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## EVIDENCE BASED PUBLIC HEALTH POLICY AND PRACTICE

## Milk and dairy consumption, diabetes and the metabolic syndrome: the Caerphilly prospective study

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**Objectives:** To report a negative association between milk or dairy consumption and the metabolic syndrome and to examine associations within the Caerphilly cohort.

**Setting:** A representative sample of men aged 45–59 years in Caerphilly, UK.

**Participants and data:** Data on fasting blood glucose and plasma insulin, fasting plasma triglycerides and high-density lipoprotein cholesterol, body mass index, and blood pressure were used to define the metabolic syndrome in terms of levels of two or more variates within the top 10%. The clinical importance of the syndrome was assessed from 20-year incidence of diabetes, vascular events and deaths. The relationships between the syndrome and the consumption of milk and dairy products was examined using data from both a semiquantitative food frequency questionnaire, and from a 7-day weighed intake record which had been kept by a 1:3 subsample of the men.

**Main results:** There were 2375 men without diabetes in the cohort. The prevalence of the metabolic syndrome was 15%. Men with the syndrome had significantly increased risks of a subsequent ischaemic heart disease event, death or diabetes. Negative relationships were shown between both the consumption of milk and dairy produce, and the syndrome. Adjusted odds ratio in men who regularly drank a pint of milk or more daily was 0.38 (0.18 to 0.78) and that for dairy food consumption was 0.44 (0.21 to 0.91). Milk intake showed no significant trend with incident diabetes.

**Conclusions:** The consumption of milk and dairy products is associated with a markedly reduced prevalence of the metabolic syndrome, and these items therefore fit well into a healthy eating pattern.

The metabolic syndrome has been termed the deadly quartet, and has been said to be the fastest growing disease entity in the world.<sup>1</sup> On the other hand, although it does predict vascular disease and diabetes quite powerfully,<sup>2–4</sup> it is probably not a true syndrome and is best thought of as simply an elaborate risk formula.<sup>5–7</sup>

A number of reports have shown negative relationships between the syndrome and the consumption of milk or dairy food intake.<sup>8–10</sup> Here, we report the prevalence of the syndrome in the Caerphilly cohort of middle-aged men; its importance in terms of the prediction of diabetes, vascular disease events and death, and the relationship of the syndrome with the consumption of milk and dairy foods.

## METHODS

The Caerphilly Cohort Study was set up in 1979–83. It was based on 2512 men aged 45–59 years.<sup>11</sup> Data were collected at baseline on items relevant to the identification of the metabolic syndrome. After exclusion of men with diabetes, men were judged to have the syndrome if they had two or more of the following criteria:

- a plasma insulin level within the top 10% ( $\geq 163$  mmol/l) and/or a plasma glucose within the top 10% ( $\geq 6.1$  mmol/l)
- a body mass index (weight/height<sup>2</sup>) within the top 10% ( $\geq 30$  kg/m<sup>2</sup>)
- a high-density lipoprotein cholesterol level within the lowest 10% ( $< 0.92$  mmol/l) and/or plasma triglyceride level within the top 10% ( $\geq 3.25$  mmol/l)
- a systolic blood pressure within the top 10% ( $\geq 166$  mmHg) and/or a diastolic pressure within the top 10% ( $\geq 104$  mmHg), together with self-reported hypertension.

Food consumption was assessed at baseline from a semi-quantitative food frequency questionnaire completed by all the men with help from their partner. This included the quantity of milk usually drunk each day. A representative 1:3 sample of the men also kept a 7-day weighed dietary intake record.<sup>12</sup> Nutrient intakes were calculated using appropriate food composition tables. The total intake of milk was recorded as all milk drunk and added to drinks, milk added to cereals, milk used in puddings and other recipes, together with dried milk converted to the equivalent weight of whole milk.

At 5-year intervals, the men were re-examined. Self-reported diabetes was recorded and incident vascular events were identified.<sup>13 14</sup> A diagnosis of ischaemic heart disease (ICD I21-5, 10th revision) included deaths certified as due to ischaemic heart disease together with non-fatal myocardial infarction. Ischaemic stroke (ICD I63-4) was diagnosed according to accepted criteria. Follow-up was continued for approximately 20 years.

## RESULTS

After the exclusion of men with diabetes from the cohort, data are available for 2375 men. The numbers who fulfilled the separate criteria of the metabolic syndrome are shown in table 1. Approximately 15% fulfilled the criteria set for the metabolic syndrome—namely, two or more of the separate criteria. Of the 640 sample of men who had kept a 7-day weighed dietary record, did not have diabetes at baseline, and complete data were available for 603 men. Of these, 14% fulfilled the criteria for the syndrome.

