Proposal of a Nutritional Quality Index (NQI) to Evaluate the Nutritional Supplementation of Sportspeople

Alba Palacin-Arce¹, Celia Monteagudo¹, Juan de Dios Beas-Jimenez², Fatima Olea-Serrano¹*, Miguel Mariscal-Arcas¹,²,³

¹ Research Group on Nutrition, Diet and Risk Assessment-AGR255, Nutrition and Food Science Department, University of Granada, Granada, Spain, ² Andalusian Centre of Sport Medicine (CAMD), Junta de Andalucía, Spain, ³ Food Technology, Nutrition and Food Science Department, University of Murcia, Murcia, Spain

* foloa@ugr.es

Abstract

Background
Numerous supplements are used by sportspeople. They are not always appropriate for the individual or the sports activity and may do more harm than good. Vitamin and mineral supplements are unnecessary if the energy intake is sufficient to maintain body weight and derives from a diet with an adequate variety of foods. The study objectives were to evaluate the main nutrients used as supplements in sports and to propose a nutritional quality index (NQI) that enables sportspeople to optimize their use of supplements and detect and remedy possible nutritional deficits.

Material and Methods
A nutritional study was performed in 485 sportspeople recruited from Centros Andaluces de Medicina del Deporte, (CAMD). All completed socio-demographic, food frequency, and lifestyle questionnaires. The nutritional quality of their diet and need for supplementation were evaluated by scoring their dietary intake with and without supplementation, yielding two NQI scores (scales of 0-21 points) for each participant.

Results
A superior mean NQI score was obtained when the supplements taken by participants were not included (16.28 (SD of 3.52)) than when they were included (15.47 (SD: 3.08)), attributable to an excessive intake of some nutrients through supplementation.

Conclusions
These results indicate that sportspeople with a varied and balanced diet do not need supplements, which appear to offer no performance benefits and may pose a health risk.
INTRODUCTION

The potential health hazards of sedentary life and the health benefits of increased daily physical exercise have long been recognized. The very high and growing prevalence of obesity has prompted international bodies (WHO, FAO, etc.) to launch multiple initiatives to encourage a healthy diet and daily physical activity[1,2]. Millions of individuals worldwide now practice regular exercise to prevent or combat disease and enhance their quality of life or to improve their physical condition for participation in sports activities[3].

The performance of sportspeople is influenced by numerous physical, psychological, nutritional, and environmental factors. Nutritional status plays a key role, and minor dietary errors at critical times can ruin months or even years of hard training[4]. In fact, as the margin between victory and defeat becomes ever narrower, sportspeople increasingly resort to nutritional supplements[5,6]. There has been an exponential growth over recent years in the consumption of supplements, largely composed of proteins, amino acids, vitamins and minerals, and this has been especially marked among sportspeople[7].

Many supplements are promoted, with no sound scientific foundation, for enhancing performance and muscle mass as part of normal training or competition routines and for facilitating recovery after training or sports injury[8]. Around 85% of elite athletes are reported to take supplements, including vitamins, minerals, proteins, and/or creatinine, among others. These should be used with care in order to minimize risks, but it appears that sportspeople rarely wait for convincing proof of their effectiveness or safety[9]. In general, vitamin and mineral supplements are not considered necessary if the usual diet contains an appropriate variety of foods that provide sufficient energy to maintain the body weight[10,11]. However, supplements may be required by sportspeople who restrict their energy consumption or remove one or more food groups in order to lose weight or by those whose diets are unbalanced and deliver a low density of micronutrients[12].

Sportspeople frequently consume supplements that are not always appropriate for their bodies or for their sports activity and that may have no effect or may even exert adverse effects[9]. The American College of Sports Medicine, American Dietetic Association, and Dieticians of Canada have issued warnings about the frequently incorrect and unsafe utilization of nutritional ergogenic aids, which should only be taken after careful evaluation of their safety, effectiveness, potency, and legality; it was emphasized that individual nutritional guidance and advice should be based on a complete nutritional assessment by experts[12]. Nutritional indexes used for this purpose should evidently be as comprehensive as possible, and there is a need for an instrument that takes account of the consumption of supplements and includes all micronutrients (e.g., ramified or sulphured amino acids).

