Nationwide Survey on Nutritional Habits in Elite Athletes

Part II. Mineral and Vitamin Intake*

A. M. J. van Erp-Baart1, W. M. H. Saris2, R. A. Binkhorst, J. A. Vos, and J. W. H. Elvers

Department of Physiology, University of Nijmegen, Nijmegen
1TNO-CIVO Toxicology and Nutrition Institute, Zeist
2Department of Human Biology, University of Limburg, Maastricht, The Netherlands

Abstract


The nutritional habits of elite athletes competing at a national and international top level were determined. Groups of endurance strength, and team sport athletes participated. All athletes trained at least 1–2 h daily. The purpose of the study was to quantify the mineral and vitamin intake and to identify the magnitude of the nutrient supplementation use.

Information on food intake was obtained by a 4- or 7-day food diary. It was found that calcium and iron intake was positively related to energy intake. In low energy intakes (< 10 MJ) iron intake might be insufficient.

In general, vitamin intake with food was in agreement with the Dutch recommendations. However, if energy intake is high (> 20 MJ) the amount of refined carbohydrate is increased. Consequently, the nutrient density for vitamin B1. Therefore, under these conditions, supplementation for vitamin B1 must be considered. The low vitamin intake found in lower energy intakes can be improved by proper nutritional advice.

In body building and in professional cycling, high dosages of vitamins are used. The other groups of athletes used only moderate quantities of vitamin supplements.

It is concluded that vitamin and mineral intake is sufficient, when energy intake ranges between 10 and 20 MJ/day.

Key words

nutritional habits, elite athletes, minerals, vitamins

Introduction

Athletes look for any competitive edge through training, material, and dietary manipulation. In this process many coaches and athletes apparently believe that supplementation of vitamins and minerals is essential to improve performance. The thought behind this practice is: Little is good, so more must be even better. Therefore, athletes are great consumers of nutritional supplements, despite the opinion among researchers that micronutrient supplementation is only beneficial if intake is marginal (4, 18, 2).

Information about how well-balanced the athlete's diet is, is limited. Especially elite athletes competing on an international level are mostly not involved in studies to quantify nutritional intake. On the other hand, this particular group may be at risk because of the high intensity and duration of the exercise and the fact that by traveling from one match to another, food intake depends on local restaurant facilities.

The purpose of this investigation was to quantify micronutrient intake of elite athletes involved in different types of sports and to identify the magnitude of supplementation practice of vitamins and minerals in relation to the diet.

Methods and Materials

From 1978 to 1986 the nutritional habits of different elite sport groups were determined. In each of the three major types of sports, endurance, strength, and team sport, groups or individual athletes were asked to participate. Criteria for selection of the type of sport was based on its popularity in the Netherlands. Furthermore, stress was laid on being an elite athlete competing on an international level. The minimal amount of training hours had to be 1–2 h daily for 5 days/week.

To increase the number of young athletes, two groups of sub-top athletes competing on a national level were included (swimming and gymnastics).

To obtain information on nutritional habits, the athletes kept a food diary for 4 days, and if possible this was extended to 7 days. Descriptions of the methods and the

* Supported by a grant from the National Sport-Totalisator Foundation, The Hague, The Netherlands
Fig. 1  Daily mean iron and calcium intake in relation to mean energy intake in endurance, strength, and team sport athletes (for explanation of group numbers, see Table 1).

characteristics and anthropometric data of the different groups are given in detail in Van Erp-Baart et al. (7).

Results

Unless otherwise mentioned, the tables and figures represent vitamin and mineral intake without supplements. To obtain objective criteria, the Dutch recommended daily allowances (DRDA) are used (15, 16). These recommendations are safe levels of intake for a group. To indicate that certainly some individuals of the group have a less than adequate intake, the 80% level was chosen as the cutoff point to consider a group at risk.

Mineral Intake

In Fig. 1 the mean calcium (Ca) intake is presented in relation to the mean energy intake. A significant relation was found between the mean Ca intake (in mg) and the mean energy intake (in MJ): $Y = 102.87 X + 141.38$, where $Y = \text{Ca}$ and $X$ is energy ($r = 0.85$, $P < 0.05$) (Fig. 1). The DRDA for Ca is 700–900 mg/day for adults and female adolescents. For adolescent boys it is 900–1200 mg/day. If we take the lowest recommendations into consideration, all groups of athletes exceeded the DRDA. Also the iron (Fe) intake is significantly related to the energy intake: $Y = 1.13 X + 3.09$, where $Y = \text{Fe}$ in mg and $X$ is energy in MJ ($r = 0.86$, $P < 0.05$) (Fig. 1). The DRDA for iron is 9 mg/day for male adults, 15 mg/day for female adults and male and female adolescents. Fe intake was in agreement with or higher than DRDA in male adults and in female runners, rowers and cyclists. Low iron intakes were found in the female S and T athletes and the swimming girls. The extremely high intake in female cyclists (E10) was the result of nutritional advice for extra intake of iron-rich food items because some women suffered from iron-deficient anemia. As a result foodstuffs such as liver, apple syrup, and iron-enriched rose hip syrup were frequently chosen in this group.

