AIS SPORTS SUPPLEMENT FRAMEWORK POSITION STATEMENT

CONTEXTUAL INFORMATION

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INTRODUCTION

Sports nutrition guidelines provide recommendations for the intake of energy, nutrients and other dietary components that support training adaptations and competition performance, while supporting athlete well-being. A "food first" approach, which promotes a focus on unprocessed & conventional foods, is a foundation goal of an evidence-based sports nutrition plan. However, some supplements & sports foods can play a small but valuable role in such a plan. Indeed, the use of supplements and sports foods is widespread among athletes due to the enthusiastic marketing of these products within the sporting environment, but also reflective of the high prevalence of supplement intake in the general community. The issues around supplements and sports foods for athletes are specialised and include potential benefits as well as disadvantages and dangers. In the past, sporting organisations and expert groups have taken a conservative view: focussing on the negative themes, branding supplements as ineffective and unnecessary, and discouraging athletes from their use.

Nevertheless, the manufacture and marketing of sports supplements has flourished, leaving many athletes without access to empathetic expert advice, and vulnerable to claims that are not evidence-based. Many athletes rely on information sources outside the sporting organisations which are neither impartial nor credible. This Position Statement outlines the principles and implementation of evidence-based use of supplements and sports foods in sport, with a focus on features and requirements of the Australian HP sports system, drawing on the expertise derived from the activities of the AIS Framework group and the IOC Working Group on Dietary Supplements.

What is a supplement?

The definition of a supplement or sports food is problematic because of the lack of a single and universal classification scheme or regulatory approach to these products (Dwyer *et al.*, 2018). Furthermore, as manufacturers innovate their production of "functional foods" or add new ingredients to conventional sports foods, the distinction between food, sports food and supplement becomes even more blurred. A range of different classification themes is possible (see Table 1) but none is singly able to meet the needs for education and practice within HP sport.

Table 1. Different systems under which sports foods and supplements might be classified

Definition	Example of categories	Comments
Legal/Regulatory definitions	• FDA definition (USA) of dietary supplement: A product (other than tobacco) intended to supplement the diet that bears or contains one or more of the following dietary ingredients: a vitamin; a mineral; a herb or other botanical; an amino acid; a dietary substance for use by man to supplement the diet by increasing the total dietary intake; or a concentrate, metabolite, constituent, extract, or combination of any ingredient described previously • FSANZ (AUS) definition of formulated supplementary sports food: A product that is specifically formulated to assist sports people in achieving specific nutritional or performance goals. They are intended to supplement the diet of sports people rather than be the only or main source of nutrition. • TGA (AUS) definition of sports supplements which are therapeutic goods: Goods for oral administration that are represented (expressly or by implication) as being for the improvement or maintenance of physical or mental performance in sport, exercise or recreational activity, and are supplied in dosage form of tablet, capsule or pill	• The jurisdiction of regulatory bodies may not cover all the environments in which the products can be found/purchased • In some countries – including Australia – different types of products are covered by different regulatory bodies. This can be confusing for the consumer. In addition, some products fall into an interface between these bodies and may be difficult to regulate. • Since many definitions are derived from a legal perspective, they may not cover the practical use of these products
Form	• Foods • Drinks • Powders • Capsules/pills • Potions/Small volume liquids	• Historically, this definition might have aligned with factors that assisted an athlete to identify the risks associated with a product: for example, a sports food might similar in manufacturing environment and ingredient lists to everyday foods whereas a pill might contain ingredients that are more unusual/risky or be manufactured with different hygiene and safety protocols. • This distinction has become more blurred with new product development, especially as the list of ingredients in functional foods and sports foods has grown
Availability	• Prescription-only pharmacy • Over-the-counter pharmacy • Sports shops • Health food shops • Supermarkets • Internet and mail order • Multi-level marketing	• The source of a sports food or supplement may provide some level of risk assessment regarding safety and efficacy, with products sold under some supervision (e.g. pharmacies) being more reputable or allowing some advice about their intake than products sold with less oversight (e.g. internet sites). • These distinctions have become more blurred with the increase in on-line sales of all products

Definition	Example of categories	Comments
Function	• Direct performance effect • Weight loss • Weight/muscle gain • Recovery • Illness prevention • Fuel/Energy support • Prevention/treatment of nutrient deficiency	• This is the way that many supplements are marketed • Many supplements of this type are multi-ingredient, with these ingredients varying in their ability to achieve the claimed function • The efficacy of products cannot be judged from their claims, since many claims are not regulated or enforced
Evidence base	• Well supported • Undecided support • Minimal scientific support	• Products fit in these categories on a dynamic basis since the evidence around different products may ebb and flow according to new research findings • The evidence base for a product should be linked to a specific use, rather than a universal application to all scenarios (e.g. sports, athletes) or all protocols of timing/dose • While this classification system may help an athlete to make some judgements about the potential use of a supplement product, and is the primary characteristic of the AIS Sports Supplement Framework, other aspects of the product (contamination risk, expense) should be included in decision making

FDA = Food and Drug Administration (https://ods.od.nih.gov/About/DSHEA_Wording.aspx#sec31994);
FSANZ = Food Standards Australia New Zealand (https://www.foodstandards.gov.au/consumer/nutrition/sportfood/Pages/default.aspx);
TGA = Therapeutic Goods Administration (Australia); https://www.tga.gov.au/changes-regulation-sports-supplements-australia

Several authorities have made useful contributions to understanding supplement uses in sport. These include the International Olympic Committee (IOC) IOC Working Group on Supplements, which developed a working definition of supplements used by athletes (Maughan *et al.*, 2018):

- A food, food component, nutrient, or non-food compound that is purposefully ingested in addition to the habitually-consumed diet with the aim of achieving a specific health and/or performance benefit.

A working definition of supplements and sports foods in Australia is proposed, with comparison to other products with which they may have some overlap or shared characteristics:

- **Supplement:** single or multi-ingredient product in powder, limited volume liquid, pill or capsule form providing nutrients or other dietary components to achieve a specific health and/or performance benefit.
- **Sports Food:** food or drink formulated to help people achieve specific nutritional or performance goals by providing a convenient form of general nutrition support of athletes or a targeted use around exercise
- **Fortified food:** conventional food to which vitamins and minerals only (or other micronutrients) are added during processing to increase its nutritional value.
- **Functional Food:** foods enriched with additional nutrients or components outside their typical nutrient composition for the purpose of enhancing the functional properties of the inherent nutrient profile of the food e.g. concentrated proteins like lactoferrin, phytosterols, probiotics.

Regulation of supplements and sports foods in Australia

In Australia, supplements and sports foods are covered by either the Food Standards Code or the Therapeutic Goods Act 1989. Whether a product is classified as a food or a therapeutic good depends on factors including the ingredients, marketing claims and the form in which it is presented (e.g. pill, bar, powder, drink etc). A tool provided by TGA guides the general distinction between food and medicine interface (https://www.tga.gov.au/food-medicine-interface-guidance-to).

The Food Standards Code is regulated by Food Standards Australia New Zealand (FSANZ), a statutory authority within the Australian Government Department of Health which governs food production, safety, and labelling. Although this is a federal activity, compliance with the Code is monitored by various authorities in each states and territory. Sports foods are covered by Standard 2.9.4 Formulated supplementary sports foods (FSSF). This Standard is currently under review following a Ministerial request (Proposal P1010, October 2018).

The Therapeutic Goods Administration (TGA) is responsible for regulating the manufacturing, supply, sale, and advertising of therapeutic goods, which cover medicines and "complementary medicines" including dietary supplements. Australia has a risk-based approach where lower risk medicines/ complementary medicines can be listed on the Australian Register of Therapeutic Goods (ARTG) with an AUST-L number, while higher risk medicines must be registered on the ARTG with an AUST-R number. While registration notes that the TGA has evaluated the product for safety, quality and efficacy, low-risk listed medicines, which includes most supplements are regulated for safety and quality only.

On 30 November 2020, after extensive consultation around the safety and marketing concerns in relation to sports supplements/sports foods, an update to subsection 7(1) of the Therapeutic Goods Act was implemented (Therapeutic Goods Administration, 2020). This update targeted sports supplements containing higher-risk ingredients with therapeutic claims, moving them to the cover of the ARTG and its requirements around safety, quality and advertising. The new regulations apply to products that make claims related to sport, exercise or recreational activity and provide for the following categories of sports supplements:

- Sports supplements containing ingredients that are appropriate for food, and presented as food (e.g. protein powders, nutrition bars, sports drinks) are regulated as foods
- Sports supplements presented in pill, tablet or capsule form and containing only lower risk ingredients are regulated as a 'listed medicine' and labelled with an AUST L number. They can be purchased from general retail stores including supermarkets and health food stores without the need for a prescription. Products in this category have until November 2023 to transition to these requirements.
- Sports supplements presented in pill, table or capsule form but containing higher risk ingredients are classified as a 'registered medicine' and must carry an AUST R number on their labels. Higher risk ingredients include substances listed within the schedules of the Australian Poisons Standard (e.g. prescription medicine ingredients) or substances banned for use in sport by the World Anti-Doping Agency. Depending on their ingredients and health claims, these sports supplements may be available at general retail stores, or at pharmacies either with the advice of a pharmacist or requiring a doctor's prescription.

