
Lluís Serra-Majem¹,²,³,*, Ma Cruz Pastor-Ferrer⁴, Conxa Castell³, Lourdes Ribas-Barba¹, Blanca Román-Viñas¹, Laia Font Ribera¹, Antoni Plasencia³ and Lluis Salleras⁵

¹Community Nutrition Research Centre, University of Barcelona Science Park, Baldri Reixac 4, Torre D 4A1, 08028 Barcelona, Spain: ²Department of Clinical Sciences, University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain: ³Division of Public Health, Department of Health, Generalitat of Catalonia, Barcelona, Spain: ⁴Department of Biochemistry, Hospital Germans Trias i Pujol, Badalona, Spain: ⁵Department of Public Health, University of Barcelona, Barcelona, Spain

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Abstract

Objective: The purpose of this study was to assess the 10-year trend in lipid and antioxidant vitamin levels in the Catalan population from 1992 to 2003.

Design: Two cross-sectional surveys were carried out in Catalonia, Spain, during 1992–93 and 2002–03. A subsample of the individuals participating in the surveys agreed to undergo a biochemical evaluation.

Subjects: Eight hundred and eighty individuals (393 males and 487 females) in the 1992–93 nutritional survey and 429 individuals (205 males and 224 females) in the 2002–03 nutritional and health survey. The subjects’ ages ranged from 18 to 74 years.

Results: Mean total cholesterol decreased from 5.3 to 5.1 mmol l⁻¹ (P < 0.005), and the prevalence of hypercholesterolaemia decreased, especially in males (from 23% to 10% in males from 50 to 64 years old, P < 0.05). Mean cholesterol high-density lipoprotein (HDL) values decreased in the entire sample (from 1.4 to 1.3 mmol l⁻¹, P < 0.001) and there was an increase in the percentage of population with low values of HDL (from 10% to 19%, P < 0.001). An increase in the percentage of the population with values of α-tocopherol at marginal risk levels (from 6% to 9%) and with low values of β-carotene (from 59% to 66%) was observed. The mean values for retinol increased in both males (from 1.99 to 2.44 µmol l⁻¹, P < 0.001) and females (from 1.69 to 2.29, P < 0.001).

Conclusion: Although there was a decrease in the percentage of population with hypercholesterolaemia, the decrease in HDL cholesterol worsened the lipid profile of the Catalan population. The increase in the values of some antioxidant vitamins did not affect the entire population since an increase in the number of individuals with marginal values was observed.

Biochemical markers are useful for the evaluation of nutritional status within a population, to estimate their dietary intake and to determine the prevalence of risk factors for the leading causes of morbidity and mortality.

Plasma lipid levels are one of the main risk factors for the prevention of cardiovascular diseases, which are the principal cause of mortality in developed countries. Although mortality related to cardiovascular diseases have stabilised in Spain in the last decades⁴, trends of hospital morbidity rates related to such diseases have shown an increase⁵. Even though ischaemic heart disease is still the leading cause of mortality among Spanish males and the third cause of mortality among Spanish females, Spain exhibits a lower rate of mortality related to cardiovascular diseases compared to countries in central and northern Europe⁶,⁷. On the other hand, the prevalence of hypercholesterolaemia in Spain increased from 6% in 1987 to 15% in 1999 and decreased to 11% in 2001⁸.

Plasma levels of antioxidants have shown a relationship with all-cause mortality⁹,¹⁰, cardiovascular disease⁹,¹¹, certain cancers¹²,¹³, insulin resistance¹⁴ and degenerative diseases¹⁵. Subclinical deficiencies of such vitamins are related to some of these diseases, especially in those subjects having greater oxidative stress¹⁶. In 1992–93, the Catalan government developed an Evaluation of Nutritional Status of the Catalan population, which included a biochemical assessment¹⁷. Blood lipid analysis included total cholesterol (TC), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL)}
cholesterol (HDL) and serum triglycerides (TG). β-Carotene, retinol and α-tocopherol were also determined.

Following WHO (World Health Organisation) recommendations, the 1991 Health Plan for Catalonia established as part of its objectives that by the year 2000 less than 20% of the population would have hypercholesterolaemia. To evaluate the compliance with such recommendations, it was stated to develop population nutritional surveys periodically. In 2002–03, a new Nutrition and Health Examination Survey of the Catalan population included an evaluation of the biochemical status of the population.