In table 2, the clinical importance of the syndrome is assessed. There were marked increases in incident disease events in men with the syndrome at baseline. For ischaemic heart disease, the adjusted risk ratio (RR) was 1.79 (95% CI

**Table 1** Criteria of the metabolic syndrome and the numbers of data available for analyses

|   |              |
|---|--------------|
| Criteria of the metabolic syndrome                            |              |
| Fasting insulin in top 10%                                    | ≥163 mmol/l  |
| and/or fasting glucose in top 10%                             | ≥6.1 mmol/l  |
| BMI (height/weight <sup>2</sup> )                             | ≥30          |
| HDL cholesterol level in lowest 10%                           | <0.92 mmol/l |
| and/or triglycerides level in top 10%                         | ≥3.25 mmol/l |
| Systolic blood pressure in top 10%                            | ≥166 mm Hg   |
| and/or diastolic in top 10%                                   | ≥104 mm Hg   |
| Numbers of men  |              |
| Number of men in the cohort                                   | 2512         |
| Men omitted at baseline                                       |              |
| Men who reported diabetes                                     | 54           |
| Fasting blood glucose >7.8 mmol/l                             | 28           |
| No information on diabetes                                    | 55           |
| Total excluded  | 137          |
| Number in the present analyses                                | 2375 (100%)  |
| Number who fulfilled the insulin/glucose criteria             | 240          |
| Number who fulfilled the BMI criterion                        | 278          |
| Number who fulfilled the lipid criteria                       | 381          |
| Number who fulfilled the blood pressure criteria              | 663          |
| Based on these criteria                                       |              |
| Men who fulfilled no criterion                                | 1241         |
| Men who fulfilled one criterion                               | 609          |
| Men who fulfilled two criteria                                | 279 (15.2%)  |
| Men who fulfilled three criteria                              | 67           |
| Men who fulfilled four criteria (164 men had incomplete data) | 15           |

BMI, body mass index; HDL, high-density lipoprotein.

1.36 to 2.37) and for deaths from any cause, 1.46 (1.12 to 1.88). Prediction of incident diabetes was particularly strong, with a RR of 4.09 (2.92 to 5.74). While the RR of ischaemic stroke was increased, this was not significant.

Table 2 also shows incident disease events and deaths for numbers of the criteria other than the two or more which defines the syndrome. As expected, other than for stroke, there were enormously strong gradients in the risk with increase in the number of criteria fulfilled. This is particularly evident in the data for incident diabetes.

Table 3 shows a marked negative and significant relationship between milk consumption and the presence of the syndrome. In the total cohort, men who drank one pint of milk or more per day had an adjusted odds ratio (OR) for the syndrome of 0.38 (0.18 to 0.78) relative to men who stated that they drank little or no milk. Data for the men who had kept the 7-day intake records show a closely similar effect, the odds of having the syndrome in the quarter of men with the highest milk intake relative to that in the quarter of men with the lowest intake being 0.43 (0.20 to 0.95).

Data from the 7-day weighed dietary intake records enabled us to estimate the total calorie intake of each man from dairy foods, defined as milk, cheese and yoghurt. The adjusted relative odds for the occurrence of the syndrome in quarters of men defined by increasing consumption of dairy foods was 1.00; 0.48; 0.51 and that in the quarter of men with the highest dairy intake was 0.40 (0.20 to 0.79). The trend in these data is significant (table 4). In fact, the association with dairy foods defined to also include butter and cream is almost identical (relative odds in the quarter of men with the highest intake 0.44 (0.21 to 0.91),  $p = 0.023$ ).

Finally, although the data are sparse, table 5 presents data for incident diabetes in relation to milk consumption at baseline. There is little suggestion of a trend ( $p = 0.247$ ), and neither the adjusted OR in the quarter of men with the highest intake of milk nor the highest consumption of dairy foods (not shown) are significant (0.57 (0.20 to 1.63) and 0.74 (0.26 to 2.05), respectively).

## DISCUSSION

This study is based on a large representative population sample of middle-aged men.

The definition of the metabolic syndrome that we have used is relatively close to that proposed by the World Health Organization.<sup>15</sup> This and many other definitions use specific levels of blood pressure, lipids, blood glucose etc, each of which is defined in original units. This ignores differences between laboratories, and such differences can be large. Although the use of criteria in terms of "the top 10%" of a variate ignores differences between populations, we believe that such differences are likely to be relatively small. In any case, the fundamental difficulties with the whole concept of the syndrome raise more important questions than small differences in diagnostic criteria.

