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Helping athletes to select botanical supplements for the right reasons: A comparison of self-reported reasons for use versus evidence-based supplement claims

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Abstract

Use of food supplements (FS) by athletes is well characterised but there is little information on 'herbal' or 'botanical' FS beyond 'natural'. This study determined, by questionnaire, whether athletes' main self-reported reason for using FS was reflective of what was written on product labels or, when these claims were unavailable, was in accordance with the scientific literature. In 217 elite ($n=55$) and amateur ($n=162$) athletes living on the island of Ireland, 71% ($n=153$) consumed any kind of FS, with 16% ($n=34$) of the entire cohort deemed botanical consumers. 'Protein' (21%, $n=46$), 'vitamin D' (17%, $n=37$) and 'vitamin C' (15% $n=32$) were most consumed with the top reasons for use being 'to support health', 'to prevent illness/for immunity purposes' and 'recovery'. There was generally good agreement between approved nutrition and health claims for such products and athletes' main reported reasons for use. Only the amateur athletes in our pool described using botanical supplements, with reasons for use stated as 'sleep improvement' (21%), 'recovery' (14%), 'supporting health' (12%) and 'energy' (12%), resulting in poor agreement with either approved claims or scientific evidence. Only half of amateur athletes knew if their botanical FS were third-party tested. Athletes and practitioners require guidance to avoid consuming supplements for which there is little scientific evidence, and which may risk being contaminated/fraudulent.

KEYWORDS

contamination, doping, food supplements, health, herbals, third-party testing

INTRODUCTION

Food supplements (FS) are frequently consumed by athletes for health, performance and/or strength-related reasons with use rates ranging from 40% to 100% depending on factors such as competition level, type of sport and definition of food supplement used (Daher et al., 2022; Garthe & Maughan, 2018; Knapik et al., 2016; Lauritzen & Gjelstad, 2023). Generally, vitamins and/or minerals are the most reported type of FS consumed (Daher et al., 2022; Knapik et al., 2016;

Lauritzen & Gjelstad, 2023) with protein and/or protein derivatives featuring in some studies for males (Daher et al., 2022; Knapik et al., 2016). However, athletes frequently report consuming supplements composed of 'botanical', 'herbal' or 'plant' ingredients, often despite a limited body of evidence and at higher levels than the general population (Kim et al., 2011; Millen et al., 2004; Timbo et al., 2006; Wu et al., 2011). A recent analysis of Norwegian doping control forms confirms intakes of botanical supplements across all sports (with a mean report level for 'botanicals or natural supplements' of

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3.6%) but with higher reports of use in muscular endurance sports such as alpine skiing (up to 14%) (Lauritzen & Gjelstad, 2023). Nevertheless, botanicals or herbals are often poorly characterised, with previous studies combining different botanicals in one category and with no clear insight as to their reasons for use by athletes beyond being 'natural', such as reported by Lauritzen and Gjelstad (2023).

This general lack of information regarding use of botanicals or herbal supplements perhaps arises due to a lack of consensus globally about how best to categorise and describe them. Botanical ingredients and herbs have been purportedly used for centuries for the support and maintenance of physiological functions and with a long tradition of use in many cultures (McDaid et al., 2020; Li & Weng, 2017). Although most botanicals are not endorsed for athletes as they are currently lacking substantial scientific evaluation, the International Olympic Committee considers such herbal/botanical products as a category of FS (Maughan et al., 2018). However, in the United States, Canada and the wider European Region, there exist differences in legislation, terminology and associated guidance regarding the same. Such supplements are classified as a category of 'dietary supplement' within the United States (Dietary Supplement Health and Education Act, FSA, 1994) and a category of 'food supplement' in the European Union (Directive 2002/46/EC) and the United Kingdom. In both jurisdictions, there are generally clear definitions regarding the ability of such products to supplement the normal diet and be present in concentrated doses in a variety of presentation forms (e.g. pills, powders and capsules) (McDaid et al., 2020). However, in the wider European region specifically, depending on the herbal product and dose, a single botanical or herbal ingredient can be designated as an herbal medicine or herbal medicinal product, and this is often determined at a national level and on a case-by-case basis (McDaid et al., 2020). Furthermore, what may be deemed an ingredient in a medicine in one country may be determined as FS in another (European Commission, 2020). As an additional challenge, while there is clear legislation and process in the European Union (regarding the use of proven claims about how vitamin and mineral supplements can influence nutrition and health outcomes (nutrition and health claims, NHC) (Regulation 1924/2006/EC; Department of Health and Social Care, 2019)), a current regulatory impasse means that no such pathway exists for products containing botanical or herbal ingredients. As such, there is no necessity at present for claims on botanicals to have undergone scrutiny by scientific bodies such as the European Food Safety Authority for Europe or appropriate UK scientific assessment bodies under the nutrition labelling, composition and standards common framework (NCLS)

under retained EU law (REUL) (OHID, 2023). Under such circumstances, this may place athletes living in Europe and the United Kingdom at risk of purchasing botanicals with unsubstantiated or potentially misleading health claims. This is in addition to the more general concerns regarding supplement use in athletes regarding potential FS misuse and inadvertent doping risk (Baylis et al., 2001).

Previously, we have documented the use of FS and botanical food supplements (BFS) in a cohort of 217 elite and amateur athletes living on the island of Ireland (McDaid et al., 2023). The present analysis aims to understand the reasons for such supplement use by the athletes, specifically for botanicals, and, furthermore, to determine whether the athletes' self-reported reasons for use were in agreement with any nutrition or health-related claims on products as sold. Where product-specific information was unavailable, we examined the scientific literature for consensus and/or evidence of efficacy.

