Vitamin preparations are frequently taken by athletes. The goal of such intakes is to satisfy the belief that extra vitamins may lead to a better performance on the one hand, and to assure adequate daily intakes on the other hand.

It may be difficult to make statements based on the available literature since the outcome of many studies is so contradictory. The following paper deals with the facts and summarizes the possible consequences of the findings for athletes and their coaches and therefore for sports medical or nutritional advice.

Vitamin C

Studies done during the Second World War brought the knowledge that insufficient vitamin C intake lowered performance during physical activity and increased the sensation of exhaustion, anorexia and muscle pain.

These negative side effects disappeared after a daily supplementation of 200 mg ascorbic acid (Matthes, 1940; Martin du Pan, 1943). An equilibrated balance of vitamin C therefore seems to be one of the conditions to optimize performance (Horak-Zeniscek, 1978). In the literature it is suggested that vitamin C plays an essential role in metabolic and tissue building processes such as intermediate carbohydrate metabolism collagen synthesis, amino-acid metabolism and hormone synthesis.

Hoogerwerf (1963) and Pirani (1952) suggest a better liver glycogen storage with optimal vitamin C intake and relation to lower lactic acid production in the blood during endurance type of activity (Pelikan, 1956) and short intensive exercise (Caselli, 1973) has been reported.

Other authors suggest a relation to decreased infection susceptibility (Parizkova, in Haymes, 1980; Mann, 1977), enhanced heat acclimation (Strydom, 1976) and oxygen utilization (Howald, 1975), all factors important to elite athletes.

It has been suggested that especially as a result of intensive endurance activity the body may become vitamin C depleted. Studies showed that vitamin C is released from the liver and adrenals in animals after exercise (Stojan, 1967). Increased excretion in the urine (Senger, 1975) as well as in the sweat (Nöcker, 1978; Mathews, 1979) is also suggested.

However, studies are conflicting and real evidence is lacking.

Few studies have been done on the effect of extra intake, above normal recommended daily intake levels. However, no effects on laboratory exercise performance were found (Caselli, 1973; Perlin, 1973; Horak-Zeniscek, 1978).

More controlled, recent studies also brought conflicting data.

Richardson (1983) found that single contraction time of the isolated gastrocnemius rat muscle, induced by electrical
stimulation, was increased by 19%. Strength was not affected. Keith (1983) on the other hand, could not show effects on maximal grip strength and strength endurance in humans. Suboticanec (1984) recently showed a statistically significant increase in maximal oxygen uptake after supplementing 70 mg/day. Thorough examination of their data demonstrated that a total daily intake of 80 mg is needed for optimal aerobic power. This is more than the RDA of 60 mg/day (NRC, 1980).

The question thus arises about how adequate the normal foods, taken by the athletes, supply this suggested amount of the vitamin.

**B vitamins**

Many investigations have been done with respect to these vitamins especially because of their role in energy metabolism.

**Vitamin B₁ (thiamin).** Vitamin B₁ plays an important role in the oxidative decarboxylation of pyruvate to acetyl CoA, for entrance in the Krebs cycle and subsequent oxidation to ATP.

The need depends on energy expenditure and is influenced by carbohydrate intake (Sauberlich, 1970; 1979; Troll, 1978). For this reason the RDA is set at 0.5 mg/1000 kcal (NRC, 1980). Among sports physiologists it is now accepted that thiamin requirement of athletes is enhanced due to their increased energy metabolism and the relative high carbohydrate portion in their daily food. Losses through substantial sweating (McArdele, 1981; Findeisen, 1980) is suggested and inadequate thiamin intake (Vytshikova, 1958; Howald, 1975) as well as resulting biochemical deficiencies as shown by increased enzyme activities have been reported (Haralambie, 1975; Van Dam, 1979; Keul, 1979; Van der Beek, 1982). Such inadequate intakes can easily result from the combined increased losses and poor eating habits.

De Wijn (1980) showed the high intake of refined carbohydrate foodstuffs with a low vitamin content among rowers (35% of total daily energy intake) and Jette (1978) found that during a carbohydrate loading regimen (80 energy % carbohydrates) vitamin B₁ intake decreased markedly. This is in agreement with our findings during the Tour de France of 1979 that thiamin intakes as expressed in nutrient density on successive competition days were too low (0.26 mg/1000 kcal) as compared to resting days (0.43 mg/100 kcal). This difference was mainly caused by the use of highly concentrated carbohydrate meals. From these data it can be assumed that an increased thiamin intake in athletes will be of benefit in avoiding biochemical deficiencies and in optimizing carbohydrate metabolism as shown in two recent studies.