The objectives of this study were to evaluate the main nutrients used as supplements in sports and to propose a nutritional quality index (NQI) that enables sportspeople and other groups to optimize their use of supplements and detect and remedy possible nutritional deficits. Two NQI scores were obtained for each individual: one based on FFQ data alone and the other also including nutrient intake from supplements, as recorded in the life habits questionnaire, with the aim of comparing and evaluating the advantages or drawbacks of the supplement intake of the participants.

MATERIALS AND METHODS

Participants

Volunteers were recruited from among affiliated members of the eight Andalusian Sports Medicine Centers (CAMD, Centros Andaluces de Medicina del Deporte) and of the Sierra Nevada
High Altitude Training Centre (CAR, Centro de Alto Rendimiento) in Southern Spain. Each participating centre invited its members to participate in the study, with the incentive that volunteers would each receive a report on their nutritional status and diet upon its completion. The study inclusion criteria were a good health status, the practice of sports on at least two days/week, and informed consent to participation in the study, which was conducted in accordance with the Declaration of Helsinki (October 2000) and approved by the ethics committee of the University of Granada. Alphanumeric codes were assigned to participants to preserve their anonymity in the data treatment.

**Questionnaire**

Participants were administered with a document containing: a questionnaire on their socio-demographic characteristics (including sports activities), a semi-quantitative food frequency questionnaire (FFQ), and a questionnaire on life habits (e.g., smoking, eating/drinking, consumption of products to improve performance). The socio-demographic data gathered were: province, sex, age, marital status, educational level, profession, place of work and sports activity, including the modality, level and phase of the season (e.g., competition, training, etc.).

The FFQ has been validated and used in numerous studies[13–15]. It records the consumption or not of each food, the number of times consumed per day, week, or month during the previous year, and the amount consumed each time in g, mL, or domestic measures (e.g., platefuls, glassfuls, tea/table spoonfuls, etc). The daily food and nutrient intake was calculated (in g or mL) from the FFQ by multiplying the standard serving size of each item by the value corresponding to the consumption frequency: never = 0; 1–3 times/ month = 0.07; 1–2 times/ week = 0.21; 3–4 times/ week = 0.50; 5–6 times/ week = 0.80; 1 time/day = 1; and 2–3 times/ day = 2.5 [16–18]. These data were processed by using the Dial version 1.19 diet program[19]. Results were analysed by food group, considering 12 main groups, i.e., cereals, dairy products, eggs, meat, fish, legumes, vegetables, fruits, sweets, fats/oils, alcohol and stimulants.

**Proposed NQI for supplementation (NQIs)**

The index is based on the daily recommended intake[20] and daily tolerable upper intake level (UL) for the product/supplement in question, as recommended by the WHO and numerous authors[21–27]. In the case of protein, there is no established UL, which was considered to be two-fold the recommended intake for sportspeople[28] in the present study. The optimal intake of each nutrient was considered to be between 2/3 of the recommended intake and the UL value; intake within this range was scored as 1 and intake below or above this range was scored as 0. The score ranged between 0 and 21 points. The nutrients considered were: total proteins and amino acids (valine, leucine, isoleucine, and sulphured amino acids), B group vitamins (B1, B2, B3, B6, folic acid), vitamin A, vitamin D, vitamin C, and vitamin E) and mineral salts (calcium, iron, selenium, zinc, copper, and iodine and magnesium). Two scores were obtained for each study participant: one derived from the sum of the values obtained from the FFQ for the different nutrients consumed in the daily diet; and the other also including the values of the nutrients consumed in supplements, as recorded in the life-habits questionnaire.

**Statistical analysis**

SPSS-19 (IBM Inc. Chicago, IL, USA) was used for the data analyses, applying the Student’s t-test and ANOVA for the comparison of means and performing stepwise linear regression. The statistical tests applied are given in the table footnotes. \( P < 0.05 \) was considered significant in all tests.
RESULTS

Study inclusion criteria were met by a total of 515 volunteers. After exclusion of those who failed to complete the questionnaires in a correct manner, the final study sample comprised 485 healthy sportspeople (72.2% males and 27.4% females) aged between 18 and 69 yrs. The mean age was 27.95 (SD 11.69) yrs in the males and 19.89 (SD 7.83) yrs in the females.

