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Vegetarian diet and athletes

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Abstract

A balanced intake of macro- and micro nutrients is crucially important for conditioning, recovery from fatigue after exercise, as well as for injury prevention. An increasing number of athletes have adopted vegetarian diets for one or more reasons and actually there is no available evidence to support either a beneficial or a detrimental effect of a vegetarian diet on sport performance. Therefore, it is widely accepted that appropriately planned vegetarian diets can provide sufficient nutrient energy with an appropriate range of carbohydrate, fat, and protein intake to support performance and health. On the other hand, questions have been raised by some investigators regarding unique risks of the vegetarian diet, including oligomenorrhea and amenorrhea, iron deficiency, vitamin B₁₂ deficiency, vitamin D deficiency, and impaired mineral status. In the present overview those items are described with the aim of identifying intervention warnings for vegetarian athletes. **Keywords:** vegetarian, athletes, diet, nutrition, deficiency

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Introduction

Athletes require an adequate food intake to meet the high level of energy expenditure, to maintain the body homeostasis, to prevent exercise-related stress disorders, to achieve an appropriate body composition, and to sustain athletic performance. Balanced nutrition is critically important for conditioning, recovery from fatigue after exercise, and injury prevention¹. Food choice is a complex product of multiple influences including culture, family, and availability of specific foods, and the nutritional value of each diet is reflected in these variables and choices. An increasing number of athletes have adopted vegetarian diets for one or more reasons, including ecological, economical, religious, health, or ethical motivations.

There are several types of vegetarian diets that have widely divergent nutritional contents and require differentiation:

- The general vegetarian diet allows no consumption of meat and fish are consumed while eggs, milk, cheese and honey are allowed.
- The lacto-vegetarian diet also excludes eggs.
- The vegan diet excludes the consumption of all animal-related foods, including dairy products.
- The crudest diet is limited exclusively to fruits and vegetables.
- The fruitarian diet includes only fruits and seeds
- The eco-vegan diet is similar to vegan diet that requires nourishment coming only from biological cultivations^{2,3}.

While vegetarian diets have been associated with several health benefits⁴ including lower mortality and morbidity from diabetes, ischemic heart disease, dyslipidemia, hypertension and

obesity⁵⁻⁸, there are several nutrients which are difficult to obtain from plant foods alone. Moreover, the absence of some micronutrients, such as vitamin B₁₂ (cyanocobalamin) in plant-derived foods, underscoring the fact that strict vegetarian diets must rely on fortified foods or supplements to obtain an adequate intake of essential micronutrients⁹.

With regard to physical activity, there is no available evidence to support either a beneficial or a detrimental effect of a vegetarian diet on sports performance, especially when carbohydrate intake is adequate. Appropriately planned vegetarian diets can provide sufficient nutrient energy with an appropriate range of carbohydrate, fat, and protein intake to support performance and health. In fact, vegetarian athletes can meet their protein needs from exclusively plant-based sources when a variety of these foods are consumed daily and food energy intake is adequate¹⁰⁻¹².

On the other hand, questions have been raised by some investigators regarding unique risks of the vegetarian diet, including oligomenorrhea and amenorrhea^{13,14}, iron deficiency¹⁵, vitamin B₁₂ deficiency^{16,17}, vitamin D (cholecalciferol) deficiency¹⁸, and impaired mineral status¹⁹. Of particular concern is the issue of amenorrhea among competitive female athletes^{13,14}. It is well known that the prevalence of oligomenorrhea and amenorrhea among athletes is about 20% and that can increase to almost 50% in some competitive athlete groups. The cause is not fully understood, but low dietary energy intake is considered to be one of the major factors in the suppression of the hypothalamic-pituitary-ovarian axis²⁰. Several authors have shown that amenorrheic athletes typically have low concentrations of estradiol and progesterone,



and some investigator have noted that a significant proportion of female athletes with amenorrhea were vegetarians²⁰. Since some authors demonstrated lower circulating oestrogen levels in vegetarians when compared to non-vegetarians and showed that these hormonal differences were associated with higher fibre and lower fat intakes, it could be argued that the nutrient composition of some vegetarian diets maybe predisposed to amenorrhea^{20;21}. However, these studies were not able to clearly determine whether the cause was the vegetarian diet per se or other factors, such as a heavy exercise training programme coupled with a lower energy intake. In this regard, certain authors observed that when vegetarian athletes are properly nourished their menstrual cycle function is normal, suggesting that a low energy intake, not diet quality, is the major cause of amenorrhea, and that when brought into a positive energy balance, hormonal profiles return to normal and menstruation is restored²². Certainly, more research is needed in this area. Moreover, some studies have come to very different conclusions regarding the protein requirements of physically active individuals based on a lack of consensus as to whether protein requirements are influenced by physical activity^{23;24}.

