 (526)	1592 (518)	1878 (620)	1946 (646)	1925 (621)
Mean (SD) saturated fat (% of energy)	11.1 (3.2)	9.2 (2.3)	7.0 (2.1)	10.8 (3.0)	8.8 (2.4)	6.1 (2.0)
Mean (SD) n-3 fatty acids (% of energy)	0.7 (0.3)	0.7 (0.3)	0.8 (0.4)	0.7 (0.5)	0.7 (0.3)	0.9 (0.6)
Mean (SD) *trans* fatty acid (% of energy)	1.8 (0.8)	1.5 (0.5)	1.0 (0.5)	1.8 (0.8)	1.5 (0.6)	0.9 (0.5)
Mean (SD) alcohol (g/d)	6.0 (12.8)	4.3 (9.1)	2.9 (5.4)	13.4 (17.1)	9.1 (12.3)	6.3 (10.3)
Mean (SD) folate (µg/d)	389 (229)	488 (262)	613 (294)	542 (318)	699 (331)	874 (449)
Mean (SD) cereal fiber (g/d)	4.0 (1.7)	5.9 (2.2)	8.4 (4.0)	5.3 (2.1)	7.8 (2.8)	11.2 (4.8)
Mean (SD) fruit fiber (g/d)	1.3 (0.6)	4.0 (0.4)	8.7 (2.6)	1.8 (0.7)	5.1 (0.5)	11.4 (3.5)
Mean (SD) legume fiber (g/d)	0.2 (0.1)	1.0 (0.1)	3.4 (1.6)	0.4 (0.3)	1.7 (0.2)	5.3 (2.1)
Clinical characteristics:						
Heart failure	Not available	Not available	Not available	8	9	8
Received acute therapy during hospital stay	Not available	Not available	Not available	34	34	36
Anterior MI	Not available	Not available	Not available	39	48	45
ST elevation MI	Not available	Not available	Not available	42	40	43
Normal left ventricular ejection fraction	Not available	Not available	Not available	84	80	80

Table 1 (continued)

Characteristics	Women			Men		
	Lowest fifth	Third fifth	Highest fifth	Lowest fifth	Third fifth	Highest fifth

Nutrients were energy adjusted.

MET=metabolic equivalent task; CABGS=coronary artery bypass surgery; PMH=postmenopausal hormone use.

*Baseline diet factors are taken from participant's first post-MI food frequency questionnaire; Lifestyle factors are taken from corresponding questionnaire by date of first post-MI food frequency questionnaire.

†Pre-MI diet is taken from participant's most recent food frequency questionnaire before initial MI onset.

‡Change of diet from pre-MI to post-MI is calculated as change=(post-MI diet–pre-MI diet).

§Age is not age standardized.

Table 2| Multivariate adjusted hazard ratios for all cause and cardiovascular mortality according to fiber intake after initial myocardial infarction (MI)

Estimates	Continuous (per 10 g increment)	Fifths of fiber intake after MI					P for trend
		First (lowest)	Second	Third	Fourth	Fifth (highest)	
All cause mortality							
Women (n=682):							
Median intake (g/day)	—	12.95	16.54	19.12	22.33	27.40	—
Cases/person year	—	173/4183	150/4247	123/4171	134/4195	102/4214	—
Basic model adjusted hazard ratio (95% CI)*	0.65 (0.56 to 0.76)	1.00	0.85 (0.68 to 1.07)	0.67 (0.53 to 0.85)	0.74 (0.58 to 0.93)	0.50 (0.39 to 0.64)	<0.0001
Multivariate adjusted hazard ratio (95% CI)†	0.82 (0.68 to 1.00)	1.00	0.94 (0.74 to 1.20)	0.80 (0.61 to 1.04)	0.98 (0.74 to 1.30)	0.71 (0.51 to 0.98)	0.07
Men (n=451):							
Median intake	—	16.34	20.90	24.36	28.50	35.60	—
Cases/person year	—	104/3206	92/3216	93/3229	83/3206	79/3212	—
Basic model adjusted hazard ratio (95% CI)*	0.79 (0.68 to 0.91)	1.00	0.85 (0.64 to 1.13)	0.80 (0.60 to 1.07)	0.64 (0.48 to 0.87)	0.63 (0.47 to 0.86)	0.0008
Multivariate adjusted hazard ratio (95% CI)†	0.88 (0.72 to 1.07)	1.00	1.03 (0.75 to 1.42)	0.99 (0.71 to 1.38)	0.85 (0.59 to 1.23)	0.82 (0.54 to 1.25)	0.25
Pooled multivariate adjusted hazard ratio (95% CI)	0.85 (0.74 to 0.97)‡	1.00	0.97 (0.80 to 1.18)	0.87 (0.71 to 1.07)	0.93 (0.74 to 1.16)	0.75 (0.58 to 0.97)§	0.03
Cardiovascular mortality							
Women (n=336):							
Median intake	—	12.95	16.54	19.12	22.33	27.40	—
Cases/person year	—	80/4183	76/4247	56/4171	76/4195	48/4214	—
Basic model adjusted hazard ratio (95% CI)*	0.71 (0.58 to 0.88)	1.00	0.93 (0.67 to 1.28)	0.65 (0.46 to 0.93)	0.93 (0.67 to 1.28)	0.55 (0.38 to 0.79)	0.003
Multivariate adjusted hazard ratio (95% CI)†	0.95 (0.71 to 1.25)	1.00	1.00 (0.70 to 1.42)	0.74 (0.50 to 1.10)	1.27 (0.86 to 1.88)	0.85 (0.54 to 1.35)	0.83
Men (n=222):							
Median intake	—	16.34	20.90	24.36	28.50	35.60	—
Cases/person year	—	46/3206	47/3216	47/3229	41/3206	41/3212	—
Basic model adjusted hazard ratio (95% CI)*	0.82 (0.67 to 1.00)	1.00	0.96 (0.63 to 1.46)	0.89 (0.58 to 1.35)	0.71 (0.46 to 1.10)	0.73 (0.47 to 1.12)	0.07
Multivariate adjusted hazard ratio (95% CI)†	0.87 (0.66 to 1.16)	1.00	1.09 (0.68 to 1.73)	0.93 (0.57 to 1.52)	0.85 (0.49 to 1.45)	0.89 (0.49 to 1.61)	0.52
Pooled multivariate adjusted hazard ratio (95% CI)	0.91 (0.75 to 1.11)¶	1.00	1.03 (0.78 to 1.37)	0.81 (0.60 to 1.10)	1.11 (0.81 to 1.52)	0.87 (0.60 to 1.24)**	0.46

