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Research article

Dietary supplementation habits in international natural bodybuilders during pre-competition

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ABSTRACT

Bodybuilding is characterized by high-rates of sport supplementation. This is the first study to compare the supplementation patterns of winners (WB) and non-winners (NWB) among international natural bodybuilders during contest preparation. Fifty-six natural bodybuilders (5 women) (age = 28.85 ± 8.03 years; final body mass = 71.50 ± 10.28 kg), 19 WB (athletes who had achieved victory in an official natural bodybuilding championship at least once) and 37 NWB (athletes who never achieved victory), from 18 countries (55.36% from Spain) responded to this cross-sectional online survey related to their nutritional habits, strategies and supplementation practices. WB were significantly older ($p = 0.024$), completed more competitive seasons ($p = 0.027$) and participated in more competitions in the last contest year ($p = 0.011$). There were no significant differences between WB and NWB for years training for bodybuilding ($p = 0.055$), weeks of dieting for competition ($p = 0.392$), and body weight at the start ($p = 0.553$) and end ($p = 0.330$) of the season. Beverage and supplement consumption, purchasing patterns, and information sources did not differ between groups ($p > 0.05$). In conclusion, natural bodybuilding WB tended to be older and had more competitive experience, but shared similar supplementation protocols to NWB. Athletes' supplementation patterns were influenced by different sources of information. However, these natural bodybuilders mainly purchased their supplements through the internet without guidance from a coach or dietitian.

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1. Introduction

Sport supplements are legal dietary compounds which in conjunction with a healthy and balanced diet are used to improve wellbeing and athletic performance, increase muscle mass, or decrease body fat [1,2]. Supplement ingestion prevalence varies widely between different sport disciplines (i.e., 11–100%) [3]. Bodybuilding athletes are a principal consumer of supplements evidenced by the large number and variety of supplements used by this population [4,5]. For example, authors of prior research on bodybuilders in the metropolitan area of Naples, Italy reported that 81.31% of that study bodybuilders use supplements, and of those users 65.52% are male and 34.48% female. Furthermore, 35.51% of these bodybuilders reported performance-enhancing hormone use (males = 71.05%, females = 28.05%) and 97.37% of the hormone-using bodybuilders also reported consuming dietary supplements [5]. Although positive correlations between supplement and banned substance use was documented in athletes, whether the use of dietary supplements plays a causal role in increasing the likelihood of using banned substances is not yet fully clear [6,7].

In response to the high rates of drug use among bodybuilders, "natural" or drug-tested bodybuilding competitions emerged in the late 1970's [8], which has grown in popularity in recent years [9]. As an aesthetics-based sport, bodybuilding performance is dictated by having low fat levels, high levels of muscle mass, and muscular symmetry. This is commonly accomplished through adherence to training regimens primarily centered on free weight exercises, representing a fitness trend that has garnered substantial popularity around the globe [10,11]. Drug-controls are generally based on World Anti-Doping Agency (WADA) criteria (i.e., urine and/or blood evaluations) and/or polygraph analyses [12]. Natural bodybuilding athletes are subjected to strict regulations which dictates competitive sanctions if doping-tests are failed [13].

Natural bodybuilders commonly use sports supplements like creatine, protein powder, amino acids (i.e., branched-chain amino acids, glutamine or essential amino acids), vitamins and stimulants such as found in "pre-workouts" that contain caffeine and other ingredients [14]. Depending on the specific product or ingredient, sports supplements are formulated to exert benefits through multiple mechanisms such as enhancing rates of muscle protein synthesis, supporting exercise metabolism, enhancing muscle contractility, reducing perceived exertion, improving mood state or by providing health-related benefits [15,16]. However, sport nutrition recommendations for dietary supplement use differ between educational bodies [1,16]. These variations may, in part, be attributed to the differences between sports disciplines and the specific performance demands of each sport and what might meaningfully enhance it (e.g., team sports or weightlifting) [17]. Thus, statements related to other sports should be cautiously interpreted, and bodybuilding specific guidelines are likely needed.

