Plasma vitamin C and food choice in the third Glasgow MONICA population survey

Wendy L Wrieden, Mary K Hannah, Caroline Bolton-Smith, Roger Tavendale, Caroline Morrison, Hugh Tunstall-Pedoe

Abstract

Study objective—To determine the contribution of different foods to the estimated intakes of vitamin C among those differing in plasma vitamin C levels, and thereby inform dietary strategies for correcting possible deficiency.

Design—Cross sectional random population survey.


Participants—632 men and 635 women, aged 25 to 74 years, not taking vitamin supplements, who participated in the third MONICA study (population survey monitoring trends and determinants of cardiovascular disease).

Measurements and main results—Dietary and sociodemographic information was collected using a food frequency and lifestyle questionnaire. Plasma vitamin C was measured in non-fasted venous blood samples and subjects categorised by cut points of 11.4 and 22.7 µmol/l as being of low, marginal or optimal vitamin C status. Food sources of dietary vitamin C were identified for subjects in these categories. Plasma vitamin C concentrations were compared among groups classified according to intake of key foods. More men (26%) than women (14%) were in the low category for vitamin C status; as were a higher percentage of smokers and of those in the older age groups. Intake of vitamin C from potatoes and chips (fried potatoes) was uniform across categories; while the determinants of optimal versus low status were the intakes of citrus fruit, non-citrus fruit and fruit juice. Optimal status was achieved by a combined frequency of fruit, vegetables and/or fruit juice of three times a day or more except in older male smokers where a frequency greater than this was required even to reach a marginal plasma vitamin C level.

Conclusion—Fruit, vegetables and/or fruit juice three or more times a day increases plasma vitamin C concentrations above the threshold for risk of deficiency.

Methods

The WHO MONICA Project (MONItoring trends and determinants of CArdiovascular disease) monitored rates of coronary heart disease (CHD), and trends in classic coronary risk factors by repeated population surveys, in defined populations worldwide over 10 years.1

The Scottish MONICA population, Glasgow north of the River Clyde, had among the highest male CHD rates and the highest female rates of any MONICA population in 1985–87,2 and ranked highly within Scotland for disease rates3 and social deprivation.4 Although not included in the core study, a multinational MONICA optional study on plasma antioxidant vitamins showed low concentrations of these in Scottish populations, and an inverse correlation with disease rates.5 Within the limited data from Glasgow and Aberdeen there was a relation between estimated intake of vitamin C, derived from a food frequency questionnaire used for the Scottish Heart Health and MONICA surveys,6 7 and non-fasting plasma concentrations of vitamin C, if smokers and non-smokers were separated.6 Accordingly it was decided to measure plasma antioxidant vitamin concentrations more extensively in the third Glasgow MONICA population survey in 1992, and to relate these to demographic factors, to coronary risk factors and to self-reported food frequency responses. This report is concerned with the relation of intakes of particular foods to plasma vitamin C concentrations, and the implication for dietary advice within the population. Given the poor life circumstances and high CHD rates of this population8 the findings provide further evidence of the link between poor diet and disease.

The vitamin-antioxidant hypothesis relates sub-optimal levels of certain vitamins, short of frank deficiency, to increased risk of chronic diseases.9 10 12 For example the relative risk for ischaemic heart disease of men with low plasma vitamin C (< 22.7 µmol/l) combined with low plasma carotene was almost twice, and that for stroke four times, that of those with higher values.12 In addition, a persistent serum concentration of less than 5.7 µmol/l would be likely to lead to scurvy and signs of this deficiency disease have been observed at levels as high as 7.41 to 13.7 µmol/l.16 For this analysis we have used common conventional cut points of 11.4 and 22.7 µmol/l9 10 15 (equivalent to 0.2 mg/dl and 0.42 mg/dl) to categorise those with seriously low plasma concentrations from those with marginal and optimal values, albeit based on single non-fasting specimens.
between January and August 1992. Participants were sent a detailed lifestyle and food frequency questionnaire to complete, and were asked to attend a local survey clinic without fasting, where the questionnaire was checked by a survey nurse, and they underwent physical measurements and blood sampling.