Table 1 lists the estimated value reported for each nutrient considered in the index (without and with supplementation) alongside the percentage of the dietary reference intake (DRI) to which it corresponds (DRI source is specified in the footnotes). The mean intake of all nutrients was >100% of the DRI, with the exception of valine, leucine, methionine/cysteine and vitamin D. The mean intake of all nutrients significantly differed from the mean DRI, with the exception of iodine, selenium and methionine/cysteine (p > 0.05). The mean value of the index was 16.28 when supplements were not included and 15.49 when they were. For both indexes, the lowest value was 2 points and the highest was 21. In the males, the mean score was 16.47 (SD 3.14) without versus 15.69 (SD 2.85) with supplement intake, and in the females, it was 16.09 (SD 3.31) without versus 15.19 (SD 3.15) with supplement intake, with no significant gender differences.

Table 1. Intake of nutrients with respect to Dietary Reference Intake (DRI) and NQI mean value for both groups. *

| Nutrient                        | Dietary intake | % DRI      | Dietary intake + Supplements | % DRI      | p†        |
|--------------------------------|----------------|------------|-----------------------------|------------|-----------|
| Protein (g/d)                  | 141.03 (56.90) | 137.3      | 143.02 (57.59)              | 160.0      | <0.001    |
| Valine (mg/g protein)          | 29.68 (13.43)  | 92.7       | 31.33 (18.06)               | 97.9       | <0.05     |
| Isoleucine (mg/g protein)      | 27.36 (12.49)  | 109.4      | 29.10 (18.47)               | 116.4      | <0.05     |
| Leucine (mg/g protein)         | 43.49 (19.94)  | 85.3       | 44.22 (19.79)               | 86.7       | <0.05     |
| Methionine&Cysteine (mg/g protein) | 23.87 (34.64) | 82.9      | 21.68 (13.00)               | 83.2       | 0.318     |
| Calcium (mg/d)                | 1486.35 (559.59) | 148.6      | 1491.45 (561.18)            | 149.1      | <0.05     |
| Iron (mg/d)                   | 27.11 (12.60)  | 288.9      | 27.26 (12.64)               | 290.3      | <0.001    |
| Iodine (µg/d)                  | 178.14 (70.49) | 118.8      | 179.72 (74.58)              | 119.8      | 0.188     |
| Magnesium (mg/d)              | 585.07 (219.09) | 153.91     | 592.18 (221.80)             | 155.7      | <0.001    |
| Selenium (µg/d)               | 177.81 (82.33) | 323.3      | 201.28 (486.51)             | 366.0      | 0.303     |
| Zinc (mg/d)                   | 18.04 (7.01)   | 180.1      | 18.25 (7.07)                | 182.1      | <0.001    |
| Copper (mg/d)                 | 1.40 (0.45)    | 155.8      | 1.40 (0.44)                 | 155.8      | <0.001    |
| Vitamin B1 (mg/d)             | 2.62 (1.07)    | 223.7      | 2.71 (1.16)                 | 231.1      | <0.001    |
| Vitamin B2 (mg/d)             | 3.30 (1.34)    | 265.7      | 3.38 (1.38)                 | 271.7      | <0.001    |
| Vitamin B3 (mg/d)             | 39.13 (18.85)  | 253.8      | 39.91 (19.69)               | 258.84     | <0.05     |
| Vitamin B6 (mg/d)             | 4.51 (1.81)    | 346.9      | 4.66 (1.92)                 | 358.3      | <0.001    |
| Folic acid (µg/d)             | 623.82 (276.45) | 156.0      | 627.50 (280.10)             | 156.9      | <0.05     |
| Vitamin C (mg/d)              | 319.46 (159.16) | 373.0      | 323.55 (162.18)             | 377.6      | <0.001    |
| Vitamin A (µg/d)              | 960.36 (537.90) | 114.9      | 989.01 (555.61)             | 118.4      | <0.001    |
| Vitamin D (µg/d)              | 7.04 (4.78)    | 47.0       | 7.24 (4.95)                 | 48.3       | <0.001    |
| Vitamin E (mg/d)              | 17.04 (8.33)   | 113.6      | 17.60 (8.74)                | 117.3      | <0.001    |
| NQI**                         | 16.28 (3.22)   | -          | 15.48 (3.00)                | -          | <0.001    |

* Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids (2002/2005). Washington DC: National Academy Press.
** NQI: Nutritional Quality Index
† Student’s t-test for paired samples.

doi:10.1371/journal.pone.0125630.t001
Table 2 shows the consumption of each nutrient in tertiles: first, above the UL; second, between 2/3 of the recommendation and the UL, and third below 2/3 of the recommendation. The consumption of each intake was in the third tertile for >60% of participants. Stepwise regression analysis revealed that only nine of the items significantly contributed to the indexes; these were the same items for both indexes but made distinct percentage contributions to the scores. For instance, protein accounted for 35% of the index score when supplements were not included compared with only 6% when they were (Table 3).

Logistic regression analysis (Table 4) showed that the use of nutritional supplementation was influenced by educational level, type of sport (group v. individual), current or past smoking habit and the history of a dietary regime. There was a greater likelihood of supplementation in participants with a medium educational level (OR = 0.36, 95%CI: 0.13–1.04), those involved in group sports (OR = 2.59, CI 95%: 0.95–7.03), non-smokers (OR = 4.20, 95%CI: 0.91–19.48) and those who had never been on a diet (OR = 2.52, 95%CI: 0.94–6.78).

**DISCUSSION**

There has been a continuing increase in the use of supplements, especially by sportspeople[5]. In the present study of 485 healthy active sportspeople, around two-thirds consumed some type of supplement, mostly preparations based on proteins, ramified amino-acids, vitamins and/or minerals, similar to reports by other researchers[29].

Macronutrient and micronutrient requirements may be higher in sportspeople, due to their physical exertions, but these were amply met by the daily diet of almost all of the participants. Thus, the requirement for protein was met by the dietary intake of almost all (96.5%) of the participants; however, 59.5% of the participants exceeded the UL for protein by taking supplements, potentially putting their health at risk. A study in the UK associated a protein intake above the UL with various adverse effects, and concluded that it should not exceed two-fold the recommended level[20,22]. Other authors claimed that a protein intake >35% of the energy intake has no adverse effects but that a percentage above 45% can be life-threatening if maintained for several weeks[30]. It should be taken into account that the protein UL values considered in the present study were two-fold higher than the recommendations for adult sportspeople, which are much higher than those for the general population[31].

Because the replacement level of minerals is low, deficits can usually be avoided by consuming a healthy and balanced diet. Nevertheless, athletes frequently have problems in this respect due to increased excretion (from exercise or other factors) and problems of intestinal absorption[32]. This is mainly a concern with iron and calcium, whose deficit can be responsible for anaemia and osteoporosis, among other diseases, although long-term supplementation may do more harm than good[33]. The dietary intake of minerals was adequate for the majority of participants in the present study, and the use of supplements offered no advantage. In fact, supplementation increased the percentage of participants with an excessive intake of magnesium (>UL).

Vitamins cannot be synthesized and must therefore be obtained daily in the diet. Sportspeople require more vitamins than sedentary people due to their higher energetic metabolism. However, they generally consume more food to compensate for the greater caloric output generated by exercise, thereby increasing their vitamin intake. Consequently, vitamin deficits are rare unless the diet quality is inadequate, and supplements are unnecessary. Furthermore, there is increasing evidence from animal and human studies that supplementation with antioxidants can have a negative effect on sports performance[34–36]. On the other hand, the dietary vitamin D intake was below 2/3 of the DRI in 80% of our study participants, and an intake between this value and the UL was achieved by some of these through supplementation. Table 1 depicts the percentage of

---

**Table 2**

| Nutrient | Tertile 1 | Tertile 2 | Tertile 3 |
|----------|----------|----------|----------|
| Protein  | Above UL | 2/3 UL   | Below 2/3 UL |
| Magnesium| Above UL | 2/3 UL   | Below 2/3 UL |
| Calcium  | Above UL | 2/3 UL   | Below 2/3 UL |