Results of the contribution of heme- and non-heme-bound iron and supplementation to the total iron intake is given in Table 1. In top cycling the largest amount of iron supplements were taken. The female athletes took supplements on medical advice.
**Vitamin Intake**

In Figs. 2–6 the intake of vitamin A, B1, B2, B6, and C are presented. The total intake from food and supplements is depicted as percentage of the DRDA level.

The intake of vitamin A is presented in Fig. 2. The DRDA is 0.85 mg/day. Taking the 80% level of DRDA into account, female gymnasts (S5, S6) and female bodybuilders (S7) had a low vitamin A intake.

The intake of vitamin B1 is presented in Fig. 3. The DRDA for vitamin B1 is 0.4 mg/4.2 MJ. Intake of vitamin B1 with food was low in E1 and E2 (professional cyclists).

In Fig. 4 the intake of vitamin B2 is presented. The DRDA for vitamin B2 is 1.6 mg and 1.7 mg/day for adult and adolescent males, respectively. An intake of 1.3 mg and 1.4 mg/day for adult and adolescent females is advised.
Compared with these recommendations intake of vitamin B₆ with food was sufficient for all groups of athletes.

In Fig. 5 intake of vitamin B₆ is presented. The DRDA for vitamin B₆ is 0.02 mg/g protein. Taking the 100% level into account, it is surprising to see that only triathletes (E3) exceeded that level. Taking the 80% level, vitamin B₆ intake with food was low in professional cyclists (E1, E2), in team sport athletes (except handball), and in adult strength athletes.

In Fig. 6 vitamin C intake is presented. Intake of vitamin C with food was sufficient for all the groups (DRDA for vitamin C 70 mg/day) except for young female swimmers and gymnasts and adult female handball players.

With respect to the intake of supplements, vitamin B complex and vitamin C supplements are frequently used by a great number of athletes.

**Discussion**

Obviously it is not certain that when the average nutrient intake of a group is equal to the recommended daily allowances, no individual will be deficient. It depends on the range of intake and individual requirements. Waterlow (17) calculated on the basis of known individual intake and requirements that when 50% of the subjects within a group have an intake less than the DRDA (that means median intake of the groups meets the DRDA), about 6% of the group will have an intake less than their requirements.

However, the scientific basis for estimates of requirements is uncertain. The information about individual variation in the requirements is unknown in most cases. The information of requirements during hard physical work is even more scarce.

Therefore, it is extremely difficult to judge the adequacy of the individual's intake based on the mean intake of the group, especially if one takes the methodological problems into account, as pointed out in the previous paper by van Erp-Baart et al. (7). On the other hand, it is likely that when the mean intake is below a certain cutoff point some individuals will be at risk. In this respect the chosen 80% level as a cutoff point is a purely pragmatic approach.

Based on these considerations, it is of interest to study the nutritional intake and to analyze whether possible inadequate intakes can be improved by proper food intake or supplementation if necessary.

**Minerals**

Ca intake was in comparison with the lowest DRDA level sufficient for all groups of athletes. Our results indicate that the lower intake in female athletes can partly be explained by the low energy intake in these groups. To answer the question of whether an increased need for Ca exists in intensively training athletes, Drinkwater et al. (6) have recently found that female runners with secondary amenorrhea have lower bone density than their nonactive peers. The reason for this phenomenon is not yet known. It is hypothesized that the estrogen level might be responsible for this (9). Therefore, they advised a Ca intake of 1500 mg/day for these athletes. It is however uncertain whether such intake will prevent low bone density. From our regression analysis, a calculated energy intake of at least 13.2 MJ/day is needed to meet such a high Ca intake. In none of our female athlete groups was this energy intake recorded.

In comparison with the DRDA iron intake is low in some young, female athletes. It is well established that athletes, especially female endurance athletes, suffer from low Hb and ferritin levels, which is a marker for iron storage. Besides the plasma volume expansion as a physiologic adaptation to regular exercise (10), increased losses or reduced dietary intake can explain the so-called sports anemia. In addition to the normal menstruation iron loss, Haymes (8) pointed out that in sweat iron can be lost up to 4 mg/liter. Another important factor in our opinion, especially in endurance types of sports, is the negative influence on iron absorption of vegetarian food habits. It is well known that iron in food is present in two chemical structures, as hemebound (H) and non-hemebound (NH) iron. H iron is better absorbed by the body than NH iron. An increased intake of iron is therefore advised when NH iron in combination with fiber-rich food is consumed (5). Athletes with vegetarian food habits usually eat more NH iron in combination with fiber-rich food.

