

# Nutritional supplement use among university athletes in Singapore

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## ABSTRACT

**Introduction:** Nutritional supplements used by athletes can be classified as sports food, dietary supplements and ergogenic aids. The aim of this study was to examine the use of such supplements among university athletes in Singapore.

**Methods:** 82 athletes from 16 sport disciplines completed a questionnaire which sought information on demographical parameters, type of supplements, frequency of use, motivations, knowledge, expenditure and side effects.

**Results:** The prevalence of supplement use was 76.8 percent and 20 different products were used. Each individual consumed a mean and standard deviation of  $3.18 \pm 1.7$  products over a 12-month period. The mean number of products consumed daily was  $2.1 \pm 1.2$ . Popular products included sports drinks, vitamin C, multivitamins and traditional/herbal preparations such as essence of chicken, bird's nest and ginseng. Before using a product, 65.9 percent sought information, usually from the media, the Internet, coaches and fellow athletes. However, many did not know where to obtain reliable information and 86.4 percent were also unaware that supplementation can have adverse effects.

**Conclusion:** Although there is a high prevalence of supplement use in our study population, many do not have accurate information about these products. Hence, there is an urgent need to provide athletes with education and access to scientific and unbiased information.

**Keywords:** dietary supplements, ergogenic aids, nutritional supplements, sports food

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## INTRODUCTION

In the quest to be the strongest and fastest, many athletes consume unproven, potentially harmful, or even banned nutritional supplements. In 1996, consumer spending

on supplements in the United States was USD 6.5 billion. By 2002, this had ballooned to USD 18 billion, with sports nutritional products making up one-third of sales.<sup>(1)</sup> In 1998, worldwide consumption of creatine was 2.7 million kilogrammes,<sup>(2)</sup> and sales of hydroxy-methylbutyrate (HMB) reached USD 50–60 million, despite any clear proof of its efficacy in increasing muscle mass or strength.<sup>(3)</sup> Nutritional supplements can be grouped into dietary supplements, ergogenic aids and sports foods. Their use among athletes ranges from 46% to 100%.<sup>(4-10)</sup> This large variation may be partly explained by methodological differences such as the definition of supplements, characterisation of use and mode of data collection. For example, a study that involved 21,225 university athletes and did not include multivitamins, reported a rate of 42%.<sup>(11)</sup> Other studies, which included multivitamins, reported rates ranging from 65.4% to 98.6%.<sup>(6-10)</sup> Although there is data supporting the ergogenic potential of sports drinks, caffeine and creatine, most other purported supplements have not been shown via scientific studies to enhance sports performance.<sup>(5,11,12)</sup> Inappropriate use or contamination may cause potential health problems,<sup>(13-15)</sup> and the athlete also risks flouting anti-doping regulations.<sup>(16-19)</sup>

With the exception of two publications on Asian athletes,<sup>(20,21)</sup> the bulk of our current knowledge on supplement use comes from studies on the Caucasian population.<sup>(4,6-8,10,22)</sup> Kim and Keen, in a study on 1,355 high-school athletes from Korea, reported that 35.8% used vitamin/mineral products.<sup>(20)</sup> Slater et al, in a survey limited to elite athletes in Singapore, reported a rate of 77%.<sup>(21)</sup> Hence, the practices of university athletes in Asia remain undocumented. This group is unique as they are highly educated with ready access to scientific literature and the Internet, and yet, would have been exposed to traditional herbal/botanical products since birth – factors that may influence their supplementation pattern. This study was thus designed to assess the (a) prevalence of supplement use; (b) relationships, if any, between supplementation and gender, academic background, sports characteristics; (c) reasons for and patterns of use; (d) effects of supplementation; (e) knowledge; (f) expenditure; and (g) the type of information that athletes wanted.