Moreover, new supplement design trends are constantly emerging which attempt to exploit plausible ergogenic pathways. For example: (a) anti-fatigue agents such as capsaicinoids which may modulate strength endurance, work performed or nociception [18–20]; (b) nitric oxide precursors such as nitrates or citrulline malate which may enhance strength and power [21]; (c) relaxation and/or sleep-care agents such as lavender, ashwagandha or melatonin [22,23], (d) "fat burners" which contain substances which may play a role in lipolysis, β-oxidation, or enhance metabolic rate such as caffeine, *p*-synephrine, green tea extract or yohimbine [16, 24–26]. Further, multi-ingredient formulas are frequently marketed to provide added ergogenic effects due to purported synergistic ingredient interactions (e.g., nitrates and citrulline are proposed to stimulate different NOS-pathways) [27].

Given the constantly changing supplement market, and the distinction between untested and natural bodybuilders, further research is needed to better understand supplementation practices of natural bodybuilders. Furthermore, previous studies have mainly considered small sample sizes (i.e., mostly case-studies) in specific geographical regions but not in international areas [28]. Moreover, there are not previous specific studies focused on the supplementation patterns of natural bodybuilders, in this sense, prior research only assessed this topic as a complementary, but not as the main aim of the study. This fact may bias the number of substances asked in the surveys and the questions performed concerning the habits of the athletes. For this reason, although supplementation rates in bodybuilders are high, the current knowledge about the acquisition, consumption and classification of the supplements purchased and ingested by this population is still lacking. Accordingly, larger international samples of athletes competing in drug-free federations need to be aggregated and delineated based on competition success, to better understand the landscape of supplement use in natural bodybuilding. Therefore, the aim of this study was to describe and compare for the first time the supplement intake patterns of a sample of international natural bodybuilders delineated based on their competition success.

2. Materials and methods

2.1. Participants

Fifty-six participants in the discipline of natural bodybuilding were included in this study, with five of them being women. The participants were stratified into two groups: the "winners" (WB), consisting of 19 natural bodybuilders who had achieved victory in an official natural bodybuilding championship at least once during their athletic careers (age range 26–37, weight: 72 ± 14.5) and "non-winners" (NWB) comprised of 37 natural bodybuilders who had not secured a championship victory (age range 22–31, weight: 73 ± 8.6). For inclusion in the research study, participants were required to meet the following criteria: (I) they must have been affiliated with a natural bodybuilding federation that conducts drug testing at least once in their career, (II) achieved a ranking within the top 10 in some official competitive event, and (III) undergone drug testing, either through polygraph, blood, or urine analysis, either before or after their competitive engagements. The exclusionary criterion entailed the use of prohibited substances. Of the 51 male athletes, 26 competed in the men's physique division and 25 in the men's bodybuilding category. All the female competitors reported competing in the bikini division. Competitors classified their nationality as: (a) Spanish = 31; (b) Ecuadorian = 4; (c) Ukrainian = 2; (d) Chilean = 2;

(e) American = 2; (f) Peruvian = 2; (g) Polish = 2; (h) New Zealander = 1; (i) Australian = 1; (j) Macedonian = 1; (k) Italian = 1; (l) French = 1; (m) Portuguese = 1; (n) Mexican = 1; (o) Colombian = 1; (p) Nigerian = 1; (q) Singaporean = 1; (r) German = 1. The participants' rankings in international official competitions were verified by means of communication with their respective governing natural bodybuilding federations. This survey study was approved by the ethics committee of the Catholic University of Murcia (Code: CE012209) in accordance with the Helsinki Declaration. All participants gave their informed consent to use their responses for research purposes and indicated their agreement to one of the online survey items.

2.2. Study design

A quantitative, cross-sectional design was employed to explore the practical problem of supplementation intake behaviors among natural bodybuilders on a global scale. This was achieved by extending invitations to a diverse cohort of natural bodybuilders to complete a tailored survey regarding their supplement consumption patterns, facilitated through the dissemination of advertisements on social media platforms.

