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Fueling for and recovering from resistance training: The periworkout nutrition practices of competitive powerlifters

Andrew King PgDip [a,*], Kedric Kwan MSc [a], Ivan Jukic PhD [a], Caryn Zinn PhD [a], Eric Helms PhD [a,b]

[a] *Sport Performance Research Institute New Zealand (SPRINZ), Auckland University of Technology, Auckland, New Zealand*
[b] *Department of Exercise Science and Health Promotion, Muscle Physiology Laboratory, Florida Atlantic University, Boca Raton, Florida, USA*

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ABSTRACT

Purpose: Nutrient timing is a concept that emphasizes the intentional ingestion of whole or fortified foods, and dietary supplements, to adequately fuel for, and recover from, acute and chronic exercise. The nutrition strategies used by powerlifters around training sessions have not, to our knowledge, been previously investigated. This study explored the self-reported periworkout (before, during, and after) nutrition practices of competitive powerlifters, including what, why, and information source that informed practice, with comparison to current sport nutrition guidelines.
Methods: Actively competing male (n = 240) and female (n = 65) powerlifters completed a cross-sectional online survey of self-reported periworkout nutrition practices in the pre-, intra-, and postexercise periods, fasted training, and supplementation. Data are presented as the number (n) and percentage (%) of all powerlifters practicing a given strategy followed by a % of responses reporting various practices or beliefs within this strategy. Categorical subgroups (sex, age, and weight class; and competitive caliber) were analyzed with a chi-square test or Fisher's exact test and denoted where significant ($P \leq 0.05$).
Results: Most powerlifters reported paying specific attention to nutrition practices in the pre-exercise period (n = 261; 85.6%) by ingesting more carbohydrate (CHO) rich foods (n = 234; 89.6%) for the purpose of assisting in training performance (n = 222; 85.1%). Most powerlifters reported intraexercise nutrition strategies (n = 211; 69.2%), of which most included ingesting more CHO rich foods (n = 159; 74.5%) for the purpose of feeling less hungry and/or boosting energy levels during training (n = 129; 61.1%). Most powerlifters reported paying attention to postexercise nutrition (n = 244; 80%), by ingesting more protein rich foods (n = 182; 74.6%) for the purpose of recovering better for the whole day (n = 152; 62.3%) and enhancing the benefits of training (n = 149; 61.1%). Most powerlifters did not complete training sessions in the fasted state (n = 262; 85.9%). Most powerlifters reported paying attention to supplementation before training (n = 237; 77.7%), of which preworkout formulas (n = 137; 57.8%), energy drinks (n = 101; 42.6%), creatine (n = 88; 37.1%), and caffeine pills (n = 70; 29.5%) were most reported. Supplementation was used to assist in training performance (n = 197; 83.1%) and increase wakefulness/alertness (n = 183; 77.2%). Males reported more often than females that they informed multiple elements of their nutrition practices with the information they *read or watched somewhere* (P = 0.002−0.012).
Conclusion: The periworkout nutrition practices used by competitive powerlifters followed current sport nutrition guidelines, by using CHO sources to fuel for training and ensuring the provision of protein postexercise. Competitive powerlifters may wish to exert caution with supplementation, as there is a risk of harm or inadvertent doping.

Introduction

Powerlifting is a strength sport that includes three main lifts: the back squat, bench press, and deadlift. Powerlifters are distinguished in classes by weight, sex, and age, and whether they use supportive lifting equipment or not (equipped and classic,

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*Corresponding author. Tel.: +64 021 059 7432.
E-mail address: andrew.king@aut.ac.nz (A. King).

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respectively). Performance is determined by the athlete with the greatest cumulative load lifted across the three lifts, in the respective class. In this regard, the primary goal of the powerlifter is to improve maximal strength via training and nutrition. Resistance training (RT), as completed by powerlifters, results in several adaptations favorable for maximal strength development, such as neuromuscular adaptation (e.g., increased motor unit recruitment, skill acquisition), changes in muscle architecture, and the accumulation of lean muscle mass (i.e., hypertrophy) [1,2]. Of these, skeletal muscle hypertrophy is a strong predictor of performance in powerlifting [3,4]. Accordingly, nutrition strategies are of interest longitudinally to support adaptation, and acutely, to adequately fuel for and recover from individual training sessions. For instance, energy intake across the competitive calendar may be periodized depending on the phase of training (e.g., off-season or competition preparation) to optimize body composition (e.g., lean mass accumulation and body weight manipulation) [5]. On the other hand, acute nutrition strategies may include rapid weight loss for powerlifters in a weight class with an upper limit in the days/hours before competition [6], or the deliberate timing of macronutrients and/or supplements before, during, and after training or competition to aid performance.

Nutrient timing is the intentional ingestion of whole and fortified foods, and dietary supplements, to fuel for and recover from acute and chronic exercise [7]. Nutrient timing research typically considers carbohydrates (CHO) and protein of primary interest, as the role of timing dietary fat for athletes performing RT is not clear [7]. The timing of CHO is of consideration due to its role as an important fuel source during higher intensity exercise, of which CHO's stored form in skeletal muscle, muscle glycogen, is of particular importance for fueling high intensity muscle contraction [8]. Indeed, the acute ingestion of CHO improves RT volume performance in some circumstances [9]. In addition, dietary protein is of interest as it is a trigger of, and substrate for, muscle protein synthesis, which is the incorporation of acids into bound skeletal muscle proteins (e.g., myofibrillar and mitochondrial proteins) [10]. RT also triggers the synthesis of myofibrillar proteins [11], which—acting synergistically with essential amino acids derived from dietary protein [12,13]—contribute to skeletal muscle mass accumulation. Overall, there is potential for the timed ingestion of macronutrients to affect training performance and chronic adaptation of competitive powerlifters.

