CHAPTER 21

Special needs: the vegetarian athlete

Greg Cox

21.1 INTRODUCTION

Vegetarian diets are now part of mainstream eating in Western countries. A number of studies have reported both short- and long-term health benefits of vegetarian eating. To date, most studies investigating food intakes of vegetarians have investigated groups following such diets for religious reasons, or groups who differed from non-vegetarians in other lifestyle habits. Vegetarians do not represent a homogeneous group of people. Individuals choose to adopt a vegetarian diet for a number of different reasons. Cultural and religious nominations, moral beliefs concerning animal rights, health implications and environmental issues are all motivating factors.

In a national survey of 9242 American runners, researchers found that 8.2% of female runners and 2.7% of male runners self-reported following a vegetarian diet (Williams 1997). Barr (1986) reported 37% of 209 Canadian recreational female athletes followed a 'semi-vegetarian' diet (no red meat), with 1.9% following a lacto-ovo-vegetarian diet. Reasons for adopting a vegetarian diet may differ between athletes and untrained individuals. In order to meet increased carbohydrate (CHO) requirements for training or to assist in weight control, some athletes may adopt a vegetarian diet. Vegetarian or near-vegetarian eating patterns are more likely to be found in endurance athletes such as runners, cyclists and triathletes, that is, those athletes continually striving to consume a high-CHO diet and maintain a low BM.

This chapter describes various categories of vegetarian diets and discusses the impact of vegetarian eating on meeting current dietary goals and guidelines for optimal sports performance. Studies investigating the benefit of consuming a vegetarian diet on sports performance are reviewed. Potential nutritional concerns of different categories of vegetarian diets in an athletic population are also discussed. Practical guidelines for health professionals to ensure appropriate nutritional strategies are used to assist vegetarian athletes in meeting daily nutritional requirements are outlined.

21.2 CATEGORIES OF VEGETARIAN DIETS

According to the *Little Oxford Dictionary of Current English* (1980), 'vegetarian' refers to 'one who eats no animal food or none obtained by destruction of animal life'. In daily use, the term vegetarian is used more broadly than this strict definition, describing diets based exclusively on plant-based foods, to diets including some flesh foods. Table 21.1 defines numerous vegetarian diets. The fruitarian diet is the most restrictive form of vegetarian diet, with individuals relying solely on raw fruits, nuts and seeds. The lacto-ovo-vegetarian diet is more commonly followed and is the most liberal form of vegetarian diet.

Table 21.1 *Classification of vegetarian diets*

Type	Comments
Fruitarian	Diet consists of raw or dried fruits, nuts, seeds, honey and vegetable oil.
Macrobiotic	Excludes all animal foods, dairy products and eggs. Uses only unprocessed, unrefined, 'natural' and 'organic' cereals, grains and condiments such as miso and seaweed.
Vegan	Excludes all animal foods, dairy products and eggs. In the purest sense, excludes all animal products including honey, gelatine, silk, wool, leather and animal-derived food additives.
Lacto-vegetarian	Excludes all animal foods and eggs. Does, however, include milk and milk products.
Lacto-ovo-vegetarian	Excludes all animal foods, however, includes milk, milk products and eggs.

The term 'vegetarian' has also been incorrectly used to describe a diet where red meat is excluded, with chicken, cheese and fish included as staple meat alternatives. Many people, athletes included, regard themselves as vegetarians simply because they avoid eating red meat. Some individuals avoid eating red meat because they don't like the taste, the smell or the appearance. Others, typically endurance athletes, exclude red meat from their diet as they believe it is high in fat and/or cholesterol (Burke & Read 1987). These individuals rarely explore suitable alternatives to red meat and simply replace red meat with chicken, fish and/or cheese. This eating plan has been referred to as 'quasi-', 'semi-', or 'part-time' vegetarian. Rather than defining this style of eating as vegetarian, which it is not, perhaps it is more correctly referred to as 'fussy meat-eating'. Many health professionals, dietitians included, are quick to misclassify this group as vegetarians. This chapter describes the nutrient composition and examines nutritional concerns relevant to each category of vegetarian eating as well as 'fussy meat-eating'.

21.3 EFFECT OF A VEGETARIAN DIET ON EXERCISE PERFORMANCE

Vegetarian dietary practices appear to have a protective effect from lifestyle diseases seen in many affluent countries. Lower mortality rates from coronary artery disease and certain forms of cancer, and lower risks of obesity and diabetes are typical among vegetarian populations (Snowdon & Phillips 1985; Levin et al. 1986; Burr & Butland 1988; Burr & Sweetnam 1994; Giovannucci et al. 1994). Lifestyle factors other than diet may partially account for the observed health differences seen between vegetarians and non-vegetarians (Phillips & Snowdon 1985; Dwyer 1988; Thorogood et al. 1994).