METHODS

Study design and population

To capture athletes' consumption of FS and botanicals including reasons for use and additional attitudes and behaviours to FS, an online survey was developed using Qualtrics XM (Qualtrics, Provo, Utah, USA). Survey question development and validation and survey dissemination methods have been outlined previously in full (McDaid et al., 2023). In brief, the 31-question online survey was developed based on previous similar studies as well as gaps in literature, and dissemination was primarily online via social media and through in-person recruitment through the Sports Ireland Institute. As outlined in McDaid et al. (2023), within this survey, FS were described as they are advertised and sold to consumers on the island of Ireland (i.e. as defined under relevant food law, e.g. EU Directive 2002/46/EC), noting that sports and energy drinks are classed as food rather than FS. Furthermore, as part of the survey, and in case athletes were unsure what constituted a BS or herbal supplement, a definition was provided along with some pictorial suggestions: 'Botanicals are either the whole, part, fragmented or cut parts of plants, algae, lichen or fungi. Botanical preparations are obtained by processing the botanicals in some way e.g. pressing, squeezing, extraction, fractionation, distillation, concentration, drying up and fermentation. The final product can be in powdered (comminuted) form, tinctures, extracts, essential oils, expressed juices and processed exudates. More information is available here: <https://www.efsa>.

europea.eu/en/topics/topic/botanicals'. For full details of information provided, see the Supplementary Material (McDaid et al., 2023). Both elite and amateur athletes aged 18 years or over and living on the island of Ireland were eligible. Ethical approval for the survey was granted by Queen's University Belfast Research and Ethics Committee for the Faculty of Medicine, Health and Life Sciences (MHLS 21_133), and data capture occurred between December 2021 and May 2022.

For the present analysis, the focus was on determining the reasons surveyed athletes were using FS and botanicals, and assessing the agreement between self-reported reasons for use and the nutrition and health claims listed on the product label. To do so, a four-step approach was taken as outlined in Figure 1 below.

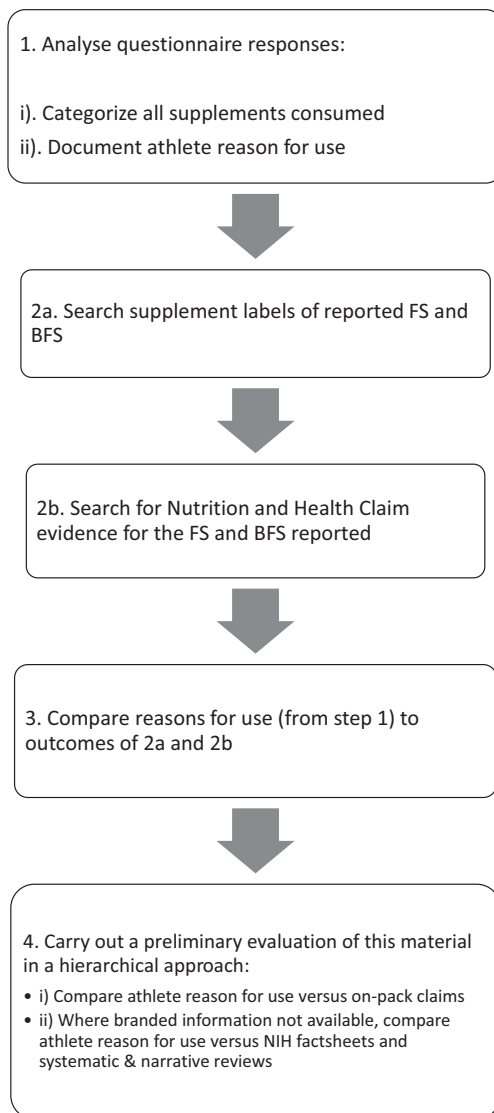


FIGURE 1 Overview of study design. BFS, botanical food supplements; FS, food supplements; NIH, US National Institute of Health.

Step 1: identification and classification of supplements consumed from questionnaires and their reasons for use

The analyses presented were based on the following survey questions which specifically asked, in matrix style tables, for the following two prompts: (1) 'If you currently take any botanical supplements, please provide some details in the table below', and (2) 'If you currently take any general food supplements, please provide some details in the table below'. In the matrix style tables, respondents could provide details on up to five supplement products including the product brand name, supplement name, frequency of use, dose, reason(s) for use, if use changed prior to competition and whether they believed the product was third-party tested or not. Athletes could provide a single 'main' reason for use for each supplement with no athlete reporting consumption of more than three supplements.

All FS and botanical products reported by respondents were identified from the questionnaire responses and categorised by supplement type (e.g. vitamin D, creatine, ashwagandha or turmeric) to determine the most frequently consumed supplements. Self-reported reasons for use were also captured and both data on supplement type and athlete reason for use were extracted into an Excel database.

Step 2a and step 2b: examination of supplement labels for claims relating to nutrition and/or health and third-party certification status

All FS reported by respondents were searched manually online using generic search engines such as Google and Bing to identify both product labels and any claims listed on pack relating to nutrition and/or health (nutrition and health claims, NHC). Where applicable, details of any NHC were taken directly from the supplement brand website and recorded in an Excel database. Where this information was not available directly from a supplement brand website, label information was recorded from secondary retail outlets selling the product online, where typically full product information is listed for consumers. All products that could be searched (i.e. with a supplement name and brand name available) were then searched for batch testing/third-party certification status using Informed Sport (the accredited (ISO 17025) testing and certification programme for FS most frequently used in practice in Ireland and as recommended by research colleagues in Sport Ireland (DT and SM)). This is a database of all substances which are third-party/batch tested and certified globally and found at www.sport.wetestyourtrust.com using the batch-tested search bar.

The certification status of all products as reported by respondents in this survey was then recorded.