**MEASUREMENT OF PLASMA VITAMIN C**

Venepuncture with minimum use of a tourniquet was followed by immediate separation of plasma using lithium/heparin as an anticoagulant. Plasma samples were rapidly frozen using dry ice and stored at −20°C for up to five days before transport to Dundee where they were stored at −80°C. Vitamin C was analysed using a fluorometric assay. Subjects were classified into three categories according to their plasma vitamin C concentration. Less than 11.4 µmol/l was described as low, 11.4–22.7 µmol/l as marginal and above 22.7 µmol/l as optimal.

**INTAKE OF VITAMIN C**

The food frequency questionnaire was developed from one already validated against weighed intake in both a Welsh and a Scottish population. In the validation of the original questionnaire mean vitamin C intakes estimated from the food frequency questionnaire were slightly lower than from the weighed intake but overall intakes from the two methods were statistically significantly correlated. However, the questionnaire used in this study had been adapted to include a question on tomatoes and a better defined question on fruit juice. An attached lifestyle questionnaire provided information on supplement use but for this analysis it was the impact of food choice on plasma vitamin C that was being studied so supplement takers were excluded to avoid confusion. The food frequency questionnaire asked subjects about frequency of consumption (number of days each week, once a month, rarely or never) of over 65 different foods and drinks. Twenty seven of these were relevant to calculations of the intake of vitamin C—obtained by multiplying the food frequency by the standard portion sizes and then by the average vitamin C content obtained from the UK food composition tables. For simplicity these foods were amalgamated into 11 food groups before calculation of their contribution to total intakes, and these contributions and totals were then calculated and averaged for each of the three plasma vitamin C categories.

**STATISTICAL ANALYSIS**

The percentage in each plasma vitamin C category, was calculated by gender, age, smoking habit and social class. The percentage of men and women who reported not eating the foods in the vitamin C rich food groups were compared across the plasma vitamin C categories. Proportions were compared using the χ² test. Plasma vitamin C was compared in groups classified according to their consumption of certain foods or smoking habit. Before comparison, plasma vitamin C values were log transformed to normalise the distribution before testing the significance of differences between group means using Student’s t test or analysis of variance with a test for linear trend. Means of these transformed values were back transformed to give the geometric mean for tabulation.

Untransformed means of vitamin C intake were used to show the contribution of each of the 11 food groups to vitamin C intake.

Results

There were 1958 participants in the MONICA survey, giving a corrected response rate of 65.1% for those approached. Of these, 96 were excluded for incomplete food frequency responses, 285 for taking, or not stating whether they took vitamin supplements, and in a further 310 blood samples were refused or were inadequate for both the core analytes and for plasma vitamin C. This left 1267 people with full data for this MONICA sub-study (632 men and 635 women), or 64.7% of all responding participants.

Table 1 shows the percentage of subjects in each plasma vitamin C group by gender, age, smoking habit and gender/social class.
Table 2  Percentage of subjects in each plasma vitamin C group not eating foods contributing to vitamin C intake

<table>
<thead>
<tr>
<th>Plasm vitamin C group</th>
<th>% Low</th>
<th>% Marginal</th>
<th>% Optimal</th>
<th>Linear trend</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus fruits</td>
<td>67</td>
<td>53</td>
<td>42</td>
<td>***</td>
</tr>
<tr>
<td>Fruit juice</td>
<td>63</td>
<td>49</td>
<td>31</td>
<td>**</td>
</tr>
<tr>
<td>Potatoes (other than chips)</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Chips (fried potatoes)</td>
<td>16</td>
<td>15</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Non-citrus fruit</td>
<td>42</td>
<td>34</td>
<td>17</td>
<td>***</td>
</tr>
<tr>
<td>Green vegetables and salads</td>
<td>20</td>
<td>10</td>
<td>17</td>
<td>***</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>49</td>
<td>38</td>
<td>29</td>
<td>***</td>
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<td>Other vegetables</td>
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<td>3</td>
<td>*</td>
</tr>
<tr>
<td>Milk</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Tomatoes (fresh, tinned, pureed)</td>
<td>22</td>
<td>18</td>
<td>14</td>
<td>**</td>
</tr>
<tr>
<td>Other foods†</td>
<td>12</td>
<td>6</td>
<td>4</td>
<td>**</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus fruits</td>
<td>56</td>
<td>54</td>
<td>32</td>
<td>***</td>
</tr>
<tr>
<td>Fruit juice</td>
<td>54</td>
<td>46</td>
<td>23</td>
<td>***</td>
</tr>
<tr>
<td>Potatoes (other than chips)</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>**</td>
</tr>
<tr>
<td>Chips (fried potatoes)</td>
<td>13</td>
<td>10</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Non-citrus fruit</td>
<td>24</td>
<td>21</td>
<td>11</td>
<td>***</td>
</tr>
<tr>
<td>Green vegetables and salads</td>
<td>14</td>
<td>10</td>
<td>4</td>
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<tr>
<td>Soft drinks</td>
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<tr>
<td>Milk</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Tomatoes (fresh, tinned, pureed)</td>
<td>19</td>
<td>14</td>
<td>8</td>
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</tr>
<tr>
<td>Other foods†</td>
<td>7</td>
<td>5</td>
<td>3</td>
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</tr>
</tbody>
</table>