To date, the majority of dietary surveys of vegetarians have been on females of various ages. The perceived nutritional concerns of vegetarian diets are more relevant to females than males (i.e. inadequate iron and calcium intakes), which explains to some extent the reason for the focus. Overall, a vegetarian diet appears conducive to maximising exercise performance for athletes during training and competition (American Dietetic Association 1997). Vegetarians' reported intakes are usually higher in CHO than non-vegetarians, containing adequate protein, iron, and calcium (see Table 21.2). Nieman (1988) suggests that athletes who practise a near-vegetarian diet are more likely to meet current recommendations for CHO. Fat intakes appear similar to those of meat eaters, however, some studies have reported lower total fat intakes in female vegetarians (Tylavsky & Anderson 1988; Nieman et al. 1989; Haddad et al. 1999). Not surprisingly, numerous studies report lower saturated fat and cholesterol intakes in female lacto-ovo-vegetarians and vegans compared with non-vegetarians (Janelle & Barr 1995; Ball & Bartlett 1999; Haddad et al. 1999).

Despite numerous studies investigating the health benefits of a vegetarian diet, few studies have examined exercise performance differences between vegetarians and non-vegetarians. Hanne et al. (1986) reported no differences in aerobic or anaerobic capacities of 49 (29 male; 20 female) lacto-ovo-vegetarian and lacto-vegetarian athletes, compared with 49 (29 male; 20 female) matched (for age, body size, and type of physical activity) non-vegetarian athletic controls. Synder and colleagues (1989) reported similar results, finding no differences in maximal oxygen uptake between nine female athletes following a modified vegetarian diet (< 100 g of red meat per week) and nine female athletes following a mixed diet.

Nieman and colleagues (1989) compared haematologic, anthropometric and metabolic factors of 19 elderly female vegetarians with 12 elderly non-vegetarians (mean ages 72.3 ± 1.4 and 69.5 ± 1.0 years, respectively). Vegetarian subjects had significantly lower blood glucose and cholesterol levels, and tended to have less body fat than non-vegetarians. No electrocardiographic differences were observed between groups at sub-maximal or maximal exercise workloads. Also, no differences were observed between groups for maximal oxygen uptake.

In another study, Nagel et al. (1989) noted no difference in performance between 50 runners consuming a lacto-ovo-vegetarian diet or 60 runners consuming a conventional Western diet during a 1000 km stage foot-race. Researchers formulated the diets to contain CHOs, fats and protein in the ratio 60 : 30 : 10 for both dietary groups. Half of each group completed the race, with the order of finishers and total running time no different between groups.

In a series of studies, using a crossover design, researchers investigated the effect of a six-week lacto-ovo-vegetarian diet and a six-week mixed diet on immune parameters, serum sex hormones and exercise performance in eight well-trained male endurance athletes (mean $VO_{2\ max}$ = 68 mL/min/kg) (Richter et al. 1991; Raben et al. 1992). Diets were isocaloric and formulated to contain similar macronutrient contents (57% and 58% of energy from CHOs, 28% and 29% of energy from fats, and 15% and 13% of energy from protein for the lacto-ovo-vegetarian diet and mixed diet, respectively). Researchers concluded that measures of immune function, endurance performance to exhaustion, isometric strength and muscle glycogen levels were not different between the two diet periods. However, testosterone levels decreased significantly following the lacto-ovo-vegetarian diet. Reasons for this reduction in testosterone were unclear and may have been indirectly related to diet. Researchers suggested that the higher fibre intake during the vegetarian dietary treatment or the sudden change in dietary intake may explain the observed reduction in testosterone levels.

Studies have not directly examined the effect, if any, of a vegetarian diet on exercise performance. Studies have controlled for inherent differences between vegetarian diets and non-vegetarian diets, used populations that are not representative of athletes or failed to accurately assess training and competition performance. The training and competition benefits of consuming a high-CHO diet, which is achieved more easily with a vegetarian diet than a mixed diet, have been well researched (Simonsen et al. 1991). Future research is required to determine any possible benefits of consuming a vegetarian diet on exercise performance.

21.4 NUTRITION CONSIDERATIONS FOR VEGETARIAN ATHLETES

21.4.1 Energy

Table 21.2 summarises dietary surveys of females following vegetarian diets compared with non-vegetarian controls. Only one study in Table 21.2 reports dietary data for female vegetarians who are athletes. It is difficult to collect dietary intake information on vegetarian athletes, particularly elite-level athletes, due to small numbers of athletes choosing a vegetarian diet.

As can be seen from Table 21.2, vegetarian diets are often higher in fibre, raising concern about the ability of vegetarian athletes to consume adequate kilojoules to meet daily energy requirements (Grandjean 1987; Ruud 1990). Meat alternatives for vegetarians, such as legumes, dried beans and dried peas, are high-fibre foods. Incorporating vegetarian meat alternatives such as nuts, tofu, tempeh, textured vegetable protein and commercially prepared meat analogues, helps increase energy density. Pritikin (1984) suggested that vegetarian athletes could consume sufficient kilojoules, even when daily energy requirements are high.

