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# Vitamin status in different groups of the Spanish population: a meta-analysis of national studies performed between 1990 and 1999

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## Abstract
*Objective:* Studies performed on the nutritional status of the Spanish population have been very heterogeneous with respect to methodology, sample size, geographical location, socio-economic level and health status of the subjects involved. In order to gain an overall view of the state of knowledge in this area, a meta-analysis was performed on the results of all such studies undertaken in Spain between 1990 and 1999.
*Results:* The dietetic data reviewed showed mean intakes similar to those recommended. The results obtained for the biochemical parameters analysed were within normal limits. However, results for some vitamins were very close to the lower established limits for the reference intervals (recommended intakes or blood levels), meaning that a variable percentage of subjects show values lower than those recommended. The percentage of subjects with intakes below those recommended for niacin, vitamin $B_{12}$ and C was small. The percentage of inadequate intakes of thiamine and riboflavin was small as well. However, for all other vitamins, especially D and E, the number of people with intakes below recommended was rather high, particularly so in some studies. At blood level, deficiencies of vitamins $B_{12}$, A and E were infrequent. However, for all other vitamins, prevalence of deficiency varied within a wide range. With respect to vitamins D, $B_1$, $B_2$ and $B_6$, over 50% of the population showed inadequate levels.
*Conclusions:* The methodologies used in the studies included in this review were very varied and the knowledge gained is still incomplete. Despite the average Spanish diet often being regarded as satisfactory, this review and other studies show the situation can be improved.

**Keywords**
Vitamins
Meta-analysis
Spanish population
Children
Adolescents
Pregnant women
Elderly people
Deficiencies

At the present time, the nutritional reality of the Spanish population is drawing much attention[1]. However, it is also a source of controversy. The message that the diet is perfect, and a little variety is enough to guarantee its balanced nature, is often heard. There are, however, no arguments to back such a statement[2,3].

Several studies indicate the existence of nutritional imbalances. The consumption of fat and protein is too high, while that of carbohydrates and fibre is insufficient. The possibility that sub-clinical vitamin and mineral deficiencies exist has also been suggested[3–6].

Studies performed to date have been heterogeneous in their methodology, sample size, geographical location, and the socio-economic level and health status of the subjects involved. It is therefore urgent that knowledge on the nutritional problems of the Spanish population be gained as a first step in the introduction of adequacy measures[4,6].

The aim of the present investigation was to perform a meta-analysis on the results of vitamin status studies performed over the last 10 years, in order to gain an overall view of our knowledge in this area.

## Methods

### Search for studies to be combined

The search for studies to combine was performed electronically by consulting the MEDLINE, EMBASE and IME databases. It has been estimated that automated databases cover more than two-thirds of scientific output in this field[7]. A manual search was also made of specialised libraries.

The search strategy consisted of selecting epidemiological or clinical studies in the areas of food, nutrition or dietetics, written in English, French or Spanish (although undertaken by national teams), performed and published

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between the years 1990 and 1999, and which looked into the dietary intake of vitamins or blood indicators of vitamin status. Data from unpublished studies were not included.

Given that 76 studies were selected for combination and meta-analysis, it is very unlikely that the results obtained and the relationships described are artefacts due to a publishing bias. However, there are some limitations to the method since determinants do exist that decide whether an investigation is published (type of design and results in agreement with established knowledge etc.)[8]. This fact should be considered.

### *Inclusion/exclusion criteria*

The following were included in the meta-analysis:

- papers from authors of national affiliation;
- written in English, French or Spanish;
- performed and published between 1990 and 1999;
- performed in populations with no established diagnosis of metabolic or organic illness; and
- performed with validated methodology.

Studies excluded were those without precise, quantitative information, those which gave no means, standard errors or standard deviations, and those whose averages differed by more than three times the observed global mean.

Since the dietary study of people aged between 20 and 60 years was undertaken with great rigour in other papers[4], in the present study it was possible to perform a meta-analysis of the published blood results of people of all ages, as well as on the vitamin intakes of pregnant women, those under 20 years of age and those over 60 years.

