Heart rate, employment status, and prevalent ischaemic heart disease confound relation between cereal fibre intake and blood pressure

MICHAEL J LICHTENSTEIN,¹ MICHAEL L BURR,² ANN M FEHILY,² AND JOHN W G YARNELL²

From the Division of General Internal Medicine,¹ B-2106 Medical Center North, Vanderbilt University Medical Center, Nashville, Tennessee 3732 USA; and the MRC Epidemiology Unit,² 4 Richmond Road, Cardiff CF2 3AS, Wales

SUMMARY Cross sectional data from a survey of 2512 men aged 45–49 years were used to examine the confounding effects of heart rate, employment, and ischaemic heart disease (IHD) on the relation between cereal fibre intake and blood pressure. Daily cereal fibre intake (g/day) was associated with systolic pressure ($r = -0.053$, $p < 0.01$), diastolic pressure ($r = -0.057$, $p < 0.01$), and heart rate ($r = -0.071$, $p < 0.01$). The associations were strengthened in employed men and inapparent in unemployed men. Unemployed men had more IHD than employed men. Persons with any manifestation of IHD had significantly higher blood pressure and heart rates but ate less cereal fibre (7.0 v 7.9 g/day, $p < 0.001$) than those without IHD, regardless of employment status. In employed men, after adjustment for age, body mass index, prevalent IHD, and heart rate, systolic pressure changed -0.186 mmHg (95% CI = -0.362 , -0.009) and diastolic pressure changed -0.111 mmHg (95% CI = 0.228 , 0.005) for each gram of cereal fibre eaten daily. The association between cereal fibre intake and blood pressure was inapparent in unemployed men. Heart rate, employment, and prevalent IHD confound the association between cereal fibre intake and blood pressure. Future work concerning this relationship will have to account for the effects of these variables.

It is necessary to discover the determinants of blood pressure because blood pressure is a principal risk factor for ischaemic heart disease (IHD). Even those determinants having a small effect are important since a reduction in a population's mean blood pressure of 2–3 mmHG could potentially save as many lives as current antihypertensive therapy.¹ Factors having a small effect on blood pressure may be difficult to detect because of their low order correlations with blood pressure or confounding relations with other variables.

Cereal fibre has been postulated to be a determinant of blood pressure. Some studies have shown an inverse relation between cereal fibre intake and blood pressure,^{2–4} others have not.^{5,6} The relation between these two factors may have been missed in some studies because they were too small. Alternatively, the apparent link between the two factors is really non-causal and the association arises from confounding variables related to both cereal fibre and blood pressure.

The opportunity was taken to examine data from a large survey to see whether a relation could be found

between cereal fibre and blood pressure, and then to see whether any such relation could be explained by employment, prevalent ischaemic heart disease, and heart rate. Our hypothesis was that employed healthier individuals would have lower blood pressures and heart rates but also would eat diets with more cereal fibre.

Methods

The Caerphilly heart disease study is based on a cohort of 2512 men aged 45–49 years in South Wales. Details of the study aims, methods, and cohort assembly have been published.⁷

Blood pressure, heights, weights, and electrocardiograms (ECG) were obtained and questionnaires were completed at evening clinics. Body mass index was calculated as kg/m². Blood pressure was measured by one observer using either a random-zero or regular mercury sphygmomanometer. A single blood pressure recording was taken from the straightened left arm with the person seated. Daily cereal fibre intake was estimated from a food

Heart rate, employment status, heart disease confound relation between cereal fibre intake and blood pressure 331

frequency questionnaire which had been previously validated against weighed dietary records.⁸

IHD was characterised as "none" or "any manifestation". To have "any manifestation" a subject had to have (a) angina pectoris or possible myocardial infarction from the London School of Hygiene and Tropical Medicine Chest Pain Questionnaire, and/or (b) major or minor Q waves, ST and T wave changes, or left bundle branch block on ECG (Minnesota codes 1.1 to 1.3, 4.1 to 4.4, 5.1 to 5.3, and 7.1).⁷

Correlation coefficients were used to examine relations between continuous variables.⁹ Relations between variables and cereal fibre intake were then examined by stratification, presentation of means and standard deviations. Differences between means were compared using an unpaired *t* test. Multiple linear regression was used to examine the relation between cereal fibre, confounding variables and blood pressure.⁹

Results

Daily cereal fibre intake estimates were calculated for 2421 subjects. Of these, 2404 had their employment status noted. These groups form the basis for the analysis. Missing values account for slight differences in totals in the tables.