Step 3: matching athletes' reasons for use (step 1) with the NHC listed on pack (steps 2a and 2b)

Following the manual search of products and the establishment of certified status (steps 2a, 2b), the NHCs on product labels were compared with the reported reasons for use recorded by athletes (Step 1). A percentage agreement rate was calculated to infer a level of agreement between the reasons why athletes were taking FS/botanicals and whether this reflected how the product was marketed or intended for use. This 'matching' step was conducted for the FS and botanicals most frequently reported by athletes and where there also existed information on reported reasons for use (i.e. only for those athletes who recorded why they took a supplement in the matrix table questions).

Step 4: analysis of material collected

A hierarchical approach was adopted to all information collected as outlined below.

In the first instance, botanical products for which brand information was available online had their NHC recorded as described above. However, in some instances, some botanical ingredients/products could not be searched online for on-pack NHC (e.g. due to lack of inclusion of a brand name in athlete response—athletes only provided an ingredient name, such as turmeric) or if they did not have any on-pack NHC listed. In these instances, the main botanical ingredient was searched on the USA National Institute of Health's botanical fact sheets (URL: [Botanical Supplement Fact Sheets \(nih.gov\)](https://www.nlm.nih.gov/medlineplus/botanicalsupplementfact.html)) for evidence, efficacy, safety and any doping concerns. Additionally, recent systematic reviews (or narrative reviews where systematic reviews were unavailable) were examined for evidence of efficacy, safety and any doping concerns. In this case, an agreement rate could not be calculated and instead, a statement on whether there was agreement with reported reasons for use and existing evidence from the two chosen sources was provided.

Data analysis

Data were computed and analysed using both Excel (Microsoft) and SPSS (IBM Technology Corporation). Results were reported as frequency (n) and percentage (%). For the present analysis, the most frequently

reported FS were reported in [Tables 2](#) and [3](#) (i.e. supplements consumed by $n=2$ or more athletes). Supplements excluded from analysis in [Table 3](#) included BFS with fewer than two consumers, supplements which could not be found online or did not have any nutrition or health claims on product labelling, supplements with no reported reason for use and supplements with reported reason for use noted as 'other'. Percentage agreement rates were calculated for [Tables 2](#) and [3](#) by calculating the percentage for each individual supplement based on the number of participants reporting a correct main reason for use in agreement with NHCs on that product for each FS or botanical category divided by the total reported use of the supplement.

RESULTS

Athlete characteristics

Previously, we have documented botanical food supplement use in a cohort of 217 elite and amateur athletes living on the island of Ireland (McDaid et al., 2023). [Table 1](#) outlines demographic, sporting and supplement use characteristics of survey respondents. In brief, $n=55$ elite athletes and $n=162$ amateur athletes took part in the online survey, with a total of 68% ($n=148$) reporting 'yes' to questions regarding the use of any kind of FS. However, upon data analysis, it was apparent that despite reporting 'no, but I would use in the future' to questions on BFS use, an additional five amateur athletes were actually BFS consumers. Therefore, for the purposes of the present analysis, they were re-classified here as 'yes' resulting in 71% ($n=153$) of the total cohort using FS of any kind and 16% ($n=34$) of the total cohort being botanical consumers.

In total, $n=300$ (100%) supplements (any) were reported by the cohort and $n=59$ (20%) of these were categorised as botanicals, with $n=241$ (80%) being non-botanical FS. Upon data cleaning to compare reasons for using FS and BFS products with on-pack NHC, a number of FS and BFS products were excluded from the analyses presented in [Table 2](#) and [Table 3](#) due to either; no reason for use reported, product could not be found online or there was no available NHC for analysis. Therefore, 62% ($n=150$) of the total non-botanical FS reported and 68% ($n=40$) of the total BFS reported were included in the subsequent analyses.

Athletes' use of general FS

For general FS ($n=241$), the most frequently consumed types by athletes ($n=217$) were 'protein' (20%, $n=46$), 'vitamin D' (17%, $n=37$) and 'vitamin C' (15%, $n=32$).

TABLE 1 A descriptive overview of the demographic characteristics of elite and amateur athletes.

Variable	Elite athletes (<i>n</i> = 55)		Amateur athletes (<i>n</i> = 162)	
	Male <i>n</i> (%)	Female <i>n</i> (%)	Male <i>n</i> (%)	Female <i>n</i> (%)
Country of Residence				
Northern Ireland	13 (43)	10 (40)	56 (69)	63 (79)
Republic of Ireland	17 (57)	15 (60)	25 (31)	17 (21)
Age (years)				
18–24	19 (63)	18 (72)	19 (24)	28 (35)
25–30	5 (17)	6 (24)	22 (27)	24 (30)
31–39	5 (17)	1 (4)	25 (31)	17 (21)
40+	1 (3)	0	15 (19)	10 (13)
Level of sport				
Club level—regional, national and community games	3 (10)	1 (4)	45 (56)	55 (26)
National championships	3 (10)	1 (4)	22 (27)	15 (19)
International championships—European, world	21 (70)	20 (80)	10 (12)	6 (8)
Medallist—world Championships/Olympic games	1 (3)	2 (8)	—	—
Other	2 (7)	1 (4)	4 (5)	5 (6)
Do you currently use food supplements (not including botanical food supplements)?				
Yes	17 (57)	15 (60)	48 (59)	39 (49)
No	13 (43)	10 (40)	33 (40)	41 (50)
Do you currently use botanical food supplements?				
Yes	0	2 (8)	18 (23)	14 (18)
No, but I would consider using in future	25 (83)	12 (48)	52 (65)	41 (51)
No, I would not consider using them	4 (13)	10 (40)	9 (11)	21 (26)
Prefer not to say	1 (3)	1 (4)	1 (1)	—

The reasons most reported by athletes for using FS were 'to support health', 'to prevent illness/for immunity purposes', 'recovery' and 'to fulfil part of my dietary requirements'. A higher proportion of elite athletes reported 'for preventing injury' (8%) as a reason for using FS compared to amateur athletes (1%). However, twice as many amateur athletes (4%) reported 'strength' as a reason for use compared to elite athletes (2%) (data not shown).