An interactive decision tool can assist manufacturers or consumers to determine whether a sports supplement is a therapeutic good as a result of this update (https://www.tga.gov.au/my-sports-supplement-therapeutic-good).

Supplement practices of athletes

Many surveys confirm that dietary supplements represent a multi-billion dollar industry, popularly used by most members of the general community at rates that are only increasing. For example, the Council for Responsible Nutrition, a body funded by the supplement industry, conducts an annual survey on supplement use within the United States. The most recent (2019) activity, which surveyed 2000 adults by Ipsos poll, reported the highest prevalence of supplement use in its 20 year history (Council for Responsible Nutrition, 2020). Indeed, 77% of respondents reported the use of dietary supplements (79% of females and 74% of males), with the highest prevalence of use (81%) among the 35-54 age group and a 70% prevalence among young adults of 18-34 years (Council for Responsible Nutrition, 2020). Although very few official surveys have been conducted on the Australian community, information taken from the 20014-2015 National Nutrition Survey (> 19,000 people) found that 43% of adults (35% of males, 50% of males) had taken a dietary supplement within the previous two weeks, with the prevalence among adolescents being 20% (O'Brien *et al.*, 2017). In both surveys, vitamin and mineral supplements were the most widely used products. Reasons for discrepancies in information about the prevalence of supplement use include differences in the definition of dietary supplement, but most importantly, the way the information is framed and collected (e.g. do you take supplements? vs did you take a supplement in the last two weeks?).

Information about supplement use within athletic populations has also been collected using different protocols (often neither standardised nor validated), over different time frames and using different definitions of supplements; these issues directly influence the outcomes (Knapik *et al.*, 2016; Garthe & Maughan, 2018). Some studies have investigated the accounts of supplement use provided at Doping Control stations where athletes are asked to disclose products taken in the previous days (Corrigan & Kazlauskas, 2001; Tsitsimpikou *et al.*, 2009). On such occasions, athletes face different pressures around their willingness/ability to provide truthful accounts and may have temporarily ceased their use of some products. Furthermore, the populations on which such data are available is not representative of wider athlete populations. On the other hand, there have been several reviews and/or meta-analyses of supplement surveys on a range of athletic groups, where most of the information has been collected via questionnaires and/or interviews to identify supplement use over the previous 3-12 months (Sobal & Marquart, 1994; Knapik *et al.*, 2016; Garthe & Maughan, 2018). Whereas one such review identified a mean prevalence of supplement use by 46% of athletes (Sobal & Marquart, 1994), the other reviews focussed more on the variability of the findings and variable methodological quality of the available studies (Knapik *et al.*, 2016; Garthe & Maughan, 2018). Depending on the survey, the population and the definition of a supplement, it is likely that 40-100% of athletes are consumers of supplements and sports foods (Garthe & Maughan, 2018). Typical qualitative findings of such reviews are summarised in Table 2 and include apparent differences in supplement use according to various characteristics of the athlete. Although there is a need for an improvement in the number and quality of studies of supplement use among athletes in general, there is a particular lack of information on the needs and practices of special populations such as athletes with disabilities. The few available studies of these athletic populations suggest unique needs related to performance, underlying medical issues and specific risks of nutrient deficiencies (Madden *et al.*, 2017; Madden *et al.*, 2018).

Table 2. Characteristics of Supplement Use Among Different Types of Athletes

Feature	Characteristics of Supplement Use
Sex	Some studies report males are higher users of supplements while others report the reverse (Sobal & Marquart, 1994). It is possible that the differences relate to the type of supplements being used, or the culture/characteristics of the sport (Garthe & Maughan, 2018). For example, male athletes are more likely to use creatine and performance supplements, while female athletes are more likely to use vitamin supplements (Knapik *et al.*, 2016; Garthe & Maughan, 2018).
Age	According to the review of Garthe & Maughan (2018), there is evidence that supplement use among athletes starts at a younger age and is in higher prevalence than in the general community. Furthermore, their analysis of surveys of supplement use in sport identified an increase in the prevalence, type and number of supplements used in conjunction with the increase in an athlete's age and their training load.
Calibre	There is consistent evidence that elite athletes report a higher prevalence of supplement use than their lower calibre counterparts (Sobal & Marquart, 1994; Knapik *et al.*, 2016; Garthe & Maughan, 2018).
Type of sport/event	The prevalence, number and type of supplements used by athletes varies according to the physiological needs and limitations within a sport or event, and its culture (Knapik *et al.*, 2016; Garthe & Maughan, 2018).

Many of the supplement surveys of athletes have commented on the rationale or motivation for supplement use. Although this information can also be expected to suffer from the limitations of the methodological design of these studies, the five most commonly cited reasons for athletes using supplements in the most recent review of practices amongst elite athletes in Australia (Waller, *et al.*, 2019) included...

- Enhance recovery (63%)
- Maintain health (59%)
- Improve energy (50%)
- Boost immunity (43%)
- Improve training and competition performance (34%)

In the same review of supplementation practices of elite Australian athletes, the small number who reported not taking supplements indicated their primary reason for not using supplements was because 'a healthy diet makes them unnecessary.

Risks and rewards of supplement use

Rewards: valuable uses of sports foods and supplements

Over the past 60 years, sports nutrition has evolved into a specialised integration of science and practice that assists athletes to achieve their performance goals, while supporting health and well-being (Burke & Hawley, 2018). A successful sports nutrition plan should achieve the attributes of being evidence-based, personalised, periodised, practical to implement, within the rules or codes of the relevant sport, and consistent with the larger framework of the athlete's nutrition goals and requirements (Thomas *et al.*, 2016). A "food first" approach, which promotes a focus on unprocessed and conventional foods within nutrition practices and dietary choices, is a foundation goal. The benefits of such an approach consider accessibility, nutrient-density, expense, sustainability (Meyer *et al.*, 2020), promotion of the social and cultural roles of food intake, and awareness that many health benefits of food are derived from the food matrix and yet unidentified dietary components and their interactions rather than individual nutrients (Aguilera, 2019).

However, some uses of supplements and sports foods can assist an athlete to meet their basic nutrient needs or to achieve special nutrient targets related to exercise. Consuming nutrients from a supplement/sports food rather than whole foods or conventional processed foods may be beneficial because of various features of the supplement:

- the amount of the nutrient in the supplement may be a known, larger or more compact dose of nutrient compared to foods;
- the supplement/sports food may provide a combination of key nutrients in a single source; and/or
- the form of the supplement/sports food may be more practical to store, prepare or consume than traditional foods, especially in scenarios involving exercise or an athlete's special lifestyle.

The value of nutrient-focused supplements and sports foods requires an assessment of the individual athlete's background nutritional status, their ongoing nutrient requirements and their capacity to meet nutrient needs from the available food supply (Larson-Meyer *et al.*, 2018).

Alternatively, a sports supplement/food may supply other food elements/components that can directly or indirectly support performance:

- A few food components/elements are known to directly enhance capacity for a specific type of exercise;
- A few food components/elements are known to support issues such as adaptation, sleep, manipulation of body composition, and the risk of illness and injury, which can indirectly lead to better performance.

Examples of products or components that meet these descriptions will be identified within material related to the Australian Institute of Sport Supplement Framework (see Appendix 1 and resources at www.ais.gov.au/nutrition/supplements) and resources produced for the IOC Consensus on Supplements in High Performance Sport (Maughan *et al.*, 2018; Peeling *et al.*, 2018; Rawson *et al.*, 2018). This section will summarise the principles of scenarios in which supplements/sports foods might provide advantages over conventional foods in assisting the athlete to implement a sports nutrition plan. Table 3 summarises the characteristics of supplements or sports foods which may be valuable in addressing common goals in sports nutrition.