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**Table I. Type of sports played.**

Sport	Males	Females	No. (%) <sup>*</sup> of total respondents
Team sports <sup>a</sup>	11	20	31 (37.8)
Sea/water sports <sup>b</sup>	12	13	25 (30.4)
Multidisciplinary endurance <sup>c</sup>	7	2	9 (11.0)
Middle/long distance running <sup>d</sup>	3	6	9 (11.0)
Racquet sports <sup>e</sup>	2	6	8 (9.7)
Total	35	47	82 (100)

<sup>a</sup> Basketball, netball, floorball, soccer, sepak takraw, touch rugby

<sup>b</sup> Canoeing, canoe-polo, dragon boat

<sup>c</sup> Biathlon (running & swimming), triathlon

<sup>d</sup> 1,500 m to 10,000 m track events, cross-country

<sup>e</sup> Badminton, tennis, squash

<sup>\*</sup>Percentages may not add up to 100 due to rounding

## METHODS

Students, aged 18 years and older, enrolled in a university in Singapore and members of at least one university sports team, were invited to participate. Participation was voluntary. The study was approved by the Ethics Committee and Institutional Review Board of our hospital and carried out with the university's consent. Participants completed a self-administered questionnaire that had been pilot-tested to ensure clarity and to eliminate open-ended questions. To enhance compliance and alleviate anxiety, the aims were clearly stated on the introductory page, which also carried a statement ensuring anonymity.

The 42 questions included demographics, sports characteristics, the athletes' aspirations, body image perception and eating habits. Those who consumed supplements within the past 12 months had to select the products used from a list of 25 items which included herbals and botanicals. They were also asked to name any other product which they had used. Participants had to state the frequency and reasons for use, as well as any beneficial or adverse effects. They were also asked whether they had sought knowledge about a product before use, the source of knowledge and the type of information they wished to receive. The questionnaire was distributed via the individual team captains. Respondents were given one week to return the completed questionnaires. To encourage participation, the athletes were informed that they would be provided with the results, and a pamphlet containing information about the ten most popular products was also distributed to all respondents within one month of study completion.

Statistical analysis was performed using the Statistical Package for Social Sciences version 12.0 (SPSS Inc, Chicago, IL, USA). Descriptive data were calculated as frequencies. The association between supplement use and the study variables was assessed by chi-square

( $\chi^2$ ) analysis, and Student's *t*-test was performed for the comparison of means between continuous variables. Significance was accepted at  $p < 0.05$ . All data are presented as the mean  $\pm$  standard deviation.

## RESULTS

A total of 82 completed questionnaires were received from athletes across a spectrum of 16 sport disciplines. This corresponded to a response rate of 42.5% (82 of 193 athletes). The respondents' mean age was  $21.9 \pm 2.5$  (range 18–33) years, and 91.4% were Chinese. There were 35 (42.7%) males and 47 (57.3%) females. The mean body mass index (BMI) of the athletes was  $21.3 \pm 2.2$  kg/m<sup>2</sup>, with 17 (20.7%) classified as overweight and 10 (12.2%) as underweight.<sup>(23)</sup> 28% of the respondents were final-year students, with the remaining 72% comprising freshmen and sophomores in equal proportions. Most (72.5%) indicated that securing a good job or doing well academically was more important than success in sports. Nearly 90% consumed most of their meals from campus cafeterias or hostels during a typical school day. Dietary practices were relatively sound, with 94.7% selecting rice, pasta or bread as healthy, low-fat carbohydrate sources. A similar proportion chose lean meat or eggs as sources of high-quality protein. More female than male athletes (32 vs. 15,  $p = 0.02$ ) wanted to change their body composition, by reducing weight, improving tone or building muscle mass.

Most respondents participated in at least two different sports, with 24.1% taking part in one and 22.4% in up to four disciplines. More than half (55.2%) had been involved in the same sport for longer than four years, with 91.4% having participated in local inter-institutional or league competitions. 31% had also competed overseas. The mean time invested in sports per week was  $11.9 \pm 6.1$  hours, with 38% allocated to cardiovascular, 29% to sports-specific, and 14% to resistance training. Sports with similar physical and metabolic requirements were grouped for analysis (Table I). 63 (76.8%) athletes reported using one or more supplements during the past 12 months. They used a total of 20 different products (Table II), with each individual consuming a mean of  $3.18 \pm 1.7$  (range 1–9) products. A larger proportion of male athletes (66.7% vs. 33.3% females) used supplements. The maximum number of products consumed in a day was six (mean  $2.1 \pm 1.2$ ). Table III presents the primary reasons for supplementation.