Agreement between reasons for using FS and nutrition and health claims

Table 2 also outlines the rate of agreement between self-reported reasons for using general FS versus their approved NHC, with agreement rates of between 55% and 75%. 'Multivitamin' supplements, with an agreement rate of 15/20 had the highest rate of agreement (75%), whereas 'creatine', with an agreement rate of 6/11, had the lowest (55%).

Athletes' use of BFS

Current botanical supplement use was almost entirely reported by amateur athletes only, being documented for *n* = 34 (16%) of the total cohort, of which 32 were amateur athletes. Although two elite athletes initially reported use, they only provided limited information regarding use and could not be included in further analysis.

Of the 40 botanical products reported, *n* = 14 were, to the best of the athletes' knowledge, third-party tested, 6 were not, and for *n* = 20 botanical products, athletes reported 'not sure'. The most reported reasons for using botanical supplements fell into the 'other' category (24%). Since this question involved a drop-down list of possible reasons and could not facilitate a free text entry, 'other' reasons were not explored further. However, 'sleep improvement' (21%), 'recovery' (14%), 'to support health' (12%) and 'energy' (12%) were the most reported responses apart from 'other'. Notably, athletes who consumed

TABLE 2 Comparison of the agreement rate between elite and amateur athletes' reasons for using food supplements with the corresponding on-pack nutrition and health claims made on branded products^a.

Supplement type	Percentage of total general FS included in analysis (n = 150 products)	Number of products	Athlete's main reported reason for use (% and n)	On-pack nutrition and health claims (NHC) made (n)	Agreement rate between main reason for use and on-pack NHC ^b
Protein	20%	30	<ul style="list-style-type: none"> • Recovery (57%, n = 17) • Increase muscle mass (20%, n = 6) • To fulfil part of my dietary requirements (17%, n = 5) • To prevent injury (3%, n = 1) • Strength (3%, n = 1) 	<ul style="list-style-type: none"> • Increase muscle mass (23) • For muscle repair/recovery (23) • Support muscle function (5) • To increase energy levels (1) 	19/30 63%
Vitamin D	16%	24	<ul style="list-style-type: none"> • To support health (58%, n = 14) • To prevent illness/for immunity purposes (25%, n = 6) • To fulfil part of my dietary requirements (13%, n = 3) • To prevent injury (4%, n = 1) 	<ul style="list-style-type: none"> • Bone and joint health (21) • Immune system health (15) • Muscle function (11) • Anti-inflammatory (1) • Support health/general wellbeing (1) • Muscle repair/recovery (1) 	16/24 67%
Multivitamins	13%	20	<ul style="list-style-type: none"> • To support health (42%, n = 8) • To prevent illness/for immunity purposes (26%, n = 6) • To fulfil part of my dietary requirements (16%, n = 3) • Recovery (11%, n = 2) • To increase energy levels (5%, n = 1) 	<ul style="list-style-type: none"> • To increase energy levels (14) • Immune system support (11) • Brain health (8) • Support health/general wellbeing (4) • Muscle function (4) • Bone and joint health (3) • Heart health (2) • Vision health (2) • Metabolism support (1) 	15/20 75%
Vitamin C	11%	17	<ul style="list-style-type: none"> • To support health (41%, n = 7) • To prevent illness/for immunity purposes (59% n = 10) 	<ul style="list-style-type: none"> • Immune system support (14) • To increase energy levels (11) • Bone and joint health (4) • Brain health (2) • Support health/general wellbeing (2) • Muscle repair/recovery (1) • Vision health (1) • Hair/Skin/Nail health (1) 	12/17 71%
Fish oils/Omega 3	10%	15	<ul style="list-style-type: none"> • To support health (60%, n = 9) • Brain function/alertness (26%, n = 4) • Recovery (7%, n = 1) • To prevent injury (7%, n = 1) 	<ul style="list-style-type: none"> • Heart health (9) • Brain health (7) • Muscle function (5) • Vision health (5) • Bone and joint health (5) • Immune system support (2) • Anti-inflammatory (1) • Support health/general wellbeing (1) • Muscle repair/recovery (1) 	12/15 67%

TABLE 2 (Continued)

Supplement type	Percentage of total general FS included in analysis (n = 150 products)	Number of products	Athlete's main reported reason for use (% and n)	On-pack nutrition and health claims (NHC) made (n)	Agreement rate between main reason for use and on-pack NHC ^b
Creatine	7%	11	<ul style="list-style-type: none"> • Strength (64%, n = 7) • Power (27%, n = 3) • To increase energy levels (9%, n = 1) 	<ul style="list-style-type: none"> • Performance (6) • Strength (4) • To increase energy levels (4) • Muscle repair/recovery (2) • Increase muscle mass (1) • Endurance (1) 	6/11 55%
Collagen	3%	5	<ul style="list-style-type: none"> • To prevent injury (50%, n = 2) • To support health (25%, n = 1) • Recovery (25%, n = 1) 	<ul style="list-style-type: none"> • Muscle function (2) • Hair, skin and nail health (2) • Bone and joint health (2) • Recovery (1) 	3/5 60%

^aSupplements excluded from this analysis included: supplements which could not be found online/did not have a displayed on-pack nutrition/health claim, supplements with no reported reason for use, supplements with the reason for use noted as 'other', supplements where no brand name was provided, only an ingredient name.