In addition to the provision of key macronutrients, dietary supplementation around training is of interest to RT athletes both for its potential effects on acute training performance and chronic adaptation (i.e., strength and muscle gain). For example, there is robust evidence that daily creatine monohydrate supplementation improves strength and body composition indices [14–16] and caffeine ingestion improves outcomes of muscle strength, power, and endurance [17,18]. The efficacy of these supplements on exercise performance is reflected in the International Olympic Committee's (IOC) position statement on dietary supplements [19] and the International Society of Sport Nutrition's position stand on caffeine [20]. However, many dietary supplements often lack robust evidence supporting their effects on health and performance, may cause adverse side-effects, and can contain contaminants, underdosed primary ingredients, and banned substances [21–23]. Therefore, different acute nutrition strategies have the potential to either positively influence training performance and chronic adaptation, or in some cases undermine health and performance.

Previously, the general nutrition practices of powerlifters were reported [24], but to our knowledge, no previous study has explored the nutrition strategies used by powerlifters before, during, and after their training sessions. Therefore, we surveyed actively competing powerlifters on their current acute nutrition practices around training (pre-, intra-, and postexercise) and use the term "periworkout nutrition" as an umbrella term to reflect these acute nutrition practices [25]. An exploration of the periworkout nutrition practices used by competitive powerlifters allows for a current account of these athletes' practices, the reasoning for their practices, and a discussion of how current periworkout nutrition practices relate to sport nutrition guidelines.

Methods

The methods of the present study were published in full previously [24]. An open invite, anonymous international survey was built using Qualtrics software (Seattle, WA, USA) and distributed via social media between November 2020 and February 2021 to investigate the self-reported nutrition practices and beliefs of competitive powerlifters. Participant inclusion criteria were to 1) be 18 y of age or older, and 2) have competed in a drug-free sanctioned powerlifting competition within the previous 18 months. The study protocol was approved by the Auckland University of Technology Ethics Committee (20/312).

Survey content

The questionnaire was split into ten sections, of which the last five (i.e., periworkout nutrition practices) are of interest in this manuscript. In order of appearance, Section 1 covered participants' descriptive characteristics and training history. Sections 2 to 5 covered nutrition practices across the competitive cycle, within specific competitive phases (e.g., the offseason or competition phase), on harder training days, and on easier training days, respectively. The results for sections 1 to 5 were reported previously [24]. The last five sections (sections 6–10) covered pre-exercise nutrition, postexercise nutrition, fasted training, intraexercise nutrition, and supplementation practices, respectively. A full transcript of the questionnaire with display logic can be found in Supplementary File I.

Definitions for concepts were provided to participants in the survey. A hard training day was defined as a high volume and/or high intensity session. A rest/easier training day was defined as passive or active recovery or a lower volume accessory day where none of the three powerlifting lifts were completed. A key training session was defined as a high quality/intensity session consisting of at least one of the powerlifting movements (including variations/derivatives). Fueling was defined as eating foods before training. Fasting was defined as the completion of a training session without eating food or calorie containing drinks in the 8 h prior.

Statistical analysis

Only fully completed questionnaires were analyzed. Missing data checks were performed to verify data integrity. Descriptive data were presented as number (n) and percentages (%). Categorical data were assessed by chi-square test and Cramer's V (φ_c). Where >20% of cells had an expected count of less than 5, Fisher's exact test was used. For the weight-class subgroup (4 × 2 contingency table), a follow-up individual chi-square test (or Fisher's exact test where the >20% expected count rule was violated) with Holm-Bonferroni correction was performed when a statistically significant result was observed. Cramer's V was interpreted as negligible (0.00 and under 0.10), weak (0.10 and under 0.20), moderate (0.2 and under 0.4), relatively strong (0.4 and under 0.6), strong (0.6 and under 0.8), and very strong association (0.8–1.0) [26]. Statistical significance was set at $P \le 0.05$. Data were prepared and analyzed in SPSS (version 27.0; IBM Corp, Armonk, NY), and follow-up chi-square and Fisher's tests were completed in R language for statistical computing (R Foundation for Statistical Computing, Vienna, Austria, 2021; Version 4.2.2) using the *Fifer2* package (https://github.com/dustinfife/fifer2/). The dataset and analysis code are available on the Open Science Framework: https://osf.io/xdu7s/.

Participants could select multiple answers for most questions; therefore, the percentage of responses for some questions could add up to more than 100%. Text answers to "other" responses were grouped into common themes/responses by the primary investigator (A. K.). Responses were analyzed by subgroups based on competitive division (males versus females), age class (subjuniors and juniors [SJ + J] versus open and masters [O + M]), weight class (women's under 63, 57, 52, and 47 kg classes [W63-] versus women's under 72, 84 kg classes and 84 kg plus class [W72+] versus men's under 83, 74, 66, 59, and 43 kg classes [M83-] versus men's under 93, 105, 120 kg classes and 120 kg plus class [M93+]), and competitive caliber (i.e., IPF points where higher values indicate stronger powerlifters relative to bodyweight) from the best three-lift total in competition (less than 80 IPF points [79- IPF] versus 80 IPF points or more [80+ IPF]).

Results

Descriptive statistics for the participant sample are presented in Figure 1.

Question 1. Pre-exercise nutrition

Overall, 85.6% (n = 261) of participants reported paying attention to fueling within 1 to 4 h before key training sessions, of which 89.6% (n = 234) ate more CHO rich foods and 85.1% (n = 222) reported paying attention to pre-exercise nutrition to assist with training performance. Males more often than females (P = 0.020; φ_c = 0.133), M83+ more often than W63- (P = 0.026; φ_c = 0.218), and SJ + J more often than O + M (P = 0.036; φ_c = 0.120), reported drinking more calorie containing drinks before training. Regarding why specific attention was paid to pre-exercise nutrition, 80+ IPF more often than 79- IPF reported feeling more energized for the day (P = 0.013; φ_c = 0.143) and SJ + J more often than O + M reported that they like to not feel hungry for the training session (P = 0.005; φ_c = 0.160). The detailed results for pre-exercise nutrition practices are presented in Figure 2.

Males more often than females reported informing their pre-exercise nutrition practices by *reading or watching something* (P = 0.004; φ_c = 0.167) and from their *training partner* (P = 0.032; φ_c = 0.122). M83- (P = 0.031; φ_c = 0.227) and M93+ (P = 0.031; φ_c = 0.228) more often reported informing their pre-exercise nutrition practices by *reading or watching something* than W72+. The information sources used to inform pre-exercise nutrition practices are comprehensively presented in Table 1.