The purpose of this study was to evaluate the distribution of serum lipid levels (TC, HDL, LDL and TG) and fat-soluble vitamins in the adult population of Catalonia in 2002–03 and to analyse their trends since 1992–93, the latter being the date from which nutrition policies promoting healthy eating and lifestyle among the population had been implemented.

**Material and Methods**

**Sample**
The sample of the Evaluation of Nutritional Status of the Catalan population for the 1992–93 included 2446 persons aged 18 to 74 years. Thirty-eight per cent of the interviewees (n = 893) agreed to participate in the biochemical analysis of nutritional status. Of these persons, blood samples from a subsample of 378 individuals were randomly selected for determining levels of β-carotene, retinol and α-tocopherol.

The biochemical analysis for 2002–03 was conducted in a subsample (n = 429) aged 18 to 74 years of those subjects participating in the Catalan Nutrition and Health Survey 2002–03 (n = 1396), which was in and of itself a subsample of the Catalan Health Survey 2000 (ESCA) (n = 8400) carried out by the Department of Health and Social Security of the Generalitat de Catalunya.

**Analytical determinants**

**ENCAT 1992–93 survey**
In 1992–93, samples were obtained and processed by a mobile team at health centres that had been selected among those available in municipalities that were included in the sample. Blood samples were collected between 8 and 10 a.m. in 12-hour fasting conditions. Samples were processed immediately after being collected. Blood was centrifuged at 3000 r.p.m. for 15 min at 8°C, after having undergone a period of pre-centrifugation for 30 min. Serum was fractioned into aliquot portions via disposable pipettes. Samples for lipid analysis were immediately placed in portable coolers, maintained at 4°C and sent to the Biochemistry Service at the Vall d’Hebrón Hospital in Barcelona for analysis within 24 hours post-extraction. Samples for analysing vitamins were frozen at −80°C and transported in portable freezers to the Biochemistry Service at the Germans Trias i Pujol Hospital in Badalona.

Serum TC, high-density cholesterol (HDL), low-density cholesterol (LDL) and triglycerides (TG) were analysed. TC and TG were determined by enzymatic methods CHOD-PAP and GPO-PAP, respectively, using the autoanalyser Hitachi 747 and reagents from Boehringer-Mannheim.

HDL was determined by the Assmann et al. method, after precipitation of LDL, very-low-density lipoproteins and chylomicrons with phosphotungstic acid and magnesium chloride. LDL was calculated with the Friedewald formula (LDL = TC − (TG/5 + HDL)) only for those samples having triglyceride concentrations lower than 300 mg dl⁻¹.

Serum concentrations of β-carotene, retinol and α-tocopherol were obtained by high-resolution liquid chromatography with ultraviolet detection. Given that commercial quality control teams did not exist at the time samples were collected, blood bank donor samples were used as control and it was determined as a coefficient of variation. The coefficients of variation (CV) intra and inter-assay ranged from 6% to 9.9% for β-carotene, from 4.5% to 7.3% for retinol and from 3.5% to 8.4% for α-tocopherol.

**Nutrition and Health 2002–03 survey**
In the 2002–03 biochemical evaluation, blood samples were obtained between 9 and 11 a.m. in fasting conditions. Samples were labelled and processed in the laboratory of the health region that corresponded to the centre where extractions were realised. Upon reaching the laboratory they were centrifuged and separated into aliquots, labelled and frozen at −20°C and then transferred to the biochemical laboratory at the Germans Trias i Pujol Hospital in Badalona.

The methodology to analyse serum lipids and vitamins was the same as the one utilised in the ENCAT (Evaluation of Nutritional Status in Catalonia) 1992–93 study.

The cut-off points utilised to assess lipid concentrations were as follows: TC: <5.18, 5.18–6.21 and ≥6.22 mmol l⁻¹; LDL: <2.59, 2.59–3.36, 3.37–4.13 and ≥4.14 mmol l⁻¹; HDL: <1.04, 1.04–1.55 and ≥1.56 mmol l⁻¹; TG: <1.67, 1.67–2.25 and ≥2.26 mmol l⁻¹.