Based on the food selection, it was concluded that the endurance athletes in our study tended to a vegetarian diet (7) with a NH iron intake of 60% - 80% of the total intake. In this light recommendations of 9 - 15 mg iron/day may be inadequate. On the other hand, there is no evidence that a safe level of intake of 30 mg iron as proposed by Colgan (4) is necessary.
Vitamins

In general vitamin intake was satisfactory except for vitamin B₉. This finding is of interest in light of the knowledge that in The Netherlands legislation forbids vitamin fortification of food except for vitamin A and D in margarine. Only for a strict number of dietary food products, as for instance the iron and vitamin C enriched rose hip syrup, does legislation permit fortification. Therefore, the levels of vitamin intake from food found in these groups can be considered as the “natural” intake. This is in contrast to most of the other industrialized countries where a more liberal policy concerning vitamin fortification is applied. Based on these considerations, it is concluded that this study confirms the general opinion that the athlete on a well-balanced diet meets the vitamin requirements and further supplementation is unnecessary (18).

Analyzing the data in more detail, it seems that in some groups specific vitamin intake was at risk. In professional cyclists vitamin B₁ and B₆ intake was low. Under these extreme circumstances athletes almost daily need a very large energy intake in combination with a high CHO intake. Therefore their food choice can be considered as well-balanced in this respect. However, in general, carbohydrate-rich food with an acceptable nutrient density is also voluminous. Therefore, refined food items such as sweet cakes or soft drinks are chosen. Especially when the contribution of these products to the total energy intake is high, micronutrient density drops. For energy-related vitamins such as vitamin B₁, this can lead to an intake below the RDA. In such a situation supplementation is necessary (12). Another interesting observation was the relationship between housing facility and food consumption. For instance, during the Tour de France and Tour de L’Avenir only white bread (French baguette) was eaten. Consequently, the major source of vitamin B₁ as found in most of the other groups eating wholemeal bread was missing.

Selective abstention from food items can have an important effect on nutrient intake. In female top gymnastics and body building intake of butter or margarine was low or not selected at all to reduce energy intake. Consequently, vitamin A intake was low. Other important sources of vitamin A such as vegetables did not compensate for the diminished intake. Still the diets of these groups were well-balanced, taking into account that energy intake had to be reduced. Vitamin A intake then reaches low levels and again in such situations extra attention is necessary to cover adequate vitamin intake.

Vitamin B₆ metabolism is linked directly to protein intake. Taking the abundant protein intake into account, in general the low levels of vitamin B₆ intake are to be considered as marginal and may hasten the onset of insufficient intake. In a report of the Dutch Nutritional Council on the rationale of vitamin fortification, it was concluded that in several population groups vitamin B₆ intake is marginal (16). However, the analytical methods to measure B₆ concentrations in food are questionable. The vitamin B₆ values based on the microbiological or the new HPLC method differ considerably. In a comparison of 24 food items, the new HPLC technique gave a mean 81% higher value for vitamin B₆ compared with the food table values based on the microbiological method (13). In addition, the number of newly detected biochemical vitamin B₆-deficient subjects in different population groups do not show a higher frequency compared with the other B vitamins in the Netherlands. Based on these considerations, the Nutritional Council in the Netherlands decided to advise not to fortify food with vitamin B₆.

With respect to vitamin supplementation, it is not surprising to see that in most sport groups vitamin supplements are taken. However, the amount and type of vitamin pills varies considerably. In most groups only small dosages, equal to the recommended level, are taken. In a study of Stewart et al. (14) among the general adult population of the United States, it was found that about 50% of the subjects questioned used mostly single vitamin components. Furthermore, vitamin C was the most widely used supplement (90%). Parr (11) found in athletic groups a percentage of users of 40%–60%. In our study, the same pattern of vitamin supplementation was found, except for the professional cyclists and the body building groups, where the level was sometimes 15 times the recommendations.

As mentioned before supplementation might be necessary if energy intake is high, but the reason why in body building such high intakes are used, remains unanswered.

In the literature, early studies on the need of vitamins deal with the clinical deficiencies observed in relation to low intakes. Nowadays attention must be given to high levels of vitamin intake. Although in a clinical situation megadoses of vitamins are used to treat neurologic or psychiatric diseases, only in some vitamin-dependent inborn errors of metabolism it is beneficial (3). On the other hand a high vitamin B₆ dose can cause neurologic complications such as sensory neuropathy in apparently healthy persons. Also interaction between micronutrients can result in increasing needs when there is an unbalanced intake, as have been found in the use of vitamin B₁ (1).

The consumption of vitamins in the general population in the Netherlands is far less than what is known about the use in the United States. Nevertheless, in Dutch athletes the use of extra vitamin supplement is comparable. Therefore, it can be concluded that despite the scientific evidence this belief in extra possibilities to improve performance is strong and further research is needed to gather more arguments for proper advice to athletes.

Summarizing the results of this study leads to the following conclusions:

1. Calcium and iron intake is positively related to energy intake. Therefore, with low energy intakes Ca and iron can become marginal. Thus, intake might be problematic for female athletes and in weight-reducing diets.

2. In general, vitamin intake was according to the recommendations and in the literature no indications have been found yet to increase the recommended level. However, if energy intake is high (> 20 MJ) supplementation for vitamin B₁ must be considered. The low vitamin intake we found in lower energy intake can be improved by proper nutritional advice.
3. The widespread use of vitamin supplements among athletes compared with the general population in the Netherlands confirms the strong beliefs among these groups that supplementation is essential to improve performance.

References