---

**Table 3**

| Nutrient | Contribution % |
|----------|----------------|
| Protein  | 35%            |
| Magnesium| 6%             |
| Calcium  | 4%             |

---

**Table 4**

| Variable          | OR    | 95% CI         |
|-------------------|-------|----------------|
| Education Level   | 0.36  | 0.13–1.04      |
| Type of Sport     | 2.59  | 0.95–7.03      |
| Smoking Status    | 4.20  | 0.91–19.48     |
| Dietary Regime    | 2.52  | 0.94–6.78      |
Table 2. Distribution of the population (%) according to the relationship of nutrient intake with UL and DRI values.

| Nutrient                  | ≥ UL  | 2/3 DRI-UL | < 2/3 DRI |
|---------------------------|-------|------------|----------|
| Protein                   | DI    | 96.5       | 3.5      |
|                           | DI + S| 39.0       | 1.5      |
| Valine                    | DI    | 76.1       | 18.5     |
|                           | DI + S| 76.9       | 16.7     |
| Isoleucine                | DI    | 63.4       | 35.1     |
|                           | DI + S| 65.1       | 33.4     |
| Leucine                   | DI    | 63.4       | 35.1     |
|                           | DI + S| 65.1       | 33.4     |
| Methionine & Cysteine     | DI    | 58.7       | 37.5     |
|                           | DI + S| 60.3       | 36.8     |
| Calcium                   | DI    | 89.8       | 5.4      |
|                           | DI + S| 89.0       | 5.2      |
| Iron                      | DI    | 88.5       | 2.8      |
|                           | DI + S| 88.8       | 2.5      |
| Iodine                    | DI    | 91.3       | 8.7      |
|                           | DI + S| 91.3       | 8.7      |
| Magnesium                 | DI    | 95.3       | 4.1      |
|                           | DI + S| 95.5       | 4.3      |
| Selenium                  | DI    | 95.2       | 2.3      |
|                           | DI + S| 95.2       | 2.3      |
| Zinc                      | DI    | 96.3       | 2.8      |
|                           | DI + S| 96.3       | 2.8      |
| Copper                    | DI    | 99.0       | 1.0      |
|                           | DI + S| 99.0       | 1.0      |
| Vitamin B₁                 | DI    | 44.1       | 2.5      |
|                           | DI + S| 41.9       | 2.6      |
| Vitamin B₂                 | DI    | 31.7       | 1.4      |
|                           | DI + S| 29.9       | 1.4      |
| Vitamin B₃                 | DI    | 29.1       | 2.3      |
|                           | DI + S| 28.7       | 2.3      |
| Vitamin B₆                 | DI    | 97.6       | 2.4      |
|                           | DI + S| 94.2       | 5.8      |
| Folic acid                | DI    | 83.7       | 5.9      |
|                           | DI + S| 83.0       | 5.9      |
| Vitamin C                 | DI    | 96.6       | 3.4      |
|                           | DI + S| 96.6       | 3.4      |
| Vitamin A                 | DI    | 75.2       | 24.8     |
|                           | DI + S| 76.6       | 23.4     |
| Vitamin D                 | DI    | 19.6       | 80.4     |
|                           | DI + S| 21.0       | 79.0     |
| Vitamin E                 | DI    | 86.4       | 13.6     |
|                           | DI + S| 82.2       | 17.8     |

DI = Dietary Intake; DI + S = Dietary Intake + Supplements.

doi:10.1371/journal.pone.0125630.t002
the mean value of all nutrients, showing that all DRIs are exceeded except for vitamin D. The mean intakes of selenium, vitamin C, vitamin B2, niacin (B3), and B6 were between 2.5- and 3.8-fold higher than recommended levels. Recent studies have reported that nutritional supplementation does not offer a clear benefit for patients with chronic diseases and may even have

Table 3. Nutrients that together contribute to > 95% of the NQI scores (stepwise regression).