Question 2. Intraexercise nutrition

Overall, 69.2% (n = 211) of participants reported consuming food and/or calorie containing drinks during training. CHO rich foods were most common (74.5%, n = 159) and their consumption was more often reported by 80+ IPF than 79- IPF (P < 0.001; φ_c = 0.212). 80+ IPF more often than 79- IPF reported consuming more calorie-containing energy drinks (P = 0.032; φ_c = 0.123). O + M more often than SJ + J reported consuming more protein drinks (P = 0.046; φ_c = 0.114). Regarding the purpose of intrasession nutrition, 61.1% (n = 112) answered that it made them feel less hungry or boosted energy levels, which was reported more often by 80+ IPF than 79- IPF (P = 0.044; φ_c = 0.115) and SJ + J than O + M (P = 0.035; φ_c = 0.121). 80+ IPF more often than 79- IPF reported that intrasession nutrition is used to aid training performance (P = 0.006; φ_c = 0.157) and a part of consuming enough calories over the day to support hard training (P = 0.004; φ_c = 0.164). 79- IPF more often than 80+ IPF reported not consuming food during training (P = 0.009; φ_c = 0.151) because they felt it did not help training performance (P = 0.002; φ_c = 0.176) or that it caused digestive issues (P = 0.035; φ_c = 0.121). The detailed results for intraexercise nutrition practices are presented in Figure 3.

Males more often than females (P = 0.002; φ_c = 0.179) reported informing their intraexercise nutrition practice by *reading or watching something*. SJ + J more often than O + M reported informing their intrasession nutrition practice from their *coach* (P = 0.009; φ_c = 0.149). The information sources used to inform intraexercise nutrition practices are comprehensively presented in Table 1.

Question 3. Postexercise nutrition

Overall, 80% (n = 244) of participants reported paying attention to postexercise nutrition, of which 152 (62.3%) and 149 (61.1%) reported recovering better for the whole day and an enhancement of the benefits from the training session as the purpose, respectively. Protein rich foods were most popularly selected (74.6%, n = 182), which SJ + J more often reported than O + M (P = 0.004; φ_c = 0.165). 80+ IPF more often than 79- IPF reported eating more foods in general after training (P = 0.007; φ_c = 0.155) and 79- IPF

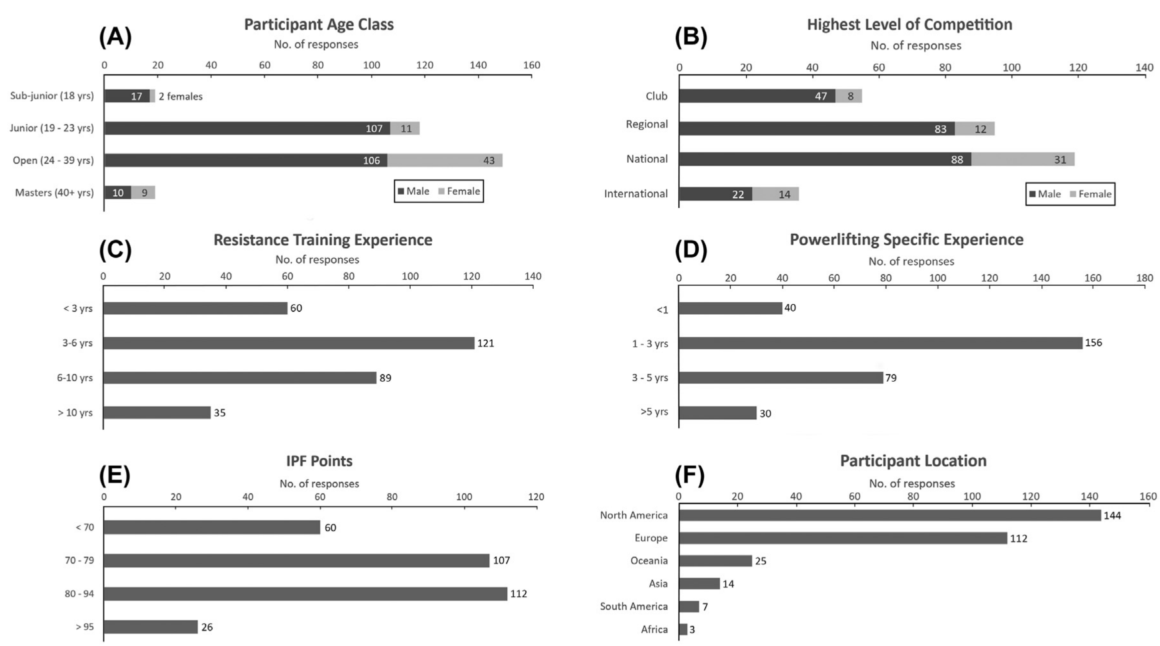

Figure 1. Descriptive participant characteristics of (A) age class, (B) competitive caliber, (C) resistance training experience in years, (D), powerlifting specific experience in years, (E) International Powerlifting Federation (IPF) points based on best total in competition, and (F) participants location. For (F), participants were from 47 countries, which were grouped by continent.