Table 3. Common scenarios in which supplements or sports foods offer different advantages in addressing selected sports nutrition goals

Sports Nutrition Goal	Roles for food	Roles for supplements/sports foods
To provide adequate energy availability to meet the body's requirements for health and function, as well as the specific energy costs of exercise.	Food should provide most of the athlete's energy needs to simultaneously supply the range of nutrients needed to achieve other sport/health goals and to fulfil other roles of food in an athlete's life.	Athletes with high energy requirements may take advantage of the convenience of sports foods to allow energy intake to occur at times/scenarios in which it is challenging to eat conventional foods (e.g., poor food availability due to lifestyle or the logistics around exercise sessions). Sports foods may be useful in scenarios requiring a compact, low-fibre and easily consumed energy-source.
To achieve the specific fuel needs for the muscle and central nervous system including the quantity and timing of carbohydrate (CHO) intake that optimises carbohydrate availability for key sessions or competitive events.	The wide variety of CHO-rich items in our food supply typically offers many choices to meet CHO intake targets while also providing other features that may be valued according to the occasion/individual e.g., micronutrient density, protein content, energy content, gut absorption characteristics and practicality of consumption.	CHO-rich sports bars, drinks, gels and other forms may provide a practical contribution to fuel intake around exercise due to special features such as targeted doses/concentrations/CHO types, convenient packaging, compact size, ease of consumption and gut absorption etc. These features may also be useful in wider scenarios in which compact, low fibre, easily consumed and rapidly absorbed sources of CHO are required.
To provide protein in the quantity, quality and timing that optimises training adaptations and recovery goals.	The wide variety of protein-rich items in our food supply typically offers many choices to meet protein intake targets, while also providing other features valued by athletes according to the occasion/individual e.g., micronutrient density, protein quality, energy content, practicality of consumption, food origin.	Protein-rich liquids, powders, bars or other forms may provide a practical source of high-quality protein to meet targets around key timing of intake or increased requirements, when it is not possible to consume conventional foods. Convenience of protein supplements may be related to challenges around food availability (e.g., post-exercise), appetite/gut comfort (e.g., a high-energy diet) or the need to supplement sub-optimal quality or origin of protein in the available food supply.

Sports Nutrition Goal	Roles for food	Roles for supplements/sports foods
At times, to achieve desired reductions in body mass or body fat, or to achieve desired increases in lean mass and body mass.	Changing body composition involves manipulation of energy and macronutrient intake as well as training characteristics. Changes in the type, timing and serving sizes of food choices can achieve changes in energy density and nutrient density to meet needs.	Although weight loss and mass gain products are among the most popular supplements on the market, no ingredients provide a short cut or magic bullet. The convenience offered by some sports foods may be useful in the practical achievement of increased energy intake. Increased and strategic protein intake, which makes use of the convenience of protein supplements, may be part of a program to gain lean mass or maintain it in the face of BM loss.
To meet requirements for micronutrients involved in health and adaptation, including supplying the increased requirements that arise from regular exercise.	Foods provide a variety of micronutrients and other health-promoting compounds. Although requirements for some of these may be increased by regular exercise, this is generally accommodated by the accompanying increase in energy requirements. A well-chosen diet that includes a range of nutrient-dense foods within an appropriate energy intake should meet all known requirements, as well as provide other compounds with roles yet to be discovered. Fortified and functional foods may provide additional amounts of these substances in food-based eating plans.	There are some occasions (e.g., travel) and individuals (e.g., those on energy-restricted diets or with food intolerances/avoidances due to cultural or personal dislikes) where it is not possible to consume sufficient intake of micronutrients. Furthermore, some athletes are at risk of developing deficiencies or sub-optimal nutritional status of key nutrients (e.g., iron, calcium, Vitamin D). The use of micronutrient supplements may be warranted to prevent or treat sub-optimal nutritional status, particularly under the supervision of an appropriately trained nutrition/medicine expert.
To reduce the risk of injury and to enhance the process of injury rehabilitation by providing nutritional support for the various phases of repair and recovery.	Nutritional status related to energy availability, and key nutrients such as protein, calcium and Vitamin D, assists with reducing injury risk and training-related damage/soreness. Various non-nutrient phytochemicals (e.g., various polyphenols) in nutrient-dense foods may also contribute. Such goals should be included in food choices within an eating plan. An injured athlete may need to adjust energy intake in view of changed energy expenditure. Eating strategies to increase key nutrients may be permissive for recovery even direct enhancement cannot be measured.	Some supplements provide these key nutrients (protein) or "recovery" ingredients found in food in a concentrated and convenient form (e.g. fruit concentrates, creatine, fish oils, collagen proteins). The evidence for the use of some of these special ingredients is still evolving but may prove to be robust over time.

Sports Nutrition Goal	Roles for food	Roles for supplements/sports foods
To reduce the risk of illness by supporting the immune system. To maintain gut health and comfort including minimising the risk of discomfort/damage during exercise.	A well-chosen diet providing a diverse range of nutrient-dense foods, including foods containing pre- and pro-biotics, is likely to support a healthy gut microbiome and immune system. The intake of some food components before or during exercise may cause gut discomfort in some individuals, requiring manipulation of food choices during these sessions.	Probiotic supplements may have evidence-based uses in sports nutrition around gut health and immune system support. Other supplements or supplement ingredients may also play a role in immune support or response to illness; research is evolving for a few of the compounds with such claims. Most sports foods are developed to exclude ingredients that may cause gut problems during exercise adding to their convenience for sue uses.
To maintain adequate hydration status in replacing the sweat losses associated with exercise, especially in hot and/or humid conditions.	Individuals typically manage to replace daily fluid losses via the intake of fluids and the water content of foods. Losses and requirements are likely to be increased in athletes and may sometimes require focused attention to fluid intake pre-, during- or post-exercise to achieve hydration targets. The salt content of the diet is typically more than sufficient to replace the electrolytes lost in sweat.	In some scenarios during and after exercise, the use of sports drinks or electrolyte supplements provides convenience in meeting goals for fluid and electrolyte replacement.
To make well-considered use of performance ingredients: compounds which may directly enhance sports performance. Although many substances are claimed to produce such an effect, the overwhelming majority of these claims are not evidence-based. However, a few products – caffeine, creatine, bicarbonate, ß-alanine, beetroot juice/ nitrate and glycerol are considered to be evidence-based performance supplements when used in the appropriate scenarios according to established protocols.	Many of the evidence-based performance supplements are components of food and are therefore already found in an athlete's diets. ß-alanine and creatine are amino acids/peptides found in "white meats" and "red meats", respectively. Beetroot juice, is a rich source of dietary nitrate, as are green leafy vegetables. Caffeine is regularly consumed by almost all adults from a variety of beverages and foods. Sodium bicarbonate is a common household product used in cooking and cleaning, while glycerol is added to many foods as a thickener or texture modifier. While they have presence or uses in our food sources, sports science research has identified specific protocols of intake that lead to a performance benefit.	Daily intakes of ß-alanine and creatine required to maximise muscle stores equate to 1-2 kg of meats and are therefore impractical to consume in an everyday diet. Sports supplements can allow athletes to consume a known dose in a more compact form, as well as supply a dietary replacement for vegetarians. Glycerol and bicarbonate can be purchased in their "household" form to meet established protocols, although supplement forms may further facilitate their use by being packaged into convenient doses. Beetroot juice concentrates and other forms (e.g., powders) allow a reliable nitrate dose to be consumed in a small volume to replace 500-1500 ml of juice of variable nitrate content. Meanwhile, caffeinated sports foods and supplements (e.g., gums) can also allow a small but effective dose of caffeine to be consumed at targeted times around sport. This may sometimes be preferable to the intake of coffee where the variable caffeine content may deliver an ineffective or unnecessarily large dose.

Rewards: the placebo effect

The placebo effect describes a favourable outcome arising simply from an individual's belief that they have received a beneficial treatment or experience. In a clinical environment or research setting, a placebo is given in the form of an inert substance or treatment that satisfies the patient/participant's symbolic need to receive a 'therapy'. In a sports setting, the glowing testimonials provided by athletes around a new supplement are often attributed to a positive psychological effect associated with expectations around the product. This placebo effect is often dismissed as not being "real". Nevertheless, and despite the low size and quality of the sports-specific literature, there is evidence that the placebo effect is a robust neurobiological phenomenon and worthwhile in terms of its contribution to sports performance (Hurst *et al.*, 2019; Raglin *et al.*, 2020).

A meta-analysis of studies of the placebo effect and sports performance notes that supplements have often been used as the study theme (Hurst et al., 2019), with studies being likely to report a performance benefit in response to a placebo treatment when it is purported to be caffeine. For example, performance of a 10-km cycling time trial was altered in a dose–response relationship according to subjects' beliefs about the amount of caffeine that they had consumed prior to their performance (Beedie *et al.*, 2006). Although no caffeine was consumed in any of three experimental trials, mean power outputs were reduced by 1.3% compared to baseline testing in a trial in which subjects believed they had received a placebo treatment, while when they believed they had consumed 4.5 g/kg and 9.0 g/kg doses of caffeine, mean power increased by 1.3 and 3.1% respectively (Beedie *et al.*, 2006).

Additional well-controlled studies are needed to better describe the potential size and duration of the placebo effect and whether it applies equally to all athletes and across all types of performance. While characteristics of an individual appear to influence responsiveness to placebo effects, situational factors are also involved (Hurst *et al.*, 2019). Overall, nutrition-based placebos have been found to produce a small to moderate effect-size on performance enhancement, with the effects varying according to the expectation of the participants (Hurst *et al.*, 2019). These can be enhanced via previous experiences and conditioning activities, including full briefing about what they believe they are receiving (Clark *et al.*, 2000). Athletes who reported an intention to use supplements have been shown to gain a larger benefit from the placebo effect associated with a purported new supplement (Hurst *et al.*, 2017). Furthermore, it has been suggested that greater performance effects are gained from inert substances that are believed by athletes to be banned (Hurst *et al.*, 2019). Although the main interest in placebo effects in sport is often directed to the methodology used in studies to properly disguise a treatment and/or account for the psychologically-driven motivation of subjects, its direct effect on performance in relation to supplement use should not be ignored. Although it is sometimes used as a justification for the use of any supplement (viz, that even if the product has no physiological benefit, the athlete may still benefit from a psychological boost), there is no guarantee that this will occur. Indeed, a more valuable application would be in conjunction with the use of evidence-based products, whereby the athlete should be properly informed about their use and advantages of the product to maximise both the physiologically- and psychologically-underpinned benefits (Hurst *et al.*, 2019).