| Nutrients | Dietary intake* R² | Dietary intake + Supplements R² |
|-----------|--------------------|---------------------------------|
| Protein   | 0.355              | Zinc 0.381                      |
| Isoleucine| 0.560              | Leucine 0.616                   |
| Zinc      | 0.679              | Folic acid 0.712                |
| Vitamin A | 0.748              | Vitamin A 0.777                 |
| Leucine   | 0.805              | Protein 0.832                   |
| Folic acid| 0.861              | Isoleucine 0.867                |
| Vitamin D | 0.901              | Iron 0.903                      |
| Iron      | 0.939              | Vitamin D 0.938                 |
| Niacin    | 0.957              | Niacin 0.955                    |

doi:10.1371/journal.pone.0125630.t003

Table 4. Factors influencing the intake of supplements in the study population (logistic regression).

| Factor                  | OR (CI 95%)          |
|-------------------------|----------------------|
| Fat (%)                 | 0.964 (0.90, 1.04)   |
| Education level*        |                      |
| Low (Ref.)              | 0.165                |
| Medium                  | 0.36 (0.13, 1.04)    |
| High                    | 0.62 (0.25, 1.58)    |
| Group sport             |                      |
| No (Ref.)               | 2.59 (0.95, 7.03)    |
| Yes                     | 4.20 (0.91, 19.48)   |
| Period of season        |                      |
| Pre-season (reference)  | 1.18 (0.36, 3.87)    |
| Competition             | 1.88 (0.68, 5.16)    |
| Recovery/Transition     | 2.59 (0.95, 7.03)    |
| Smoker                  |                      |
| Yes (Ref.)              | 0.37 (0.13, 1.04)    |
| No                      | 4.20 (0.91, 19.48)   |
| Ex-smoker               |                      |
| Yes (Ref.)              | 0.37 (0.13, 1.04)    |
| No                      | 4.20 (0.91, 19.48)   |
| Dietary regime          |                      |
| Often (Ref.)            | 2.221                |
| Sometimes               | 1.43 (0.26, 7.86)    |
| Once                    | 0.41 (0.04, 4.42)    |
| Never                   | 2.52 (0.94, 6.78)    |
| “Light” products        |                      |
| Yes (Ref.)              | 0.739                |
| No                      | 1.26 (0.50, 3.21)    |
| Sometimes               | 0.87 (0.35, 2.12)    |
| Comprehension of nutritional information on the label | |
| Yes (Ref.)              | 0.632                |
| No                      | 0.75 (0.32, 1.75)    |
| Sometimes               | 0.55 (0.15, 2.07)    |

Reference: yes to supplementation
* low = primary schooling; medium = secondary schooling/vocational diploma, high = university studies.

doi:10.1371/journal.pone.0125630.t004
negative effects; nevertheless. It was recently concluded in widely-read editorial in the Annals of Internal Medicine[37] that although available evidence does not rule out minor or major benefits or harm in small population subgroups, it is well established that the addition of (most) mineral or vitamin supplements to the diet of well-nourished adults offers no benefits and might even be harmful.

Study limitations include the preponderance of male participants, although this reflects the fact that the regular performance of intense physical activity is more than two-fold more frequent among males than among females, at least in Spain[38]. There is also a need for further research on specific sports disciplines and types of participant (e.g., professional or amateur).

A major strength of our index of nutrient intake is that it can be applied to any population group, not solely sportspeople. Supplements are marketed to the general population and are used in work and study settings and for “self-medicating” purposes. The benefits of these supplements are poorly understood and may be outweighed by their negative effects. Consumers may often be unaware of their components or their action mechanism. The method proposed here allows evaluation of the need for supplementation and the potential adverse effects associated with specific nutrients in any individual.

In conclusion, supplementation appears to offer no performance benefits to healthy active sportspeople and may pose a health risk. We propose a method to estimate the quality of diets and the need for supplementation by using the same index to rate the intake of individuals with and without supplementation. Our findings confirm that sportspeople do not need nutritional supplementation if they follow a varied and balanced diet.

Acknowledgments

The authors are grateful to the High Performance Centre of Sierra Nevada and the Sports Medicine Centres of Andalusia for their collaboration in this study and thank Richard Davies for his assistance with the English version. Furthermore, the authors are grateful to the Junta de Andalucía, Spain (Research Group AGR-255 “Nutrition. Diet and Risk Assessment”), a collaboration agreement with the Andalusian Centres of Sports Medicine (Junta de Andalucía) and the FPU program of the Spanish Ministry of Education and Science. Study participants were recruited through the project “Nutritional and diet assessment methodologies applied to the Andalusian sportsperson in Andalusian Sports centres”, Research project FMD2010SC0071 of the Junta de Andalucía.