Plasma vitamin C groups are Low <11.4 µmol/l, Marginal 11.4–22.7 µmol/l, and Optimal 22.7 µmol/l and above. **p<0.001, ***p<0.0001, *p<0.05. †Other foods are liver, fruit tarts and custards, fruit cake, tinned fruit, jellies, savoury snacks and sweet spreads.

**Figure 1**  Contribution of foods to vitamin C intake by different plasma vitamin C categories. Unlabelled bands represent a mean contribution of less than 4 mg/day.

**KEY POINTS**

- In a deprived urban population half the men and one third of women had sub-optimal plasma vitamin C concentrations.
- Citrus fruit and fruit juice are the main dietary determinants of optimal vitamin C status but potatoes and chips (fried potatoes) are a major source for those with low status.
- Male smokers over 45 require over three portions of fruit, vegetables and fruit juice simply to reach a marginal to adequate plasma vitamin C concentration.
- Advice to lower intake of chips must ensure adequate replacement of their vitamin C contribution.
- Consumption of citrus fruit juice should be encouraged for those unwilling to eat fruit and vegetables.

Similarly the percentage of men in the low category among manual workers was twice that of those in this category among the non-manual social classes.

Table 2 gives the percentage of subjects not eating foods in the vitamin C rich food groups. Over half of subjects in the low category did not consume citrus fruits or fruit juice. These were two of the main contributors to vitamin C intake in the optimal category (fig 1). A significant positive trend existed between consumption of citrus fruits, fruit juice, potatoes (women only), non-citrus fruits, green vegetables and salads, soft drinks (men only), other vegetables (men only), tomatoes and increasing vitamin C status.

Figure 1 shows the mean intakes from each food group for men and women and illustrates the greater contribution in the optimal group compared with the other two from citrus fruit, fruit juices, non-citrus fruit and green vegetables. Citrus fruit, followed by fruit juice and potatoes were the highest contributors among men with optimal plasma concentrations. Citrus fruit, fruit juice and non-citrus fruit were the highest contributors to vitamin C among women with optimal plasma concentrations. Potatoes and chips (fried potatoes) contributed similar amounts of vitamin C across the plasma categories but comprised a higher percentage of vitamin C in the marginal and low categories because total vitamin C intake was lower.

Table 3 gives comparisons of mean plasma vitamin C in frequent versus infrequent consumers of each key food. The geometric means (antilogs of mean log_{10} plasma vitamin C) are given to allow comparison with the cut off values of plasma vitamin C defining the low and marginal categories. The definition of frequent intake varied according to the food involved to allow approximately equal numbers in the Frequent and Infrequent Groups. Means of plasma vitamin C were higher among the frequent (compared with infrequent) consumers of citrus fruit (except for young men), fruit juice, non-citrus fruit and green vegetables but...
Table 3  Mean† (95% CI) plasma vitamin C concentrations (µmol/l) in frequent versus infrequent consumers of the vitamin C rich foods groups by age group and smoking habit