^bPercentage agreement rates were calculated by calculating the percentage for each individual supplement based on the number of participants reporting a correct main reason for use in agreement with NHCs on that product for each FS or botanical category divided by the total reported use of the supplement. For example, for protein, 19 of the protein supplements reported by athletes had an agreement between the reason the athlete used the protein supplement and the specific on-pack NHC.

botanicals reported 'sleep improvement' much more often as a reason for use, compared to general FS within the cohort. Botanical supplement users were also asked if their botanical use changes prior to competition (this detail was only captured for botanical FS use). Botanical supplement use was reported to not change by 71% of amateur athletes, while 13% take botanicals more often and 10% reported that they increase their supplement dose prior to competition. Approximately 3% reported that they stopped taking botanicals prior to competition.

Agreement between reasons for using BFS and nutrition and health claims

As outlined, due to data gaps, we utilised a hierarchical approach in relation to comparing athletes' reasons for using botanical supplements and NHC in the order of (1) branded NHC listed on pack or retail websites, (2) NIH factsheets and (3) systematic (and narrative) reviews.

Table 3 provides information for botanical products that could be identified online, had available NHC and had information on reasons for use as reported by athletes. In total, the four supplement types outlined in Table 3 make up 38% of the total botanicals reported in the survey and with much lower agreement rates than for general FS. For example, turmeric/curcumin was the most frequently reported botanical but had an agreement rate of 20%, while there was a 0% agreement rate for 'beetroot' and 'ashwagandha'. Although a 50% rate could be calculated for 'maca root', there were only two consumers of this product (Table 3).

For the remaining botanical supplements, Table 4 lists the information comparing athletes' reason for use and existing evidence on efficacy as per NIH/systematic/narrative reviews as well as any safety concerns. Although it was not possible to calculate actual rates of agreement, results were generally mixed when comparing athletes' self-reported reasons for use and the existing evidence of efficacy. Four of the botanicals assessed were judged as not in agreement with the self-reported reasons for use (*Rhodiola rosea*, cannabidiol, apple cider vinegar and turmeric/curcumin), one was in agreement with evidence (valerian) and two were in agreement for short-term use only (products containing echinacea and ashwagandha). Of note, two botanicals appear in both Tables 3 and 4, which were reported by athletes in instances not only where brand-specific information was available and allowed direct comparison with NHC on pack (Table 3) but also where the botanical ingredient was provided by athletes but no brand information listed and therefore direct comparisons as per Table 3 were not possible (Table 4). For turmeric/curcumin, similar reasons for use were reported by the athletes (support health) but with no agreement

TABLE 3 Comparison of the agreement rate between amateur athletes' reasons for using botanical food supplements with the corresponding on-pack nutrition and health claims made on branded products^a.

Botanical supplement type	Percentage of total botanicals reported (n = 40)	Number of consumers	Athlete's main reported reason for use (%; n)	On-pack nutrition and health claims (NHC) made (n)	Agreement rate between main reason for use and on-pack NHC ^b
Turmeric/curcumin	13%	5	<ul style="list-style-type: none"> Recovery (60%, n = 3) Joint health (20%, n = 1) Support health (20%, n = 1) 	<ul style="list-style-type: none"> Joint health (3) Flexibility support (1) Anti-inflammatory (2) 	2/5 20%
Beetroot	10%	4	<ul style="list-style-type: none"> Endurance (75%, n = 3) Increase energy (25%, n = 1) 	<ul style="list-style-type: none"> Provides adequate dietary nitrate 	0/4 0%
Ashwagandha	10%	4	<ul style="list-style-type: none"> Support health (25%, n = 1) Sleep improvement (75%, n = 3) 	<ul style="list-style-type: none"> Adaptogen (stress relief) (4) 	0/4 0%
Maca	5%	2	<ul style="list-style-type: none"> Strength (50%, n = 1) Increase energy (50%, n = 1) 	<ul style="list-style-type: none"> Increase energy (1) Increase stamina (2) Endurance (2) 	1/2 50%

^aSupplements excluded from this analysis included: Supplements with n = <2 consumers, supplements which could not be found online/did not have a displayed on-pack nutrition/health claim, supplements with no reported reason for use, supplements with the reason for use noted as 'other' and supplements where no brand name was provided, only an ingredient name.

^bPercentage agreement rates were calculated by calculating the percentage for each individual supplement, based on the number of participants reporting a correct main reason for use in agreement with NHCs on that product for each FS or botanical category divided by the total reported use of the supplement.

regarding the NHC listed on pack (Table 3) and with the literature (Table 4), suggesting that there is only low-moderate quality evidence for use in certain disease conditions or for pain relief rather than for 'supporting general health' per se (Table 4).

DISCUSSION

This study shows that elite and amateur athletes on the island of Ireland were more likely to consume general FS than botanical supplements. All athletes had relatively similar reasons for using general FS and with evidence of largely good agreement between the athlete's reasons for using FS versus approved claims relating to nutrition and health in the European Union. In contrast, while botanical supplements were less frequently consumed, and mostly by amateur athletes only, a greater diversity of reasons for their use was reported than for regular FS, and with much poorer agreement between athlete reason for using botanicals and either approved claims or evidence from the scientific literature. Half of amateur athletes reporting botanical use were unsure if their supplements of choice were third-party tested. This study suggests that educational tools are needed to support athletes regarding use and the function of such supplements.