21.4.2 *Protein*

Daily protein requirements are slightly higher for athletes (1.2–1.5 g/kg BM/d) than for sedentary people (see Chapter 5). Concern has been raised regarding the ability of vegetarian athletes, in particular vegan athletes, to meet these added demands (Grandjean 1987; Ruud 1990). Although vegetarians often consume less protein than non-vegetarians, the Australian Recommended Dietary Intake (RDI) for protein of 0.75 g/kg BM/d (National Health & Medical Research Council 1991) is easily met (see Table 21.2).

Plant food sources of protein often contain low levels of one of the essential amino acids and may (certainly not exclusively) have low digestibility compared to animal sources of protein. Some concern currently exists, at least at the consumer level, that insufficient levels of amino acids in plant foods will result in inadequate protein intake. In a recent review, Young and Pellett (1994) state that mixtures of plant proteins can serve as a complete source of amino acids, providing that the daily total protein intake met daily recommendations. It was thought that complementing plant sources of protein at individual meals was necessary to provide all essential amino acids. The American Dietetic Association (1997) stated that combining plant sources of protein in such a way as to meet all the essential amino acids is unnecessary. Vegetarian diets can provide adequate protein without the use of supplements or special foods, if daily energy demands of the athlete are met (American Dietetic Association 1997).

21.4.3 *Iron*

Athletes, particularly female endurance athletes, are at greater risk of low iron stores than non-athletes (Fogelholm 1995). Iron requirements are usually higher in athletes (especially endurance and adolescent athletes) than in untrained people. The American Dietetic Association (1993), in a position statement on vegetarian diets, concluded that vegetarians in developed countries were not at greater risk of iron deficiency than non-vegetarians. However, recent studies have reported low iron status in male and female vegetarians compared with omnivores, despite similar or

Table 21.2 *Average daily nutrient and energy intakes from dietary surveys comparing female vegetarians to non-vegetarians*

Reference	Type of diet	Diet assessment	Age (yr)	N	Energy (MJ/d)	CHO (g/d)	P (g/d)	P (g/kg/d)	Fat (g/d)	Ca++ (mg/d)	Fe++ (mg/d)	Fibre (g/d)	Vit C (mg/d)
Non-athletes													
Marsh et al. (1988)	LOV	7 d weighed FR	66.8	10	6.74	-	56	-	65	898	12.3	5.2	92
	NV		64.4	10	6.86	-	68	-	77	712	13.3	4.7	105
Tylavsky & Anderson (1988)	LOV	QFFQ	73.0	88	6.41	216	55	0.87	56	823	10.7	5.6	184
	NV		78.8	287	6.83	188**	70***	1.16	88***	902	10.2	4.2**	157**
Nieman et al. (1989)	LOV	7 d	72.3	19	5.95	228	44	0.75	49	-	-	23.2	-
	NV	FR	69.5	12	6.09	186***	56	0.88	61*	-	-	13.3**	-
Pedersen et al. (1991)	LOV	3 d	35.5	34	7.64	264	63	1.08	67	931	20.0	26.0	316
	NV	FR	29.4	41	7.14	218*	75*	1.26	61	873	22.0	15.0**	184
Tesar et al. (1992)	LOV	6 d semi-weighed	62.9	28	6.91	242	63	1.02	56	820	13.0	10.3	143
	NV	FR + 24 hr DH	62.9	28	6.94	199**	77*	1.22	62	863	15.5	7.6**	118*
Janelle & Barr (1995)	V	3 d FR	28.0	8	8.04	300	51	0.87	64	578[2*]	17.7	35.0[1*]	186[1*]
	LOV		25.8	15	8.46	288	57	0.97	76	875	13.7	24.7	141
	NV		27.9	22	8.72	284	77*	1.24	75	950	15.3	22.4	116
Ball & Bartlett (1999)	LOV	12 d	25.3	50	6.9	211	54	-	60	-	10.7	24.4	150
	NV	weighed FR	25.2	24	6.9	183	67**	-	65	-	9.9	17.3**	111**
Haddad et al. (1999)	V	3 d	36.0	15	7.09	-	52	-	52	590	17.6	38.0	275
	NV	FR + 24hr DH	33.5	10	8.24	-	74***	-	76*	830	15.3	15.0[3]	125*
Athletes													
Synder et al. (1989)	MV	3 d	37.8	9	7.46	229	59	1.05	71	-	14.7	-	-
	NV	FR	39.2	9	6.99	186*	73*	1.22	71	-	14.0	-	-

Diet: V = vegan, LOV = lacto-ovo-vegetarian, MV = modified vegetarian, NV = control,
FR = food record, QFFQ = quantitative food frequency questionnaire, DH = dietary history
*, **, ***, Mean intake of NV differed from means of V, LOV and MV at $P < 0.05$; $P < 0.01$, $P < 0.001$
[1*] Significant at $P < 0.05$ compared to LOV and NV
[2*] Significant at $P < 0.05$ compared to NV only
[3*] Significant at $P < 0.001$ compared to NV and V

higher iron intakes (Ball & Bartlett 1999; Haddad et al. 1999). Among athlete populations, where iron requirements are increased, it is still unclear whether vegetarian diets can provide adequate bioavailable iron.