Risks: expense

An obvious concern with the use of sports foods and supplements relates to their cost; many are expensive and most are more expensive than the conventional food choices they replace. This may reflect the price of the additional processing or packaging, the inclusion of novel or specialised ingredients, additional requirements such as third-party auditing, or simply, what the market will pay for something that is perceived as valuable. Although some athletes are well rewarded for their sporting success or have sponsorships with supplement manufacturers, many athletes face economic challenges, and the issue of expense is compounded for teams and sports programs that have to supply the needs of a group of athletes. The use of supplements/sports foods may create an additional burden to an athlete's financial situation or displace expenditure on other items that might be of greater value.

Expense must be carefully considered when there is little scientific evidence to support a product's claims of direct or indirect benefits to athletic performance. But even where benefits do exist, the athlete (or team) must acknowledge the cost and prioritise it appropriately within their total budget.. At times, the expense of a supplement or sports food may be deemed money well spent, particularly when the product provides the most practical and palatable way to achieve a nutrition goal, or when the ergogenic benefits have been well documented. On other occasions, the athlete may choose to limit the use of expensive products to the most important events or training periods. Lower-cost alternatives to some supplements and sports foods can be found for a budget-conscious athlete to use, particularly on less critical occasions. For example, a fruit smoothie fortified with milk powder is a less expensive choice to supplement energy and protein intake than most protein supplements or liquid meal products, while home-made sports drinks can be made with diluted fruit juice and salt.

Risks: health and safety issues

The use of supplements and sports foods carries a small but real risk of adverse effects related to the safety and composition of the product per se, as well as inappropriate practices around their use. Although Australian regulations require supplements and sports foods to be manufactured to Good Manufacturing Practice standards and to provide safety information within their applications for listing/registration, they are considered low risk products with voluntary compliance to the appropriate code. Furthermore, monitoring of compliance is generally targetted to scenarios in which non-compliance or safety issues have been identified post-marketing. Regulation and monitoring thresholds may be different in other countries (Dwyer *et al.*, 2018). Information sourced from website-based databases around supplement recalls from the USA Food and Drug Administration (https://www.fda.gov/food/recalls-outbreaks-emergencies/recalls-foods-dietary-supplements) and the Australian Therapeutic Goods Administration (www.tga.gov.au/recall-actions-database) note a range of reasons for product recalls. These include failure to gain listing/registration, inclusion of undeclared ingredients on poisons lists or prescription lists, prescence of impurities (e.g. lead, glass) or bacterial contamination, and a failure to contain the listed dosages of their ingredients. Products or ingredients that have been removed from the market, or reformulated with different ingredients due to such serious health problems include tryptophan supplements (Kilbourne *et al.*, 1996), ephedra (Phillips, 2004) dimethylhexanamine - also known as DMAA (Brown & Buckley, 2013), hydroxycitric acid – also known as Garcinia Cambogia (Crescioli *et al.*, 2018), and the popular weight loss supplements, Hydroxycut and Oxy-elite Pro, which have some doubts about the cause of numerous reports of adverse events (Ronis et al., 2018). There are numerous reports of irregular composition of supplements. For example, DNA analysis identifed that ~25% of herbal supplements (e.g. ginseng) are adulterated or non-authentic, with products in Australia being among the highest risk of being problematic (Ichim, 2019; Ichim & De Boer, 2021). Among pre-workout supplements sold in Australia, the caffeine content ranged from 59-176% of the label claims (Desbrow *et al.*, 2018). Even among products considered to be evidence-based, there is considerable variability in the dose of active ingredients: an analysis of 21 different beetroot juice products advertised to athletes found a coefficient of variation of 30% in the nitrate content of different lots of the same product and a ~50-fold range in the content of different products, with only two providing a clinically relevant dose in a single serve (Gallardo & Coggan, 2019). A commercial creatine product was found to fail to contain creatine or to lead to a rise in plasma creatine concentrations after consumption (Harris *et al.*, 2004). A study of 134 protein powders noted that more than 70% contained detectable levels of lead and other heavy metals, with vegetarian powders having higher levels than those derived from animals (e.g. whey and egg), while organic products were more likely to be contaminated than non-organic brands (Clean Label Project, 2018).

Although there are case reports of serious side-effects associated with these and other supplements, it is difficult to get data on how widespread these problems are. Most of the information about adverse effects of supplements comes from post-marketing surveillance by regulators, consumer complaints made to manufacturers, and hospital reports. For example, nationally-representative surveillance data for the United States from 63 hospital emergency departments during 2004-2013 were obtained by Geller *et al.* (2015). They estimated that an annual tally of 23,005 visits to the emergency department and 2154 admissions to hospital could be attributed to adverse events related to dietary supplements. Among young adults between the ages of 20 and 34 years, weight-loss or energy products were responsible for more than half these visits (Geller *et al.*, 2015). Meanwhile, separate data from the same period was provided by the FDA Center for Food Safety and Applied Nutrition Adverse Event Reporting System (Timbo *et al.*, 2018), representing periods where notification by manufacturers of consumer complaints of advertse events was voluntary then mandatory. Results showed a total of ~15,400 incidents of supplement-related adverse events over the decade, with greater number being reported during mandatory reporting periods, more being reported by female consumers, and among products used by 20-35 year old, most problems were associated with body building, wieght loss and energy supplements. Hospitalisation was required in 25% of the reported events, and 2% of reports involved a death. By comparing the data from the two sources, authors concluded that only 2% of adverse events associated with supplement use are reported to authorities (Timbo *et al.*, 2018). Although this information pertains to the US rather than Australia or other countries, it highlights some of the difficulties in obtaining data on safety issues around supplement use. In addition, such reports may fail to consider minor issues that may nevertheless interfere with an athlete's performance or training consistency.

It should be noted that even evidence-based products can produce side-effects and adverse effects, particularly in higher doses, and that some of the adverse effects are due to consumer practices rather than the ingredient. For example, bicarbonate supplements can produce gastrointestinal discomfort (Carr *et al.*, 2011) and performance impairment rather than improvement (Grgic, 2020), while caffeine in large (>9 mg/kg) doses has an increased risk of problems such as anxiety, increased heart rate, jitters and poor sleep hygiene, which may also be seen in some individuals at lower doses (Burke, 2008; Wikoff *et al.*, 2017). Interactions with other products taken at the same time is possible (Burke, 2017), and athletes who consume multiple supplements each day, particularly of multi-ingredient products, are more at risk of inadvertent interactions or large doses of problematic substances. Severe toxicity and death associated with extreme doses of caffeine (>10 g) have occurred in relation to supplement use (Burke, 2019).

Risks: Anti-doping rule violations and inadvertent doping

A number of ingredients found in supplements are included on the International Standard Prohibited List (World Anti-Doping Agency, 2021b) which forms part of the World Anti-Coping Code (World Anti-Doping Agency, 2021a). These include substances found in various categories of the Code: S1: Anabolic Agents (including Anabolic-Androgenic Steroids such as androstenedione, DHEA and 19-norandrostenedione and other Agents such as clenbuterol); S2: Peptide Hormones, Growth Factors, Related Substances and Mimetics (including Peptide Hormones and their Releasing Factors such as Growth Hormone Releasing Peptides); S3: Beta-Agonists (such as Higenamine); S4: Hormone and Metabolic Modulators (including Aromatase Inhibitors, Anti-estrogenic substances and Metabolic Modulators such as AMPK- activators) and S4: Stimulants Prohibited in Competition (such as Sibutramine and Octapamine). Although some of these substances may be prohibited from sale in Australia, they can be bought via internet as over-the-counter products in other locations such as the United States. Other banned substances such as Selective Androgen Receptor Modulators (SARMS) are illegal in both Australia and the US, but may nevertheless be presented as supplements available for purchase via the internet. Drug education programs highlight the need for athletes to read the labels of supplements and sports foods carefully to ensure that they do not contain such banned substances. This is a responsibility that athletes must master to reduce the risk of an anti-doping rule violation (ADRV). However, it is challenged in many cases by a general lack of urgency attributed to the perception that supplements are 'natural' and by the inability of athletes to recognise the different chemical and street names that can be used to describe various prohibited substances.