Athletes must understand that a balanced diet is essential to meet their individual energy requirements and it must suit the specific needs of the physical exercise demands. Even if a vegetarian diet per se does not seem to be associated with detrimental effects on athletes, vegetarians must achieve an optimal nutrient intake through careful planning^{25;26}. Diet intake quality can be evaluated in several different ways. One of the easiest ways is to determine the proportion of specific nutrient types supplied by the diet itself. Nutrients are generally classified as either macronutrients or micronutrients. The former include carbohydrates, proteins, fats, macro minerals, and water. Micronutrients, which include vitamins, minerals, and phytochemicals, derive their name from the fact that they are needed in relatively small amounts. When planning a diet for athletes all of those nutrients should be taken into consideration.

Carbohydrates

Carbohydrates should represent the largest portion of the athlete's diet, and endurance athletes should ensure adequate carbohydrates in their diet to optimise

glycogen stores. Indeed, several studies showed that a large carbohydrate intake may optimise muscle and liver glycogen stores with a positive impact on physical performances^{27;28}. Sports nutrition guidelines recommend that 60-65% of total energy should come from carbohydrates^{24;29}. Carbohydrate intake is not usually an issue for vegetarian athletes since most carbohydrates are of plant origin. There are two main types of carbohydrates: simple carbohydrates and complex carbohydrates. Fruits and milk are rich in simple carbohydrates. Usually, refined sugars, such as table sugar, sweets, and syrups, are not considered a good source of carbohydrates for vegetarians since they do not provide sufficient fibre, vitamins, or minerals beneficial to vegetarians. Complex carbohydrates can be easily derived from cereals and root vegetables. Less refined food, such as brown rice and wholewheat breads and pastas, are preferred carbohydrate sources for their higher content of essential dietary fibre and B vitamins.

Fats

Even if several recent studies suggest that highly trained athletes may perform better on "high-fat" diets, it is still recommended that <30% of total energy intake should come from fats^{30;31}. In fact, previous studies highlighting the beneficial effects of low-fat diets showed methodological biases, such as small sample sizes or non-randomised samples^{33;33}.

Vegetarian athletes may easily meet their energy and nutrient needs consuming high-fat foods, such as nuts and seeds, olives, olive oil, sesame oil, canola oil, and avocado. On the other hand, it is still possible to find vegetarian athletes with diets too rich in saturated fats mainly from full-cream dairy products. In more restrictive vegetarian diets with a <10% fat intake, these may have some benefit to the overall health of subjects with a known personal or family history of cardiovascular disease, while the severe fat restriction will be detrimental for optimal athletic performance, particularly for those athletes engaged in heavy training.

Protein

Protein requirements in physically active subjects are still a matter of debate. As summarised in different reviews, there is no universal consensus that protein requirements are influenced by physical activity^{23;24;34}, but it



is accepted by many that the protein requirements of athletes vary according to the practised discipline, the level of training and the total energy intake derived from carbohydrates. On average, it is recommended that athletes consume 1.5g of protein/kg/d²⁵. However, some authors suggest that protein requirements are approximately 1.2- to 1.6g/kg/d for athletes practising endurance disciplines and approximately 1.6- to 1.7g/kg/d for strength athletes³⁵. Despite this controversy over protein requirements, it has to be noted that an inadequate intake of carbohydrates increases the utilisation of protein for energy needs and as a result, the total dietary protein requirements. In fact, during prolonged physical activity, athletes with low glycogen stores metabolise twice as much protein as those with adequate stores as result of the increased gluconeogenesis³⁶.

Vegetarian athletes can easily achieve adequate protein intake from plant-protein foods, such as legumes, grains, nuts and seeds, as well as all the essential and non-essential amino acids if a variety of foods is consumed. A well-planned vegetarian diet should contain, on average, 12.5% of energy from protein³⁷. It has to be underlined that strength-trained athletes or those with high training levels or low carbohydrate energy intakes may need to include more protein-rich foods.