Upon clicking links or navigating to the survey URL, the respondents were presented with an information sheet stating the purpose of the study, the nature of the questions, and the fact that the survey was anonymous. The survey consisted of 21 questions that can be divided into following categories.

- 1 *single-choice consent question*,
- 3 *demographic questions* (nationality, age and weight),
- *5 dichotomous questions* (yes-no questions regarding prohibited substances),
- *4 multiple-choice questions* (with respect to the acquisition of supplements),
- *1 categorical question* (regularity of consuming various non-alcoholic beverages),
- *5 closed-ended single-response questions* (regarding bodybuilding training history, weeks of dieting and water consumption habits prior competition),
- *2 open-ended single-response* (most significant accomplishment in natural bodybuilding).

Control questions were included in the survey to prevent duplicates or inaccuracies of the responses. For this purpose, reformulated questions of the main identifying items were included throughout the survey. For example, participants were asked regarding their most significant natural bodybuilding accomplishment twice (see questions 12 and 21 of Appendix 1). If inaccurate information was detected, the record was removed. After data collection, a manual search for duplicates was also performed. Results were reported jointly and separately for WB and NWB.

2.3. Statistical analysis

Descriptive data of the variables are presented as means and standard deviation (SD). Median and interquartile range were used as descriptive values for non-normal data instead. The homogeneity of the data variance (Levene's test) was confirmed ($p > 0.05$) and a Kolmogorov-Smirnov test was performed to determine normality. To detect differences between WB and NWB, Mann-Whitney U tests were used in the cases where data were not normally distributed: I) age, II) years training for bodybuilding, III) years competing in bodybuilding (i.e., number of competitive seasons), IV) number of competitions performed in the last competitive year, V) weeks of dieting for competition, VI) body weight at the start and VII) end of preparation for competing, and, VIII) liters of water usually consumed during preparation. Response differences between WB and NWB for categorical variables related to doping, sweetener, beverage and supplement use were analyzed using the Pearson Chi-squared test. Statistical significance was set at $p < 0.05$. Where the Pearson Chi-squared test was implemented, Cramer's V was implemented as a measure of the strength of association between the variables and represented in absolute values [29]. The magnitude of the association was evaluated using the following scale: very weak (0–0.049); weak (0.05–0.099); moderate (0.10–0.149); strong (0.15–0.249); very strong ($\geq$0.25) [30]. The magnitude of the differences was reported for each categorical variable as the percentage difference between WB and NWB. For non-normal variables, Common Language Effect Size (CLES) was calculated as the magnitude of the proportion of observations in a group that are greater than observations in the other group. CLES does not provide cut-off ranges, however, higher values reveal a larger median magnitude

Table 1
Comparison of participants' characteristics between winning (WB) and non-winning (NWB) natural bodybuilders.

Variable	WB	NWB	Mann-Whitney *U* Test	Effect Size (CLES)
Age (years)	31 (26, 37)	27 (22, 31)	$p = 0.024$*	0.67
Training experience (years)	9.0 (5.0, 12)	6.0 (2.7, 10)	$p = 0.055$	0.59
Competitive experience (years)	3.0 (1.0, 4.0)	2.0 (1.0, 2.0)	$p = 0.027$*	0.63
Number of contests last year	3.0 (1.0, 4.0)	2.0 (1.0, 2.0)	$p = 0.011$*	0.72
Diet duration (weeks)	24 (16, 24)	20 (16, 24)	$p = 0.392$	0.53
Body mass at diet onset (kg)	85 (65, 92)	86 (74, 88)	$p = 0.553$	0.52
Body mass at competition (kg)	72 (57, 78)	73 (68, 77)	$p = 0.330$	0.57
Water consumption (liters)	4.0 (3.0, 5.0)	4.0 (3.0, 6.0)	$p = 0.710$	0.51

Median (interquartile range). CLES; Common Language Effect Size.

of the effects between the groups. Statistical analyses were performed using the software package SPSS (IBM SPSS version 25.0, Chicago, IL, USA).