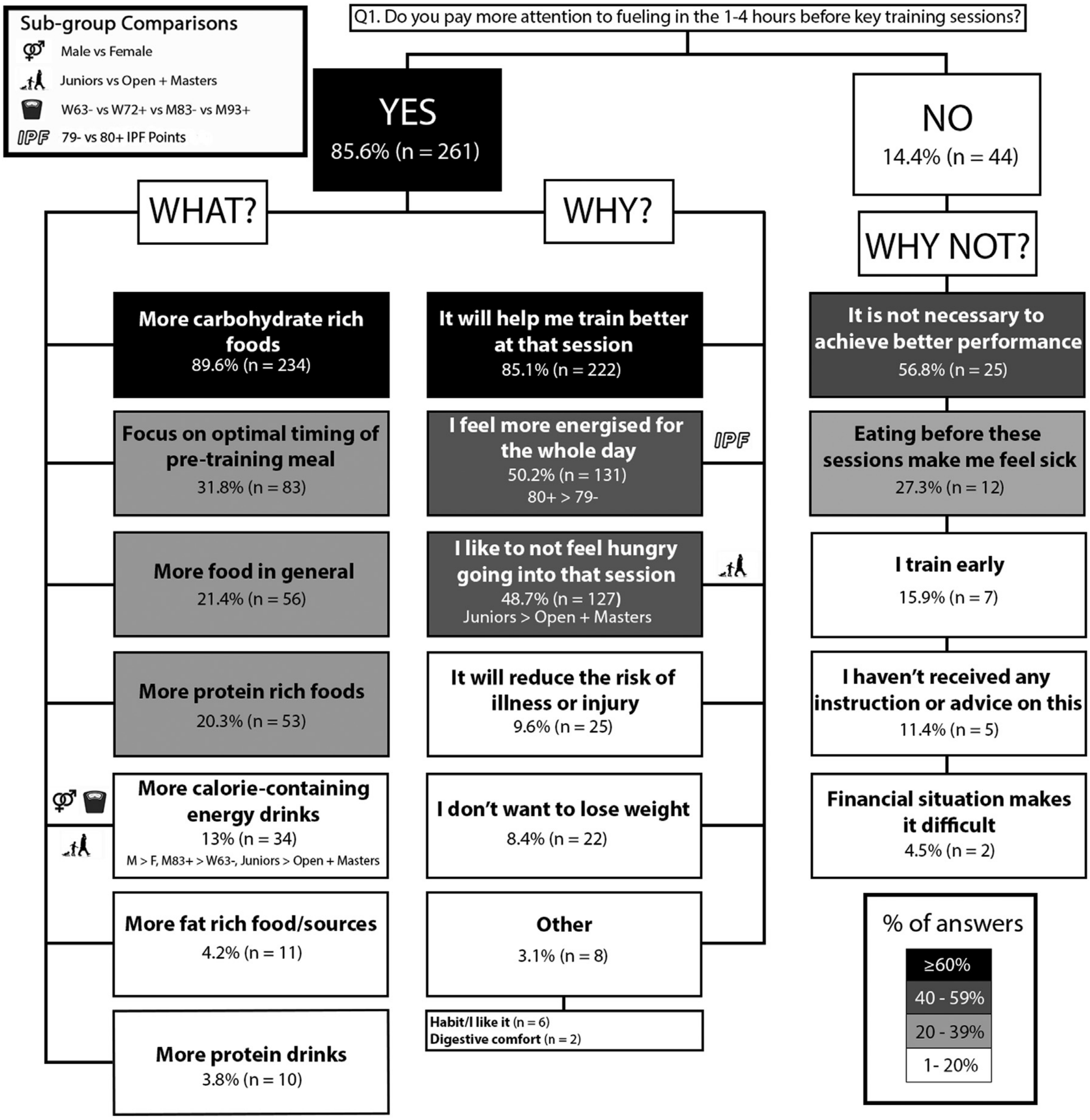

Figure 2. Q1: Pre-exercise nutrition practices of 305 actively competing powerlifters. The prevalence of reported specific attention being paid to fueling in the 1 to 4 h before a key training session, and the reason for following this practice. Percentages (%) are presented as the proportion of all participants that chose a specific answer (YES/NO), followed by a % of responses reporting various practices and reasons within these strategies. Number (n) of participants has been provided. Answer boxes and circles are color coded based on the % of responses: ≥ 60%, black box with white font; 40 to 59%, dark grey box with white font; 20 to 39%, light grey with black font; < 20%, white box with black font. Symbols are used to indicate statistical significance from chi-square (or Fisher's Exact) test between subgroups for sex (vector sex symbol), age class (human life cycle symbol), weight class (weight scale symbol), and International Powerlifting Federation (IPF) points (IPF symbol). Where significant differences were detected, the direction of difference is indicated in the corresponding box/circle (e.g., males reported more often than females would be indicated by M > F).

more often than 80+ IPF reported not paying specific attention to postexercise nutrition ($P = 0.029$; $\varphi_c = 0.125$). The detailed results for postexercise nutrition practices are presented in Figure 4.

Males more often than females ($P = 0.003$; $\varphi_c = 0.170$), SJ + J more often than O + M ($P = 0.010$; $\varphi_c = 0.147$), and 80+ IPF more often than 79- IPF ($P = 0.025$; $\varphi_c = 0.128$) reported informing their postexercise nutrition practice with information from *reading or watching something*. O + M more often than SJ + J reported *a scientist* as the source of information for their postnutrition practice ($P = 0.031$; $\varphi_c = 0.124$). Males more often than females reported that their attention to postexercise nutrition was informed from their *training partner* ($P = 0.046$; $\varphi_c = 0.114$). 79- IPF more often than 80+ IPF reported informing their practice of not paying specific attention to postexercise nutrition with information from *reading or watching something* ($P = 0.007$; $\varphi_c = 0.155$). The information sources used to inform postexercise nutrition practices are comprehensively presented in Table 1.

Question 4. Fasted training

Overall, 85.9% ($n = 262$) of participants did not complete any training sessions in the fasted state. The most common reasons were that fasted training impairs performance (76.7%, $n = 201$) and to avoid training while feeling hungry (72.1%, $n = 189$). SJ + J more often than O + M reported that they did not go 8 h without eating

Table 1
Source of information informing periworkout nutrition practices of powerlifters

Question	Answer	Source of information (n)									
		No specific source	*I read/ watched it*	*Coach*	*Sport Nutr.*	*Dietician*	*Scientist*	*Friend*	*Training partner*	*Personal trainer*	*Other*
Do you pay more attention to fuelling in the 1 to 4 hours before key training sessions?	Yes (n = 261)	79	119†,§	74	51	21	26	19	16†	7	18
	No (n = 44)	37	3	4	2	1	0	0	0	0	1
Do you consume food and/or calorie containing drinks during training?	Yes (n = 211)	96	74†	37‡	28	10	16	10	14	5	8
	No (n = 94)	78	8	5	4	3	2	0	0	0	1
Do you pay more attention to your nutrition after key training sessions?	Yes (n = 244)	73	114†,‡,‖	70	48	16	19	14	14†	8	14
	No (n = 61)	43	16#	3	3	2	3	0	1	1	2
Do you intentionally complete training sessions in the fasted state?	Yes (n = 43)	33	6	2	0	1	0	0	1	0	2
	No (n = 262)	163	62†	33	28	12	18	8	10	8	6
Do you pay attention to supplementation in the 2 h preceding training sessions?	Yes (n = 237)	85	106†	54	39	17	34	20	20†,‡	13	9
	No (n = 68)	49	15	3	3	1	5	1	1	0	2