Athletes who spent more than five hours per week on cardiovascular training were more likely to use sports foods ( $p = 0.04$ ), multivitamins ( $p < 0.01$ ) and

**Table II. Type of supplements and frequency of use.**

Supplement	Mean frequency of use (per week)		No. of subjects	Percentage of users
	Competition season	Off-season		
<b>Sports foods</b>				
Sports drinks	4.1	1.9	57	90.4
Sports bars*	3.4	1.1	13	20.6
Meal replacement	4.3	1.3	4	6.3
<b>Dietary supplements</b>				
Vitamin C	6.0	5.6	31	49.2
Multivitamins	6.3	5.5	19	30.2
Glucosamine sulphate/chondroitin	6.8	5.9	13	20.6
Calcium tablets	5.8	4.7	6	9.5
Fish oils	6.0	6.0	5	7.9
Vitamin E	6.3	6.3	4	6.3
Antioxidants	5.7	5.3	4	6.3
Iron tablets	5.5	5.5	3	4.8
Vitamin B complex	3.0	0	3	4.8
<b>Ergogenic aids</b>				
Red Bull energy drink	2.8	1.0	13	20.6
Protein powder/amino acids /weight gainers	5.0	2.5	6	9.5
Slimming products	7.0	7.0	2	3.2
Coenzyme Q10	7.0	7.0	1	1.6
Creatine	11.0	0	1	1.6
<b>Herbals/traditional products</b>				
Essence of chicken	4.5	3.8	7	11.1
Bird's nest	1.0	1.0	7	11.1
Ginseng products	4.0	3.5	3	4.8
Gingko biloba	3.0	3.0	1	1.6

\* Includes carbohydrate/energy gels and bars

antioxidants ( $p = 0.04$ ). Those who played three or more sports had a greater likelihood of using products such as vitamin C, multivitamins and glucosamine ( $p = 0.02$ ). The use of these supplements, as well as herbal/traditional products, was also higher in females, who consumed them for general health benefits ( $p < 0.04$ ). Athletes in team sports that required intermittent bursts of effort, such as soccer and basketball, were more likely to consume Red Bull energy drink ( $p = 0.03$ ). Freshmen were less likely than seniors to use supplements ( $p < 0.01$ ). The use of sports drinks ( $p < 0.01$ ) and sports bars ( $p = 0.04$ ) was significantly higher during the training/competition season than off-season. The main reason for their use was to provide fluid and energy (Table III). Athletes who wanted to gain muscle mass were also more likely to use protein/amino acids ( $p < 0.01$ ). No significant inter-seasonal variation was observed for products that were consumed for general health benefits.

With the exception of slimming products and Red Bull energy drink, all the athletes using ergogenic aids were males. No significant relationship was identified between the use of the various groups of supplements and body mass index, duration in sport, participation level or academic background. Supplement use was also not significantly influenced by dietary habits, priorities in life, social activity volume or body image perception. The mean monthly expenditure on supplements was S\$34.19

$\pm 33.81$  (range S\$1–150). 28% spent S\$10 or less, 60% spent S\$11–50 and 12% spent above S\$51. Expenditure was independent of gender and other characteristics of the population studied. The majority purchased their supplements from health food stores (Table IV).

More than one-third (36.3%) of supplement users reported either no or minimal knowledge about the product they consumed. Males were more likely than females (81% vs. 52%) to research a product before purchase ( $p = 0.04$ ) and athletes with more knowledge were more likely to use supplements ( $p < 0.01$ ). The most frequent explanation (38.5%) for not seeking further information was that “the product must be safe since it is commonly available.” Other reasons included laziness (23.1%) and faith in the recommendations of the coach (7.7%) or family members (7.7%). 93% indicated that they would like to know more about supplements, but did not know where to obtain reliable information. Most (54%) were concerned about safety and potential side effects. Despite this, 86.4% were unaware that supplements can adversely affect health, and only 29.5% were certain that they did not contravene sports doping regulations. Table V shows the sources from which our athletes obtained information, and Table VI lists the information they wanted.