Values for the concentration of vitamins were standardised for serum lipid concentrations. Cut-off values applied to vitamin concentrations were as follows: β-carotene: <0.4 μmol l⁻¹ (deficit), retinol: <0.7 μmol l⁻¹ (severe deficit) and α-tocopherol: <11.6 μmol l⁻¹ (severe deficit), 11.6–23.1 (marginal deficit) and ≥23.2 μmol l⁻¹ (normal).

The comparison of the mean values and the percentage of the distribution of the variables are shown.
Results

In 1992–93 the final sample included 880 individuals (393 males and 487 females) for the lipid analysis and 337 individuals (144 males and 193 females) for the vitamin analysis, aged 18 to 74 years. In 2002–03, 429 subjects (205 males and 224 females) aged 18 to 74 years participated in the lipid and vitamin evaluation.

Mean plasma concentrations of TC, LDL, HDL and TG are shown in Table 1. In the 1992–93 evaluation, mean value for TC was 5.26 mmol l\(^{-1}\) (203.5 mg dl\(^{-1}\)) in males and 5.28 mmol l\(^{-1}\) (204.3 mg dl\(^{-1}\)) in females. Women had higher TC levels, except for the age group of 35–49 years where men had higher values. In the 2002–03 analysis\(^1\) the mean value for TC was 5.1 mmol l\(^{-1}\) (197.3 mg dl\(^{-1}\)) for males and females. In men, mean TC levels increased with age throughout middle age and then decreased, reaching a peak at ages 35–49 years. For women mean TC values increased in every age group, until ages 65–74 years. Mean TC levels decreased during the decade from 5.3 to 5.1 mmol l\(^{-1}\) (\(P<0.005\)), with males showing a higher decrease over all age groups than females. By age groups, and gender, only females from 50 to 64 years old showed a significant decrease (from 5.8 to 5.5 mmol l\(^{-1}\)). Individuals aged 18–34 and women aged 65–74 years maintained the same TC levels.

Mean LDL values remained stable, 3.30 mmol l\(^{-1}\) (127.4 mg dl\(^{-1}\)) in 1992–93 and 3.26 mmol l\(^{-1}\) (125.9 mg dl\(^{-1}\)) in 2002–03, with higher values at older ages in both genders and both surveys. In 1992–93 women showed lower LDL values than males except for those from 50 to 64 years (3.71 mmol l\(^{-1}\)), who had higher values than males of the same age group (3.59 mmol l\(^{-1}\)). In 2002–03, the LDL values in females were lower than in males except for the age group of 50–64 years and 65–74 years. The mean LDL values decreased in the interval of the period analysed in all age groups, except for males and females from 18 to 34 where the values remained stable (2.9 mmol l\(^{-1}\) in males and 2.7 mmol l\(^{-1}\) in females) and females from 65 to 74 where an increase was observed (from 3.5 to 3.7 mmol l\(^{-1}\)).

Mean HDL was 1.44 mmol l\(^{-1}\) (53.9 mg dl\(^{-1}\)) in 1992–93 and 1.34 mmol l\(^{-1}\) (50.2 mg dl\(^{-1}\)) in 2002–03 (\(P<0.001\)), with women showing higher levels than men. The HDL values decreased in the period analysed from 1.29 to 1.20 mmol l\(^{-1}\) in males (\(P<0.001\)) and from 1.57 to 1.48 in females (\(P<0.005\)). Only males from 65 to 74 years and females from 35 to 49 years maintained the same HDL levels.

Mean serum TG was 1.17 mmol l\(^{-1}\) (103.57 mg dl\(^{-1}\)) in 1992–93 and 1.08 mmol l\(^{-1}\) (95.6 mg dl\(^{-1}\)) in 2002–03 (\(P<0.01\)). Men had higher TG levels than females except for women aged 65 to 74 years in the 2002–03 survey. In the period analysed, males showed a decrease in the TG levels, from 1.34 to 1.21 mmol l\(^{-1}\) (\(P<0.01\)), and only individuals from 18 to 34 showed an increase (from 1.03 mmol l\(^{-1}\) to 1.11 mmol l\(^{-1}\)). Only females from 35 to 49 years showed a significant decrease in their TG levels (from 0.90 to 0.85 mmol l\(^{-1}\), \(P<0.05\)).