We have previously reported that the FS most commonly reported by athletes were protein, vitamin D and vitamin C, whereas the most reported BFS were turmeric, curcumin, ashwagandha and beetroot extract (McDaid et al., 2023). Here, we show that both elite and amateur athletes reported using general FS related to 'support health', 'for immunity purposes', 'recovery' and 'to fulfil dietary requirements'. 'Preventing injury' was reported more frequently as a reason for using FS among elite athletes, while 'strength' was more common among amateur athletes. Such reasons for the use of FS are similar to those reported in other cohorts (Graybeal et al., 2022; Jovanov et al., 2019; Mata et al., 2021; Munoz et al., 2020; Roy et al., 2021; Vento & Wardenaar, 2020). BFS use by athletes is less well characterised, and where provided, reasons for use are suggested as relating to a 'natural' component (Roman et al., 2017). Our cohort indicated a wide variety of reasons for their use within an 'other category' where athletes could provide unprompted reasons which were related to 'sleep improvement', 'recovery', 'to support health' and 'to increase energy'. While our cohort is small, these findings indicate there is a demand and interest by athletes to consume supplements, including botanicals, to aid their recovery, performance and health and merits deeper exploration in larger cohorts.

Our primary interest was to capture the level of agreement between the athletes' reasons for using supplements compared to those claims listed on product packaging (NHC). Where branded information was

TABLE 4 Comparison of the agreement between amateur athletes' reasons for using botanical food supplements with existing evidence of efficacy from the National Institute of Health, systematic and narrative reviews (i.e. information in this table details instances where no branded information was available to allow comparison with on-pack nutrition and health claims, only ingredient information was provided)^a.

Product information	Athlete's reported reason for use	Evidence from NIH botanical fact sheets and existing systematic reviews	Safety/doping concerns	Agreement of athlete reason for use and existing evidence? ^b
Rhodiola Rosea	Performance anxiety	NIH—not enough evidence from studies in people to allow for conclusions on whether it is helpful for any health-related issue (NCCIH, NIH, 2020). Overall, few human studies investigate efficacy. SR—May alleviate symptoms of mild anxiety and depression and may enhance mood. Results are not definite due to lack of evidence. More RCTs with lower risk of bias are required (Konstantinos & Heun, 2020) SR—Positive effect on athletic ability and performance, reduction in pain and muscle damage after exercise, improved skeletal muscle damage, enhanced antioxidant capacity thereby reducing oxidative stress and improved explosive power. (Lu et al., 2022)	Possible side effects include dizziness, dry mouth or excessive saliva production. (NIH, 2020) https://ods.od.nih.gov/factsheets/list-botanicals/ No obvious side effects were found. Appears to be a safe and effective supplementation for sports and exercise (Lu et al., 2022) Permitted for use by WADA.	No—overall lack of evidence for use for performance anxiety and more RCTs needed. Stronger evidence for its use in athletic performance.
Ashwagandha	Sleep	NIH—Possibly effective for insomnia and stress (NCCIH, NIH, 2020). Lack of evidence regarding safety with long-term use. SR—Appears to have a beneficial effect in improving sleep in adults. However, data on serious adverse effects are limited and more safety data would be needed to assess safety for long-term use (Cheah et al., 2021) SR—Ashwagandha is more efficacious than placebo for improving variables of strength/power, cardio-respiratory fitness and fatigue/recovery in healthy men and women (Bonilla et al., 2021)	Possibly safe use up to 3 months. Long-term safety unknown. May lower blood pressure and cause sleepiness. Can possibly interact with antidiabetic drugs, antihypertensive drugs, immunosuppressants, thyroid medications and sedative medications (NIH—Medline Plus, 2022) https://ods.od.nih.gov/factsheets/list-botanicals/https://medlineplus.gov/ Some adverse health effects associated include gastrointestinal upset, diarrhoea, vomiting and (in rare cases) liver injury. Can also induce abortion and should be strictly avoided by pregnant women (NIH—Department of Defense Dietary Supplement Resource, 2021) https://ods.od.nih.gov/factsheets/list-all/ Not prohibited by WADA	Yes—for short-term use. Other evidence suggests possible beneficial use for athletic performance.

(Continues)

TABLE 4 (Continued)

Product information	Athlete's reported reason for use	Evidence from NIH botanical fact sheets and existing systematic reviews	Safety/doping concerns	Agreement of athlete reason for use and existing evidence? ^b
Echinacea	Immunity	NIH—May slightly reduce chances of catching a cold. Not enough evidence for effectiveness with other conditions. Lack of evidence regarding safety with long-term use (NCCIH, NIH 2020) SR—Promising evidence for its use in the prevention of upper respiratory tract infections. No evidence for an effect on the duration of any respiratory tract infections (David & Cunningham, 2019).	Short-term use for most adults is probably safe and long-term safety is unknown. Side effects include digestive tract symptoms such as nausea or stomach pain. Can have allergic reactions, which may be severe. Risk of interactions with medications is low (NCCIH, NIH, 2020) Appears to be safe with short-term use (David & Cunningham, 2019) Not prohibited by WADA.	Yes—for short-term use for the prevention of upper respiratory tract infections.
Valerian	Sleep improvement	NIH—Mixed results from studies (up to 2013) on the use of valerian for sleep disorders due to small sample sizes of RCTs, using different amounts and sources of valerian, measurement of varying outcomes and inconsideration of potential bias resulting from high participant withdrawal rates. Overall evidence is inconclusive. (NCCIH, NIH, 2013) https://www.nih.gov/ SR—Valerian could be a safe and effective herb to promote sleep and prevent sleep-associated disorders (Shinjo et al., 2020)	Few adverse events were reported by clinical study participants. Headaches, dizziness, pruritus and gastrointestinal upset are the most common effects reported in trials, but similar effects were reported for placebo groups (NCCIH, NIH, 2013) https://www.nih.gov/ No serious adverse events were reported in included studies from childhood to old age.	Yes—appears to be safe and effective.
CBD	Recovery	NIH—CBD cannot be sold as a dietary (food) supplement in the United States according to the Food and Drug Administration. Lack of SRs investigating use of CBD for athletic recovery *NR—Anti-oxidative, anti-inflammatory, analgesic and neuroprotective properties. Studies on athletic populations are yet to be performed. Many athletes currently supplementing with CBD products despite lack of evidence (Close et al., 2021) *NR—Evidence for the potential use of CBD as an ergogenic aid to improve recovery processes during exercise and sport-related fatigue is promising, but rigorous human clinical trials are required (McCartney et al., 2020; Rojas-Valverde, 2021)	Lack of robust evidence from clinical trials in humans on the efficacy and safety of CBD use for athlete recovery (Rojas-Valverde, 2021). No longer prohibited by WADA.	No—overall lack of evidence from robust human clinical trials.