The majority (95.9%) did not report any adverse effects from supplement use. One runner experienced diarrhoea after eating sports bars and a canoeist had

**Table III. Reasons for using the ten most popular products.**

Supplement	Reasons for use	No. (%) of users
Sports drinks	Provide energy and fluids	50 (87.7)
	Provide energy	5 (8.7)
	Reduce fatigue	2 (3.5)
Vitamin C	Stay healthy and prevent illness	24 (77.4)
	Supplement inadequate diet	4 (12.9)
	Provide energy	2 (6.4)
	Do not know	1 (3.2)
Multivitamins	Stay healthy and prevent illness	9 (47.4)
	Supplement inadequate diet	7 (36.8)
	Reduce fatigue	3 (15.8)
Sports bars	Provide energy	11 (84.6)
	Reduce fatigue	2 (15.4)
Red Bull energy drink	Provide energy	7 (53.8)
	Provide energy and fluids	3 (23.1)
	Improve performance	2 (15.4)
	Reduce fatigue	1 (7.7)
Glucosamine sulphate /chondroitin	Protect joints	13 (100)
Essence of chicken	Supplement inadequate diet	4 (57.1)
	Stay healthy and prevent illness	2 (28.6)
	Reduce fatigue	1 (14.3)
Bird's nest	Stay healthy and prevent illness	5 (71.4)
	Do not know	2 (28.6)
Protein/amino acid /weight gainers	Gain muscle mass	5 (83.3)
	Reduce fatigue	1 (16.7)
Calcium tablets	Protect bones	4 (66.7)
	Supplement inadequate diet	2 (33.3)

palpitations after drinking Red Bull. Most users (81.4%) felt that they benefited from supplementation, with 43% of those consuming sports drinks reporting improved hydration. Other reported benefits from athletes who consumed dietary supplements and herbal/traditional preparations included increased energy (18%), reduced fatigue (15.9%), reduced upper respiratory tract infections (11.4%), and speedier post-workout recovery (11.4%). Among those who used ergogenic aids, only one person reported a positive effect on actual sports performance and one-third were uncertain if the products fulfilled their promises. 19 (23.2%) respondents did not consume any supplements. Their reasons are presented in Table VII.

## DISCUSSION

This study shows that the prevalence of nutritional supplement use among university athletes in Singapore is similar to their peers in the West.<sup>(7-9,24)</sup> It is also similar to that of our elite athletes.<sup>(21)</sup> The most popular products were sports drinks and vitamin/mineral supplements. In the West, such supplements are also popular, followed by creatine and protein supplements.<sup>(6,7,9,11)</sup> With the exception of energy drinks, the use of other ergogenic aids was significantly low in our study population. Only one athlete, a canoeist, used creatine, a stark contrast

**Table IV. Place of purchase of supplementary products.**

Place	No. (%) of users
Health food store	32 (50.8)
Pharmacy	13 (20.6)
Supermarket	8 (12.7)
Vending machine	7 (11.1)
Friends	2 (3.1)
Internet	1 (1.6)
Total	63 (100)

**Table V. Sources of information about supplements.**

Source	No. (%) of users
Media (magazines, newspapers, Internet)	25 (39.7)
Friends/fellow athletes	15 (23.8)
Coach/trainer	10 (15.9)
Healthcare professionals (dietitians/doctors/pharmacists)	7 (11.1)
Textbooks	4 (6.3)
Sales representative/promoter	1 (1.6)
Family members	1 (1.6)
Total	63 (100)

to the 11%–28% reported in the literature.<sup>(9,25,26)</sup> Over-the-counter sale of the prohormones, androstenedione and dehydroepiandrosterone (DHEA), is banned in Singapore,<sup>(27)</sup> and none of the athletes admitted to using them.