However, even when athletes take such precautions, inadvertent intake of banned substances from supplement products can still occur. This is because some supplements contain banned products without declaring them as ingredients; this is typically a result of contamination or poor labelling within lax manufacturing processes, although there have been cases where therapeutic doses of steroid compounds have been detected in supplements suggesting a deliberate strategy by manufacturers to gain 'street popularity' when testimonials of the favourable results of use are circulated (Geyer *et al.*, 2008; Judkins & Prock, 2013). Contamination of a finished supplement can occur via the use of adulturated raw ingredients, or during the manufacture and transport procedures when products known to contain banned ingredients are allowed to cross-contaminate other products in which they should not be present. Credible evidence of product contamination was first uncovered by a study carried out by a laboratory accredited by the International Olympic Committee (Geyer *et al.*, 2004). This study analysed 634 supplements from 215 suppliers in thirteen countries, with products being sourced from retail outlets (91%), the Internet (8%) and telephone sales. None of these supplements declared pro-hormones as ingredients, and they came from manufacturers that produced other supplements containing pro-hormones as well as companies that did not sell these products. Ninety-four of the supplements (15% of the sample) were found to contain hormones or pro-hormones that were not stated on the product label. A further 10% of samples provided technical difficulties in analysis such that the absence of hormones could not be guaranteed. Of the 'positive' supplements, 68% contained pro-hormones of testosterone, 7% contained pro-hormones of nandrolone, and 25% contained compounds related to both. Forty-nine of the supplements contained only one steroid, but forty-five contained more than one, with eight products containing five or more different steroid products. According to the labels on the products, the countries of *manufacture* of all supplements containing steroids were the USA, The Netherlands, the UK, Italy and Germany; however, these products were *purchased* in other countries. In fact, 10–20% of products purchased in Spain and Austria were found to be contaminated. Just over 20% of the products made by companies selling pro-hormones were positive for undeclared pro-hormones, but 10% of products from companies that did not sell steroid-containing supplements were also positive. The brand names of the 'positive' products were not provided in the study, but included amino acid supplements, protein powders, and products containing creatine, carnitine, ribose, guarana, zinc, pyruvate, HMB, *Tribulus terrestris*, herbal extracts and vitamins/minerals. It was noted that a positive urinary test for nandrolone metabolites occurs in the hours following uptake of as little of 1 µg of nandrolone pro-hormones. The positive supplements contained steroid concentrations ranging from 0.01–190 µg per gram of product (Geyer *et al.*, 2004).

Since then, evidence of poor product labelling, deliberate adulteration and contamination have continued to emerge from independent studies (Baume *et al.*, 2006; Geyer *et al.*, 2008) and from reports by commercial companies that undertake specific audits of supplement products (Judkins *et al.*, 2007), including one in Australia (HASTA, 2015). In some cases, the data suggest that the risks of product contamination have reduced, while in others there is evidence that there is merely a change in the prohibited ingredients involved. In the earliest instances, pro-hormone substances seemed to provide the greatest risk of the 'inadvertent' ADRV via supplement use, with a positive test for the steroid nandrolone being one of the possible outcomes. 'Body building' supplements promoting mass gain are the most likely products to contain these and other anabolic-androgenic substances. At other times, stimulants have become the most prevalent supplement-related cause of ADRV, with many National Anti-Doping Agencies reporting an increase in cases of use of products such as DMAA (Outram & Stewart, 2015). Stimulant contamination or mislabelling is most likely to occur in products targeting weight loss or promoted as 'energy boosters', particularly in preparation for an exercise session ('pre-workout supplements'). In any case, there is evidence that products from almost all categories of the WADA List have been found as undeclared ingredients in supplements (Ayotte *et al.*, 2001; Catlin *et al.*, 2001; Green *et al.*, 2001; Kamber *et al.*, 2001; Mathews, 2018; Walpurgis *et al.*, 2020).

Concerns about the presence of banned substances in supplements and sports foods range from health issues, in the case of large doses, to doping outcomes, even in the case of minute amounts of the product. Analytical techniques employed by many accredited laboratories are sufficiently sensitive to detect incredibly small amounts of banned substances that may be present in a biological sample, well below the level that might need to be ingested to have therapeutic effects. Nevertheless, although an athlete who ingests this may or may not produce a biological sample with a detectable amount of the banned substance depending on the level of contamination, the frequency of intake and portion size of the contaminated product (e.g. a powder consumed in a 30-60 g serve vs a 600 mg capsule), the duration of the period between ingestion and the test, the absorption characteristics of the supplement and the individual's metabolism (Watson *et al.*, 2009; Watson *et al.*, 2010; Walpurgis *et al.*, 2020).

Of course, there is no way to gather evidence to unconditionally support an athlete's claim that the detection of banned substances via a urine test can be attributed to their unknowing ingestion of the product via a supplement (Walpurgis *et al.*, 2020). Even in cases where subsequent testing of a supplement has shown that it does contain prohibited substances, this does not prove that it was the only source of banned substances used by the athlete or that it was consumed inadvertently. Furthermore according to WADA's principle of strict liability, every athlete is responsible for the presence of a prohibited substance or its markers/metabolites in his or her biological samples, irrespective of whether or not the ADRV was committed unintentionally or deliberately (World Anti-Doping Agency, 2021a). In various real-life cases, actual sanctions have varied from a suspended sentence to full imposition of a ban from participation in sport, differing according to the sporting authority/ organisations involved, further referrals to courts of arbitration, and the detection of other mitigating circumstances (Abrahamson, 2005; Futterman, 2012; Walpurgis *et al.*, 2020). Regardless of the sanction, the athlete will carry an indelible reputation of having incurred an ADRV; even in cases where athletes have received large financial compensation from supplement manufacturers or reduced periods of suspension from their sporting activities, the sullying of their reputation has caused overwhelming personal distress and loss of income. Therefore, the risk of the ADRV from supplement use is of major concern to sport (Abrahamson, 2005; Futterman, 2012; Walpurgis *et al.*, 2020)

It should also noted that many athletes believe that anti-doping rules only apply to elite or professional athletes, and in particular, that levels of sporting competition in which there is no/little monitoring of biological samples are free from the risk of ADRVs. This may vary between jurisdictions. In Australia, the Sport Integrity Australia Act 2020 recognises that the National Anti-Doping Scheme applies to all athletes (registered members/competitors) of sporting organisations who are national signatories to an anti-doping code (Australian Government, 2021). This includes classifications of "International-level" and "National-level" athlete, the declared sporting events and competitions which determine national level status, and others who are included in SIA Testing Pools. However, the current WADA anti-doping code (World Anti-Doping Agency, 2021a). include eleven different types of behaviours in which evidence can be used to make a case for an ADRV, rather than the simple case of an analytical finding (the detection of banned substances in a biological sample). These violations includes the purchase, importation, possession or supply of supplements containing banned substances by athletes. Indeed, there have been past cases where the seizure of such goods by Customs authorities have led to an ADRV and doping sanctions applied to athletes in amateur and non-elite grades of sport. Sport Integrity Australia now recognises a category of "Lower-level athlete" and has the discretion on whether to proceed with a matter and, if a non-testing violation is proven, greater flexibility in recommending a sanction. Australian athletes need to stay abreast of such information, as provided by Sport Integrity Australia (www.sportintegrity.gov.au).

Finally, before concluding considerations around anti-doping risks, it is important to consider that some foods can be a source of banned substances, with most focus on the use of anabolic agents such as clenbuterol in animal husbandry in countries such as China and Mexico (Walpurgis *et al.*, 2020), and the potential for fortified or functional foods to include raw ingredients that may be contaminated. While the former issue is usually brought to the attention of athletes undertaking international travel, a recent investigation was undertaken of the risks associated with protein-fortified foods (PFFs) in context of the Australian high performance sporting system (O'Brien *et al.*, 2021). This report included an audit of processed foods in which the addition of one or more isolated protein sources is noted within the ingredients list of the product label, and covered by the FSANZ code. An additional audit of cafes and foodservice outlets was undertaken to cover ready to purchase protein-fortified foods (smoothies, balls, bars) which were either made on premises with the addition of supplement protein powders or procured as pre-prepared products with an unknown origin of protein source (O'Brien *et al.*, 2021). One of the findings of this report was that such foods were not covered within the current supplement/sports foods frameworks, such as the AIS Sports Supplement Framework (see below), but potentially involved similar issues which needed to be addressed within HP sport. Since a key recommendation involves the inclusion of these foods within supplement and anti-doping considerations, the findings of the report are summarised below, while the full report is available here.