Creatine

When considering athletic performance, it should be remembered that creatine concentrations have been found to be lower in vegetarian athletes when compared to non-vegetarians³⁸. The estimated daily requirement of creatine is 2g. Non vegetarians typically get 1g creatine/d from meat, the rest is synthesised, mainly in the liver, using the amino acids arginine, methionine and glycine as precursors. It has also been demonstrated that inadequate dietary creatine intake from meat sources is not compensated by increased endogenous creatine production^{39; 40}.

Currently, little is reported with regard to the long-term effects of creatine supplementation in vegetarian athletes. Different studies have demonstrated that creatine supplementation increases muscle concentrations of creatine and improves performance during repeated bouts of high-intensity activity³⁸⁻⁴⁰. Other studies failed to show any effects of creatine

on power performances⁴¹. Almost all studies demonstrated that creatine supplementation has no effect on aerobic performances. Vegetarian athletes should be aware of the potential to have lower body creatine pools when compared to non-vegetarian counterparts. It seems reasonable to suggest creatine supplementation for vegetarian athletes engaged in repeated bouts of short-term high-intensity exercise, but this may not be necessary for endurance athletes.

Iron and Zinc

Concerns have been raised about micronutrient availability in vegetarian athletes. It has been suggested that the increase of dietary fibres and phytic acids may reduce the bioavailability of zinc, iron, and some trace minerals⁴². The increased iron loss in some sport disciplines is well known, mainly due to gastrointestinal bleeding⁴³, heavy sweating, haemolysis, and in women, menstruation. For this reason, some athletes engaged in endurance disciplines are at increased risk of iron depletion and even iron deficiency anaemia⁴⁴. Even if mild iron deficiency seems not to affect health or athletic performances, it has to be taken into consideration that low iron stores, even without anaemia, have been associated with decreased endurance capabilities⁴⁵.

In the vegetarian diet, iron is consumed in the non-heme state which has a relatively low absorption rate (2-20%) when compared with the heme iron (15-35%)⁴⁶. Moreover, several plant-derived substances, such as tea tannins, bran, polyphenols, egg yolk, soy bean products, and phytic acid may interfere with iron absorption⁴⁷. Low iron intake and reduced absorption taken together may reduce the body's iron stores in some athletes. Indeed, it has been demonstrated that female vegetarian runners had a lower iron status when compared to non-vegetarian runners⁴⁸. In most cases, vegetarian athletes can achieve proper iron status without iron supplementation if they avoid foods that interfere with iron absorption and increase the intake of those substances known to optimise the absorption of non-heme iron, such as vitamin C, citric acid, malic acid, tartaric acid, fructose, and sorbitol.

Zinc is another micronutrient of concern in vegetarian athletes. Some authors highlighted that exercise increases zinc urinary excretion⁴⁹. This observation is of particular interest



when considering vegetarian athletes with low zinc intake or bioavailability. In fact, the high phytate concentrations of some plant-derived foods may reduce zinc absorption even when known plant-derived sources of zinc, such as dried beans, soy products, nuts and seeds are consumed. Other known inhibitors of zinc absorption include oxalate, fibre and polyphenols, such as tannins^{42;50}. Based on those observations, concerns have been raised that vegetarian athletes, especially during adolescence, may have difficulty maintaining adequate zinc levels.

Although more research is needed, vegetarian athletes should be aware of the potential iron and zinc deficiency linked to their diet choices and that iron and/or zinc supplementation may be necessary, particularly in athletes who follow the stricter nutritional regimens. It is important to emphasise that the zinc and iron supplements should include no more than 100% of the recommended dietary allowance to avoid negative interactions with the absorption of other nutrients⁵¹.

Vitamins

Vegetarian diets can fulfil most of the vitamin requirements, except for vitamin B₁₂ (cyanocobalamin), vitamin D (cholecalciferol) and vitamin B₂ (riboflavin). Riboflavin is required for a wide variety of cellular processes and like the other B group vitamins, it plays a key role in energy metabolism. Riboflavin is, in fact, important for the conversion of proteins, fats and carbohydrates into energy, as well as for the synthesis and repair of various tissues⁵². Riboflavin is normally present in a number of foods and the amount needed is directly linked to the total energy intake. For all of those reasons, riboflavin plays an important role when considering both the athlete's overall health and performance. Dietary intake of riboflavin may be limited in vegetarian diets, in particular in those subjects who avoid the consumption of soy milk and soy milk products. As a matter of fact, several studies showed that subjects with marginal riboflavin status may have increased requirements when they begin to be physical active⁵³. Vegetarian athletes, and in particular those who avoid dairy products, should be instructed to increase their intake of plant sources of riboflavin, such as whole grain cereal, soybeans, soymilk, almonds, asparagus, bananas, sweet potatoes and wheat germ.