3. Results

A post hoc analysis derived an achieved power of 0.88, considering a statistical significance level of 0.05, a sample size of 56 participants, 1 degree of freedom, and a substantial effect size indicated by a noncentrality parameter of 10 (G*Power 3.1.9.4, Franc Faul, Kiel University, Germany). No significant differences were found between WB and NWB for years training for bodybuilding ($p = 0.055$), weeks of dieting for competition ($p = 0.392$), body weight at the start ($p = 0.553$) and end ($p = 0.330$) of contest preparation and liters of water usually consumed during the contest preparation phase ($p = 0.710$) (Table 1). However, significant differences were found for age ($p = 0.024$), number of competitive seasons ($p = 0.027$) and number of competitions performed in the last competitive year ($p = 0.011$). The probability that the WB group exhibited a more dedicated and rigorous competition approach than NWB group, with longer training and competitive experience, an extended diet duration, increased water consumption, and lower body weight at the start and end of the preparation period, exceeded 50% (all CLES $\geq$0.51).

No significant differences between WB and NWB were found for the use of any supplement (p range = 0.089 to 0.982) or sweeteners ($p = 0.900$). Furthermore, the magnitude of associations was inconsistent ranging from very weak to strong (Cramer's V range: 0.00–0.23), while the probability of substantial differences was relatively low, with all CLES values being less than 22% (Table 2).

There were no significant differences between WB and NWB for any beverage intake (p range = 0.470 to 0.871). Additionally, the magnitude of associations was inconsistent and ranged from very weak to strong (Cramer's V range: 0.00–0.19), while the magnitude of the differences can be considered low (CLES $\leq$16.9%) (Table 3).

No significant differences between WB and NWB were found for where competitors obtained the supplements (p range = 0.488 to 0.789), who recommended or prescribed them (p range = 0.202 to 0.757) or where they obtained information about the supplements (p range = 0.185 to 0.778). The magnitude of associations ranged from very weak to strong (Cramer's V range: 0.04–0.18). The magnitudes of the differences can be considered low (CLES $\leq$15.4 %) (Table 4).

4. Discussion

This study provides information concerning the supplementation patterns (i.e., from acquisition to ingestion) of an international sample of natural bodybuilding athletes, predominantly from Spain (55.36%). The primary study findings can be summarized as follows: (I) there were no discernible variations in supplementation patterns between WB and NWB natural bodybuilders, (II) creatine and whey protein stood out as the most widely favored supplements in both WB and NWB groups, (III) athletes in the WB category

Table 2
Comparison of the use of supplements and sweeteners between winning (WB) and non-winning (NWB) natural bodybuilders during contest preparation.

Variable	WB (%)	NWB (%)	Pearson Chi-squared test	Cramer's V	Magnitude of the difference (%)
Ashwagandha	31.6	43.2	$p = 0.397$	0.11	−11.6
BCAAs	26.3	29.7	$p = 0.789$	0.04	−3.4
Beta-alanine	21.1	10.8	$p = 0.300$	0.14	11.7
Caffeine	57.9	54.1	$p = 0.784$	0.04	3.8
Capsaicin	5.3	5.4	$p = 0.982$	0.00	−0.1
Carbohydrates	31.6	29.7	$p = 0.887$	0.19	1.9
Citrulline	21.1	18.9	$p = 0.849$	0.02	2.2
Creatine	94.7	91.9	$p = 0.696$	0.05	2.8
EAAs	31.6	40.5	$p = 0.512$	0.08	−8.9
EGCG	15.8	27.0	$p = 0.346$	0.20	−11.2
Fat Burners	63.2	48.6	$p = 0.303$	0.13	14.6
Joint-Health Supplement	21.1	27.0	$p = 0.625$	0.06	−5.9
Lavender	10.5	8.1	$p = 0.764$	0.09	2.4
Magnesium	36.8	29.7	$p = 0.589$	0.07	7.1
Melatonin	57.9	37.8	$p = 0.153$	0.19	20.1
Minerals	26.3	29.7	$p = 0.789$	0.04	−3.4
Multivitamin	73.7	59.5	$p = 0.293$	0.14	14.2
Nitrates	5.3	10.8	$p = 0.491$	0.09	−5.5
Omega 3	63.2	67.6	$p = 0.744$	0.04	−4.4
P-Synephrine	15.8	37.8	$p = 0.089$	0.23	−22.0
Pre-Workouts	68.4	56.8	$p = 0.397$	0.11	11.6
Protein/Oat Bars	21.1	29.7	$p = 0.488$	0.09	−8.6
Sweeteners	63.2	64.9	$p = 0.900$	0.01	−1.7
Vitamin C	36.8	32.4	$p = 0.741$	0.04	4.4
Vitamin D	42.1	45.9	$p = 0.784$	0.03	−3.8
Whey Protein	94.7	89.2	$p = 0.491$	0.09	5.5
Yohimbine	10.5	5.4	$p = 0.481$	0.09	5.1