<table>
<thead>
<tr>
<th>Food</th>
<th>Frequent intake</th>
<th>25–44 years</th>
<th>45–74 years</th>
<th>25–44 years</th>
<th>45–74 years</th>
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<tr>
<td></td>
<td></td>
<td>Smokers</td>
<td>Never and ex-smokers</td>
<td>Smokers</td>
<td>Never and ex-smokers</td>
</tr>
<tr>
<td></td>
<td>Yes (≥1)</td>
<td>24 (19.1 to 30.5)</td>
<td>37 (30.4 to 45.8)</td>
<td>17 (14.1 to 19.8)</td>
<td>31 (26.9 to 36.6)</td>
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<tr>
<td></td>
<td>No</td>
<td>19 (15.6 to 22.6)</td>
<td>43 (36.3 to 50.14)</td>
<td>11 (8.9 to 12.9)***</td>
<td>16 (13.7 to 19.4)***</td>
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<tr>
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<td>Yes (≥1)</td>
<td>24 (18.9 to 30.7)</td>
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<td>20 (16.7 to 24.7)</td>
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<td>11 (9.3 to 12.8)***</td>
<td>21 (17.8 to 25.2)**</td>
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<tr>
<td>Fruit juice</td>
<td>Yes (≥1)</td>
<td>22 (18.2 to 27.1)</td>
<td>42 (33.5 to 52.4)</td>
<td>14 (2.3 to 16.6)</td>
<td>23 (20.2 to 27.4)</td>
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<td>Potatoes</td>
<td>Yes (≥3)</td>
<td>20 (16.3 to 23.8)</td>
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<td>24 (20.7 to 28.2)</td>
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<tr>
<td>Chips (fried potatoes)</td>
<td>Yes (≥3)</td>
<td>28 (21.6 to 35.3)</td>
<td>46 (40.0 to 53.6)</td>
<td>17 (14.1 to 20.8)</td>
<td>30 (26.1 to 35.4)</td>
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<tr>
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<td>19 (15.9 to 22.5)*</td>
<td>34 (27.2 to 42.2)*</td>
<td>11 (9.6 to 13.4)**</td>
<td>17 (14.1 to 20.3)**</td>
</tr>
<tr>
<td>Non-citrus fruit</td>
<td>Yes (≥3)</td>
<td>24 (19.3 to 28.9)</td>
<td>48 (40.3 to 56.2)</td>
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<td>19 (15.6 to 23.3)</td>
<td>33 (27.6 to 40.5)**</td>
<td>11 (9.2 to 13.1)**</td>
<td>18 (15.2 to 21.6)**</td>
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<td>Green vegetables and salads</td>
<td>Yes (≥3)</td>
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<td>34 (27.2 to 42.2)**</td>
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<tr>
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<td>Soft drinks</td>
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<td>11 (9.7 to 13.5)**</td>
<td>23 (19.4 to 27.3)</td>
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<tr>
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<td>40 (35.6 to 45.9)</td>
<td>13 (11.7 to 15.1)</td>
<td>24 (21.0 to 26.9)</td>
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<td>33 (27.1 to 41.4)**</td>
<td>17 (14.0 to 19.9)</td>
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<td>48 (43.1 to 54.3)</td>
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<td>33 (26.5 to 42.1)**</td>
<td>16 (13.1 to 20.2)**</td>
<td>24 (20.5 to 29.1)***</td>
</tr>
<tr>
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<td>48 (41.3 to 54.8)*</td>
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<td>48 (41.3 to 54.8)*</td>
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<tr>
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<td>27 (21.2 to 33.8)</td>
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<tr>
<td>Chips (fried potatoes)</td>
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<td>31 (24.3 to 38.9)</td>
<td>49 (44.2 to 55.0)</td>
<td>22 (17.4 to 27.8)</td>
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<td>30 (24.1 to 38.2)***</td>
<td>19 (15.4 to 22.9)</td>
<td>29 (24.1 to 34.7)***</td>
</tr>
<tr>
<td>Non-citrus fruit</td>
<td>Yes (≥4)</td>
<td>31 (25.3 to 38.2)</td>
<td>38 (30.7 to 46.1)</td>
<td>24 (20.3 to 29.1)</td>
<td>42 (37.6 to 47.5)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>21 (17.1 to 25.4)**</td>
<td>45 (39.2 to 50.9)</td>
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</tr>
<tr>
<td>Green vegetables and salads</td>
<td>Yes (≥3)</td>
<td>26 (22.1 to 31.4)</td>
<td>42 (36.4 to 47.4)</td>
<td>25 (20.1 to 31.0)</td>
<td>34 (29.0 to 40.5)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>24 (18.1 to 31.1)</td>
<td>43 (34.5 to 55.0)</td>
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<td>37 (31.4 to 42.6)***</td>
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<td>26 (22.2 to 29.7)</td>
<td>42 (38.1 to 47.4)</td>
<td>20 (17.4 to 23.6)</td>
<td>35 (31.7 to 39.2)</td>
</tr>
</tbody>
</table>

†Geometric mean from antilogarithm of mean log plasma vitamin. Definition of Frequent intake allows approximately equal numbers in Frequent and Infrequent groups. ***p<0.001, **p<0.01, *p<0.05 significant of difference between frequent and infrequent consumers using the Student’s t test.