Significant differences ($P < 0.05$) of chi-square (or Fisher's Exact test) marked as: † male > female; ‡ Juniors > Open + Masters; ¶ Open + Masters > Juniors; § M83- & M93+ > W72+; ‖ 80+ IPF Points > 79- IPF Points; # 79- IPF Points > 80+ IPF Points.
Data are presented as numerical frequencies.
Sport Nutr Sport Nutritionist.
"Other" includes medical doctor, physiotherapist, and family member.

(P = 0.031; φ_c = 0.123). Of the participants (14.1%, n = 43) that completed at least some training sessions in the fasted state, fasted training most often occurred the morning after an overnight fast (81.4%, n = 35) and because it was more convenient to go straight to training than eat first (86%, n = 36). The detailed results for fasting practices are presented in Figure 5.

Males more often than females (P = 0.012; φ_c = 0.144) reported informing the practice of not completing fasted training with information from *reading or watching something*. The information sources used to inform fasting practices are comprehensively presented in Table 1.

Question 5. Supplementation

Overall, 77.7% (n = 237) of participants reported paying attention to supplementation in the 2-h preceding training. O + M more often than SJ + J reported paying attention to supplementation for all key sessions. SJ + J more often than O + M reported paying

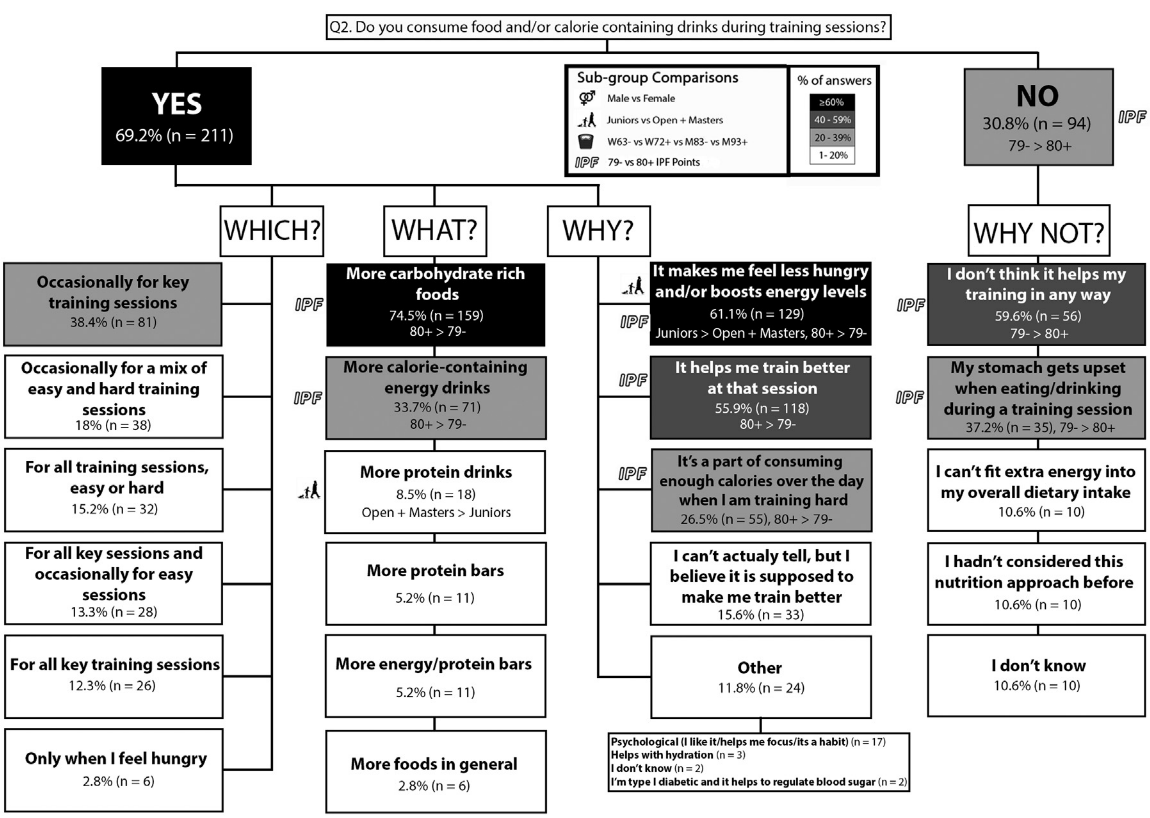

Figure 3. Q2: Intraexercise nutrition practices of 305 actively competing powerlifters. The prevalence of consuming food and/or calorie containing drinks during training sessions (YES/NO), followed by the type of training session, what is consumed, and the reason for this practice. Description of how to interpret is in the Figure 2 caption.