- Supermarket audits identified a large number of PFFs for sale within the food supply. The addition of one or several isolated protein ingredients within processed foods is widely used by food manufacturers to comply with FSC legislation associated with protein claims made on foods.
- An audit of cafes and foodservice outlets found that an array of PFFs (such as smoothies, protein balls, protein bars) were available for purchase. Foods were either fortified with 'protein supplement' powders or procured pre-prepared products with an unknown origin of protein source. This area of food supply presents a higher risk of contamination than large scale food manufacturing due to the lack of consistency and oversight of the source of protein ingredients, alongside inclusion of other novel botanical ingredients known to be high risk for WADA prohibited substances.
- The majority of NSOs identified dietary supplements as a risk of contamination with WADA prohibited substances, identifying the use of third-party batch testing certification such as HASTA and Informed Sport as an effective process of reducing risk. Only two NSO supplement policies mentioned fortified foods in relation to contamination with WADA prohibited substances.
- NSO supplement policies typically aligned with recommendations outlined by SIA and the AIS Sports Supplement Framework in relation to supplement use. However, neither of these organisations has addressed risk associated with PFFss and as such this issue has not been included within the majority of NSO supplement policies.
- Sports dietitians working for or with NSOs regularly recommended the use of dietary supplements especially isolated protein powders and protein containing sports foods. Additionally, the majority of sports dietitians recommended the use of certified batch tested supplements when recommending the above sports foods. However, less than half of the sport dietitians surveyed regularly recommended the use of PFFs and the majority were confused about the requirement of batch testing in relation to PFF's, especially foods containing novel plant-based proteins such as Hemp.
- In focus groups, elite athletes appeared well educated on the use of certified batch tested supplements to reduce the risk of contamination with WADA prohibited substances. However, athletes were not able to identify the difference between a protein supplement, a PFF and a food high in protein. Further, athletes were unable to identify hemp protein as a higher risk of containing WADA prohibited substances compared to other dairy and traditional isolated protein sources. Athletes appear confused regarding which protein containing products are risky and which products should be certified batch tested.
- Protein as a macronutrient and functional ingredient was identified by food manufacturers as a major driver of consumer purchasing behaviour. Food manufacturers were unaware of isolated protein added to foods was a potential source of contamination with WADA prohibited substances. Currently, quality control processes of isolated protein ingredients and subsequently manufactured whole foods is focused on allergens and biological contaminants.
- The manufacturing processes of isolated dairy protein ingredients (such as whey and casein protein, milk solids etc.) and plant-based proteins (such as soy) are carefully regulated to minimise biological and allergen contamination. These regulations and quality control processes are suitable to ensure contamination with WADA prohibited substances is unlikely within the isolated protein ingredient manufacturing process. Additionally, if maintained within a food manufacturing system there is no additional risk of contamination with WADA prohibited substances in PFFs within Australian compared to other fortified foods, which would be considered extremely low.
- The manufacturing of food grade hemp protein is similar to dairy and plant-based proteins and therefore risk of cross contamination with WADA prohibited substances is likely similar. However, the isolated protein ingredient source of hemp protein likely contains traces of the WADA prohibited substance Tetrahydrocannabinol (THC) and other cannabinoids. This is inherent to the ingredient and not introduced via contamination during the manufacturing of the protein.
- Currently, batch testing certification companies routinely test formulated multi-ingredient protein powders/supplements) for WADA prohibited substances. Isolated protein ingredients (excluding hemp) controlled under FSANZ and GMP processes are considered 'very low risk' ingredients for cross contamination with WADA prohibited substances, however likely change risk profile once they are used in formulated multi-ingredient protein products manufactured under FSANZ standard 2.9.4. Isolated protein ingredients other than hemp are therefore an unlikely and extremely low source of risk to athletes.
- HASTA considers the need for batch testing PFFs complicated (due to the matrix of ingredients and form of the foods), excessive, and cost prohibitive for food manufacturers.

Key recommendations from the report included:

- Commercially manufactured packaged PFFs present no additional risk for containing WADA-prohibited substances than other processed foods with mixed ingredients. As such, athletes should be suitably informed regarding PFF's commercially manufactured within Australia under FASNZ offer no additional risk than other processed foods.

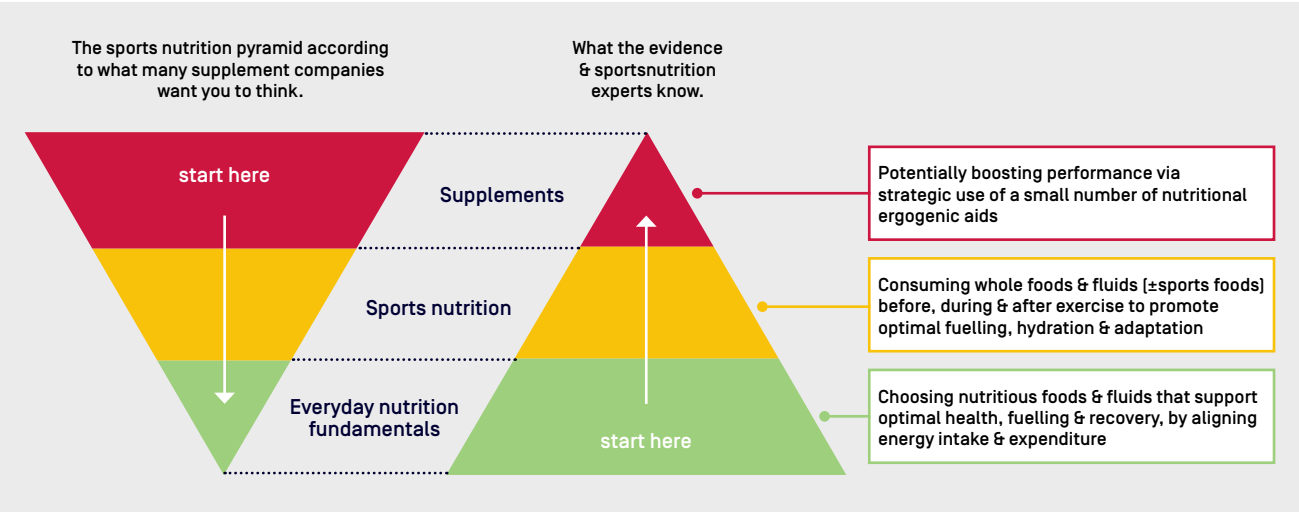
- PFFs store-prepared by cafes and foodservice outlets provide an unknown risk due to and as such should be considered comparable risk to that of other commercial protein powder products. Athletes should undertake similar risk management strategies to protein containing supplements when considering the use these PFFs.
- The SIA and AIS should include advice on the current assessed risk of PFF's to athletes alongside current recommendations regarding supplement use. NSO supplement policies should reflect and highlight the AIS and SIA supplement framework recommendations in this area.
- Hemp protein has a risk of containing traces of THC and other cannabinoids inherent to the raw plant source. Currently, there is insufficient scientific evidence regarding the contamination profile of hemp protein and as such hemp protein containing PFF's and supplements should be avoided.

Risks: special comments about young and developing athletes

The risks associated with the use of supplements and sports foods apply to all athletes. However, there are some special concerns for athletes who are less developed, either in age or in their journey along the talent progression pathway. Various expert groups have made strong statements against the use of supplements by young athletes. For example, a policy statement of the American Academy of Pediatrics (Gomez & American Academy of Pediatrics Committee on Sports Medicine and Fitness, 2005) condemns the use of performance-enhancing substances including various dietary supplements, by children and adolescents. The position statement of Sports Dietitians Australia on nutrition for adolescent athletes recommends a focus on core food groups and nutrition practices rather than the use of supplements, specifically noting that the use of supplements by developing athletes overemphasises their ability to manipulate performance in comparison with other training and dietary strategies (Desbrow *et al.*, 2014). These policies are based on the unknown but potentially adverse health consequences of some supplements and the implications of supplement use on the development of the young athlete's ethical framework. Some researchers consider supplements to be a "gateway" to the decision to take more serious compounds, including prohibited substances (Backhouse *et al.*, 2013), although any evidence of correlations between use of supplements and banned agents fails to understand the complexity of the definition and uses of 'supplements' and the difficulty of establishing a robust cause–effect relationship.

The principle that athletes under the age of 18 years be deterred from using some types of supplements – particularly, dedicated performance supplements – can be justified on the basis of a lower training load and level of resources, as well as a focus on building a sports nutrition foundation around foods. However, it should also be noted, in some sports and individual cases, that an athlete may achieve world-class levels of performance, and have achieved maturation in training load and physiological characteristics beyond the normal characteristics of an adolescent. Therefore, while safety issues around performance substances and their use are still critical, there may be some room to cater for individual circumstances (Kreider *et al.*, 2017). Nevertheless, the philosophy of developing a gradual and layered approach to training and sports nutrition strategies should be preserved and is displayed in Figure 1.