### *Collection of information*

In order to standardise the evaluation, relevant information was taken from each paper and recorded on a pre-designed form. Data collected for analysis included: the national affiliation of the researchers, the bibliographical reference of the work (authors, title, journal, year, volume, pages), sample size, characteristics of the subjects analysed (sex, age, population, special circumstances), experimental design, other features of interest, and the results obtained (mean ± standard deviation (SD)).

### *Statistical analysis of results*

Following tabulation of results in electronic spreadsheets, a quantitative, descriptive meta-analysis was performed of the intake of different vitamins and the blood parameters that indicate vitamin status for each of the sub-populations analysed. These were grouped with respect to subject age.

### *Homogeneity in the measurement of effects*

Although a certain amount of heterogeneity might allow one to generalise more, if this is too liberal, the integration of results can be more difficult[8]. Therefore, those articles in which the means differed by more than three times the observed global mean were excluded. Amongst those finally selected, it can be assumed that any heterogeneity is due to the methodology of the investigation and the biological and social characteristics of the groups studied.

## Results

The results of the meta-analysis are shown in Tables 1 and 2. Table 1 provides intake data in comparison with reference values for the Spanish population[9]. Table 2 shows biochemical vitamin-status indicator data. A structured summary of the results of each study included in the meta-analysis has been detailed in a previous publication[6].

Tables 3 and 4 summarise the number of studies reviewed and the number of individuals included in the meta-analysis. Table 3 also shows the percentage of intakes below those recommended, and Table 4 shows the blood figures below lower cut-off levels (bearing in mind the datum given by the authors of each study)[6].

## Discussion

Meta-analysis was performed on the results of 76 papers. Those which looked into vitamin intake were more numerous than those examining blood indicators of nutritional status (Tables 3 and 4).

From a dietetic point of view, vitamin C was the most studied, followed by vitamins A, $B_2$, $B_{12}$, $B_1$, D and niacin (Tables 1 and 3). At blood level, vitamins A and E received the attention of more studies (Tables 2 and 4).

The number of subjects studied was greater for investigations of the intake of vitamins C, A and $B_{12}$ (Tables 1 and 3), while vitamins A and E involved the largest number in investigations at serum level (Tables 2 and 4). However, for some vitamins, both the number of studies (especially at blood level and for vitamins D, $B_2$ and $B_{12}$, thiamine and pyridoxine) and the number of subjects studied in them were very low, indicating the need for more research if reliable conclusions are to be drawn[6].

The means of dietetic data were similar to recommended intakes, and blood values for the biochemical parameter studies were within the normal range. However, for some vitamins, figures were close to established lower limits of normality (recommended intakes or normal blood levels). This means that a high percentage of people have values below those recommended (Tables 1 and 2).

The percentage of subjects whose intakes were below recommended for vitamins $B_{12}$ and C was low, nor was it

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**Table 1** Meta-analysis data with respect to vitamin intake