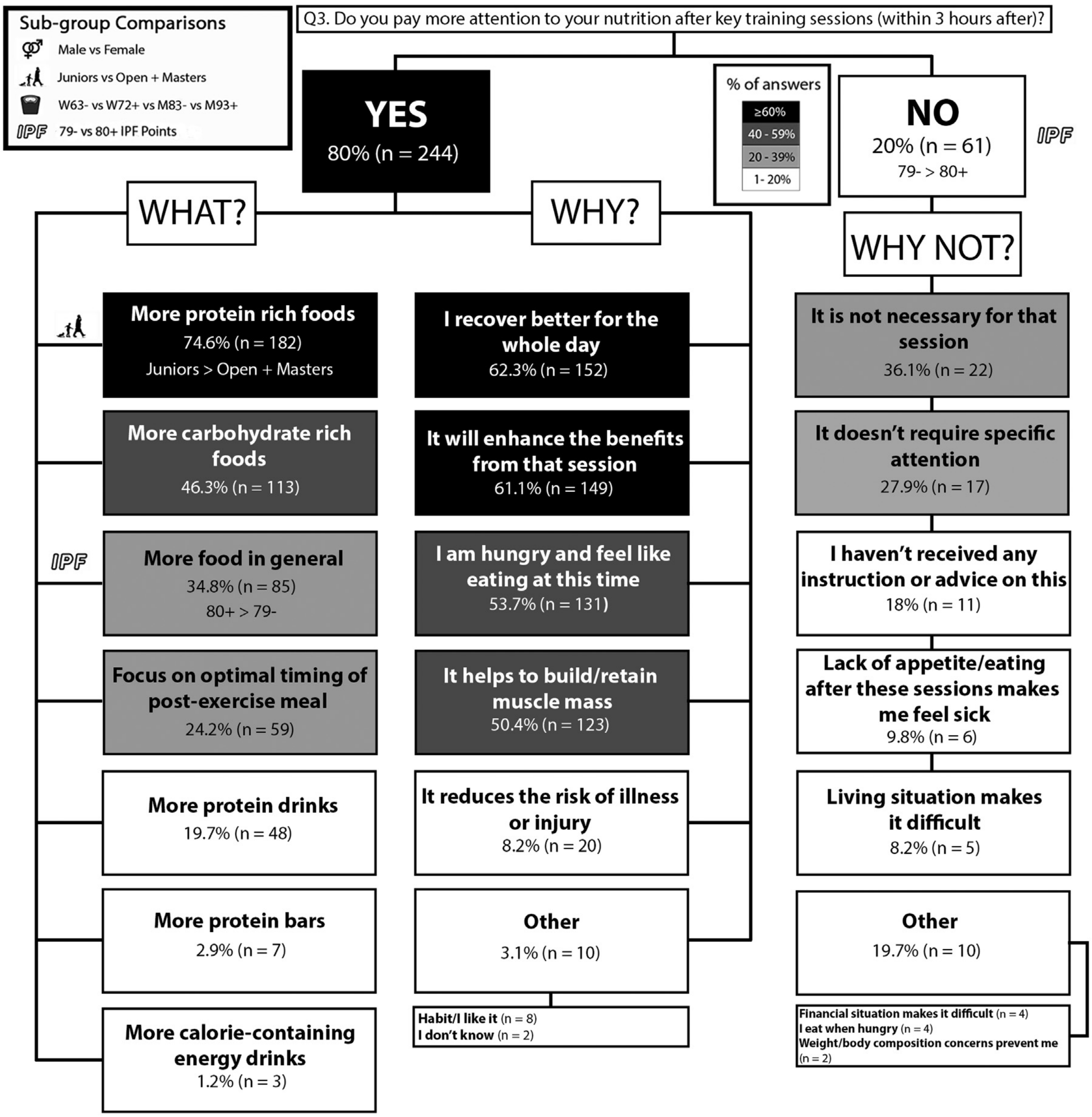

Figure 4. Q3: Postexercise nutrition practices of 305 actively competing powerlifters. The prevalence of reported specific attention being paid to nutrition after a key training session (within 3 h) (YES/NO), followed by what foods or calorie containing drinks are consumed, and the reasons for following this practice. Description of how to interpret is in the Figure 2 caption.

attention to supplementation for all key sessions and occasionally for easy sessions ($P = 0.011$; $\varphi_c = 0.145$). Regarding supplementation type, 80+ IPF more often than 79- IPF reported supplementing with an energy drink ($P = 0.042$; $\varphi_c = 0.116$) or creatine ($P = 0.038$; $\varphi_c = 0.119$). Males more often than females reported pre-exercise supplementation with caffeine pills ($P = 0.021$; $\varphi_c = 0.132$) and nitric-oxide precursors ($P = 0.018$; $\varphi_c = 0.152$). Regarding why supplementation is used, 83.1% ($n = 197$) reported using supplementation to assist in training performance which was more often reported by males than females ($P = 0.009$; $\varphi_c = 0.150$) and M83- than W72- ($P = 0.036$; $\varphi_c = 0.241$). 80+ IPF more often than 79- IPF reported that supplementation helped them feel fuller for the training session ($P < 0.001$; $\varphi_c = 0.210$). The detailed results for supplementation practices are presented in Figure 6.

Males more often than females reported a focus on supplementation with information from *reading or watching something* ($P = 0.002$; $\varphi_c = 0.178$) and/or from their *training partner* ($P = 0.016$; $\varphi_c = 0.138$). SJ + J more often than O + M reported that their focus on supplementation was informed by their *training partner* ($P = 0.020$; $\varphi_c = 0.134$). The information sources used to inform supplementation practices are comprehensively presented in Table 1.

Discussion

The purpose of the current study was to explore the peri-workout nutrition practices of competitive powerlifters. There are several key findings: 1) Most powerlifters focus on the provision of CHO before and during training to aid training performance and boost energy levels; 2) most powerlifters do not complete training sessions fasted; 3) most powerlifters emphasize protein ingestion after training to aid in recovery and