Vitamin D is essential for promoting calcium absorption and maintaining adequate serum calcium and phosphate concentrations to enable normal bone mineralisation. Vitamin D is needed for bone growth and remodelling. It also plays other roles, including the modulation of the immune system and neuromuscular function^{54;55}. Vitamin D is found in very few foods, all of animal origin including fish, liver, eggs and dairy products; Vitamin D is not present in plant foods. Vitamin D is synthesised in skin exposed to sunlight and this synthesis is usually adequate to supply the overall requirements in the summer months in temperate regions and year-round in equatorial regions. Vegetarian athletes without sufficient sunlight exposure, including those who may be required to keep their skin covered for religious or cultural reasons or who are dark-skinned, are at risk of vitamin D deficiency. In these cases, fortified foods or supplements should be taken to assure adequate body levels of the vitamin.

Vitamin B₁₂ plays a key role in the normal function of the nervous system and in erythropoiesis⁵⁶, is involved in the cellular metabolism affecting DNA synthesis and regulation⁵⁷, and also plays an important role in fatty acid synthesis and energy production⁵⁸. Since vitamin B₁₂ is found exclusively in animal products, vegetarians consuming eggs, cheese, milk or yoghurt receive an adequate supply of this vitamin. On the contrary, vegetarian athletes following stricter dietary regimens need to regularly consume B₁₂ fortified foods or supplements.

A vitamin B₁₂ deficiency can cause serious health damage. In adults, both anaemia-related symptoms and neurologic signs are usually recognisable and can be treated. It should be emphasised that maternal vitamin B₁₂ deficiency during pregnancy and lactation in vegetarians can cause irreversible neurologic damage in the infant and it is critical to provide appropriate vitamin B₁₂ supplementation to prevent this disorder^{59;60}.

Summary

- A well planned and controlled vegetarian diet appears to effectively support physical activities.
- The control of the nutritional status of vegetarian athletes can allow proper supplementation or the use of fortified foods when needed.



- Plant and animal protein sources seem to provide equivalent support to physical activities.
- Since vegetarians have lower creatine concentrations when compared to omnivores, they may experience performance increases following creatine supplementation.
- Appropriate planning and programmed follow-up are needed to monitor vitamin B₁₂, iron, zinc, vitamin D, riboflavin, and protein status.
- Oligomenorrhea and amenorrhea should be monitored in the light of a possible influence of the vegetarian diet.

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References

1. Maughan R. The athlete's diet: nutritional goals and dietary strategies. *Proc Nutr Soc* 2002; 61: 87-96.
2. Dwyer J. Convergence of plant-rich and plant-only diets. *Am J Clin Nutr* 1999; 70(3 Suppl): 620S-622S.
3. American Dietetic Association; Dietitians of Canada. Position of the American Dietetic Association and Dietitians of Canada: Vegetarian diets. *J Am Diet Assoc* 2003; 103: 748-765.
4. Key TJ, Appleby PN, Rosell MS. Health effects of vegetarian and vegan diets. *Proc Nutr Soc* 2006; 65: 35-41.
5. Appleby PN, Davey GK, Key TJ. Hypertension and blood pressure among meat eaters, fish eaters, vegetarians and vegans in EPIC-Oxford. *Public Health Nutr* 2002; 5: 645-654.
6. Kontogianni MD, Panagiotakos DB, Pitsavos C, et al. Relationship between meat intake and the development of acute coronary syndromes: the CARDIO2000 case-control study. *Eur J Clin Nutr* 2008; 62: 171-177.
7. Berkow SE, Barnard N. Vegetarian diets and weight status. *Nutr Rev* 2006; 64: 175-188.
8. Vang A, Singh PN, Lee JW, et al. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Ann Nutr Metab* 2008; 52: 96-104.
9. Murphy SP, Allen LHJ. Nutritional importance of animal source foods. *Nutrition* 2003; 133(11 Suppl 2): 3932S-3935S.
10. Barr SI, Rideout CA. Nutritional considerations for vegetarian athletes. *Nutrition* 2004; 20: 696-703.
11. Venderley AM, Campbell WW. Vegetarian diets: Nutritional considerations for athletes. *Sports Med* 2006; 36: 293-305.
12. Nieman DC. Physical fitness and vegetarian diets: Is there a relation? *Am J Clin Nutr* 1999; 70(3 Suppl): 570S-575S.
13. Barr SI. Vegetarianism and menstrual cycle disturbances: Is there an association? *Am J Clin Nutr* 1999 Sep; 70(3 Suppl): 549S-54S.
14. Benson JE, Engelbert-Fenton KA, Eisenman PA. Nutritional aspects of amenorrhea in the female athlete triad. *Int J Sport Nutr* 1996; 6: 134-145.
15. Waldmann A, Koschizke JW, Leitzmann C, et al. Dietary iron intake and iron status of German female vegans: Results of the German vegan study. *Ann Nutr Metab* 2004; 48: 103-108.
16. Allen LH. Causes of vitamin B12 and folate deficiency. *Food Nutr Bull* 2008; 29(2 Suppl): S20-34.
17. Kwok T, Cheng G, Woo J, et al. Independent effect of vitamin B12 deficiency on hematological status in older Chinese vegetarian women. *Am J Hematol* 2002; 70: 186-190.
18. Willis KS, Peterson NJ, Larson-Meyer DE. Should we be concerned about the vitamin D status of athletes? *Int J Sport Nutr Exerc Metab* 2008; 18: 204-224.
19. Kleiner SM. The role of meat in an athlete's diet: Its effect on key macro- and micronutrients. *Sports Sci Exch* 1995; 8: 1-6.
20. Loucks AB, Laughlin GA, Mortola JF, et al. Hypothalamic-pituitary-thyroidal function in eumenorrheic and amenorrheic athletes. *J Clin Endocrinol Metab* 1992; 75: 514-518.