| | Subjects studied (*n*) | Age (years) | Results of meta-analysis (mean±SD) | Recommended intake |
|---|---|---|---|---|
| Vitamin A (μg) | 2638 | 2–14 | 996±305 | 300–1000 |
| | 1812 | 14–20 | 899±273 | 800–1000 |
| | 915 | 60–91 | 846±268 | 800–1000 |
| Vitamin D (μg) | 2553 | 2–20 | 1.84±0.6 | 5–10 |
| | 479* | 20–50 | 3.01±0.7 | 5–10 |
| | 1317 | 50–90 | 2.07±0.6 | 5 |
| Vitamin E (mg) | 1754 | 2–20 | 12.3±1.1 | 6–12 |
| | 292* | 20–50 | 3.2±0.8 | 12–15 |
| | 1890 | 50–90 | 8.4±0.9 | 12 |
| Vitamin $B_1$ (mg) | 3142 | 0–20 | 1.5±0.4 | 0.3–1.2 |
| | 408* | 20–60 | 1.4±0.4 | 0.8–1.2 |
| | 1498 | 60–90 | 1.1±0.4 | 0.7–1 |
| Vitamin $B_2$ (mg) | 3144 | 0–20 | 1.5±0.6 | 0.4–1.8 |
| | 406* | 20–60 | 1.4±0.6 | 1.1–1.8 |
| | 1498 | 60–90 | 1.6±0.6 | 1.0–1.4 |
| Niacin (mg) | 3286 | 2–18 | 23.4±7.3 | 8–20 |
| | 482* | 18–60 | 31.7±8.1 | 12–20 |
| | 1141 | 60–94 | 19.6±7.6 | 11–16 |
| Vitamin $B_6$ (mg) | 366 | 0–17 | 1.78±0.5 | 0.3–2.1 |
| | 1671* | 18–60 | 1.63±0.5 | 1.6–3.6 |
| | 1047 | 60–90 | 1.42±0.4 | 1.6–1.8 |
| Vitamin $B_{12}$ (μg) | 3176 | 2–20 | 8.6±3.6 | 0.9–2 |
| | 538* | 20–60 | 8.7±5.8 | 2.0–2.2 |
| | 1510 | 60–90 | 9.2±5.3 | 2 |
| Folic acid (μg) | 2629 | 2–18 | 206±76 | 100–200 |
| | 491* | 19–65 | 258±89 | 200–400 |
| | 695 | 65–90 | 273±91 | 200 |
| Vitamin C (mg) | 4266 | 0–20 | 132±81 | 50–60 |
| | 491* | 20–60 | 169±73 | 60–80 |
| | 2556 | 60–94 | 116±72 | 60 |

* Pregnant women.

**Table 2** Meta-analysis data with respect to biochemical markers of vitamin status

| | Subjects studied (*n*) | Age (years) | Results of meta-analysis (mean±SD) |
|---|---|---|---|
| Retinol (μmol $l^{-1}$) | 2706 | 0–24 | 1.81±0.3 |
| | 620 | 24–60 | 1.76±0.3 |
| | 942 | 60–97 | 1.92±0.4 |
| β-Carotene (μmol $l^{-1}$) | 924 | 2–20 | 1.76±0.3 |
| | 886 | 20–60 | 1.95±0.3 |
| | 1199 | 60–90 | 0.98±0.3 |
| Vitamin E (μmol $l^{-1}$) | 346 | 0–20 | 28.6±8.6 |
| | 1221 | 20–60 | 38.9±7.5 |
| | 2442 | 60–90 | 40.3±6.7 |
| Vitamin $B_1$ (α-ETK) | 131 | Newborns | 1.51±0.11 |
| | 513 | 2–13 | 1.13±0.13 |
| | 131 | 16–41 | 1.25±0.17 |
| | 11 | 70–84 | 1.21±0.12 |
| Vitamin $B_2$ (α-EGR) | 131 | Newborns | 1.10±0.05 |
| | 513 | 2–13 | 1.10±0.06 |
| | 131 | 14–40 | 1.20±0.13 |
| | 83 | 40–95 | 1.08±0.11 |
| Vitamin $B_6$ (α-EGOT) | 131 | Newborns | 1.33±0.19 |
| | 131 | 16–41 | 1.71±0.23 |
| Vitamin $B_6$ (nmol $l^{-1}$) | 103 | 2–5 | 64±12 |
| | 410 | 9–13 | 69±15 |
| | 20 | 80–85 | 35.2±9.8 |
| Vitamin $B_{12}$ (pg $ml^{-1}$) | 1490 | 0–15 | 679.7±127 |
| | 280 | 65–89 | 627.3±94 |
| Serum folate (ng $ml^{-1}$) | 1227 | 0–15 | 9.9±2.4 |
| | 988 | 15–65 | 7.6±2.5 |
| Erythrocyte folate (ng $ml^{-1}$) | 582 | 2–15 | 347±88 |
| | 992 | 65–90 | 336±83 |
| Vitamin C (mg $dl^{-1}$) | 1016 | 2–14 | 1.8±0.6 |
| | 217 | 18–45 | 0.9±0.5 |
| | 76 | 45–84 | 0.8±0.5 |

α-ETK – Erythrocyte transketolase enzyme activity coefficient; α-EGR – erythrocyte glutathione reductase activity coefficient; α-EGOT – erythrocyte glutaminc–oxaloacetic transaminase activity coefficient.