The patterns and motivation for supplement use in our study population were also different. Among Western university athletes, females were more likely to supplement for general health benefits, whereas males used supplements for performance and strength enhancement.<sup>(4,10,25)</sup> The majority of users in our study consumed them for health benefits, with only one athlete stating explicitly that he consumed supplements to enhance sports performance. Our findings may be due to the different sporting cultures between the East and West. In the United States, university sport is highly prestigious and there is intense competition for sports scholarships.<sup>(22)</sup> Hence, many athletes attempt to enhance performance through supplementation.<sup>(4,22)</sup> In contrast, university sport in Singapore is less glamorous, and there is substantially less financial incentive for the student athlete to outshine his peers in the sporting arena. Only 15.5% cited sporting excellence as their top priority; the majority were more concerned with excelling academically and securing good jobs.

The use of sports drinks in our study (90%) is slightly higher than the 76.8%–86.7% rate previously reported.<sup>(7,9)</sup> It may be related to our climate, where maximal daily temperatures reach 31°C and humidity, above 90%. Our results may also reflect the type of sports played, with 53% of respondents involved in endurance disciplines.

**Table VI. Type of information about supplements that athletes wanted.**

Information wanted	No. (%) of respondents
Safety	28 (37.8)
Side effects	16 (21.6)
Beneficial effects	10 (13.5)
Evidence	9 (12.2)
Composition (contents)	6 (8.1)
Mechanism of action	5 (6.8)
Total	74 (100)

**Table VII. Reasons for not using supplements.**

Reasons	No. (%)* of non-users
Proper training	6 (31.6)
Insufficient knowledge about supplements	4 (21.1)
Proper diet	3 (15.8)
Worried about safety/side effects	3 (15.8)
Too expensive	1 (5.2)
Waste of money	1 (5.2)
Healthy enough not to require supplements	1 (5.2)
Total	19 (100)

\*Percentages may not add up to 100 due to rounding)

Sports drinks provide these athletes with a source of fluid, fuel and electrolytes that is rapidly delivered and absorbed. Dehydration increases physiological strain and compromises endurance performance via increased core temperature, cardiovascular stress, glycogen utilisation and perceived exertion.<sup>(28)</sup> Fluid and carbohydrate intake during exercise lasting more than one hour has been demonstrated to improve endurance and delay fatigue.<sup>(5,28,29)</sup> The prevalence of vitamin use among athletes ranged from 19%–94%.<sup>(1,4,6,8-10,22,24,26)</sup> Nearly 80% of supplement users in our study used them, the most popular being vitamin C and multivitamins. The common reasons justifying their use were to “stay healthy”, “prevent illness”, “supplement poor diets”, “increase energy levels” or “reduce fatigue”. This is not surprising, as university athletes have to juggle sports with academic and social commitments; hence, the temptation to correct perceived dietary or lifestyle inadequacies through supplementation is high.

Although exercise may slightly increase the requirements for certain vitamins and minerals,<sup>(30,31)</sup> many of which are involved in muscle contraction and metabolic processes during energy production, this can generally be met by the high energy intake of many athletes.<sup>(30)</sup> There is currently no conclusive evidence that supplementation enhances health or sports performance. The antioxidant nutrients, vitamins A, C, E, beta-carotene and selenium, may also protect cell membranes against free radical induced oxidative damage during intense exercise.<sup>(32,33)</sup> However, data on whether exercise increases the need for antioxidants is equivocal and conflicting, and there is no clear consensus on whether supplementation is necessary. However, supplementation may benefit athletes with pre-existing deficiencies, or who are on caloric/dietary restrictions, or travelling for prolonged periods to regions with inadequate or limited food supply.<sup>(30)</sup> In such situations, a broad range multivitamin-mineral preparation with amounts not exceeding two times the recommended daily allowance is safe and adequate.<sup>(30)</sup>