The correlation coefficients between cereal fibre intake, systolic pressure, diastolic pressure, and heart rate for the whole cohort are presented in table 1. Cereal fibre intake was associated with systolic pressure, diastolic pressure, and heart rate. Age and

body mass index were correlated with systolic blood pressure ($r=0.166$ and 0.220 respectively, $p<0.0001$) but not with cereal fibre intake ($r=-0.026$ and -0.023 respectively). Energy intake (kcal/day) was correlated with cereal fibre intake ($r=0.303$, $p<0.0001$) but not with systolic or diastolic pressure ($r=-0.019$ and -0.028 respectively).

Table 1 Correlation matrix for cereal fibre intake, blood pressure, and heart rate (*r* values) *N*=2421

	Cereal fibre intake	Systolic blood pressure	Diastolic blood pressure
Systolic blood pressure (mmHg)	-0.053**		
Diastolic blood pressure (mmHg)	-0.057**	0.664****	
Heart rate (beats/min)	-0.071***	0.183****	0.186****

** $p<0.01$, *** $p<0.001$, **** $p<0.0001$.

Table 2 Mean (SD) systolic pressure, diastolic pressure, and heart rate stratified by quintile of cereal fibre intake

Quintile cereal fibre intake (g/day)	Systolic blood pressure (mmHg)		Diastolic blood pressure (mmHg)		Heart rate (beats/min)	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
-4.0	487	142.1 (19.8)	487	89.9 (13.4)	486	72.9 (13.4)
4.1-6.0	508	141.0 (19.5)	507	88.4 (12.5)	510	72.0 (11.4)
6.1-8.0	459	141.9 (19.7)	459	88.5 (12.9)	460	71.3 (12.3)
8.1-10.4	482	140.4 (18.9)	481	88.5 (12.9)	482	71.2 (11.8)
10.5	483	138.8 (18.7)	483	87.8 (12.9)	483	70.22 (12.1)
Total	2419	140.8 (19.3)	2417	88.7 (12.9)	2421	71.5 (12.2)

Table 3 Mean (SD) systolic pressure, diastolic pressure, heart rate, and cereal fibre intake by employment status

Employment status	Systolic blood pressure		Diastolic blood pressure		Heart rate** (beats/min)		Cereal fibre** (g/day)	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Employed	1968	141.1 (19.3)	1968	88.8 (12.8)	1968	71.2 (12.1)	1917	7.8 (4.6)
Unemployed	515	139.3 (19.8)	513	87.6 (13.5)	517	73.1 (13.3)	487	7.1 (4.2)
Total	2483	140.7 (19.4)	2481	88.5 (12.9)	2485	71.6 (12.4)	2404	7.7 (4.5)

** $p<0.01$

Table 4 Mean (SD) systolic pressure, diastolic pressure, heart rate, and fibre intake by prevalent IHD

Prevalent IHD	Systolic blood pressure (mmHg)		Diastolic blood pressure (mmHg)		Heart rate** (beats/min)		Cereal fibre** intake (g/day)	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
None	1958	139.7 (18.3)	1857	87.7 (12.6)	1860	71.2 (12.1)	1802	7.9 (4.6)
Any manifestation	625	143.7 (22.1)	624	90.9 (13.7)	625	72.7 (13.0)	602	7.0 (4.2)
Total	2483	140.7 (19.4)	2481	88.5 (12.9)	2485	71.6 (12.4)	2404	7.7 (4.5)

** $p<0.01$

Table 2 presents mean systolic pressure, diastolic pressure, and heart rate stratified by quintile of cereal fibre intake. Moving from the lowest to the highest quintile, mean systolic pressure decreased 3.3 mmHg, mean diastolic pressure decreased 2.1 mmHg, and mean heart rate decreased 2.7 beats/min.

The mean blood pressure, heart rates, and cereal fibre intakes for employed and unemployed groups are shown in table 3. Blood pressures were similar for the two groups. The unemployed had significantly higher heart rates and lower cereal fibre intakes.