TABLE 4 (Continued)

Product information	Athlete's reported reason for use	Evidence from NIH botanical fact sheets and existing systematic reviews	Safety/doping concerns	Agreement of athlete reason for use and existing evidence? ^b
Turmeric/Curcumin	Support Health	NIH—Challenging to study curcumin as it is unstable and has low bioavailability when taken orally (NCCIH, NIH, 2019) https://www.nccih.nih.gov/https://www.nih.gov/ SR—Moderate quality evidence to support the use of turmeric/curcumin for relieving pain and improving physical function in osteoarthritis. Low-quality evidence for use in metabolic syndrome, inflammatory conditions and other diseases. May be useful for different conditions (Rolfe et al., 2020)	Probably safe when taken orally in the recommended amounts (NCCIH, NIH, 2019) https://www.nccih.nih.gov/https://www.nih.gov/ Turmeric/curcumin are safe and well tolerated (Rolfe et al., 2020).	No—evidence suggests possible benefits for certain diseases but lack of evidence for overall support of general health.
Apple Cider Vinegar	Support Health	NIH—Very little scientific evidence to support the safety and effectiveness of apple cider vinegar, especially as a dietary (food) supplement (NIH—Department of Defense Dietary Supplement Resource, 2020) SR—Favourable results for the effect of ACV consumption on lipid profiles and glycaemic parameters (Hadi et al., 2021). Lack of SRs into ACV supplementation on overall health parameters.	Acetic acid in concentrations >20% could be considered poisonous. Possible side effects could include low potassium, skin irritation, chemical burns and tooth erosion when ingested (NIH—Department of Defense Dietary Supplement Resource, 2020).	No—overall lack of evidence to support use of apple cider vinegar for supporting overall health.

Abbreviations: ACV, Apple Cider Vinegar; NCCIH, National Center for Complementary and Integrative Health; NIH, National Institute of Health; NR, Narrative Review; SR, Systematic Review; WADA, World Anti Doping Agency.

^aSupplements excluded from this analysis included: supplements with no reported reason for use, supplements with the reason for use noted as 'other' and supplements where a brand name was provided (such supplements are detailed in Table 3).

^bPercentage agreement rates were calculated by calculating the percentage for each individual supplement, based on the number of participants reporting a correct main reason for use in agreement with NHCs on that product for each FS or botanical category divided by the total reported use of the supplement.

provided by the athletes, we could do this. However, in instances where athletes provided a reason for use, but only imparted ingredient information rather than brand details (e.g. no brand name provided), we then compared athletes' reasons for use with evidence from the published literature (NIH factsheets and systematic and narrative reviews). To our knowledge, this is the first study to complete such an analysis. It shows that while there was some consistency between athletes' reported reasons for using general FS and approved NHC, there was a greater divergence between athletes' reported reasons for using botanical supplements and their potential health benefits which merits attention. There are multiple potential factors influencing this gap in knowledge among athletes that appear to be present including limitations in legislation regarding NHC for botanicals, places athletes source information about botanicals and whether or not these products are safe for use by competitive athletes as outlined below.

Firstly, within the wider EU region, an agreed legislative process exists for the use of claims relating to individual nutrients (e.g. protein), vitamins and/or minerals and some ingredients (Directive 2002/46/EC). Only specific claims which have been scrutinised by the European Food Safety Authority and enshrined by EU law should appear on pack with a register of all claims (approved or otherwise available) (Directive 2002/46/EC; McDaid et al., 2020). It is possible that athletes may therefore be more familiar with the product marketing which will be more aligned in wording based on approved claims. On the contrary, the status of botanical supplements NHC is 'on-hold' in the wider European region and in turn, such claims remain unsubstantiated and with no agreed form of wording of putative benefits (McDaid et al., 2020). This means that it is more probable that a variety of wording could appear on-pack labels to describe any claims or benefits. It is also probable that this is reflected here in the discrepancies identified between athletes' reasons for use and on-pack claims.

We also acknowledge the influence of the source of information. We have previously described how amateur athletes, the main consumers of botanical products in this cohort, were more likely to source information about botanicals from sources such as fellow athletes, coaches and internet sources, all of which could be considered less reputable sources of nutrition information (McDaid et al., 2023; Wardenaar & Hoogervorst, 2022). Collectively, we may be able to infer that there is a lack of knowledge among athletes who currently use botanicals on NHC and what these mean and indeed where they can source reliable information on the efficacy of botanical supplements. This study highlights a need to agree and harmonise a process regarding claims for botanical products to avoid confusion arising and for the provision of trusted sources of nutrition information for all athletes regardless of level.

In addition, a total of 50% of the amateur athletes were unsure if the products they reported using were third-party tested, which is similar to earlier reported results in a sample of Dutch amateur athletes (Wardenaar et al., 2020). This highlights another area with a potential lack of knowledge about third-party testing of supplements among amateur athletes. This is especially applicable within this particular cohort of athletes living on the island of Ireland, where Gaelic games are a popular amateur sport but with whom the top competitors are subject to anti-doping testing procedures (Gaelic Athletics Association, 2023).