Red Bull contains a mixture of carbohydrates,

taurine, glucuronolactone, vitamin B and caffeine, and it is a common energy drink sold in Singapore. Several small studies have reported that carbohydrate and caffeine consumption improves aerobic and anaerobic performance as well as cognitive functions such as concentration, alertness and reaction time.<sup>(34-36)</sup> It was postulated that the effects were from the modulation of adenosinergic receptors by caffeine and taurine. Traditional herbal preparations, such as essence of chicken, bird’s nest, ginseng and ginkgo biloba, were popular with nearly one-third of supplement users in our study, especially females. Nearly 50% of the elite athletes in Slater et al’s study consumed similar products.<sup>(21)</sup> In contrast, only 17% of the athletes in Herbold et al’s study used traditional products.<sup>(8)</sup> In that study, the athletes used Echinacea, ginseng, ciwujia and goldenseal.<sup>(8)</sup> This may reflect the different culture and health beliefs between the East and West.

Essence of chicken is a concentrated extract containing protein, peptides, free amino acids and iron. It is a popular folk remedy in East Asia, often consumed for improving appetite, metabolism, immunity, alertness and enhancing recovery from fatigue or illness. Edible bird’s nest is the processed nest of the swiftlet (*Collocalia* spp.) that is made from its saliva. It is glycoprotein rich and purported to improve immunocompetence and health. The ginsenosides (steroid glycosides/saponins) in ginseng are purported to reduce fatigue, improve aerobic conditioning, strength, mental alertness and recovery. Although some of the above benefits have been demonstrated, the studies were often small, did not utilise trained subjects or were plagued by methodological flaws.<sup>(37-39)</sup> Hence, there is currently insufficient evidence to support their use.<sup>(5)</sup>

Although the majority of our athletes did not experience side effects, supplements are not risk-free. Contaminated L-tryptophan, an amino acid popular with strength athletes, has been associated with 36 deaths from the eosinophilia-myalgia syndrome.<sup>(14)</sup> Anxiety, insomnia, headache, tachycardia and diarrhoea have been associated with caffeine pills; gastrointestinal distress with sports

bars, meal replacements and proteins; and water retention and nephritis with creatine supplementation.<sup>(2,5,25,40)</sup> Megadoses of vitamins have also been associated with various adverse effects, and bird's nest has been linked to immunoglobulin-E mediated anaphylaxis and arsenic poisoning.<sup>(13,15)</sup> Polypharmacy, or the concurrent use of more than one product, increases the risk of overdosage and toxicity. It is a common practice, with rates as high as 89% being documented.<sup>(9,10,22)</sup> Baylis et al reported that 77% of elite Australian swimmers concurrently used more than one vitamin/mineral product.<sup>(24)</sup> The athletes in our study often combined multivitamins with vitamin C (61.5%), calcium (23.1%), vitamin E (15.4%) and iron (7.7%).

In many countries, supplements are categorised as non-prescription products or food items. Hence, production and marketing are less rigorously regulated, and they are not subjected to stringent quality and safety controls. There is often no requirement for manufacturers to provide information regarding safety issues.<sup>(24)</sup> A product's composition and concentration may also differ from what is stated on the label. For example, an assay of 50 ginseng preparations revealed that ginsenoside concentrations in 44 of these ranged from 1.9% to 9.0%, and were undetectable in the remaining six.<sup>(41)</sup> More ominously, banned substances may have been either deliberately added or inadvertently included as by-products or contaminants during manufacture. In many countries, including Singapore, the onus of quality control and ensuring that supplements do not contain banned/restricted substances rests with the importer/manufacturers,<sup>(27)</sup> who, unfortunately, often have a poor track record.<sup>(16,17)</sup> The athlete consuming such products thus risks committing an inadvertent doping offence.<sup>(17,24)</sup> This may happen if they unwittingly consume a supplement containing an undeclared banned ingredient, or if they fail to recognise the relationship between certain constituents, such as the presence of ephedrine in Ma Huang. There have been reports of athletes, including at least one Singaporean, returning positive doping samples following the use of botanical supplements.<sup>(17,19)</sup>

It is encouraging that 65.9% of the athletes in our study attempted to seek more information before using a new product. This is higher than what Kristiansen et al (33.3%) and Slater et al (57%) had reported.<sup>(9,21)</sup> In Slater et al's study, a disturbing proportion (90%) believed that supplements were risk-free.<sup>(21)</sup> Many of our athletes indicated that they would use supplements if they had reliable information; however, they did not know where to obtain this, and often had difficulty deciphering true

science from "scientific-sounding" advertisements. Several also had misconceptions, the most common being that sports drinks adversely affect electrolyte levels and renal function.