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**Table 3** Summary of the dietary data included in the meta-analysis with respect to the different vitamins and percentages of subjects with intakes below recommended in the papers reviewed

| Daily intake of: | Papers reviewed (*n*) | Subjects studied (*n*) | Percentage of subjects with intakes below recommended (%) |
|---|---|---|---|
| Vitamin A (μg) | 39 | 5365 | 14–65.4 |
| Vitamin D (μg) | 29 | 4349 | 47.1–96.7 |
| Vitamin E (mg) | 26 | 3936 | 54–95.4 |
| Vitamin $B_1$ (mg) | 33 | 5048 | 0–50 |
| Vitamin $B_2$ (mg) | 33 | 5048 | 0–53.3 |
| Niacin (mg) | 29 | 4909 | 0–49.2 |
| Vitamin $B_6$ (mg) | 19 | 3084 | 13–88.5 |
| Vitamin $B_{12}$ (μg) | 34 | 5224 | 0.8–23 |
| Folic acid (μg) | 22 | 3815 | 1.6–88 |
| Vitamin C (mg) | 40 | 7313 | 0–48.4 |

**Table 4** Summary of the biochemical data included in the meta-analysis and percentage of subjects with deficient blood indicator levels in the papers reviewed

| | Papers reviewed (*n*) | Subjects studied (*n*) | Percentage of subjects with deficient blood indicator levels (%) |
|---|---|---|---|
| Retinol (μmol $l^{-1}$) | 19 | 4268 | 0–33.3 |
| Vitamin E (μmol $l^{-1}$) | 24 | 4009 | 0–32.6 |
| Vitamin $B_1$ (α-ETK) | 4 | 786 | 0–69 |
| Vitamin $B_2$ (α-EGR) | 5 | 858 | 0–59 |
| Vitamin $B_6$ (α-EGOT) | 1 | 262 | 0–54 |
| Vitamin $B_6$ (nmol $l^{-1}$) | 3 | 533 | 3.1–56 |
| Vitamin $B_{12}$ (pg $ml^{-1}$) | 9 | 1770 | 0–18 |
| Serum folate (ng $ml^{-1}$) | 11 | 2215 | 0–81.1 |
| Erythrocyte folate (ng $ml^{-1}$) | 7 | 1574 | 0–82.7 |
| Vitamin C (mg $dl^{-1}$) | 10 | 1309 | 0–58.3 |

α-ETK – Erythrocyte transketolase enzyme activity coefficient; α-EGR – erythrocyte glutathione reductase activity coefficient; α-EGOT – erythrocyte glutaminc–oxaloacetic transaminase activity coefficient.

very high for thiamine and riboflavin. However, for the remaining vitamins, especially D and E, the spread of results was very wide. Some studies showed very high percentages of subjects with insufficient intakes (Table 3).

At blood level, the dispersion of results was even greater. Deficiencies of vitamins $B_{12}$, A and E were infrequent. For the remainder, however, although the range of deficits was wide, the percentage of subjects with deficiency values was sometimes more than 50% (vitamins D, $B_1$, $B_2$, $B_6$) (Table 4).

The methodologies used were very varied. It is clear that our knowledge is incomplete and that there is much still to be done. But even the knowledge gained up to now has not been sufficiently disseminated. Several papers mention that the mean Spanish diet is satisfactory[2,3], while this meta-analysis and other studies[4] show that the situation can clearly be improved.

Meta-analysis undoubtedly increases the capacity to generalise, and is a good statistical aid for drawing conclusions[10]. The data obtained might serve as a first step in understanding the nutritional situation of the Spanish population, but they also raise many questions and highlight the need for further research with larger samples and validated methods.

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