McNeil (1983) found that increased thiamin intake in mice appeared to have a significant effect upon performance when combined with an exposure to a carbohydrate loading technique. This was not the case when the mice consumed a regular diet. A carbohydrate rich diet without increased intake of the vitamin only had a moderate non significant effect on performance improvement. Van der Beek (1984) showed definite effects on maximal oxygen uptake and anaerobic threshold as a result of marginal vitamin intake in man.

**Vitamin B₂ (riboflavin).** Since vitamin B₂ plays a role in the oxidative reactions in the mitochondria it is expected that especially longlasting exercise might influence the needs.

The American dietetic association recommends a level of vitamin intake in relation to caloric intake. NRC (1980) computes this relation as 0.6 mg/1000 kcal (RDA) although they state that there is no evidence that requirements increase.
with an increased energy metabolism. However, in a recent study by Belko et al. (1983) it is concluded that healthy young women require more riboflavin to achieve biochemical normality than is advised by NRC and further that exercise increases the requirements.

**Niacin.** Niacin functions as a co-enzyme in NAD, which plays a role in glycolyses, and is needed for tissue respiration and fat synthesis. It might therefore be theorized that this vitamin could influence aerobic capacity (Williams, 1976). Several publications can be listed in which increased intakes are advised. However, evidence is lacking (Williams, 1976). The RDA amounts 6.6 mg/1000 kcal which seems to be sufficient. Haymes (1980) reports that megadoses may even impair endurance performance.

**Vitamin B₆ (pyridoxin).** Vitamin B₆ is important for protein synthesis. Williams (1976) suggests that B₆ requirements in man appear to increase when high protein diets are consumed. Intakes of 1.75-2.0 mg/100 g protein are suggested to be optimal (NRC, 1980: Dietary standard for Canada). In a recent study (Hatcher, 1982) it was concluded that especially in endurance athletes exercise induced losses may increase the risk of poor vitamin B₆ levels.

This may be especially the case if the normal diet contains too little of the vitamin, Van Dam and Waterlooh (1978-1979).

**Vitamin B₉ (cyanocobalamin).** B₉ functions as co-enzyme involved in the transfer of single-carbon units in nucleic acid metabolism. The RDA is set at 3.0 mg/day (NRC, 1980). Although B₉ injections are a common practise throughout the sportsworld (Hirata, 1973), especially in cycling (own observations), it is concluded by Williams (1976) that this will not be of any benefit. Endurance and strength were not affected in experiments in which only vitamin B₉ was used (Montoye, 1955, 1955a). No relation to energy expenditure or protein intakes have been shown. Baker (1981) concluded that even 1.0 mg/day would cover the needs of the vast majority of the population and allow a wide margin of safety. Herbert et al. (1980) summarized the research noting that there is no evidence supporting the nutritional value of supplemented B₉ in situations where a deficiency does not exist.

**Panthenolic acid**

PA is a component of acetyl CoA: the intermediate metabolite of carbohydrate and fat metabolism that is especially important during endurance types of exercise.

Williams (1976) states in his extensive overview of the literature that some reports are suggestive of a beneficial application to physical activity but that conclusive data are not available to support this suggestion. RDA is related to energy intakes and amounts 4-7 mg/day (3000 kcal).

**Folic acid and biotin**

Effects of supplementation in relation to physical performance cannot be found in literature.

**Vitamin A and D**

The available literature dealing with A and D in relation to sports performance is very little.

Although several authors advised increased intakes for athletes, this advice seems not to be fundamented. Studies have been done on serum A levels (Hara-lambie, 1980; Borisov, 1969) but the question arises about the physiological relevance of these data since the body contains a body depot of vitamin A which should be large enough to compensate a diet totally deficient of A for months (Reich, 1976). Williams (1976) and Haymes
(1980) concluded that there is no theoretical basis for A and D supplementation.

**Vitamin E**

In the period 1970-1980 special attention was given to this vitamin after reported beneficial effects of supplementation on athletic performance. Vitamin E functions primarily as an anti-oxidizing substance and is believed to improve oxygen utilization in the muscle cell and to prevent the cell from possibly damaging effects of free oxygen radicals which are formed during intensive exercise. The available literature, however, is conflicting and until now no solid evidence seems to be present to underline the benefit of enhanced intakes (Williams, 1976; Shephard, 1974; Shephard, 1983).

**Conclusion**

From the available information it may be concluded that a deficiency of any vitamin, induced by low intakes, increased losses or the combination of these may impair physical performance.

On the other hand there is no evidence available that enhanced intakes above the normal recommended quantities will enhance physical performance. Especially with regard to endurance types of exercise athletes and their coaches or nutritional advisors should be aware from the fact that vitamin intake as a result of changes in dietary habits may be marginal and that daily losses as a result of long lasting high intensity exercise may be enhanced.

On the long term the resulting outcome may be a poor vitamin status so that supplementation of a low dosed vitamin preparation containing especially the vitamins C, and B₁ may be beneficial. Intake of megadoses of vitamins should be avoided any time.

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