Less than 18% of supplement users in our study sought information from healthcare professionals or textbooks. Nearly 80% obtained information from "questionable" sources, such as the media, the Internet, peers, coaches and trainers.<sup>(8,9,21,25,26)</sup> Similarly, 77.6% of the athletes in Herbold et al's and 41% of those in Jacobson et al's study cited family members, friends and the media as sources of information.<sup>(8,25)</sup> In addition, besides healthcare professionals, the Canadian collegiate athletes in Kristiansen et al's study also followed recommendations from friends, family members and magazines.<sup>(9)</sup> Most coaches and parents have little or no specialised sports nutrition knowledge; hence their advice may be inappropriate, inaccurate or even damaging. Sobal and Marquart surmised that younger athletes were more likely to be influenced by the media than their doctors.<sup>(22)</sup>

In many countries, although manufacturers cannot make unsubstantiated claims about health or performance benefits on product labels, advertising is loosely regulated.<sup>(27)</sup> Grunewald and Bailey, in a survey of five bodybuilding magazines, found 624 advertised products with a total of over 800 individual performance claims.<sup>(42)</sup> Athletes are constantly exposed to advertisements in glossy magazines and the Internet; supermarkets, pharmacies and "health-food" stores also entice with a bewildering array of miracle foods, potions, pills and powders promising improved endurance, faster recovery, increases in muscle mass and strength. Such ads often distort clinical studies or make misleading claims, and endorsements featuring well-known personalities often fail to mention the long hours of training or sound nutritional practices that were responsible for their success. For supplements with scientific evidence of their efficacy, such as caffeine, creatine and sodium bicarbonate, many users are also unaware that only specific athletes will benefit.<sup>(2,5,12)</sup>

Hence, athletes must be critical when reading labels or advertisements. They must be cognizant with any additive or synergistic effects of the supplements they intend to consume. Placing misguided faith in a product, or failing to follow administration guidelines, not only waste precious financial resources, but may also expose them to adverse effects or detract from other more worthwhile performance-enhancing strategies, such as sound training and nutrition. Both the U.S. Food and

Drug Administration and the American College of Sports Medicine encourage individuals to use supplements with caution and to examine a product for safety, efficacy, potency and legality with a healthcare professional prior to use.<sup>(31)</sup> Unfortunately, this group of professionals, which include doctors, dietitians, nutritionists and pharmacists, is often not easily accessible to the non-elite athlete. Hence, national sport organisations, education institutions and healthcare providers should collaborate and provide athletes and their trainers with an easily accessible, current, unbiased and scientifically sound information source.

The chief limitation of this study is the low response rate of 42.5%. This can create a responder bias and may account for the absence of significant relationships between certain variables. It may also be insufficiently powered to represent all university athletes in Singapore. However, as similar results have been reported in larger investigations with response rates below 50%,<sup>(24,25,43)</sup> we believe that our findings reflect supplementation practices in our study population. The low response may reflect the (a) distribution methodology; (b) release of the questionnaire close to examinations; and (c) detailed eight-page questionnaire format. Other limitations include the use of self-reporting data and potential unwillingness of athletes to divulge "sensitive" information regarding restricted/banned substances.

This study indicates that the prevalence of nutritional supplement use is widespread among university athletes in Singapore. Besides products with sound scientific backing, many also use supplements and traditional/herbal preparations that have not been validated by rigorous scientific investigation. As athletes and coaches have ready access to an ever-increasing range of supplements and sports foods, there is thus a need to educate them and provide reliable information regarding appropriate use, potential benefits and side effects. This will enable them to make informed decisions and reduce the risks associated with the misuse of supplements.

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