Tables 2–5 show the distribution of the population according to the proposed cut-off points for TC, LDL, HDL and TG. The proportion of the population with high serum levels of TC (\(\geqslant 6.22\) mmol l\(^{-1}\)) decreased from 18% to 12% in males and from 20% to 18% in females during the 10-year interval. Only males from 50 to 64 years showed a significant decrease in the percentage of individuals with hypercholesterolaemia (from 23% to 10%, \(P<0.05\)). In 2002–03, about 31% of the

Table 1 (1992–2003) in the mean serum cholesterol and triglycerides of the Catalan population

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>n</td>
</tr>
<tr>
<td>18–34</td>
<td>123</td>
<td>4.62</td>
<td>55</td>
</tr>
<tr>
<td>35–49</td>
<td>103</td>
<td>5.61</td>
<td>52</td>
</tr>
<tr>
<td>50–64</td>
<td>104</td>
<td>5.51</td>
<td>63</td>
</tr>
<tr>
<td>65–74</td>
<td>64</td>
<td>5.54</td>
<td>56</td>
</tr>
<tr>
<td>Total</td>
<td>394</td>
<td>5.41</td>
<td>305</td>
</tr>
<tr>
<td>18–34</td>
<td>143</td>
<td>4.65</td>
<td>63</td>
</tr>
<tr>
<td>35–49</td>
<td>148</td>
<td>5.17</td>
<td>63</td>
</tr>
<tr>
<td>50–64</td>
<td>130</td>
<td>5.84</td>
<td>56</td>
</tr>
<tr>
<td>65–74</td>
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<td>42</td>
</tr>
<tr>
<td>Total</td>
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<td>5.28</td>
<td>224</td>
</tr>
<tr>
<td>18–34</td>
<td>266</td>
<td>4.64</td>
<td>118</td>
</tr>
<tr>
<td>35–49</td>
<td>251</td>
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<td>115</td>
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<tr>
<td>50–64</td>
<td>136</td>
<td>5.69</td>
<td>119</td>
</tr>
<tr>
<td>65–74</td>
<td>138</td>
<td>5.65</td>
<td>77</td>
</tr>
<tr>
<td>Total</td>
<td>891</td>
<td>5.27</td>
<td>429</td>
</tr>
</tbody>
</table>

LDL – low-density lipoprotein; HDL – high-density lipoprotein; ns – non-significant.
population had moderately high cholesterol values (5.18–6.21 mmol/l), a proportion that increased to 47% of the population in the age group of 65–74 years old. Referring to LDL cholesterol, the percentage of males with high values decreased from 19% to 17%. In females and for all age groups in the period analysed, an increase in the percentage of individuals with the lowest as well as the highest LDL levels was shown. The percentage of population with high levels of HDL decreased from 35% to 27% (P < 0.001), in both males (from 20% to 11%, P < 0.01) and females (from 47% to 41%, P < 0.05) and for all age groups. The proportion of individuals with low levels of HDL increased (from 10% to 19%) in all age groups, especially in males from 35 to 49 years (from 17% to 37%). In the 2002–03 analysis, the percentage of population with high values for TG (≥2.26 mmol/l)
decreased (from 7% to 6%) although the change was not significant.

Mean values for \(a\)-tocopherol, \(b\)-carotene and retinol are shown in Table 6. \(a\)-Tocopherol levels increased from 31.88 \(\mu\)mol \(l^{-1}\) in 1992 to 33.59 \(\mu\)mol \(l^{-1}\) in 2003 \((P, 0.005)\). The mean concentrations of \(a\)-tocopherol increased in all age groups except for older females where the values decreased from 35.1 in 1992–93 to 34.2 \(\mu\)mol \(l^{-1}\) in 2002–03. Only females from 18 to 34 years showed a statistically significant increase (from 31.6 to 33.4, \(P, 0.05)\). Values were lower in males than in females except for the older men in the 2002–03 survey, which had higher values than females for the same age group (35.2 and 34.2 \(\mu\)mol \(l^{-1}\), respectively).