Unemployed men tended to have more illness than employed men. The prevalence of IHD was 38% in the unemployed compared with 21% in the employed group. The effect of prevalent IHD is shown in table 4. Persons with any manifestation of IHD had significantly higher blood pressure and heart rates but ate significantly less fibre. The association between employment, prevalent IHD, and cereal fibre intake is shown in table 5. The unemployed men with prevalent IHD ate an average of 1.5g cereal fibre less than employed men without IHD.

The effects of the confounding factors on the association between cereal fibre intake and blood pressure are shown in table 6. For the whole cohort, after adjustment for age alone, systolic pressure apparently changes -0.221 mmHg (95% CI = -0.338 , -0.054) and diastolic changes -0.163 mmHg (95% CI = -0.276 , -0.050) for each gram of cereal fibre eaten daily. After further adjustment for body mass index, prevalent ischaemic heart disease, employment status, and heart rate the effect attributable to fibre diminishes to -0.153 mmHg systolic (95% CI = -0.315 , 0.010) and -0.104 mmHg diastolic (95% CI = 0.212 , 0.005) for each gram of cereal fibre eaten daily. If the regression coefficients are examined by employment status the association is strengthened slightly in employed men and is non-existent among the unemployed (table 6).

Table 5 Cereal fibre intake (g/day) by employment status and prevalent IHD

Prevalent IHD	Cereal fibre intake** (g/day)					
	Unemployment		Employed		Total	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
None	301	7.4 (4.4)	1501	8.0 (4.7)	1802	7.9 (4.6)
Any manifestation	186	6.5 (4.0)	416	7.3 (4.3)	602	7.0 (4.2)
Total	487	7.1 (4.2)	1917	7.8 (4.6)	2404	7.7 (4.5)

** Differences between cells in the table are statistically significant ($p < 0.01$)

Table 6 Regression coefficients (95% confidence intervals) for changes in blood pressure associated with changes in cereal fibre intake (mmHg/g cereal fibre)*

	Systolic blood pressure	Diastolic blood pressure
Total cohort (n = 2366)**	-0.153 (-0.315 , 0.010)	0.104 (0.212 , 0.005)
cereal fibre intake		
Employed men (n = 1902)	-0.186 (-0.363 , -0.009)	-0.111 (-0.228 , 0.005)
cereal fibre intake		
Unemployed men (n = 462)	-0.004 (-0.415 , 0.407)	-0.065 (-0.347 , 0.218)
cereal fibre intake		

* Regression coefficients adjusted for age, body mass index, prevalent ischaemic heart disease, and heart rate.

** Regression coefficients also adjusted for employment status.

Discussion

The evidence relating blood pressure to cereal fibre intake is conflicting. Significant negative associations were shown in 94 volunteers,² in 117 men,³ and in 300 health-food shoppers⁴. Furthermore, a controlled trial among 57 subjects¹⁰ showed a fall in blood pressure with a vegetarian diet which included a high cereal fibre intake. On the other hand, no relation was found in 337 busmen and bank clerks,⁵ or in 112 male industrial workers,⁶ while a controlled trial showed no effect of cereal or other fibre on blood pressure in 63 subjects.¹¹

One explanation of these conflicting findings is that previous studies have been too small to detect consistently a small relation between cereal fibre and blood pressure. A randomised trial of cereal fibre supplementation would require about 850 subjects in both the control and intervention groups to have an 80% chance of detecting a 3 mmHg change in systolic blood pressure. Such a weak relation may be potentially important, however, since small reductions of blood pressure affect the risk of death and disability,¹ and moderate amounts of cereal fibre may have fewer side effects than antihypertensive drug therapy.

An alternative explanation for the inconsistent findings is the effect of confounding factors, associated (positively or negatively) with both blood pressure and cereal fibre intake. For example, the level of physical conditioning is associated negatively with blood pressure and positively with cereal fibre intake, since the people who select whole grain foods tend to be more health-conscious than others. Thus vegetarians tend to be leaner than omnivores^{12 13} and probably take more exercise on average. Since diet is an integral part of a person's way of life, it is very difficult to separate its action from that of other factors associated with it. The larger the study, the greater the possibility is of distinguishing between the

effects of dietary and other elements in the subjects' lives. The Caerphilly Study provided an opportunity to examine data from nearly 2500 men obtained during a survey of a town in South Wales.