21. Mitsuzono R, Ube M. Effects of endurance training on blood lipid profiles in adolescent female distance runners. *Kurume Med J* 2006; 53: 29-35.
22. Hanne N, Dlin R, Rotstein A. Physical fitness, anthropometric and metabolic parameters in vegetarian athletes. *J Sports Med Phys Fitness* 1986; 26: 180-185.
23. Millward DJ, Bowtell JL, Pacy P, et al. Physical activity, protein metabolism and protein requirements. *Proc Nutr Soc* 1994; 53: 223-240.
24. Lemon PW. Do athletes need more dietary protein and amino acids? *Int J Sport Nutr* 1995; 5 Suppl: S39-61.
25. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. *J Am Diet Assoc* 2000; 100: 1543-1556.
26. Position of the American Dietetic Association and the Canadian Dietetic Association, nutrition for physical fitness and athletic performance for adults. *J Am Diet Assoc* 1993; 93: 691-696.
27. Sedlock DA. The latest on carbohydrate loading: A practical approach. *Curr Sports Med Rep* 2008; 7: 209-213.
28. Burke LM. Nutritional needs for exercise in the heat. *Comp Biochem Physiol A Mol Integr Physiol* 2001; 128: 735-748.
29. Williams C. Macronutrients and performance. *J Sports Sci* 1995; 13 Spec No: S1-10.
30. Lambert EV, Speechly DP, Dennis SC, et al. Enhanced endurance in trained cyclists during moderate intensity exercise following 2 weeks adaptation to a high fat diet. *Eur J Appl Physiol* 1994; 69: 287-293.
31. Muoio DM, Leddy JJ, Horvath PJ, et al. Effect of dietary fat on metabolic adjustments to maximal VO_2 and endurance in runners. *Med Sci Sports Exerc* 1994; 26: 81-88.
32. Brown RC, Cox CM. Effects of high fat versus high carbohydrate diets on plasma lipids and lipoproteins in endurance athletes. *Med Sci Sports Exerc* 1998; 30: 1677-1683.
33. Brown RC, Cox CM, Goulding A. High-carbohydrate versus high-fat diets: Effect on body composition in trained cyclists. *Med Sci Sports Exerc* 2000; 32: 690-694.
34. Tipton KD, Wolfe RR. Protein and amino acids for athletes. *J Sports Sci* 2004; 22: 65-79.
35. Lemon PW. Effects of exercise on dietary protein requirements. *Int J Sport Nutr* 1998; 8: 426-447.
36. Maughan R. The athlete's diet: Nutritional goals and dietary strategies. *Proc Nutr Soc* 2002; 61: 87-96.
37. Venti CA, Johnston CS. Modified food guide pyramid for lactovegetarians and vegans. *J Nutr* 2002; 132: 1050-1054.
38. Lukaszuk JM, Robertson RJ, Arch JE, et al. Effect of a defined lacto-ovo-vegetarian diet and oral creatine monohydrate supplementation on plasma creatine concentration. *J Strength Cond Res* 2005; 19: 735-740.
39. Williams MH, Branch JD. Creatine supplementation and exercise performance: An update. *J Am Coll Nutr* 1998; 17: 216-234.
40. Bemben MG, Lamont HS. Creatine supplementation and exercise performance: recent findings. *Sports Med* 2005; 35: 107-125.
41. Izquierdo M, Ibañez J, González-Badillo JJ, et al. Effects of creatine supplementation on muscle power, endurance, and sprint performance. *Med Sci Sports Exerc* 2002; 34: 332-343.
42. Chiplonkar SA, Agte VV. Predicting bioavailable zinc from lower phytate forms, folic acid and their interactions with zinc in vegetarian meals. *J Am Coll Nutr* 2006; 25: 26-33.
43. Peters HP, De Vries WR, Vanberge-Henegouwen GP, et al. Potential benefits and hazards of physical activity and exercise on the gastrointestinal tract. *Gut* 2001; 48: 435-439.
44. Hunt JR, Roughead ZK. Non heme-iron absorption, fecal ferritin excretion, and blood indexes of iron status in women consuming controlled lactoovo-vegetarian diets for 8 wk. *Am J Clin Nutr* 1999; 69: 944-952.
45. Lamanca J, Haymes E. Effects of low ferritin concentrations on endurance performance. *Int J Sports Med* 1992; 2: 376-385.