Mean plasma levels for \(b\)-carotene was 0.42 \(\mu\)mol \(l^{-1}\) in the 1992–93 survey and 0.39 \(\mu\)mol \(l^{-1}\) in the 2002–03 analysis \((P<0.05)\). Women had higher carotenoid levels than men. In the 10-year interval, there was a decrease in

### Table 4
Trends (1992–2003) in the distribution of the Catalan population according to proposed cut-off points for HDL cholesterol by gender and age group

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1992–93</th>
<th>2002–03</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1.04</td>
<td>1.04–1.55</td>
</tr>
<tr>
<td>Males</td>
<td></td>
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<td>18–34</td>
<td>18</td>
<td>14.6</td>
</tr>
<tr>
<td>35–49</td>
<td>17</td>
<td>16.5</td>
</tr>
<tr>
<td>50–64</td>
<td>22</td>
<td>21.2</td>
</tr>
<tr>
<td>65–74</td>
<td>13</td>
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</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>17.8</td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–34</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>35–49</td>
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<td>2.0</td>
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<tr>
<td>50–64</td>
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<td>3.8</td>
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<tr>
<td>65–74</td>
<td>6</td>
<td>6.9</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>3.2</td>
</tr>
</tbody>
</table>

### Table 5
Trends (1992–2003) in the distribution of the Catalan population according to proposed cut-off points for triglycerides by gender and age group

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1992–93</th>
<th>2002–03</th>
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<tbody>
<tr>
<td></td>
<td>&lt;1.67</td>
<td>1.67–2.25</td>
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<tr>
<td>Males</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–34</td>
<td>109</td>
<td>88.6</td>
</tr>
<tr>
<td>35–49</td>
<td>71</td>
<td>68.9</td>
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<td>50–64</td>
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<td>65–74</td>
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</tr>
<tr>
<td>Total</td>
<td>307</td>
<td>77.9</td>
</tr>
<tr>
<td>Females</td>
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<td></td>
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<tr>
<td>18–34</td>
<td>129</td>
<td>90.2</td>
</tr>
<tr>
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<td>93.9</td>
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<td>65–74</td>
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<td>77.0</td>
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<tr>
<td>Total</td>
<td>428</td>
<td>86.1</td>
</tr>
</tbody>
</table>

### Table 6
Trends (1992–2003) in the distribution of the Catalan population according to proposed cut-off points for HDL cholesterol by gender and age group

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1992–93</th>
<th>2002–03</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1.04</td>
<td>1.04–1.55</td>
</tr>
<tr>
<td>Males</td>
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<td>18–34</td>
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<td>17</td>
<td>20.8</td>
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<tr>
<td>65–74</td>
<td>11</td>
<td>14.0</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>17.8</td>
</tr>
</tbody>
</table>

### Table 7
Trends (1992–2003) in the distribution of the Catalan population according to proposed cut-off points for triglycerides by gender and age group

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1992–93</th>
<th>2002–03</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;1.67</td>
<td>1.67–2.25</td>
</tr>
<tr>
<td>Males</td>
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<td></td>
</tr>
<tr>
<td>18–34</td>
<td>109</td>
<td>88.6</td>
</tr>
<tr>
<td>35–49</td>
<td>71</td>
<td>68.9</td>
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<tr>
<td>50–64</td>
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<td>75.0</td>
</tr>
<tr>
<td>65–74</td>
<td>49</td>
<td>76.6</td>
</tr>
<tr>
<td>Total</td>
<td>307</td>
<td>77.9</td>
</tr>
</tbody>
</table>

ns – non-significant.

HDL – high-density lipoprotein; ns – non-significant.
the mean values of β-carotene for all age groups except for those males younger than 35 years (from 0.34 to 0.40 μmol l⁻¹) and for women from 50 to 64 years, although not statistically significant.

Mean levels of retinol increased in the period of study, from 1.82 μmol l⁻¹ in 1992–93 to 2.36 μmol l⁻¹ in the 2002–03 survey (P < 0.001), both for males (from 1.99 to 2.44, P < 0.001) and for females (from 1.69 to 2.29, P < 0.001) and for all age groups. Men showed higher values of retinol concentrations (2.44 μmol l⁻¹) than females (2.29 μmol l⁻¹) except for females from 35 to 49 years in the 2002–03 (2.39 μmol l⁻¹) analysis, which had higher values than males (2.28 μmol l⁻¹).