Resting heart rate is an index of physical conditioning. Its relation to blood pressure and cereal fibre might reflect a tendency for health-conscious people to eat more fibre. If this were the sole explanation of the connection between blood pressure and cereal fibre, we might expect this association to disappear when heart rate is included in the multiple regression analysis. The association was no longer statistically significant in all subjects together when heart rate was included, but the relation reappeared when employed men were examined separately, that is, there was still a significant negative relation between cereal fibre intake and systolic blood pressure, independent of heart rate, in employed men. The absence of such a relation in the unemployed men may be attributed to their higher heart rates and greater prevalence of IHD. These non-dietary factors have a substantial effect on blood pressure and obscure any action of cereal fibre.

This study does not provide conclusive evidence as to whether cereal fibre affects blood pressure. The cross-sectional nature of the survey cannot account for any temporal relations between the two factors. For example, dietary habits may have changed in response to health or employment problems. The small correlation coefficients show that if the relation is causal it explains less than 1% of the variation in blood pressure within the population. The interrelations with heart rate and employment status provide a warning that there may be other confounding variables not considered in this study.

In spite of these problems, the relation between cereal fibre and blood pressure may still be important. Although small, the association was strengthened in employed men and persisted after adjustment for age, body mass index, prevalent IHD, and heart rate,

Future investigations of this association will have to account for the effects of employment, heart disease, and heart rate. Randomised trials, larger than those previously conducted, are needed to determine if the cereal fibre/blood pressure link is causal.

References

- ¹ Rose G. Strategy of prevention: lessons from cardiovascular disease. *Br Med J* 1981; **282**: 1847-51.
- ² Wright A, Burstyn PG, Gibney MJ. Dietary fibre and blood pressure. *Br Med J* 1979; **2**: 1541-3.
- ³ Fehily AM, Milbank JE, Yarnell JWG, Hayes TM, Kubiki AJ, Eastham RD. Dietary determinants of lipoproteins, total cholesterol, viscosity, fibrinogen, and blood pressure. *Am J Clin Nutr* 1982; **36**: 890-6.
- ⁴ Burr ML, Sweetnam PM, Barasi ME, Bates CJ. Dietary fibre, blood pressure and plasma cholesterol. *Nutrition Research* 1985; **5**: 467-72.
- ⁵ Morris JN, Marr JW, Clayton DG. Diet and heart: a postscript. *Br Med J* 1977; **2**: 1307-14.
- ⁶ Silman AJ. Dietary fibre and blood pressure. *Br Med J* 1980; **280**: 250.
- ⁷ The Caerphilly and Speedwell Collaborative Group. Caerphilly and Speedwell Collaborative Heart Disease Studies. *J Epidemiol Comm Health* 1984; **38**: 259-62.
- ⁸ Yarnell JWG, Fehily AM, Milbank JE, Sweetnam PM, Walker GL. A Short Dietary Questionnaire for use in an epidemiological survey: comparison with weighed dietary records. *Hum Nutr: Appl Nutr* 1983; **37A**: 103-12.
- ⁹ Armitage P. *Statistical methods in medical research*. Oxford: Blackwell Scientific Publication, 1971.
- ¹⁰ Rouse IL, Beilin LJ, Armstrong BK, Vandogen R. Blood pressure lowering effect of a vegetarian diet: controlled trial in normotensive subjects. *Lancet* 1983; **1**: 5-10.
- ¹¹ Brussaard JH, Van Raaij JMA, Stasse-Wolthuis M, Katan MB, Hautvast JGAJ. Blood pressure and diet in normotensive volunteers: absence of an effect of dietary fibre, protein or fat. *Am J Clin Nutr* 1981; **34**: 2023-9.
- ¹² Sacks FM, Castelli WP, Donner A, Kass E. Plasma lipids and lipoproteins in vegetarians and controls. *N Engl J Med* 1975; **292**: 1148-51.
- ¹³ Burr ML, Bates CJ, Fehily AM, St Leger AS. Plasma cholesterol and blood pressure in vegetarians. *J Hum Nutr* 1981; **35**: 437-41.