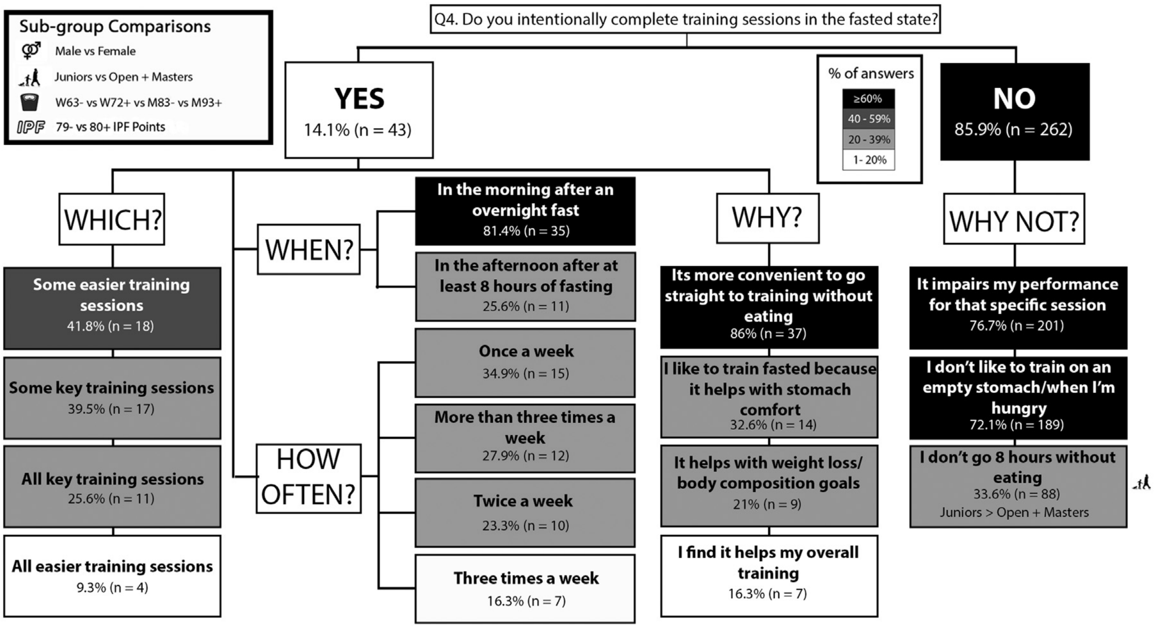

Figure 5. Q4: Fasted training nutrition practices of 305 actively competing powerlifters. The prevalence of reported intentional fasted training (YES/NO), and the reasons for following this practice. Description of how to interpret is in the Figure 2 caption.

enhance the benefits of training; and 4) most powerlifters report using supplementation for at least some training sessions to aid performance and increase wakefulness/alertness. Regarding the source of information that informed periworkout nutrition practice, there was a trend for males to report using information from *reading or watching something* more often than females. Various subgroup differences were detected, although there were no clear trends, and the associations were generally weak to moderate which limits the interpretation of the practical significance of the detected differences. Overall, these findings suggest that competitive powerlifters follow current sport nutrition guidelines.

Pre- and intraexercise fueling strategies

Most powerlifters reported paying more attention to fueling in the 1 to 4 h before key training sessions, of which most reported emphasizing CHO ingestion (Fig. 2). Similarly, over two thirds reported consuming food and/or calorie containing drinks during at least some training sessions, of which most reported an emphasis on CHO provision (Fig. 3). Along with phosphocreatine stores, CHO is an important metabolic fuel source during moderate to high-intensity exercise [27,28], of which the stored form of CHO in skeletal muscle, muscle glycogen, is considered of particular importance for higher-intensity exercise [8]. CHO may also have an influence on exercise performance via central mechanisms in which receptors of the mouth sense the presence of CHO and relay messages to the regions of the brain associated with reward and motivation [29]. Current sport nutrition guidelines recommend consuming CHO solely or with protein before and during RT for the purpose of augmenting muscle glycogen stores (that may acutely improve training performance) and promoting positive nitrogen balance, respectively [7]. Indeed, CHO ingestion before and during RT improves total session training volume performance for longer duration training sessions (>45 min), where the fast duration before training is longer (>8 h), and the ergogenic effect is larger when more sets are performed [9]. Thus, the pre-exercise (Fig. 2) and intraexercise (Fig. 3) nutrition practices of competitive powerlifters reported in the current study agree with current sport nutrition recommendations.

Postexercise nutrition practices

Most powerlifters reported paying more attention to nutrition within 3 h following training, of which most reported consuming more protein foods for the purpose of recovering better for the whole day and enhancing the benefits from training (Fig. 4). Current sport nutrition recommendations advise athletes to ingest 0.3 g/kg body weight of protein postexercise [30], as the essential amino acids derived from dietary protein are used to stimulate muscle protein synthesis and repair [31]. However, muscle protein synthesis is upregulated for at least 24 h following RT [32]; thus, it has been argued that a focus on protein intake in the few hours following training (referred to as the "anabolic window") is likely unnecessary if sufficient total daily dietary protein is consumed [33]. Indeed, there is no significant effect of protein timing on muscle hypertrophy where total daily protein intake is controlled for [34]. Thus, while the timing of protein may not be imperative, postexercise protein ingestion may be prudent for powerlifters as a practical strategy that promotes adequate total daily protein intake across the day. Authors of recent meta-analyses recommend a daily protein intake ≥1.6 g/kg body mass to optimize lean mass accretion with RT [35], but up to 2.2 g/kg BM for those wishing to maximize potential muscle gains [36]. Similarly, 1.5 g/kg daily total protein is sufficient to support strength gain with RT [37]. It should be noted that higher protein intakes are generally advised for RT athletes in a caloric deficit to aid in the preservation of lean mass [31], which is often used by powerlifters competing in weight restricted classes leading into competition. However, there are few trials [38–41] investigating the effects of higher versus lower protein intakes with RT on body composition outcomes, precluding firm recommendations for total daily protein intake during caloric deficit. Aiming for at least ~2.2 g/kg body mass daily protein during caloric deficit may be a simple strategy for powerlifters to