In a review on vegetarianism in athletes, Ruud (1990) concluded that poor absorption of non-haem iron from plant-based foods increased risk of iron deficiency in vegetarian athletes. One case study reported iron deficiency anaemia in a strict vegetarian male long-distance runner with an estimated intake of 16.8 mg/d of iron (Jacobs & Wilson 1984). The cause of iron deficiency was impossible to determine and may have been related to poor iron bioavailability which was not directly assessed, and/or high iron requirements which are likely in endurance running (Siegal et al. 1979).

Synder and colleagues (1989) investigated dietary iron intakes and haematological parameters in nine female endurance runners consuming a modified vegetarian diet (MV) (< 100 g per week of red meat) with nine controls consuming a mixed diet (RM) (including red meat). No significant difference in total iron intake between groups was noted (see Table 21.2), yet serum ferritin levels were significantly lower for athletes in the MV group. The low bioavailability of iron of MV was suspected to account for these differences. Seiler et al. (1989) also reported lower serum ferritin levels in 39 male and 11 female ultra-endurance runners who followed a lacto-ovo-vegetarian diet compared with 52 male and eight female non-vegetarian controls. However, no impairment in running performance between the two dietary groups was observed.

Vegan and lacto-ovo-vegetarian diets rely predominantly on non-haem iron sources. Sources of iron are similar in vegan and lacto-ovo-vegetarian diets, as milk and other dairy products are poor iron sources. Absorption of non-haem iron from plant foods is poor (2%–20%) compared to absorption of haem iron from animal foods (15%–35%) (Hallberg 1981). In a vegetarian diet, the abundance of naturally occurring iron inhibitors in plant foods, including phytates, polyphenols and tannins, may further inhibit iron absorption (see Chapter 11, Section 11.5.2.2). Of benefit, however, is that vegetarian diets are usually high in vitamin C and citric acid, which helps negate the effects of iron inhibitors and increases absorption of non-haem iron from food (American Dietetic Association 1997).

21.4.4 *Calcium*

Lacto-ovo-vegetarians usually report similar calcium intakes to omnivores. Pederson et al. (1991) used three-day food records to compare dietary intakes of pre-menopausal lacto-ovo-vegetarian women to non-vegetarian controls. Calcium intakes of 34 vegetarians were not significantly different to that of the 41 non-vegetarians (931 $\pm$ 69 mg/d versus 873 $\pm$ 78 mg/d). Other studies report similar or even higher calcium intakes for lacto-ovo-vegetarians compared with non-vegetarian controls (Marsh et al. 1988; Tylavsky & Anderson 1988; Slattery et al. 1991; Tesar et al. 1992).

In most dietary studies of vegetarians, vegans are combined with lacto-ovo-vegetarians, making it difficult to determine differences in calcium intakes between these groups. In one study, Janelle and Barr (1995) found that vegan females had lower calcium intakes compared to lacto-ovo-vegetarians and ominvores. Using three-day food records, reported calcium intakes were 578 mg/d, 875 mg/d and 950 mg/d, for the vegan, lacto-ovo-vegetarian and non-vegetarian groups, respectively. In contrast, Haddad and colleagues (1999) found no difference in daily calcium intakes between vegan males and females compared with matched non-vegetarian controls.

Apart from dairy products, relatively few foods provide concentrated sources of calcium (Baghurst et al. 1993). Cereal foods were the second supplier of calcium in the diet of respondents to the Australian National Nutrition Survey (McLennan & Podger 1998). Until recently, individuals who limited or excluded dairy foods had few other alternatives, relying heavily on calcium-rich green leafy vegetables, calcium-fortified tofu and cereals to assist in increasing daily calcium intake. Weaver et al. (1999) suggested that individuals who avoid eating dairy products should include calcium-fortified foods or supplements in their diet to meet daily calcium requirements. Recently, calcium-fortified soy milks, yoghurts and custards have been made available in major supermarkets in response to the growing number of people choosing to use these products.

To assess the full impact of a vegetarian diet on daily calcium balance, it is prudent to consider factors that alter absorption and retention of calcium in the body. Calcium bioavailability from plant foods is reduced in the presence of phytates and oxalates, known inhibitors of calcium absorption (Weaver & Plawecki 1994; Weaver et al. 1999). Calcium-rich plant foods such as spinach and rhubarb have high oxalate contents and provide negligible absorbable calcium. However, low-oxalate vegetables such as kale, broccoli and bok choy can provide rich sources of calcium in diets based solely on plant foods. Factors such as sodium and protein content of the diet should also be considered, as these factors significantly influence calcium urinary excretion rates (Weaver et al. 1999).