Table 7 shows the distribution of the Catalan population with concentrations of α-tocopherol and β-carotene below the threshold used to define deficiency or inadequate levels. There has been an increase in the population with a marginal deficit of α-tocopherol (from 5.8% in 1992–92 to 8.7% in 2002–03), especially so in males for whom 10.5% of the population were at marginal risk in the 2002–03 survey. For males under 35 years of age, there was an important increase in the percentage of individuals with values below 23.1 μmol l⁻¹ (from 6.8% to 18.5%). Only individuals from 65 to 74 years showed a decrease in the percentage of marginal deficit (from 8.5% to 3.0%). In the 2002–03 survey, 1.6% of females from 35 to 49 years showed a severe deficit.

An increase in the percentage of the population at risk for low β-carotene values was observed (from 58.9% in 1992–93 to 65.8% in 2002–03), except for males younger than 35 years and females from 65 to 74 years where a decrease was shown.

**Discussion**

The main finding of this study was that the Catalan population shows a slightly worsened lipid profile for the decade analysed, due to the decrease reported in the HDL levels of the population. On the other hand, a decrease in TC, LDL and TG levels, a trend that had already been previously reported for the 1980–1992 decade, counters the main findings seen. Certain European countries and the USA have shown similar trends, with a decrease in the serum lipid levels but of a different magnitude for each lipoprotein. The analysis of serum lipids conducted in the USA during the same time period also showed a decrease in the levels of TC and LDL and a decrease in the percentage of the population with hypercholesterolaemia, as shown in adults from Catalonia. The evolution of HDL and TG levels is of a different magnitude between both countries. In the USA, HDL levels increased in females, whereas levels in males remained stable. The TG levels increased in the entire population. In the Catalan population, a decrease in HDL levels is similar in both males and females. Referring to European countries, trend data from Germany showed an increase in the percentage of population with hypercholesterolaemia while trend data from the MONICA study have shown some stabilisation in HDL levels, but not a clear decrease in serum HDL cholesterol levels, which was the trend observed in the Catalan population. HDL trends have improved in certain countries such as in Finland, where a well-planned nutrition policy has been shown to have specific benefits. On the other hand, trend data from a Swiss region...
participating in the MONICA study also reported a decrease in the HDL levels of the population. Mean HDL levels in the Catalan population are lower than those reported in the Finnish population or in France, but HDL levels in the Catalan population are lower than those in other European countries. In Catalonia, as shown in other countries, TC increased with age as shown in other countries, TC increased with age. The reduction in the percentage of population with severe deficit contrasts with the notorious increase in the prevalence of overweight and obesity in the Catalan population, according to data from the same period. On the contrary, in other countries such as the USA, Japan and Finland, data show that lipid levels of TG increased together with the prevalence of overweight and obesity. Moderation in alcoholic beverage consumption has been reported in Catalonia.

It is noteworthy that the cohort of young adults had the worst profile than other age groups, data that coincide with other publications. TC, LDL and TG did not decrease in this age group, especially among males. This trend shows that improvements in the lifestyle of adults and older individuals are not affecting children and youth. Deterioration in their diet quality, as seen in observed decreases in fruit and vegetable consumption and increased fat intake, may explain these trends. In fact, the increase in obesity prevalence of the Catalan population is of a greater magnitude among children than adults. According to the enKid study, the prevalence of obesity among Catalan individuals aged 2–24 years was 9.5% in 1998–2000.

Nevertheless, the lipid profile of the Catalan population is still one of the healthiest among western societies. According to the European-based MONICA study, in the mid-1990s, Catalonia showed one of the lowest morbidity and mortality related to cardiovascular diseases lower than other European countries. In Catalonia, as shown in other countries, TC increased with age group and females had better lipid profiles than males.

The reported decrease in triglyceride levels contrasts with the notorious increase in the prevalence of overweight and obesity in the Catalan population, according to data from the same period. On the contrary, in other countries such as the USA, Japan and Finland, data show that lipid levels of TG increased together with the prevalence of overweight and obesity. Moderation in alcoholic beverage consumption has been reported in Catalonia.

It is noteworthy that the cohort of young adults had the worst profile than other age groups, data that coincide with other publications. TC, LDL and TG did not decrease in this age group, especially among males. This trend shows that improvements in the lifestyle of adults and older individuals are not affecting children and youth. Deterioration in their diet quality, as seen in observed decreases in fruit and vegetable consumption and increased fat intake, may explain these trends. In fact, the increase in obesity prevalence of the Catalan population is of a greater magnitude among children than adults. According to the enKid study, the prevalence of obesity among Catalan individuals aged 2–24 years was 9.5% in 1998–2000.