46. Chiplonkar SA, Agte VV. Statistical model for predicting non-heme iron bioavailability from vegetarian meals. *Int J Food Sci Nutr* 2006; 57: 434-450.
47. Hunt JR. . Bioavailability of iron, zinc, and other trace minerals from vegetarian diets. *Am J Clin Nutr* 2003; 78(3 Suppl): 633S-639S.
48. Snyder AC, Dvorak LL, Roepke JB. Influence of dietary iron source on measures of iron status among female runners. *Med Sci Sports Exerc* 1989; 21: 7-10.
49. Nuviala RJ, Lapieza MG, Bernal E. Magnesium, zinc, and copper status in women involved in different sports. *Int J Sport Nutr* 1999; 9: 295-309.
50. Lukaski HC. Magnesium, zinc, and chromium nutriture and physical activity. *Am J Clin Nutr* 2000; 72(2 Suppl): 585S-93S.
51. Maret W, Sandstead HH. Zinc requirements and the risks and benefits of zinc supplementation. *J Trace Elem Med Biol* 2006; 20: 3-18.
52. Woolf K, Manore MM. B-vitamins and exercise: Does exercise alter requirements? *Int J Sport Nutr Exerc Metab* 2006; 16: 453-484.
53. Lukaski HC. Vitamin and mineral status: Effects on physical performance. *Nutrition* 2004; 20):632-644.
54. Holick MF, Chen TC. Vitamin D deficiency: A worldwide problem with health consequences. *Am J Clin Nutr* 2008; 87: 1080S-6S.
55. Smolders J, Damoiseaux J, Menheere P, et al. Vitamin D as an immune modulator in multiple sclerosis: A review. *J Neuroimmunol* 2008; 194: 7-17.
56. Ryan-Harshman M, Aldoori W. Vitamin B12 and health. *Can Fam Physician* 2008; 54: 536-541.
57. Sharp L, Little J, Brockton NT, et al. Polymorphisms in the methylenetetrahydrofolate reductase (MTHFR) gene, intakes of folate and related B vitamins and colorectal cancer: A case-control study in a population with relatively low folate intake. *Br J Nutr* 2008; 99: 379-389.
58. Woolf K, Manore MM. B-vitamins and exercise: Does exercise alter requirements? *Int J Sport Nutr Exerc Metab* 2006; 16: 453-484.
59. Weiss R, Fogelman Y, Bennett M. Severe vitamin B12 deficiency in an infant associated with maternal deficiency and a strict vegetarian diet. *J Pediatr Hematol Oncol* 2004; 24: 270-271.
60. Dror DK, Allen LH. Effect of vitamin B12 deficiency on neurodevelopment in infants: Current knowledge and possible mechanisms. *Nutr Rev* 2008; 66: 250-255.