Fat burners and pre-workout categories refer to multi-ingredient formulas.

Table 3
Comparison of beverage intake between winning (WB) and non-winning (NWB) natural bodybuilders during contest preparation.

Variable	Frequency	WB (%)	NWB (%)	Pearson Chi-squared test	Cramer's V	Magnitude of the difference (%)
Coffee	<1/month	26.3	18.9	$p = 0.76$	0.08	7.4
	1-3/month	5.3	2.7	$p = 0.79$	0.06	2.6
	1/week	5.3	21.6	$p = 0.31$	0.19	−16.3
	2-4/week	5.3	8.1	$p = 0.89$	0.05	−2.8
	5-6/week	5.3	5.4	$p = 0.54$	0.00	−0.1
	1/day	10.5	16.2	$p = 0.80$	0.08	5.7
	2-3/day	31.6	21.6	$p = 0.62$	0.10	10.0
	4-5/day	10.5	5.4	$p = 0.88$	0.09	5.1
Tea	<1/month	73.7	56.8	$p = 0.34$	0.16	16.9
	1-3/month	10.5	8.1	$p = 0.84$	0.04	2.4
	1/week	0	8.1	$p = 0.51$	0.17	−8.1
	2-4/week	5.3	8.1	$p = 0.89$	0.05	−2.8
	5-6/week	0	2.7	$p = 0.73$	0.09	−2.7
	1/day	5.3	10.8	$p = 0.84$	0.09	−5.5
	2-3/day	5.3	0	$p = 0.73$	0.19	5.3
	4-5/day	0	5.4	$p = 0.79$	0.13	−5.4
Energy drinks	<1/month	57.9	43.2	$p = 0.45$	0.14	14.7
	1-3/month	10.5	8.1	$p = 0.84$	0.04	2.4
	1/week	10.5	16.2	$p = 0.86$	0.08	−5.7
	2-4/week	10.5	13.5	$p = 0.92$	0.04	−3.0
	5-6/week	10.5	8.1	$p = 0.84$	0.04	2.4
	1/day	0	2.7	$p = 0.72$	0.09	−2.7
	2-3/day	0	5.4	$p = 0.79$	0.13	−5.4
	4-5/day	0	2.7	$p = 0.72$	0.09	−2.7
Soda	<1/month	84.2	75.7	$p = 0.73$	0.09	−8.5
	1-3/month	15.8	8.1	$p = 0.67$	0.11	7.7
	1/week	0	5.4	$p = 0.79$	0.13	−5.4
	2-4/week	0	5.4	$p = 0.79$	0.13	−5.4
	5-6/week	0	0	$p = \#$	#	0
	1/day	0	2.7	$p = 0.72$	0.09	−2.7
	2-3/day	0	2.7	$p = 0.72$	0.09	−2.7
	4-5/day	0	0	$p = \#$	#	0
Diet soda	<1/month	78.9	73	$p = 0.86$	0.06	5.9
	1-3/month	15.8	5.4	$p = 0.4$	0.17	10.4
	1/week	0	5.4	$p = 0.79$	0.13	−5.4
	2-4/week	0	5.4	$p = 0.79$	0.13	−5.4
	5-6/week	0	2.7	$p = 0.72$	0.09	−2.7
	1/day	0	2.7	$p = 0.72$	0.09	−2.7
	2-3/day	5.3	0	$p = 0.73$	0.19	5.3
	4-5/day	0	2.7	$p = 0.72$	0.09	−2.7
	+6/day	0	2.7	$p = 0.72$	0.09	−2.7
Alcohol	<1/month	89.5	78.4	$p = 0.51$	0.14	11.1
	1-3/month	10.5	13.5	$p = 0.92$	0.04	−3.0
	1/week	0	2.7	$p = 0.72$	0.09	−2.7
	2-4/week	0	0	$p = \#$	#	0
	5-6/week	0	0	$p = \#$	#	0
	1/day	0	2.7	$p = 0.72$	0.09	−2.7
	2-3/day	0	0	$p = \#$	#	0
	4-5/day	0	0	$p = \#$	#	0
	+6/day	0	2.7	$p = 0.72$	0.09	−2.7
Juice	<1/month	57.9	45.9	$p = 0.57$	0.11	12.0
	1-3/month	15.8	16.2	$p = 0.73$	0	−0.4
	1/week	5.3	18.9	$p = 0.33$	0.18	−13.6
	2-4/week	5.3	8.1	$p = 0.89$	0.05	−2.8
	5-6/week	5.3	2.7	$p = 0.54$	0.16	2.6
	1/day	0	2.7	$p = 0.72$	0.09	−2.7
	2-3/day	10.5	2.7	$p = 0.80$	0.068	7.8
	4-5/day	0	2.7	$p = 0.72$	0.09	−2.7