Author Contributions

Conceived and designed the experiments: APA FOS. Performed the experiments: CM MMA. Analyzed the data: APA FOS. Contributed reagents/materials/analysis tools: JDBJ. Wrote the paper: APA FOS CM MMA.

REFERENCES

1. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. 2000. PMID: 11234459
2. Hansen BH, Holme I, Anderssen SA, Kolle E. Patterns of Objectively Measured Physical Activity in Normal Weight, Overweight, and Obese Individuals (20–85 Years): A Cross-Sectional Study. PLoS One 2013; 8(1):e53044 doi: 10.1371/journal.pone.0053044 PMID: 23308135
3. Brennan B, Elkins MR. Goal setting, problem solving and feedback improve short-term adherence to physical activity in people with stable heart failure. Br J Sports Med 2014 Feb; 48(4):343–4 doi: 10.1136/bjsports-2013-092856 PMID: 24045905
4. Maughan RJ, Shirreffs SM. Nutrition for sports performance: issues and opportunities. Proc Nutr Soc 2012; 71(1):112–9. doi: 10.1017/S0029665711003211 PMID: 22000743
5. Huang SH, Johnson K, Pipe AL. The use of dietary supplements and medications by Canadian athletes at the Atlanta and Sydney Olympic Games. Clin J Sport Med 2006; 16(1):27–33 PMID: 16377972
6. Hawley JA, Burke LM, Phillips SM, Spriet LL. Nutritional modulation of training-induced skeletal muscle adaptations. J Appl Physiol 2011; 110:834–845. doi:10.1152/japplphysiol.00949.2010 PMID: 21030665
7. Rodek J, Sekulic D, Kondric M. Dietary supplementation and doping-related factors in high-level sailing. J Int Soc Sports Nutr 2012; 9(1):51.
8. Hawley JA, Burke LM, Phillips SM, Spriet LL. Nutritional modulation of training-induced skeletal muscle adaptations. J Appl Physiol 2011; 110:834–845. doi:10.1152/japplphysiol.00949.2010 PMID: 21030665
9. Maughan RJ, Greenhaff; Plhespel P. Dietary supplements for athletes: Emerging trends and recurring themes. J Sports Sci 2011; 29(1):SS7–66
10. Maughan RJ, Depiesse F, Geyer H. The use of dietary supplements by athletes. J Sports Sci 2007; 25(S1): S103–S113
11. Seagle HM, Strain GW, Makris A, Reeves RS. American Dietetic Association: Position of the American Dietetic Association: weight management. J Am Diet Assoc 2009 Feb; 109(2):330–46. PMID: 19244669
12. Rodríguez NR, Di Marco NM, Langley S. American College of Sports Medicine position stand. Nutrition and athletic performance. Med Sci Sports Exerc 2009; 41(3):709–31. doi:10.1249/MSS.0b013e1890ab86e PMID: 19225360
13. Mariscal-Arcas M, Velasco J, Monteagudo C, Caballero-Plasencia MA, Lorenzo-Tovar ML, Olea-Serrano F. Comparison of methods to evaluate the quality of the Mediterranean diet in a large representative sample of young people in Southern Spain. Nutr Hosp 2010; 25(6):1006–13. PMID: 21519773
14. Mariscal-Arcas M, Caballero-Plasencia ML, Monteagudo C, Hamdan M, Pardo-Vasquez ML, Olea-Serrano F. Validation of questionnaires to estimate adherence to the Mediterranean diet and life habits in older individuals in Southern Spain. J Nutr Health Aging 2011; 15(9):739–43. PMID: 22089221
15. Willett WC. Nutritional Epidemiology ( Second Edition). Oxford University Press, 1998.
16. Bountziouka V, Panagiotakos DB. Statistical methods used for the evaluation of reliability and validity of nutrition assessment tools used in medical research. Curr Pharm Des 2010; 16(34):3770–51. PMID: 21128895
17. Ortega Anta RM, López Sobaler AM, Carvajales PA. Dial V. 1.19, 2008 Alce Ingenieria.
18. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids (2002/2005). Washington DC: National Academy Press. Availability in: http://www.nap.edu/catalog.php?record_id=10490 (access:15–2–2012) PMID: 12449285
19. A Model for Establishing Upper Levels of Intake for Nutrients and Related Substances. Report of a Joint FAO/OMS Technical Workshop on Nutrient Risk Assessment. WHO, Geneva, 2–6 May 2005. PMID: 17310857
20. IoM United Kingdom Department of Health. Dietary reference values for food energy and nutrients for the United Kingdom. London, Her Majesty’s Stationery Office, 1991 (Report on Health and Social Subjects No. 41).El IoM (2005).
21. Garcia Gabarra A. Ingesta de Nutrientes: Conceptos y Recomendaciones Internacionales (2ª Parte). Nutr Hosp 2006; 21(4):437–47 PMID: 16913203
22. Garcia Gabarra A. Ingesta de Nutrientes: Conceptos y Recomendaciones Internacionales (1ª Parte). Nutr Hosp 2006; 21(3):291–299 PMID: 16771109
23. Munro IC. Setting tolerable upper intake levels for nutrients. J Nutr 2006; 136(2):490S–492S. PMID: 16424133
24. Hanekamp JC, Bast A. Food Supplements and European Regulation within a Precautionary Context: A Critique and Implications for Nutritional, Toxicological and Regulatory Consistency. Crit Rev Food Sci Nutr 2007; 47:267–285. PMID: 17453924
25. Richardson DP. Risk management of vitamins and minerals: a risk categorisation model for the setting of maximum levels in food supplement and fortified food. Food Sci Technol Bull Funct Foods 2007; 4:51–66.
26. Protein and Amino Acid Requirements in Human Nutrition. Joint WHO/FAO/UNU Expert Consultation. World Health Organization Technical Report Series (2007(935):1–265, back cover)
29. Nieper A. Nutritional supplement practices in UK junior national track and field athletes. Br J Sports Med 2005; 39:645–649. PMID: 16118303