21.4.5 *Vitamin B12*

Clinical vitamin B12 deficiency is rare and is more probably associated with an absence or defect in secretion of Intrinsic Factor than inadequate intake of vitamin B12 in the diet (American Dietetic Association 1988). However, a dietary deficiency of vitamin B12 can develop in a strict vegan, fruitarian or macrobiotic diet (Herbert 1994). People consuming a mixed or lacto-ovo-vegetarian diet easily meet daily vitamin B12 requirements. Active vitamin B12 is found exclusively in animal foods and products. No active vitamin B12 is naturally found in any plant foods, including meat analogues or fermented soy products such as tempeh (Herbert 1988). For vegans, fruitarians or individuals following a macrobiotic diet, a reliable, fortified source of vitamin B12 should be included in the diet (American Dietetic

Association 1988). Dairy products and eggs provide sufficient vitamin B12 for lacto-ovo-vegetarians. Vegans should consume vitamin B12-fortified soy milks or consider vitamin B12 supplementation, or risk the possibility of vitamin B12 deficiency disease (Herbert 1988).

21.4.6 *Zinc*

Meat, meat-based dishes and dairy products provide roughly 50% of the zinc in the diet of respondents to the Australian National Nutrition Survey (McLennan & Podger 1998). Cereals are the primary zinc source in the vegetarian diet; vegetarian meat alternatives (legumes, nuts, soya products and eggs) and dairy foods are secondary sources (Gibson 1994). Studies report similar or lower zinc intakes in vegetarians compared to non-vegetarians (Haddad et al. 1999; Janelle & Barr 1995). Haddad et al. (1999) found no difference in zinc intake or zinc status of ten male and 15 female vegans compared to non-vegetarian controls. Higher intakes of dietary fibre are regularly reported in vegetarian diets which may negatively impact on zinc status (Latta & Liebman 1984).

21.4.7 *Riboflavin*

The major source of riboflavin in the diet of respondents in the Australian National Nutrition Survey was milk and milk products (McLennan & Podger 1998). For the vegan athlete who excludes soy milk and soy-milk products, consuming adequate riboflavin may be difficult as soy is a good source of riboflavin. Janelle and Barr (1995) reported lower intakes of riboflavin in eight female vegans compared with 15 lacto-ovo-vegetarians and 22 non-vegetarian controls.

21.4.8 *Creatine*

It has been demonstrated that vegetarians have lower body creatine pools than non-vegetarians (Maughan 1995). Creatine supplementation is likely to increase muscle creatine stores significantly in vegetarians if muscle creatine stores are initially low (see Chapter 17, Section 17.6.1). For vegetarian athletes competing in sports involving repeated bouts of short-term activity, creatine supplementation may therefore be beneficial (see Chapter 17, Section 17.6.1).

21.5 *VEGETARIAN EATING AND AMENORRHOEA*

Pedersen et al. (1991) found that the frequency of menstrual irregularity in vegetarian non-athletes was five times that of controls. In this study, no differences were observed in total energy intake between the vegetarians and controls, although fibre intake was significantly higher in the vegetarians than controls. In a study investigating 26 female runners, Brooks and colleagues (1984) reported a higher incidence of secondary amenorrhoea in athletes following a modified vegetarian diet (< 200 g red meat per week). Interestingly, the fat intake was significantly less for the amenorrheic runners (68 ± 8 g/d) compared with regularly menstruating runners (98 ± 11 g/d). Slavin et al. (1984) found similar results in 89 females engaging in physical activity at least twice per week. Researchers reported a higher prevalence of secondary amenorrhoea in vegetarians (31%) compared to non-vegetarians (4%). However, other studies reported no difference in menstrual irregularities between female vegetarian and non-vegetarian athletes (Hanne et al. 1986). In a recent review, Barr (1999) suggested that no single dietary or lifestyle factor solely accounted for menstrual irregularities. Further studies are required to understand the effects of vegetarian diets on menstrual status in athletes.

21.6 SUMMARY

As dietary surveys of vegetarian athletes are scarce, this chapter has reported nutrient intakes of non-athletic adult populations following lact-ovo-vegetarian and vegan diets. Many of these dietary survey studies have focussed on elderly female populations, hardly representative of athletes. Further dietary survey studies on athletic populations are required to fully understand the influence of a long-term vegetarian diet on exercise performance. Minimal information is available on the nutrient adequacy of restrictive vegetarian diets such as fruitarian and macrobiotic diets, particularly among athletic populations. The high-CHO content usually consumed in vegetarian diets is conducive to restoring and maintaining adequate glycogen stores in athletes in hard training programs. A well-planned lacto-ovo-vegetarian diet and vegan diet will meet the nutrient requirements of most athletes. However, meeting energy requirements of athletes with high energy expenditures may be difficult. Although animal foods are good sources of protein, iron, zinc and vitamin B12, and dairy products are rich sources of calcium, alternative sources are available in most vegetarian diets. Energy-dense plant foods high in protein should be encouraged for athletes with high energy and protein requirements. Food sources fortified with vitamin B12 should be included in a vegan diet to ensure adequate amounts are consumed. Further research is required to gain a better understanding of the influence of a long-term vegetarian diet on menstrual status in female athletes. Athletes following a ‘fussy meat-eating diet’ appear to face similar nutrient concerns to vegetarians and may be at greater risk of nutritional inadequacies as they often fail to replace red meat with suitable alternatives.