Nevertheless, the lipid profile of the Catalan population is still one of the healthiest among western societies. According to the European-based MONICA study, in the mid-1990s, Catalonia showed one of the lowest

### Table 7 Distribution of the Catalan population according to concentrations of α-tocopherol and β-carotene (1992–2003)

<table>
<thead>
<tr>
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ns = non-significant.
prevalences of hypercholesterolaemia among European
countries. However, should the tendency reported in
this study continue, it may be that supposed protective
factors that benefit Mediterraneans population’s health
will no longer be sufficient to prevent the increase in the
incidence of related chronic disease.

Although circulating concentrations of α-tocopherol
increased in the Catalan population, a simultaneous
increase in the percentage of population at risk for
inadequate intakes was also observed. Available data on
macro- and micronutrient intake in the 2002–03 Catalan
Nutrition Survey showed that a high proportion of the
population (33%) had vitamin E intakes below 2/3 of
the recommended dietary intake for the Spanish popu-
lation55. However, the values shown for α-tocopherol
were higher than the values reported for populations
in the USA54, France, Hungary, the UK55, Ireland and
the Netherlands56. Males in Catalonia showed higher
concentrations of retinol and lower concentrations of
β-carotene than females, a distribution that is in ac-
accordance with other population-based studies57–59. Some
publications have shown differences between males and
females in the plasma levels of α-tocopherol54, which
were not observed in the Catalan population.

There has not been a clear modification in the profile
of serum antioxidants in the Catalan population. A slight
worsening in levels of α-tocopherol and β-carotene was
reflected in an increase in the proportion of individuals
with marginal deficits for these vitamins. This would
mean that modifications in vitamin levels have not been
homogeneous for the entire population and that certain
groups of individuals have changed their nutritional
habits, such as, for example, a decreased fruit and vege-
table intake. The increase in the retinol levels for the
entire population is considered as a positive trend.

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Conflict of interest declaration: None of the authors
had any conflicts of interest in connection with this study.

Authorship responsibilities: LSM was director of the
study, was responsible for the interpretation of dietary
data and the writing of the paper; MCPF was responsible
for the laboratory analysis; CC participated in the study
concept and design and revised the paper providing
expert advice on data interpretation; LRB was responsible
for the statistical analysis and revised the paper providing
expert advice on data interpretation; BRV revised the
paper providing expert advice on data interpretation and
on the discussion of the paper; LFR provided advice on
data interpretation; AP and LS revised the paper providing
expert advice in the discussion of the paper.


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References

1 Boix R, Medrano MJ, Almazán J. Actualización de la
mortalidad por enfermedades cardiovasculares arterio-
scleróticas: enfermedad cerebrovascular y enfermedad
isquémica del corazón. Boletín Epidemiológico Semanal

2 Instituto Nacional de Estadística. Morbilidad hospitalaria
Available at http://193.146.50.130/htdocs/cardiov/isquemica/
isquemica.htm (Accessed 6 November 2006).

3 Levi F, Lucchini F, Negri E, La Vecchia C. Trends in mortality
from cardiovascular and cerebrovascular diseases in Europe

4 Sarti C, Rastenyte D, Cepaitis Z, Tuomilehto J. International
31(7): 1588–601.

5 Cerrato Crespán E, Boix Martínez R, Medrano Albero MJ.
Riesgo cardiovascular en España. Boletín Epidemiológico

6 De Waart FG, Schouten EG, Stalenhoef AF, Kok FJ. Serum
carotenoids, alpha-tocopherol and mortality risk in a
prospective study among Dutch elderly. International

7 Buijsse B, Feskens EJ, Schettgen-Gsell D, Ferry M, Kok FJ,
Kromhout D, de Groot LC. Plasma carotene and alpha-
tocopherol in relation to 10-y all-cause and cause-specific
mortality in European elderly: the Survey in Europe on
Nutrition and the Elderly, a Concerted Action (SENECA).

8 Voutilainen S, Nurmi T, Mursu J, Rissanen T. Carotenoids
and cardiovascular health. American Journal of Clinical

9 Hak AE, Ma J, Powell CB, Campos H, Gaziano JM, Willett
WC, et al. Prospective study of plasma carotenoids and

https://doi.org/10.1017/S1368980000700985 Published online by Cambridge University Press