#, not defined value.

exhibited older age, more extensive competitive experience, and greater involvement in competitions over the past year compared to their NWB counterparts, and (IV) the supplement acquisition process mirrored one another in both groups, with online purchases being the prevailing method, while athletes primarily made supplement decisions after consulting their trainers. These findings suggest that competitive success is more closely linked to an athlete's competitive experience than their supplement habits.

The supplementation consumption patterns did not differ between the WB and NWB groups. However, notable percentage differences were observed between the two groups regarding the use of Melatonin (20.1% more in the WB group) and P-Synephrine (22.0% more in the NWB group). And although our study shows that 57.9% of WB used Melatonin and 37.8% of NWB used P-

Table 4
Supplement purchasing location, information sources in winners (WB) and non-winning (NWB) bodybuilders during contest preparation.

Topic	Variable	WB (%)	NWB (%)	Pearson Chi-squared test	Cramer's V	Magnitude of the difference (%)
How did you get the supplements?	*Internet*	78.9	70.9	$p = 0.488$	0.09	8.0
	Medical clinic or dietitian's office	5.3	2.7	$p = 0.625$	0.07	2.6
	Gym	5.3	10.8	$p = 0.491$	0.09	−5.5
	Supplement Store	26.3	29.7	$p = 0.789$	0.04	−3.4
	Supermarket	5.3	2.7	$p = 0.625$	0.07	2.6
	Myself	57.9	52.2	$p = 0.757$	0.04	5.7
Who recommended or prescribed the supplement?	*Personal trainer*	42.1	35.1	$p = 0.610$	0.07	7.0
	Healthcare professional	10.5	2.7	$p = 0.218$	0.17	7.8
	Friend from the gym or supplement store	0	8.1	$p = 0.202$	0.17	−8.1
Where did you obtain information about the supplements?	*Social Networks*	31.6	16.2	$p = 0.185$	0.18	15.4
	Personal trainer	47.4	51.4	$p = 0.778$	0.04	−4.0
	Healthcare professional	5.3	8.1	$p = 0.696$	0.05	−2.8
	Friend, workout partner, or supplement store clerk	10.5	2.7	$p = 0.218$	0.17	7.8
	Research reviews	36.8	48.6	$p = 0.400$	0.11	−11.8
	Peer reviewed research	36.8	43.2	$p = 0.645$	0.06	−6.4