Because of the differences between studies in diagnostic criteria and in age distribution, comparisons of the prevalence in these older men in Caerphilly with those reported in other studies are not very meaningful. Most studies, however, yield prevalence estimates for the syndrome that are somewhat higher than the present estimates, generally around 20–30%.<sup>6 14 16</sup>

The clinical importance of the syndrome in our cohort is indicated by the significantly increased risk of subsequent ischaemic heart disease events, death and diabetes (RR 4.09, 2.92 and 5.74, respectively). These estimates are similar to those reported from other studies.<sup>3 4 6</sup>

The syndrome has been much criticised,<sup>5–7</sup> and the fact that the prediction of disease show a very marked increase with increasing numbers of the criteria that are used in the definition of the syndrome, indicates that the choice of the

**Table 2** Incident ischaemic stroke, ischaemic heart disease, diabetes and death from any cause, and the syndrome defined at baseline as two or more of the criteria (see text) and the RR for various numbers of the criteria

| Subgroup of men                | No of men | RR for an incident event (adjusted for age, smoking, social class and prevalent vascular disease) |                         |                       |                      |
|--------------------------------|-----------|---|-------------------------|-----------------------|----------------------|
|                                |           | Ischaemic stroke  | Ischaemic heart disease | Incident diabetes     | Death (all causes)   |
| Men who fulfilled the criteria |           |   |                         |                       |                      |
| None                           | 1241      | 1.00  | 1.00                    | 1.00                  | 1.00                 |
| Any one                        | 609 (28%) | 1.49  | 1.18                    | 2.24                  | 1.20                 |
| Any two                        | 279 (13%) | 1.40  | 1.85                    | 5.16                  | 1.35                 |
| Any three                      | 67 (3%)   | 1.25  | 2.00                    | 7.05                  | 1.97                 |
| All four                       | 15 (7%)   | 2.69 (0.58 to 12.45)  | 2.71 (0.88 to 8.42)     | 13.39 (4.26 to 42.08) | 6.97 (2.08 to 23.20) |
| Significance of trend          |           | $p = 0.059$   | $p = 0.000$             | $p = 0.000$           | $p = 0.000$          |
| Men with criteria              |           |   |                         |                       |                      |
| None or one                    | 1850      | 1.00  | 1.00                    | 1.00                  | 1.00                 |
| Two or more                    | 361 (16%) | 1.21 (0.80 to 1.84)   | 1.79 (1.36 to 2.37)     | 4.09 (2.92 to 5.74)   | 1.46 (1.12 to 1.88)  |

**Table 3** Association between milk intake and the syndrome at baseline

| Milk consumption      | No of men | No of men with the syndrome | RR for the metabolic syndrome (adjusted for age energy, social class and smoking) |
|-----------------------|-----------|-----------------------------|---|
| Men with an FFQ:      |           |                             |   |
| Little or none        | 139       | 30                          | 1.00  |
| < ½ pint              | 984       | 177                         | 0.71  |
| ½ to 1 pint           | 868       | 122                         | 0.56  |
| >1 pint               | 140       | 13                          | 0.38 (0.18 to 0.78)   |
| Significance of trend |           |                             | p=0.002   |
| Men with a WDI:       |           |                             |   |
| Lowest ¼              | 150       | 25                          | 1.00  |
| Next ¼                | 152       | 30                          | 1.04  |
| Next ¼                | 150       | 22                          | 0.76  |
| Highest ¼             | 151       | 12                          | 0.43 (0.20 to 0.95)   |
| Significance of trend |           |                             | p=0.026   |

FFQ, semiquantitative food frequency questionnaire; WDI, 7-day weighed intake record.

two or more criteria is very arbitrary indeed. Furthermore, prediction of disease events by the separate criteria differs enormously, and, in the present data, the top 10% of men defined by body mass index alone had no significantly increased risk of a disease event, although, the insulin/glucose criterion was a significant predictor of all the disease events, including stroke. Thus, giving equal weight to various criteria is unreasonable.

The prevalence of the syndrome is markedly associated with the consumption of milk, and this is apparent both in men grouped by their own estimates of milk consumption, and in those grouped by milk intake data obtained from the 7-day weighed intake records. Furthermore, estimates of total dairy food consumption (milk, cheese, cream, butter and yoghurt) made from the weighed records kept by 603 men show a decreasing prevalence of the syndrome with increasing dairy consumption, the adjusted RR in the quarter of men with the highest dairy intakes being 0.44 (0.21 to 0.91). Although these results could be explained by confounding, it seems most unlikely that a factor or factors further to those for which adjustments have been made could explain, let alone reverse, the trends observed.