*Adjusted for time since MI onset, age at diagnosis (continuous), and calendar year.

†Additionally adjusted for total caloric intake (fifths of kcal), physical activity (fifths of metabolic equivalents/week), aspirin use (yes or no), diabetes (yes or no), high blood pressure (yes or no), use of lipid lowering drugs (yes or no), alcohol consumption (0 g/day; 0.1-9.9 g/day; 10-29.9 g/day; or ≥30 g/day), saturated fat intake (fifths of % of total energy), n3 fatty acid intake (fifths of % of total energy), *trans* fatty acid intake (fifths of % of total energy), married (yes or no), body mass index (<21; 21-22.9; 23-24.9; 25-27.4; 27.5-29.9; >30 kg/m^2), coronary artery bypass surgery (yes or no), folate intake (fifths of µg/day), and pre-MI intake (fifths). For women, additionally adjusted for smoking (never or missing; former; current, 1-14 cigarettes/day; current, 15-24 cigarettes/day; or current, ≥25 cigarettes/day), status for postmenopausal hormone use (premenopause; never user; current user; former user).

For men, additionally adjusted for smoking (never or missing; former; current, <15 cigarettes/day; or current, ≥15 cigarettes/day), heart failure (yes or no), left ventricular ejection fraction (≥40%, <40%, or missing), and acute therapy during admission to hospital (angioplasty or thrombolytics, or none).

‡P=0.62 for heterogeneity.

§P=0.59 for heterogeneity.

¶P=0.66 for heterogeneity.

**P=0.90 for heterogeneity.

Table 3| Multivariate adjusted hazard ratios for all cause and cardiovascular mortality according to changes of fiber intake from period before to after myocardial infarction (MI)