There were some exceptions in particular groups. There was no evidence that frequent potato or chip consumption caused an increase in plasma concentrations of vitamin C and in some groups of women a significantly lower level was found in those who consumed potatoes or chips frequently. Also shown in Table 3 is that mean plasma vitamin C was higher in the non-smokers compared with the smokers and this exceeded 2.2 µmol/l in the younger non-smoking men and both age groups of the non-smoking women. For older

Figure 2  Mean log plasma vitamin C for different frequencies of fruit, vegetable and fruit juice consumption by gender/age group. *p<0.05 and **p<0.005 for linear trend in analysis of variance.
male smokers the means for all consumption
groups were below 22.7 µmol/l and only the
frequent consumers of citrus fruit, fruit juice,
non-citrus fruit, green vegetables, and soft
drinks had confidence limits for the mean
above 11.4 µmol/l.

Figure 2 shows the means (with 95% confi-
dence limits) of log$_{10}$ plasma vitamin C for
groups of smokers and non-smokers by sex and
age according to their combined consumption
of fruit, vegetables (excluding potatoes) and
fruit juice. Two reference lines are shown that
are equivalent to 11.4 and 22.7 µmol/l vitamin
C in plasma. Male and female non-smokers
under 45 years had plasma vitamin C concen-
trations in the optimal range (above 22.7
µmol/l) even if combined consumption of fruit,
vegetables and fruit juice was lower than three
times a day. These values were significantly
higher than for smokers taking an equivalent
amount of fruit, vegetables and fruit juice. The
young smokers in this consumption category
had mean plasma concentrations in the mar-
ginal range. Mean log$_{10}$ plasma vitamin C
increased with increasing frequency of fruit,
vegetables and fruit juice consumption in all
groups but concentrations in smokers only
exceeded the equivalent of 22.7 µmol/l when
consumption was equivalent to three or more
portions a day. Among the older male smokers
mean log$_{10}$ plasma vitamin C did not exceed
levels equivalent to 22.7 µmol/l even when
consumption was greater than three times a
day. Female smokers 45–74 years had a higher
mean for this consumption range that was
equivalent to “optimal” status.

**Discussion**

The cut off points of 11.4 µmol/l and 22.7
µmol/l for low and marginal plasma vitamin C
status have been used by various workers. Only one of these studies claimed to use fasted
blood samples and significant correlations
between dietary vitamin C and plasma vitamin
C have been shown with both fasted and non-
fasted blood samples. If it is assumed that the
cut off points are based on fasting samples then
it would be expected that non-fasting values
might be slightly higher because of the effect
of recent vitamin C intake. However, it must be
noted that plasma vitamin C is a continuously
distributed variable and risk of deficiency is
probably also continuous. Nevertheless the
categorisation into the three groups of low,
marginal and optimal is useful to clarify the
issues discussed here.

Over 20% (of which 70% were smokers) of
this population sample had plasma vitamin C
concentrations < 11.4 µmol/l and were there-
fore categorised as being of low vitamin C status and were therefore categorised as being of low vitamin C status (table 1). However, the mean vitamin C intake of this 20% was above 40 mg (fig 1), the United Kingdom’s Reference
Nutrient Intake (RNI) for vitamin C. The RNI
is defined as “that amount of a nutrient
necessary for almost all the population” and
would therefore be expected to be enough to
maintain plasma vitamin C concentrations at
an adequate level. Data presented here suggest
that 40 mg/day is not adequate for a significant
fraction of the population and that plasma
vitamin C concentrations can be severely
compromised by smoking and aging in men.