Furthermore, a number of other studies show this same negative association with milk consumption. In the Terhan Lipid and Glucose Study of 827 subjects,<sup>9</sup> a number of factors were found to be associated favourably with dairy consumption, including the metabolic syndrome (OR 0.69; p<0.02). In the Women's Health Study of 10 066 US women,<sup>10</sup> the adjusted OR for the syndrome in the one-fifth of the women with the highest total calcium intake was 0.66. In the DESIR study of 4976 subjects in France,<sup>17</sup> men who took more than one portion of dairy produce per day had an OR for the syndrome of 0.61

**Table 4** Association between total dairy intake and the syndrome at baseline in men who had kept 7-day weighed intake records

| Calories from dairy produce | No of men | No of men with the syndrome | RR for the syndrome (adjusted for age, smoking and social class) |
|-----------------------------|-----------|-----------------------------|--|
| Quarter                     |           |                             |  |
| Lowest ¼                    | 151       | 29                          | 1.00   |
| Next ¼                      | 146       | 21                          | 0.48   |
| Next ¼                      | 153       | 23                          | 0.51   |
| Highest ¼                   | 153       | 16                          | 0.40 (0.20 to 0.79)  |
| Trend                       |           |                             | p=0.003  |

Dairy = sum of calories from milk+cheese+yoghurt.

**Table 5** Association between milk consumption and incident diabetes in men who had kept 7-day weighed intake records

| Milk consumption | No of men | No of men who developed diabetes | RR for diabetes (adjusted for age, smoking, BMI and social class) |
|------------------|-----------|----------------------------------|---|
| Quarter          |           |                                  |   |
| Lowest ¼         | 160       | 13                               | 1.00  |
| Next ¼           | 158       | 11                               | 0.80  |
| Next ¼           | 160       | 11                               | 0.82  |
| Highest ¼        | 162       | 6                                | 0.57 (0.20 to 1.63)   |
| Trend            |           |                                  | p=0.247   |

BMI, body mass index.

(0.41 to 0.90), although in women an OR of 0.76 (0.48 to 2.56) was not significant.

The CARDIA study<sup>8</sup> is of particular interest, being prospective over 10 years in subjects aged 18–30 years. A negative association between milk consumption and the development of the syndrome was found, but only in 909 subjects (30% of the total cohort) who had been overweight at baseline. In this subgroup, the risk of the syndrome was 0.28 (0.14 to 0.58) in those with the highest dairy food intake, relative to the risk in those with the lowest dairy intake. The authors estimated that each additional daily serving of dairy foods was associated with a 21% lower odds of the development of the syndrome.

In contrast to all these are the results from 4000 women aged 60–79 years in the British Women's Heart and Health Study,<sup>18</sup> 111 women (2.8% of the total cohort) who reported that they never drank milk had an adjusted OR for the metabolic syndrome, relative to 3913 women who drank milk, of 0.55 (0.33 to 0.94). Women who drink no milk are, however, unusual. A high proportion is likely to be lactose intolerant, and such a group is unlikely to be representative of the general population.

The prediction of diabetes by milk drinking is only suggested in the present data (table 5). Neither the trend nor the relative odds in the men with the highest milk intake (0.57) is significant, nor are the odds significant when based on the consumption of all dairy foods (0.74, (0.26 to 2.05) in men with the highest dairy consumption). In a much larger study, however,<sup>19</sup> a significant protective effect of dairy food consumption was shown, the adjusted RR in the one-fifth of the women with the highest intake being 0.79 (0.67 to 0.94). These authors estimated that each daily serving of dairy foods was associated with a 4% lower risk of developing diabetes.

### What this paper adds

- Further evidence of benefit from milk and dairy foods, against a background of widespread uncertainties about the benefits of these foods
- Criticisms of the so-called "metabolic syndrome", further to those already published

### Policy implications

Milk consumption has fallen markedly in the UK during the past 25 years. This paper adds to the evidence that milk and dairy products fit well into a healthy eating pattern and that their consumption should be promoted

Elsewhere, an overview of 10 major prospective studies has demonstrated a negative relationship between milk consumption and both incident ischaemic stroke and ischaemic heart disease.<sup>20</sup> The present data add further to the evidence that milk and dairy products “fit well into a healthy eating pattern”.<sup>21</sup>

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PCE directed the Caerphilly Cohort Study, AMF collected the dietary data and JEP analysed the data. All authors contributed to writing the paper. PCE and JEP are supported by Cardiff University, and AF is a freelancer. PCE is guarantor. All the authors have seen and approved the paper. PCE directed the Caerphilly Study and has the overall responsibility for the paper. JEP analysed the data and contributed to the writing of the paper. AMF is responsible for all dietary work in the Caerphilly study and contributed to the writing of the paper.

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