Estimates	Continuous (per 10 g increment)	Fifths of changes of fiber intake from period before to after MI					P for trend
		First (lowest)	Second	Third	Fourth	Fifth (highest)	
All cause mortality							
Women (n=682):							
Median change		–3.85	0.20	2.76	5.48	9.87	
Cases/person year		189/4206	126/4209	120/4202	123/4196	124/4196	
Basic model adjusted hazard ratio (95% CI)*	0.69 (0.59 to 0.80)	1.00	0.66 (0.52 to 0.84)	0.61 (0.48 to 0.77)	0.61 (0.48 to 0.77)	0.58 (0.46 to 0.74)	<0.0001
Multivariate adjusted hazard ratio (95% CI)†	0.73 (0.60 to 0.88)	1.00	0.69 (0.53 to 0.89)	0.72 (0.55 to 0.93)	0.65 (0.49 to 0.86)	0.64 (0.48 to 0.86)	0.005
Men (n=451):							
Median change		–4.90	0.02	3.05	6.30	11.63	
Cases/person year		104/3206	92/3216	93/3229	83/3206	79/3212	
Basic model adjusted hazard ratio (95% CI)*	0.84 (0.72 to 0.98)	1.00	1.01 (0.76 to 1.35)	0.95 (0.71 to 1.27)	0.83 (0.62 to 1.12)	0.77 (0.57 to 1.04)	0.04
Multivariate adjusted hazard ratio (95% CI)†	0.82 (0.68 to 1.00)	1.00	0.97 (0.71 to 1.33)	0.88 (0.63 to 1.23)	0.86 (0.61 to 1.20)	0.76 (0.53 to 1.10)	0.11
Pooled multivariate adjusted hazard ratio (95% CI)	0.77 (0.68 to 0.90)‡	1.00	0.80 (0.65 to 0.97)	0.78 (0.63 to 0.96)	0.73 (0.58 to 0.90)	0.69 (0.55 to 0.87)§	0.002
Cardiovascular mortality							
Women (n=336):							
Median change		–3.85	0.20	2.76	5.48	9.87	
Cases/person year		88/4206	58/4209	59/4202	70/4196	61/4196	
Basic model adjusted hazard ratio (95% CI)*	0.72 (0.58 to 0.90)	1.00	0.59 (0.42 to 0.83)	0.59 (0.42 to 0.83)	0.63 (0.46 to 0.88)	0.54 (0.38 to 0.76)	0.001
Multivariate adjusted hazard ratio (95% CI)†	0.83 (0.63 to 1.09)	1.00	0.62 (0.42 to 0.91)	0.69 (0.47 to 1.02)	0.68 (0.46 to 1.01)	0.65 (0.42 to 0.99)	0.09
Men (n=222):							
Median change		–4.90	0.02	3.05	6.30	11.63	
Cases/person year		46/3206	47/3216	47/3229	41/3206	41/3212	
Basic model adjusted hazard ratio (95% CI)*	0.79 (0.64 to 0.97)	1.00	0.98 (0.66 to 1.47)	0.80 (0.53 to 1.20)	0.68 (0.45 to 1.05)	0.75 (0.49 to 1.12)	0.06
Multivariate adjusted hazard ratio (95% CI)†	0.72 (0.54 to 0.94)	1.00	0.91(0.58 to 1.41)	0.66 (0.41 to 1.05)	0.59 (0.36 to 0.97)	0.65 (0.39 to 1.08)	0.04
Pooled multivariate adjusted hazard ratio (95% CI)	0.72 (0.61 to 0.84)¶	1.00	0.74 (0.55 to 0.98)	0.69 (0.51 to 0.93)	0.64 (0.47 to 0.87)	0.65 (0.47 to 0.90)**	0.01

*Adjusted for time since MI onset, age at diagnosis (continuous), and calendar year.

†Additionally adjusted for aspirin use (never, new, always), diabetes (no, new, always), high blood pressure (no, new, always), use of lipid lowering drugs (never, new, always), married (never, always, not anymore), coronary artery bypass surgery (never, always, new), changes in smoking status (always never, always past, always current 1-14 cigarettes/day post-MI period, always current ≥15 cigarettes/day post-MI period, quit smoking after MI 1-14 cigarettes/day pre-MI period, quit smoking after MI ≥15 cigarettes/day pre-MI period), and pre-MI fiber intake (fifths).

For women, additionally adjusted for changes in total caloric intake (fifths of kcal), changes in physical activity (fifths of changes in metabolic equivalents/week), changes in alcohol consumption (fifths of changes in g/day), changes in body mass index (fifths of changes in kg/m^2), changes in saturated fat intake(fifths of changes in % of total energy), changes in n3 fatty acid intake (fifths of changes in % of total energy), changes in *trans* fatty acid intake (fifths of changes in % of total energy), changes in folate intake (fifths of changes in µg/day), and status of postmenopausal hormone use (premenopause, never, current, former).

For men, additionally adjusted for: changes in total caloric intake (thirds of kcal), changes in physical activity (thirds of changes in metabolic equivalents/week), changes in alcohol consumption (thirds of changes in g/day), changes in body mass index (thirds of changes in kg/m^2), changes in saturated fat intake (thirds of changes in % of total energy), changes in n3 fatty acid intake (thirds of changes in % of total energy), changes in *trans* fatty acid intake (thirds of changes in % of total energy), changes in folate intake (thirds of changes in µg/day), heart failure (yes or no), left ventricular ejection fraction (≥40%, <40%, or missing), and acute therapy during admission to hospital (received angioplasty or thrombolytics, or none).
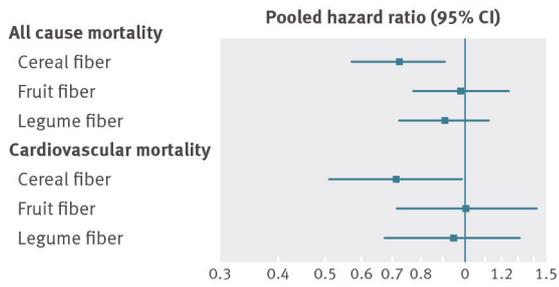
‡P=0.35 for heterogeneity.

§P=0.47 for heterogeneity.

Table 3 (continued)

Estimates	Continuous (per 10 g increment)	Fifths of changes of fiber intake from period before to after MI					P for trend
		First (lowest)	Second	Third	Fourth	Fifth (highest)	

¶P=0.53 for heterogeneity.

**P=1.00 for heterogeneity.

Figure

Pooled hazard ratios for all cause and cardiovascular mortality according to intake of fiber from cereal, fruits, and legumes in post-MI period (highest fifth versus lowest fifth). See footnote to table 2 for all adjustment variables