This effect of age, sex and smoking on plasma
ascorbate concentrations has been known for
many years and various attempts have been
made to suggest the amount of vitamin C
required for smokers to maintain similar body
pools to non-smokers and for men to
maintain the same levels as women. The
Scottish Diet report proposed a vitamin C
intake twice that of the RNI (that is, 80 mg) to
be derived from increasing fruit and vegetable
consumption but it may be that even this
amount is not sufficient to maintain optimal
plasma concentrations in the older smokers.

Consumption of the equivalent of fruit,
vegetables and fruit juice three or more times
a day by this group resulted in a plasma
concentration of vitamin C twice that of the
non or rare consumers but plasma values were
still marginal. Despite a substantial intake of
vitamin C from potatoes and chips in men it
was the lack of fruit, green vegetables and fruit
juice that characterised the low category for
plasma vitamin C in both men and women (table 2 and fig 1). This provides yet further
evidence that improvements in diet and cessa-
tion of smoking are required to increase
plasma concentrations of vitamin C in the
population.

To our knowledge this is the first report of
the sources of vitamin C in the diet for those
with plasma concentrations commensurate
with a sub-optimal vitamin C status. However,
the comparative contribution of different
sources have been reported for men and
women smokers and non-smokers and for
those in non-manual and manual occupational
groups. No distinction was made between
citrus and non-citrus fruit or non-fried pota-
toes and chips in these previously reported
studies. Potatoes (including chips) contributed
13 mg/day of vitamin C in men and 8 mg/day in
women in the survey of British adults. National Food Survey data from 1990 shows
that potatoes contributed 8 mg and processed
potato products 2 mg to vitamin C content of
the daily diet but that the contribution from
fresh potatoes has been steadily falling since
1975 and the contribution from the potato
products increasing. These figures are compa-

table to those found in this study. Figure 1
shows that one third to one half of the
contribution from potatoes is provided by
chips. However, even if men eat two large por-
tions of potatoes or chips per day, or both, the
vitamin C contributed will not exceed 40 mg,
which is unlikely to be sufficient for the older
smokers. Advice to change from chips to pasta
and rice could be counterproductive in the
group with very low plasma vitamin C concen-
trations unless they embrace the positive
message of increasing fruit and vegetable con-
sumption. Our results are similar to those
already reported that fresh fruit was the main
source of vitamin C in non-smoking women.

Not surprisingly the contribution of fruits
and fruit juice to intake of vitamin C in men with
low plasma vitamin C is no greater than that
from potatoes and chips. For citrus fruit and juice consumption this is equivalent to less than a fifth of an orange per day. Frequent consumption of potatoes and chips showed no positive effect on vitamin C status but this could be because these frequent consumers tended to be those who consumed chips and potatoes in preference to the less traditional foods associated with a healthy diet such as rice, pasta and a range of fruit and vegetables. If this low category is to improve vitamin C status there is a need to increase consumption of fruit, vegetables and fruit juice before decreasing chip consumption. Care must be taken such that those at risk of vitamin C deficiency, who are often those at risk of coronary heart disease, are not given advice to reduce fat intake (for example, cut out chips) that further compromises their vitamin C status. Encouraging people to eat fruits and vegetables that they find palatable must take precedence over reducing fatty, but relatively nutrient dense foods such as chips.

The Scottish Diet report56 set behavioural targets for the year 2005. These targets represented a compromise between the World Health Organisation recommendation11 to eat at least 400 g fruit and vegetables (not including potatoes), best translated as five a day57 and the low average amount that the Scottish people were consuming at the time (181 g). Thus for young men and women the target was set at three or more portions of fruit and vegetables per day and for those 65–74 years at least two portions. Figure 2 shows that the three portions is less than ideal for those who continue to smoke and that two portions is not sufficient for older men even if they do not smoke. However, the incorporation of citrus fruit juice may be the solution for those unable for whatever reason to take more than two portions of solid fruit and vegetables a day.

The views expressed in this paper are those of the authors alone and do not necessarily reflect those of the funding body. The Scottish MONICA project was funded by grants from the Chief Scientist Office of the Scottish Office Home and Health Department and the British Heart Foundation. Conflicts of interest: none.

Funding: the Scottish MONICA project was funded by grants from the Chief Scientist Office of the Scottish Office Home and Health Department and the British Heart Foundation.


Plasma vitamin C and food choice in the third Glasgow MONICA population survey

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*J Epidemiol Community Health* 2000 54: 355-360
doi: 10.1136/jech.54.5.355

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