Synephrine supplements, curiously the study of Chappell et al. [13] has not even listed them as one of the 12 most common supplements used by the high-level natural bodybuilders. A possible explanation for the varying supplementation habits observed among participants could be the geographical differences, with our study predominantly involving Spanish participants and the study by Chappell et al. [13] focusing on British participants. Similar results were found when it comes to beverage intake. Nonetheless, a higher prevalence of the natural bodybuilders who consume beverages less than once per months was observed among natural bodybuilders belonging to the WB group compared to natural bodybuilders in the NWB group, as detailed in Table 3. This suggests greater discipline in avoiding unnecessary calorie intake during the pre-contest phase among WB participants. Also, excessive beverage intake was generally less present in WB compared to NWB group. Therefore, while supplementation patterns were largely similar, the disparity in Melatonin and P-Synephrine use and the greater discipline in beverage intake among WB bodybuilders suggest slightly distinct approaches to pre-contest preparation compared to NWB counterparts.

It is novel that the highest rates of supplement consumption in both groups were exhibited particularly for the products with scientific support such as creatine (~92–95%) and whey protein (~89–95%) [16]. It is plausible that natural bodybuilding athletes are increasingly gravitating towards supplements with a more robust scientific foundation. For instance, whey protein and protein bars have been reported as an effective tool for maintaining muscle mass and controlling hunger [5], while creatine is reported to be suitable for increasing phosphocreatine reserves to mitigate the low availability of carbohydrates, possibly allowing athletes to minimize the loss of training volume and intensity [31]. It is possible that the same factor contributed to the high prevalence of caffeine supplementation reported in both groups (>50%). Interestingly, the reported rates of creatine use in the present study are even higher than what has been reported in prior research [32]. These findings collectively suggest that supplement strategies do not significantly differ between more and less successful natural bodybuilding athletes.

Consistent with previous research comparing amateur and professional Spanish athletes [28], our findings reveal a lack of disparities in the consumption of beverages and sweeteners between the WB and NWB groups. As previous research supports, bodybuilders do not usually include tea, coffee or other beverages during their pre-contest phase [13], however, sweeteners are reported as a popular choice among bodybuilders [28]. Conflicting findings have been discussed in peer-reviewed literature concerning the effects of non-nutritive sweeteners for weight loss and weight loss management [33]. One potential rationale for the elevated utilization of sweeteners is the necessity for bodybuilders to adhere to severely restricted caloric intakes (e.g., <30 kcal/kg of lean body mass) during contest preparation [28]. This restrictive regimen may prompt them to seek non-nutritive sweeteners as a strategy to substitute calories and address cravings, potentially elucidating the elevated prevalence of non-nutritive sweetener consumption. This approach is novel and further research is needed to corroborate it.

While no disparities were detected in terms of supplementation practices, beverage consumption, or sweetener intake between the two groups, individuals in the WB group exhibited advanced age, greater competitive experience, and a more substantial level of participation in competitions during the most recent competitive year compared to their NWB counterparts. Moreover, the probability that the WB group demonstrated a more committed and rigorous approach to competition compared to the NWB group, evidenced by extended training experience, prolonged dietary measures, heightened water intake, and reduced initial and final body weight, surpassed the 50% threshold (all CLES ≥0.51). Previous study have reported similar tendency, showing differences in total muscle mass and age between professional and amateur elite natural bodybuilders [28]. The fact that the more successful natural bodybuilders are older than less successful is not surprising having in mind the muscle protein synthesis after resistance training is limited in comparison to athletes taking exogenous testosterone [34,35]. Additionally, muscle protein synthesis responses are shorter and peak earlier in trained subjects which may potentially limit protein accretion and consequently muscle growth in the long-term [35]. Therefore, the present study suggests for the first time that success in natural bodybuilding is more determined by the experience of the athletes than the nutritional ergogenic substances consumed.