21.7 PRACTICE TIPS

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Dietary assessment

- Clarify why an athlete chooses a vegetarian diet early in the interview process. Cultural, moral, environmental and religious reasons for choosing a vegetarian diet should always be respected. Fussy meat eaters often avoid eating red meat or limit intake of dairy foods for fear of them being high in fat and/or cholesterol. For these athletes, addressing issues regarding the nutritional composition of red meat and dairy foods, and providing suitable, convenient plant or meat alternatives warrants discussion.

- Determine the style of vegetarian diet followed and assess potentially limiting nutrients. Diets of vegan athletes should be assessed for usual daily energy, calcium, vitamin B12, iron and zinc intake. Assess the athlete's nutrition knowledge, and whether efforts are made to plan well-balanced meals.

Key nutrient concerns for vegetarian athletes, including dietary strategies to address these concerns

- If an athlete has recently converted to a vegetarian diet, assess usual daily energy intake and weight history. It may be difficult for newly converted vegetarian athletes to maintain their previous energy intake if their diet contains bulky, high-fibre, wholesome CHO foods. Increasing consumption of high-fibre meat alternatives such as legumes and beans may make it difficult to meet daily energy requirements and cause an increase in flatulence. Encourage the use of energy-dense, low-bulk foods to assist in increasing energy intake. Examples of such foods include gluten meat alternatives, textured vegetable protein, tempeh, tofu, fruit juices, dried fruits, nuts, peanut or nut butter, honey and jams. For lacto-ovo-vegetarians, low-fat milk, reduced-fat cheese and other low-fat dairy products are also low in bulk and energy dense.

- Examine sources of protein, especially at the midday meal. Many lacto-ovo-vegetarians will use cheese as a convenient meat alternative, whereas vegans may fail to use suitable protein alternatives. As athletes often have limited time for meal preparation, providing examples of suitable, convenient meat alternatives for lunch is crucial. Ready-prepared beans (e.g. baked beans) are an excellent choice, along with nut and seed spreads, such as peanut butter, tahini and almond spread. Ready-made luncheon meats, derived from wheat gluten, are also an excellent sandwich meat alternative.

- Many dietitians are quick to encourage legumes or tofu as meat alternatives, failing to realise the diverse array of semi-prepared, vegetarian meat alternatives available in supermarkets. Encouraging more regular use of lentils or other dried beans or peas automatically increases the bulkiness and satiety of meals. This is a concern for athletes with high energy requirements, and those who lose their appetite after exercise. Numerous products, derived from soy, nut or vegetable protein are an energy-dense alternative. Becoming familiar with these foods will facilitate more effective counselling when dealing with vegetarian athletes.

- Assess calcium intake, particularly in a vegan diet. Determine the types of soy milk consumed, if any, and recommend calcium-fortified varieties. Other suitable non-dairy calcium-rich alternatives include tofu, soy yoghurts, soy custards, cereals and low oxalate green vegetables such as broccoli, bok choy and kale.
- Dietary intake of riboflavin may be limited in vegan athletes, particularly those who avoid consuming soy milk and soy-milk products. Rich sources of riboflavin for the vegan athlete include fortified breakfast cereals, grains, textured vegetable protein, soy milks, soy yoghurts, soy custards, soy cheeses and yeast extract spreads such as Marmite™ and Vegemite™.
- Assess sources of vitamin B12 in athletes following a vegan diet. Dairy foods and eggs provide sufficient vitamin B12 in athletes following a lacto-ovo-vegetarian diet. Vegan athletes should include a known source of vitamin B12 such as fortified soy milks.
- Assessment of iron status is warranted in all athletes following a vegetarian diet. Be sure to assess total dietary iron and factors likely to promote or inhibit iron bioavailability. Significant sources of iron for vegetarians include breakfast cereals (especially those commercially fortified with iron), bread, textured vegetable protein, legumes, dried beans, gluten-based vegetarian meat alternatives, nuts, dried fruits and green leafy vegetables. Chapter 11 describes strategies for improving total dietary iron and optimising iron bioavailablity. Iron supplements are only warranted where iron depletion or iron deficiency anaemia has been diagnosed.
- Vegetarian diets usually provide macronutrients in amounts similar to those recommended for optimal sports performance. Generally, studies show that vegetarian diets contain adequate protein, are high in CHO and low in fat. Certain athletes following a vegetarian diet, however, may have a high fat intake by consuming large amounts of full-fat dairy products and excess amounts of added fats, oils and salad dressings. Where necessary, recommend low-fat dairy foods and soy alternatives, low-fat cooking methods and meat alternatives to ensure recommended levels of fat in the diet are more easily met.
- Some female adolescent athletes following a vegetarian diet may simply be restricting dietary intake and masking disordered eating behaviour. Female adolescent athletes are sensitive to issues regarding BM and body-fat levels, and may disguise a restricted eating pattern by describing their intake as vegetarian.
- Encourage variety in food choice and consumption of protein-rich and CHO-rich foods at each meal. Vegetarian meat alternatives include lentils, dried beans and peas (ready-to-use products are available), tofu, tempeh, textured

vegetable (or soy) protein, and ready-made nut, soy or wheat-derived alternatives. Encourage athletes to experiment with new foods and direct them to suitable cookbooks specialising in vegetarian cuisine. Sanitarium Health Food Company is the largest vegetarian company within Australia and New Zealand, and produces numerous nutrition resources including cookbooks, nutritional product analysis brochures and newsletters. Their current web page address is: http//:www.sanitarium.com.au.