30. EFSA. (2011). Panel on Dietetic Products Nutrition, and Allergies (NDA). Public consultation on the draft scientific opinion on dietary reference values for protein. Availability in: http://www.efsa.europa.eu/en/consultationsclosed/call/110712.pdf

31. Panel on Dietetic Products Nutrition, and Allergies (NDA). Public consultation on the draft scientific opinion on dietary reference values for protein. Availability in: http://www.efsa.europa.eu/en/consultationsclosed/call/110712.pdf (access: 30–1–2012).

32. Suedekum NA, Dimeff RJ. Iron and the athlete. Curr Sports Med Rep 2005; 4(4):199–202. PMID: 16004828

33. Papanikolaou G, Pantopoulos K. Iron metabolism and toxicity. Toxicol Appl Pharmacol 2005; 202(2):199–211. PMID: 15629195

34. Gomez-Cabrera MC, Domenech E, Romagnoli M, Arduini A, Borras C, Pallardo FV, et al. Oral administration of vitamin C decreases muscle mitochondrial biogenesis and hampers training-induced adaptations in endurance performance. Am J Clin Nutr 2008; 87(1):142–149. PMID: 18175748

35. Ristow M, Zarse K, Oberbach A, Klötting N, Birringer M, Kiehntopf M, et al. Antioxidants prevent health-promoting effects of physical exercise in humans. Proc Natl Acad Sci U S A 2009; 106(21):8665–8670. doi: 10.1073/pnas.0903485106 PMID: 19433800

36. Nikolaidis MG, Kerksick CM, Lamprecht M. Does vitamin C and E supplementation impair the favorable adaptations of regular exercise? Oxid Med Cell Longev 2012; 2012:707941. doi: 10.1155/2012/707941 PMID: 22928084

37. Guallar E, Stranges S, Mulrow C, Appel LJ. Enough Is Enough: Stop Wasting Money on Vitamin and Mineral Supplements. Ann Intern Med 2023; 159(12):850–852. PMID: 24490268

38. National Statistic Office of Spain: National survey on Sports Habits 2012 [http://www.ine.es/].