To improve the knowledge gap among athletes on the topics of botanicals, nutrition and health claims, sourcing reputable information and third-party testing, future research could involve the development and implementation of FS-based nutrition education interventions. Nutrition education interventions designed for athletes have been effective in improving nutrition knowledge in the past (Tam et al., 2019); however, there is a lack of validated tools available to assess nutrition knowledge and future nutrition interventions around FS and botanical supplement knowledge among athletes are needed (Renard et al., 2020). As well as education interventions, there is a potential need to change FS behaviour among athletes. Wardenaar et al. (Wardenaar et al., 2024) concluded that the majority of high school athletes reported using one or more FS. Following a short, online nutritional education programme, athlete participants reported a shift to significantly higher use of (safe) third-party tested supplements (Wardenaar et al., 2023). Another study found that when athletes received adequate nutritional counselling from a registered sports dietitian, their FS choices improved to include more third-party tested products (Wardenaar et al., 2017). Furthermore, Shaw et al. reported that Australian swimmers who were influenced by a formal sports supplement programme used FS recommended by allied health-trained individuals and classified as evidence-based more frequently than other athletes who were not influenced in this way (Shaw et al., 2016).

We note the Australian Institute of Sport (AIS) classification system whereby supplements are classified into four groups using an 'ABCD' system, with 'A' representing supplements for which exists solid scientific evidence, and 'B' representing supplements with emerging evidence or interest, that both in specific situations under established protocols could lead to performance enhancement, to 'C' with no substantial evidence, to the other extreme 'D' representing prohibited products or those with a high risk of contamination (AIS, 2021). Applying this system to the FS captured in this study would yield 'A' or 'B' scores (components with emerging evidence that should be used in research or clinical settings) for general FS (e.g. vitamins and/or minerals). Some botanical FS were rated as 'B', but most of the botanicals

were rated as 'C' ('supplements with limited evidence and effects on performance'). Of note, two athletes reported use of Maca, which is rated by AIS as 'D' (high risk of contamination and/or prohibited). While Maca is not specifically banned as per the World Anti Doping Agency (WADA), the potential concern raised by AIS is that such products 'are often found in multi-ingredient products that contain banned ingredients or are at high risk of being contaminated. Therefore, they are not recommended for use' (AIS, 2021). Collectively, this suggests that beyond Maca, AIS did not have sufficient scientific evidence to place the individual botanical FS in the highest categories. In line with our study, it has been shown elsewhere that consumption of FS categorised as 'B' or 'C' was more likely in athletes at lower competition levels (Del Arco et al., 2023). In our study, only amateur athletes provided details of botanical FS use.

This study had several strengths, including that this is, to our knowledge, the first time botanical supplement use specifically has been investigated within a cohort of elite and amateur athletes living on the island of Ireland and the United Kingdom, as such allowing to cautiously generalise the results to both the United Kingdom and Europe, although more research in the area is warranted. This survey also collected data on a multitude of areas relating to botanical supplement use, including consumer knowledge, attitudes, sources of information and perceptions of risks associated with and the actual use of third-party testing related to botanical use.

This study also had several limitations. Inherently due to the recruitment and sampling strategy of targeting elite and amateur athletes living on the island of Ireland aged ≥ 18 years, there is an introduction of selection bias. No elite athletes recruited for the study provided the details of their use of botanical supplements. This could be related to the relatively high level of dietary advice these athletes have access to in comparison to amateur athletes (Wardenaar et al., 2017). However, as it is reported that elite athletes have higher supplement use than their non-elite counterparts (Knapik et al., 2016), recruiting from other elite athlete populations could potentially have resulted in much higher botanical supplement reporting than we observed and thus should be explored further in future research. Limitations in the design of the cross-sectional online survey were also present and future studies should endeavour to ask a follow-up question to those who select 'other' to gain a more representative insight into reasons for using botanicals, as well as consistently questioning the use of third-party tested supplements of all supplements: unfortunately, this question was only asked for botanicals here. A limitation of the survey was that we asked the athletes to report their 'main reason for use' rather than to provide multiple reasons for choosing

the particular FS or BFS which could have influenced the levels of agreement present. Furthermore, we used only the Informed Sport to check the testing and certification of FS since this is what is most frequently used by Irish practitioners (SM, DT); we acknowledge that we may have underestimated the certification status from other databases too (e.g. NSF [www.nsf.org]). In this research, we asked athletes if they had changed supplement use prior to competitions but we did not ask if they had changed FS use prior to taking this survey; we also acknowledge this as a limitation. Nevertheless, we believe that this analysis provides some insights into athlete rationale for using both FS and botanical supplements and highlights a knowledge gap in third-party testing and between reasons for use and scientific efficacy, especially for botanicals which warrant further attention.

In conclusion, intake of any FS by elite and amateur athletes on the island of Ireland is common, however, botanical supplement use is relatively low. Athletes' reasons for use typically relate to performance, recovery (including recovery from injury) and health. While athletes were more likely to provide reasons for choosing general FS, which were in line with accepted scientific efficacy, there was a knowledge gap here regarding botanical supplements. Guidance is needed for athletes and practitioners to help them source reliable, evidence-based information on the efficacy and safety of botanical supplements while minimising any risk of consuming fraudulent or contaminated supplements.

AUTHOR CONTRIBUTIONS

BMcD, DT, SM, JVW, FW and APN designed the study; BMcD and DT initially collected data; BMcD analysed data; BMcD, DT, SM, JVW, APN and FW undertook data interpretation; manuscript preparation was performed by BMcD, FW and APN. All authors approved the final version of the paper.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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