Problems in nutrient analysis of vegetarian diets

- Nutrient analysis of a vegetarian diet can be difficult, as many commercially available vegetarian meat alternatives are not included in food composition databases. To obtain an accurate nutrient analysis, it may be necessary to obtain nutrient information for food labels or approach the company for nutrient composition of the food. For instance, Sanitarium Health Food Company produces a range of nutrition analysis brochures for their products. However, food labels do not include a comprehensive nutrient analysis of the product and are not valid for research purposes.

Resources for vegetarians

- Refer the athlete to credible sources in vegetarianism. The Australia Vegetarian Society produces a quarterly journal (*New Vegetarian and Natural Health*) which contains reliable nutrition education messages, suitable vegetarian recipes, details of vegetarian meeting groups and restaurants throughout Australia. The current website address for the Australian Vegetarian Society is: http//:www.moreinfo.com.au/avs.
- Other recommended vegetarian website addresses include the following:
  — The International Vegetarian Union (http//:www.ivu.org) have a comprehensive website providing website addresses for the various vegetarian societies throughout the world.
  — The Vegetarian Resource Group's current website address is: http//:www.vrg.org.
  — The current website address of the Vegan Society, based in the United Kingdom, is: http//:www.vegansociety.com.

REFERENCES

American Dietetic Association. Position of The American Dietetic Association: vegetarian diets—technical support paper. J Am Diet Assoc 1988;88:352–5.

American Dietetic Association. Position of the American Dietetic Association: vegetarian diets. J Am Diet Assoc 1993;93:1317–19.

American Dietetic Association. Position of The American Dietetic Association: vegetarian diets. J Am Diet Assoc 1997;97:1317–21.

Baghurst K, Record S, Syrette J, et al. What are Australians eating? Results from the 1985 and 1990 Victorian nutrition surveys. Adelaide, Australia: CSIRO Division of Human Nutrition, 1993.

Ball MJ, Bartlett MA. Dietary intake and iron status of Australian vegetarian women. Am J Clin Nutr 1999;70:353–8.

Barr SI. Nutrition knowledge and selected nutritional practices of female recreational athletes. J Nutr Ed 1986;18:167–74.

Barr SI. Vegetarianism and menstrual cycle disturbances: is there an association? Am J Clin Nutr 1999;70:S549–S54.

Brooks SM, Sanborn CF, Albrecht BH, Wagner WW Jr. Diet in athletic amenorrhoea. Lancet 1984;1:559–60.

Burke LM, Read RSD. Diet patterns of elite Australian male triathletes. Phys Sportsmed 1987;15:140–55.

Burr ML, Butland BK. Heart disease in British vegetarians. Am J Clin Nutr 1988;48:830–2.

Burr ML, Sweetnam PM. Vegetarianism, dietary fiber, and mortality. Am J Clin Nutr 1982;36:873–7.

Dwyer JT. Health aspects of vegetarian diets. Am J Clin Nutr 1988;48:712–38.

Fogelholm M. Indicators of vitamin and mineral status in athletes' blood: a review. Int J Sport Nutr 1995;5:267–84.

Gibson, RS. Content and bioavailability of trace elements in vegetarian diets. Am J Clin Nutr 1994;59:S1223–S32.

Giovannucci E, Rimm EB, Stampfer MJ, Colditz GA, Ascherio A, Willett WC. Intake of fat, meat and fiber in relation to risk of colon cancer in men. Cancer Res 1994;54:2390–7.

Grandjean AC. The vegetarian athlete. Phys Sportsmed 1987;15:191–4.

Haddad EH, Berk LS, Kettering JD, Hubbard RW, Peters WR. Dietary intake and biochemical, hematologic and immune status of vegans compared with non-vegetarians. Am J Clin Nutr 1999;70:S586–S93.

Hallberg L. Bioavailability of dietary iron in man. Annu Rev Nutr 1981;1:123–47.

Hanne N, Dlin R, Rotstein A. Physical fitness, anthropometric and metabolic parameters in vegetarian athletes. J Sports Med 1986;26:180–5.

Herbert V. Vitamin B-12: plant sources, requirements and assay. Am J Clin Nutr 1988;48:852–8.

Herbert V. Staging vitamin B-12 (cobalamin) status in vegetarians. Am J Clin Nutr 1994;59:S1213–S22.

Jacobs MB, Wilson W. Iron deficiency anemia in a vegetarian runner. JAMA 1984;252:481–2.

Janelle KC, Barr SI. Nutrient intakes and eating behaviour scores of vegetarian and non-vegetarian women. J Am Diet Assoc 1995;95:180–6, 189.