Regarding supplement acquisition patterns, the most frequent pattern was that athletes (I) purchased their supplements on the

internet, (II) made the decision on their own to purchase their supplements, and (III) and learned about the supplements from their personal trainer or coach. Few studies have been published concerning the purchasing habits of bodybuilders, identifying that they mostly inquire about sport supplements at the gym (71.30%) followed by on the internet (64.99%) [5]. By contrast, in the present study most of the bodybuilders (70.9–78.9%) declared that they bought products from the internet followed by in a supplement store (26.3–29.7%). These divergent findings might be due to regional differences in the studied population, or because natural bodybuilders were specifically targeted. Intriguingly, although supplements were mainly "self-prescribed" (52.20%–57.90%) or suggested by personal trainers (47.4%–51.4%), a variety of other information sources were reported by athletes including social networks, research reviews and peer-reviewed scientific articles (16.2%–51.4%).

An important practical recommendation based on the study's findings is that success in natural bodybuilding is closely tied to athletes' competitive experience and training history. Therefore, athletes should prioritize long-term dedication to the sport, as this has a more substantial impact than specific supplementation strategies. Additionally, a deeper understanding of supplementation habits may lead to competition success and can help athletes to adjust their diets and supplementation more effectively, aiming for better results. However, although a positive shift towards seeking more scientifically based information about supplement benefits was noted, athletes should increase their consultation with healthcare providers, as they were rarely approached for information and supplement recommendations (in less than 10% of the occasions). In summary, a holistic approach combining long-term commitment and informed supplementation choices is key for success in natural bodybuilding.

The present survey has specific limitations that should be mentioned. Firstly, although this was an international sample of natural bodybuilders, it was predominantly from Spain with limited representation for other countries, with an overall modest sample size. Secondly, the sample was almost entirely male limiting generalizability of the present findings to female competitors, and to dissimilar or underrepresented regions. Thirdly, despite not being the main purpose of the study, neither qualitative nutritional analyses nor quantitative analyses of specific supplement ingredient doses were recorded. For this reason, it is unclear if the introduction of nutritional reports may have altered the interpretation of the current findings. Fourthly, although control questions were included to prevent inconsistencies in the responses, the anonymous nature of this survey makes possible to induce inaccuracies. Finally, this study has a cross-sectional design, which captures a single point in time and may limit its ability to provide a comprehensive understanding of athletes' supplementation practices over their entire athletic careers and the potential relationship with long-term performance outcomes.

5. Conclusions

The present study suggests that there are not specific supplementation protocols that are associated with natural bodybuilding competitive success. Rather, age (and perhaps training experience), competitive experience in bodybuilding and the number of shows per season an athlete has experienced are the primary factors which differ between WB and NWB. Notably, athletes' supplementation patterns are highly influenced by different sources of information, but rarely by healthcare providers. Natural bodybuilders mainly purchase their supplements through the internet, primarily via their own cognizance, without direct advice to do so from others. Overall, the ergogenic nutritional habits of natural bodybuilders seem to be less important than the experience of the athletes to achieve success in the competition.

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Ethics statement

The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board (Catholic University of Murcia; Code: CE012209).

Data availability statement

The final database can be downloaded through the following link: https://osf.io/cey6p/?view_only=506feea394b5478899a03afcba05f79a.

CRediT authorship contribution statement

Pablo Jiménez-Martínez: Writing – original draft, Project administration, Methodology, Formal analysis, Conceptualization. **Carlos Alix-Fages:** Writing – original draft, Supervision, Data curation, Conceptualization. **Eric R. Helms:** Formal analysis, Data curation. **Sergio Espinar:** Formal analysis, Data curation. **Henar González-Cano:** Formal analysis, Data curation. **Eneko Baz-Valle:** Formal analysis, Data curation. **Danica Janicijevic:** Writing – review & editing, Methodology. **Amador García-Ramos:** Writing – review & editing, Supervision. **Juan C. Colado:** Writing – original draft, Methodology, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e26730.

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