Figure 1. Relevance of supplement use within broader health and performance nutrition strategies



MAKING DECISIONS ABOUT SUPPLEMENT USE: A PRAGMATIC APPROACH

In many areas of life, a binary approach (good/bad, right/wrong) provides simplicity and clarity to behaviour, and when safety factors or health concerns are potentially involved, a cautious or conservative choice is generally assumed. Therefore, it is understandable that sporting authorities, including National/International Governing Bodies, Anti-Doping Agencies and Sports Medicine/Science Authorities have traditionally taken the stance of advising athletes against the use of supplements. Since there is no practical way to completely remove the doping risk associated with the use of supplements and sports foods, it is likely that this will remain the official policy of anti-doping agencies. However, the past decade has seen a shift in the attitudes of other authorities to recognise that the use of supplements and sports foods is complex and warrants a more flexible and pragmatic approach. The case study of the Australian Institute of Sport's Supplement Program/Framework provides an illustration of some of the complexities. These include the need to engage with athletes and coaches who are already using supplements, recognition of the landscape of supplement use in the broader community, and the reality that there are scenarios in which the use of sports foods, nutrient-based supplements and performance supplements contribute to the athlete's sports nutrition plan and performance outcomes. This change in philosophy has fostered education campaigns that support well-considered use of supplements within a sports nutrition plan, with important agencies such as the International Olympic Committee embracing the approach first popularised by the AIS Sports Supplement Program (Maughan *et al.*, 2018). A corner-stone of this pragmatic approach is the employment of decision trees that enable athletes to make considered decisions about a specific product before committing it to a specific use:

- Is it safe?
- Is it effective?
- Is it permitted for use in sport?

A prior question related to the athlete is also suggested, particularly to account for junior athletes and their use of sports foods and performance supplements

- Is this the appropriate time for me to consider using this product?

Decision trees related to the use of supplements used to support nutritional status (Figure 2) and Performance Supplements (Figure 3) were produced by the IOC Consensus on use of Supplements in High Performance Sport (Maughan *et al.*, 2018). It is noted that these identify scenarios in which the athlete is guided or required to seek professional assessment and advice (Larson-Meyer *et al.*, 2018), including a plan that is personalised for their intended scenario of use or a discussion of the evidence-based for the product use. Even where there is general support for the use of a performance product, there is additional value in conducting further studies that mimic the characteristics of real life sports in which it is intended for use, with features such as interaction with other supplements, the need for repeated use in heats/finals or multiple events, and individual responsiveness (Burke, 2017; Burke & Peeling, 2018).

In the sourcing of products, particularly performance supplements, for use by athletes, the exclusive use of products that have been batch tested by third-party auditing companies is strongly encouraged. These include HASTA and LGC (Informed Sport) which operate in Australia, as well as programs from other countries (e.g. NSF in the United States) which may be employed in the manufacture of internationally sourced products. There are clear roles for various members of an athlete's support team and high performance environment in assisting the athlete to make an informed decision about the use of supplements and sports foods, then act on it appropriately. Figure 4 provides an overview of a decision tree on considerations relating to supplement use within the context of the AIS Supplement Framework.

Figure 2. Decision tree for the use of supplements supporting the nutritional status of athletes

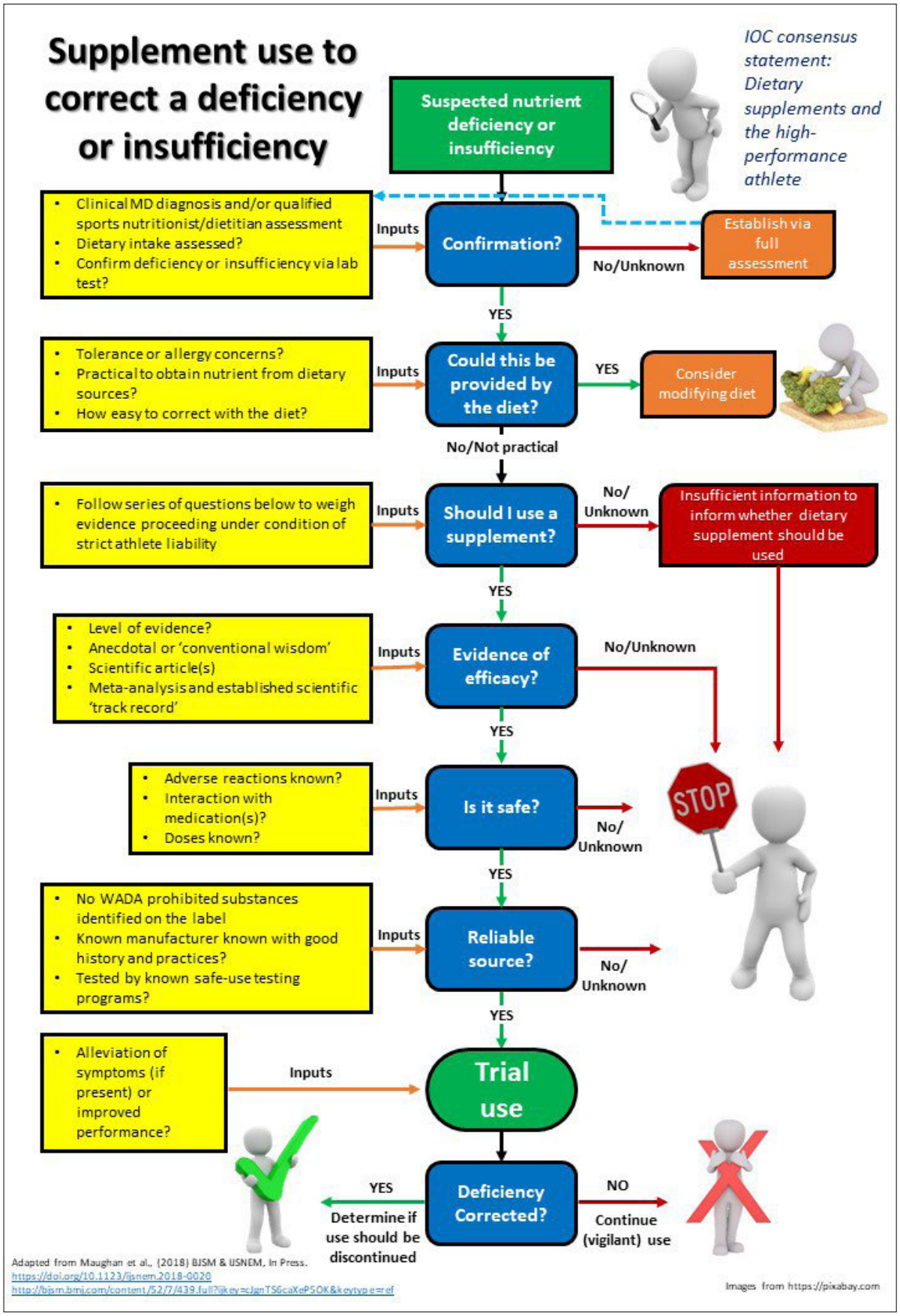


Figure 3. Decision tree for the use of supplements promoting a direct or indirect performance improvement