Latta D, Liebman M. Iron and zinc status of vegetarian and non-vegetarian males. Nutr Rep Int 1984;30:141–9.

Levin N, Rattan J, Gilat T. Energy intake and body weight in ovo-lacto-vegetarians. J Clin Gastroenterol 1986;8:451–3.

McLennan W, Podger A, eds. National Nutrition Survey: nutrient intakes and physical measurements, Australia 1995. ABS Catalogue No. 4805.0. Canberra, Australia: Australian Bureau of Statistics, 1998.

Marsh AG, Sanchez TV, Michelsen O, Chaffee FL, Fagal SM. Vegetarian lifestyle and bone mineral density. Am J Clin Nutr 1988;48:837–41.

Maughan RJ. Creatine supplementation and exercise performance. Int J Sport Nutr 1995;5:S39–S61.

Nagel D, Seiler D, Franz H, Leitzmann C, Jung K. Effects of an ultra-long-distance (1000 km) race on lipid metabolism. Eur J Appl Physiol 1989;59:16–20.

National Health & Medical Research Council. Recommended Dietary Intakes for use in Australia. Canberra, Australia: Australian Government Publishing Service, 1991.

Nieman DC. Vegetarian dietary practices and endurance performance. Am J Clin Nutr 1988;48:754–61.

Nieman DC, Sherman KM, Arabatzis K, et al. Hematological, anthropometric and metabolic comparisons between vegetarian and non-vegetarian elderly women. Int J Sport Med 1989;10:243–50.

Pedersen AB, Bartholomew MJ, Dolence LA, Aljadir LP, Netteburg KL, Lloyd T. Menstrual differences due to vegetarian and non-vegetarian diets. Am J Clin Nutr 1991;53:879–85.

Phillips RL, Snowdon DA. Dietary relationships with fatal colorectal cancer among Seventh-Day Adventists. J Natl Cancer Inst 1985;74:307–17.

Pritikin N. The brave soldiers in the ironman army travel on their stomachs. Runner's World 1984;Feb:129.

Raben A, Kiens B, Richter EA, et al. Serum sex hormones and endurance performance after a lacto-ovo-vegetarian and a mixed diet. Med Sci Sports Exerc 1992;24:1290–7.

Richter EA, Kiens B, Raben A, Tvede N, Pedersen BK. Immune parameters in male athletes after a lacto-ovo-vegetarian diet and a mixed Western diet. Med Sci Sports Exerc 1991;23:517–21.

Ruud, JS. Vegetarianism—implications for athletes. Omaha: International Center for Sports Nutrition, 1990.

Siegel AJ, Hennekens CH, Solomon HS, Van Boeckel B. Exercise-related hematuria: findings in a group of marathon runners. JAMA 1979;241:391–2.

Seiler D, Nagel D, Franz H, Hellstern P, Leitzmann C, Jung K. Effects of long-distance running on iron metabolism and hematological parameters. Int J Sports Med 1989;10:357–62.

Simonsen JC, Sherman WM, Lamb DR, Dernbach AR, Doyle JA, Strauss R. Dietary CHO, muscle glycogen, and power output during rowing training. J Appl Physiol 1991;70:1500–5.

Slattery ML, Jacobs DR, Hilner JE Jr, et al. Meat consumption and its associations with other diet and health factors in young adults: the Cardia study. Am J Clin Nutr 1991;54:930–5.

Slavin J, Lutter J, Cushman S. Amenorrhoea in vegetarian athletes. Lancet 1984;1:1474–5.

Snowdon DA, Phillips RL. Does a vegetarian diet reduce the occurrence of diabetes? Am J Public Health 1985;75:507–12.

Synder 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.

Tesar R, Notelovitz M, Shim E, Kauwell G, Brown J. Axial and peripheral bone density and nutrient intakes of postmenopausal vegetarian and omnivorous women. Am J Clin Nutr 1992;56:699–704.

The Little Oxford Dictionary of Current English. Oxford: Oxford University Press, 1980.

Thorogood M, Mann J, Appleby P, McPherson K. Risk of death from cancer and ischaemic heart disease in meat and non-meat eaters. BMJ 1994;308:1667–70.

Tylavsky FA, Anderson JJB. Dietary factors in bone health of elderly lacto-ovo-vegetarian and omnivorous women. Am J Clin Nutr 1988;48:842–9.

Weaver CM, Plawecki KL. Dietary calcium: adequacy of a vegetarian diet. Am J Clin Nutr 1994;59:S1238–S41.

Weaver CM, Proulx WR, Heaney R. Choices for achieving adequate dietary calcium with a vegetarian diet. Am J Clin Nutr 1999;70:S543–S8.

Williams PT. Interactive effects of exercise, alcohol and vegetarian diet on coronary artery disease risk factors in 9242 runners: the national runners' health study. Am J Clin Nutr 1997;66:1197–206.

Young VR, Pellett PL. Plant proteins in relation to human protein and amino acid nutrition. Am J Clin Nutr 1994;59:S1203–S12.