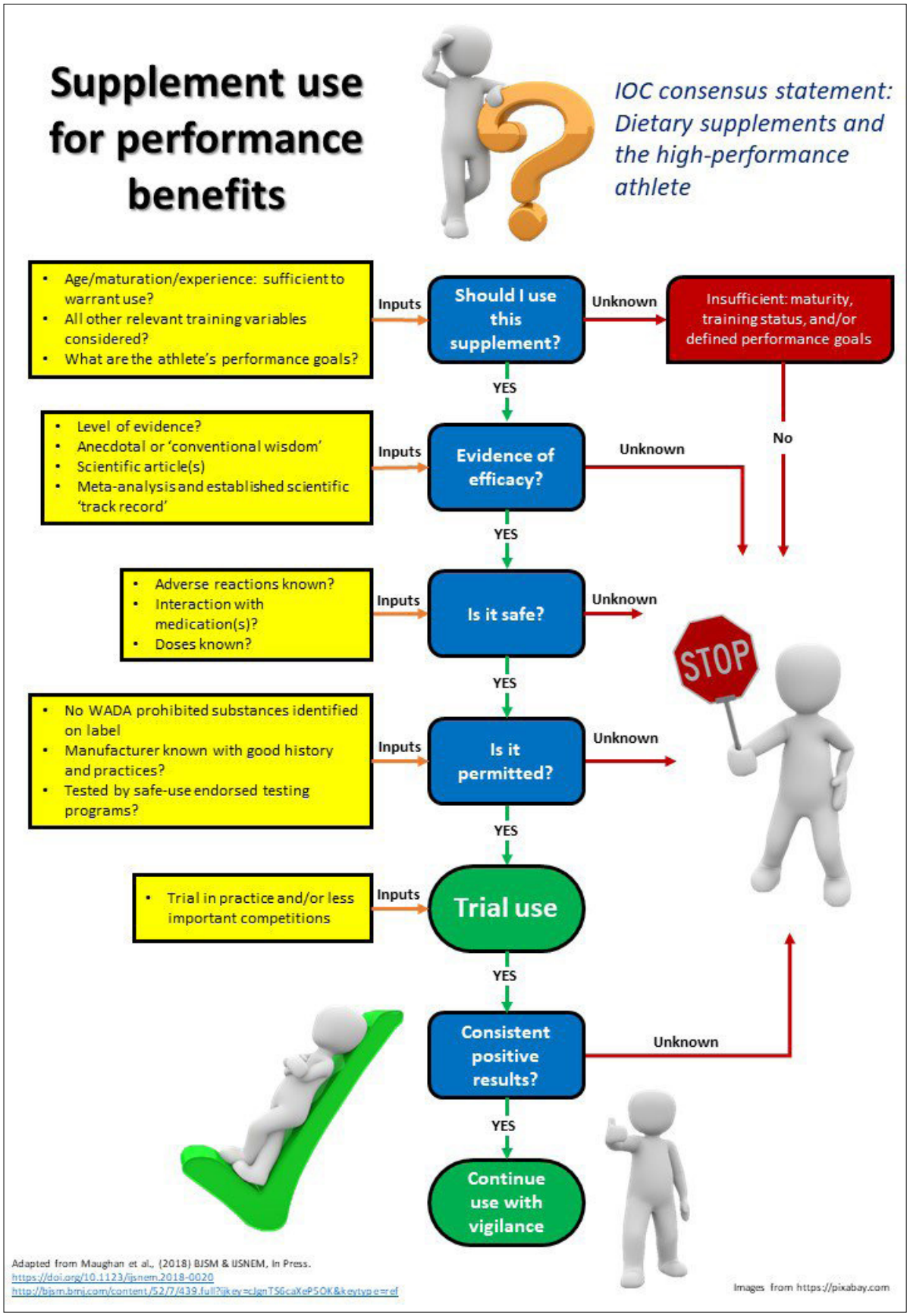
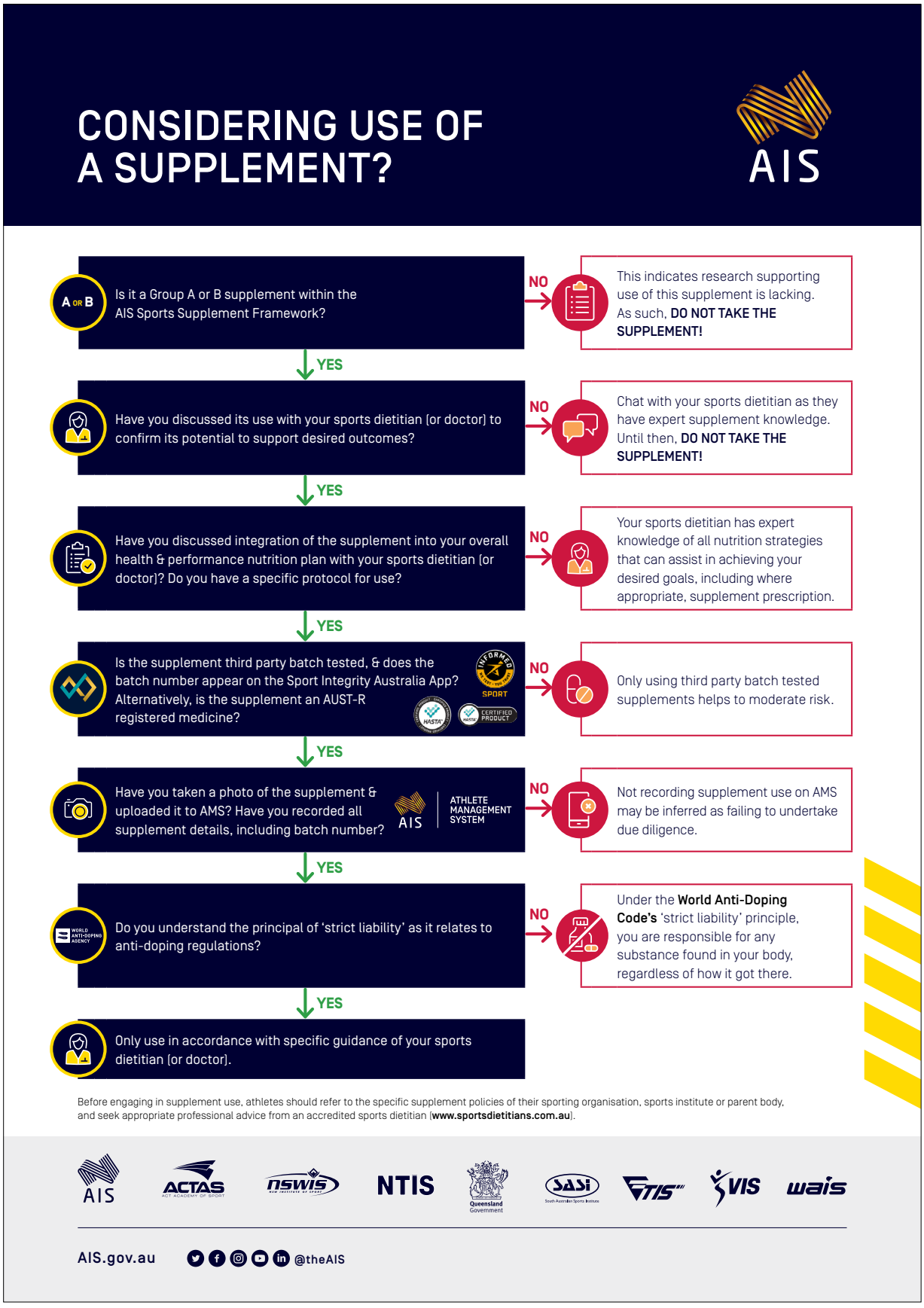


Figure 4. AIS Supplement Framework Decision Tree



ROLES AND RESPONSIBILITIES FOR SUPPLEMENT USE IN HIGH PERFORMANCE SPORT

Authorities such as Sport Integrity Australia and Sport Australia are dedicated to maintaining sport as a safe and fair environment for all athletes and other people involved in the sporting environment. Various reviews of challenges to the integrity of sport in Australia have led to the creation of a single body, Sport Integrity Australia, under the Sport Integrity Act 2020 [(Australian Government, 2021), with oversight over a range of matters including the National Integrity Framework and the National Anti-Doping Scheme which achieves Australia's responsibilities to the WADA code (World Anti-Doping Agency, 2021a). Sport Australia funds National Sporting Organisations (NSOs) to undertake responsibility for the management of their sport including compliance to anti-doping requirements, standards and guidelines for practice for Sports Science and Sports Medicine Professionals within the sports system, and the implementation of a program, policy or guidelines around the use of supplements. Although the implementation of these roles and responsibilities may different between sporting organisations, a general summary is provided in Table 4. To assist NSOs to navigate the various issues relating to supplement use, the AIS has created a **template** to assist NSO and other organisations in the development of their own guidance.

Table 4. Roles and responsibilities around supplement use in Australia's High Performance Sport environment

Party	Roles and Responsibility
Sporting Organisation	• To develop and implement a Sports Supplement policy, program or guidelines that meet the requirements of Sport Integrity Australia's National Anti-Doping Scheme, with the input of internal and external experts and practitioners. This includes the provision of adequate resources to implement the policies and the alignment of all organisational activities (e.g. maintenance of an athlete supplement use register or program to provide products to athletes) and philosophies (e.g. sponsorship) to meet its goals and practices • To employ practitioners who meet the Sport Australia SSSM Practitioner Standards and to provide an environment in which they can meet the guidelines for Best Practice around supplement use within the overall health and performance programs • To develop and implement education activities related to supplement use according to the organisation's Supplement Program/Policy/Guidelines • To remain aware of, and compliant to, all updates to requirements and practices within the National Anti-Doping Scheme and other SIA activities around supplements
Sports Science/Sports Medicine (SSSM) practitioner	• To maintain appropriate accreditation and professional competencies to meet SSSM Practitioner standards and guidelines • To recognise anti-doping rules around the practices of support personal • To contribute to, or remain aware of, the Sports Supplement Programs/Policies/Guidelines of NSOs • To implement education and practice accordingly, including management of athlete supplement registers, programs around provision of supplement/sports foods to athletes, and product inventories • To contribute to sound supplement use by athletes according to professional and individual expertise; for example: to undertake nutritional assessments for energy and nutrient support; to organize laboratory testing to monitor nutritional status, to provide individualised information to athletes around performance supplements to allow informed decisions to be made around supplement use; to integrate the effective use of sports foods within performance nutrition plans; to assist with case management or research activities around the effectiveness of use of performance supplements • To provide an interface between the athlete/coach and supplement information to ensure that athletes understand the evidence base for supplement use, are confident that they are able to achieve cutting edge practices appropriate to their level, and are aware of their responsibilities within the NSO Sports Supplement Program/Policy/Guidelines
Coach	• To remain aware of the NSO Sports Supplement Program/Policy/Guidelines and their obligations regarding compliance, including anti-doping rules around the practices of support personal • To engage with SSSM practitioners regarding supplement issues and activities to promote athlete practices are appropriate to the athlete's situation, safe, effective and within the NSO Sports Supplement Program/Policy/Guidelines • To contribute to athlete culture and knowledge about safe and effective supplement use
Athlete	• To remain aware of the NSO Sports Supplement Program/Policy/Guidelines and their obligations regarding compliance, including maintaining a supplement register • To engage with SSSM practitioners regarding supplement issues and activities to ensure that they can make an informed decision about their personal use of supplements and sports foods that is safe, effective and within the NSO Sports Supplement Program/Policy/Guidelines • To recognise that they maintain the final responsibility for their compliance to the WADA code.

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