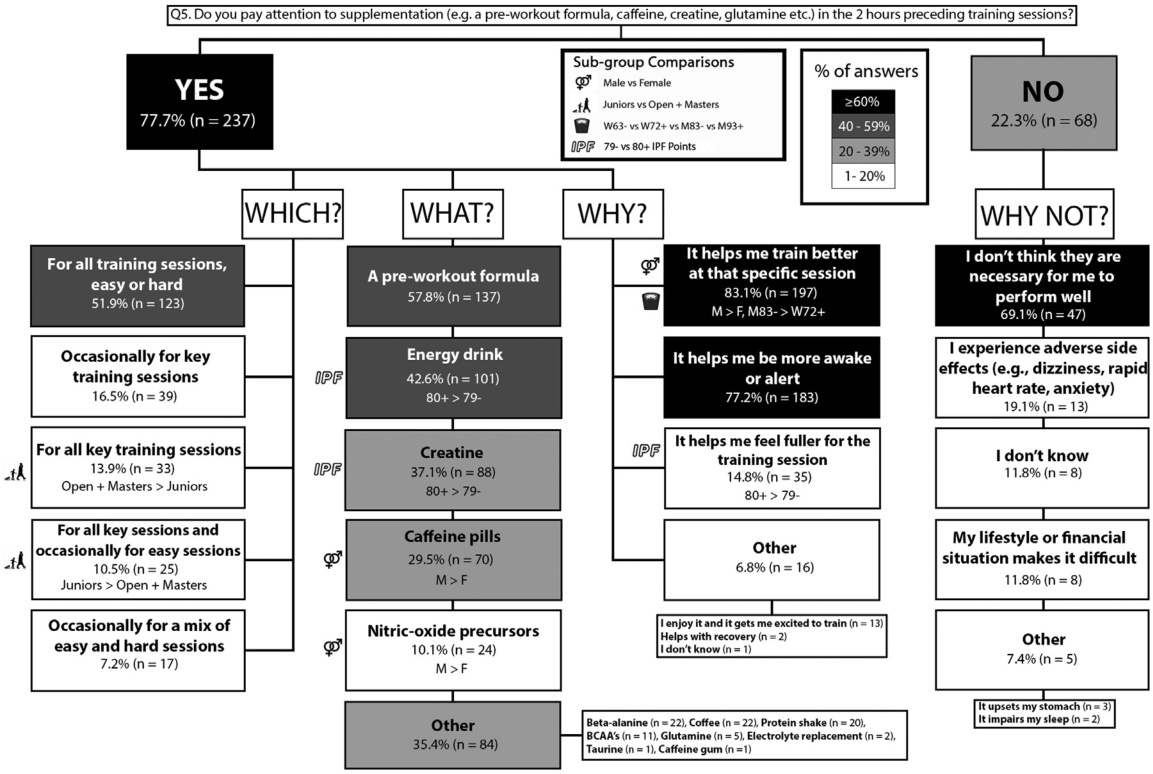

Figure 6. Q5: Pre-exercise supplementation practices of 305 actively competing powerlifters. The prevalence of reported specific attention to pre-exercise supplementation (YES/NO), followed by which training session, what type of supplement, and the reasons for following this practice. Description of how to interpret is in the Figure 2 caption.

employ. Overall, ensuring that at least 1.6 g/kg body mass total daily protein is ingested supports strength and lean mass accumulation for the powerlifting athlete, and higher intakes may be required for powerlifters undergoing caloric restriction (~2.2 g/kg BM).

In addition to protein intake, current sport nutrition recommendations also emphasize postexercise CHO ingestion to facilitate the replenishment of glycogen stores, which is a key fuel source for high intensity exercise [7,30]. Just under half (46.3%, n = 113) of powerlifters who reported emphasizing postexercise nutrition ate more CHO (Fig. 4). Recommendations for postexercise CHO ingestion aim to maximize the refueling time after bouts of exercise that are highly dependent on CHO as a fuel source, especially in preparation for a second session later in the day (e.g., am and pm sessions). However, current postexercise CHO recommendations are based on endurance exercise where multiple, potentially glycogen depleting, training sessions may be completed per day. RT induces a comparatively modest decrement in total muscle glycogen stores (24–40%) [28,42,43], and powerlifters often complete one session per day (which may not include the same muscle groups), making the applicability of common sport nutrition recommendations to strength sports less specific. Indeed, a postexercise meal delivering 1.5 g/kg CHO was sufficient to mostly replenish (91%) muscle glycogen stores 6-h after exhaustive leg extension RT [44]. Thus, for the powerlifter performing one training session per day, personal preference can guide food selection and timing of postexercise meals and snacks. This practice will likely be sufficient to meet training demands assuming athletes achieve a moderate intake of daily dietary CHO (3–7 g/kg body weight) to support glycogen replenishment, as outlined by current sport nutrition guidelines for strength/power athletes [45].

Supplementation

Most powerlifters reported paying attention to supplementation practices in the 2 h preceding training and just over half reported paying attention to supplementation before all training sessions (Fig. 6). The most common reasons for supplementation were to assist with training performance and to help with wakefulness and alertness (Fig. 6). Despite the ubiquity of supplements on the market, few have demonstrated robust effects on exercise performance. Current recommendations identify caffeine, creatine (monohydrate), nitrate, sodium bicarbonate, and possibly beta-alanine as dietary supplements that directly improve sports performance [19], of which caffeine and creatine monohydrate have robust evidence that demonstrates an ergogenic effect relevant to RT performance [46,47]. In the present study, powerlifters reported the use of caffeine as a single nutrient (caffeine pills) and in multi-ingredient products/drinks (preworkout formulas, energy drinks, coffee) in the hours preceding training. Current recommendations are to ingest a caffeine dose of 3 to 6 mg/kg body mass caffeine ~60 mins before exercise [19,20]. However, lower doses of caffeine (1–2 g/kg body mass or 1–2 cups of coffee) similarly confer a small ergogenic effect on resistance training performance as higher doses [48]. Caffeine is a stimulant, and higher doses of caffeine may cause adverse side-effects (e.g., loss of sleep, elevated heart rate, nervousness, abdominal discomfort) [20,49]. Thus, it may be prudent for athletes to start with a lower dose of caffeine (i.e., 1–2 g/kg body mass), which is then gradually increased to ascertain an appropriate ergogenic dose that considers individual response and tolerance. Unlike the acute effects of caffeine, the ergogenic effect of creatine arises with chronic supplementation that saturates intramuscular creatine stores [50]. Current guidelines are for athletes to consume

3 to 5 g/day of creatine monohydrate, with higher doses for larger athletes (5−10g/day) [47]. Taken together, only a few supplements (i.e., caffeine and creatine) are backed by robust evidence, and those that are, confer small effects on training performance.

The term “supplementation” was not defined for participants in the current study, and the posed question emphasized acute ingestion before a training session and offered examples of what could be considered ergogenic supplements or sports foods [51]. The IOC defines a dietary supplement as: “A food, food component, nutrient, or nonfood compound that is purposefully ingested in addition to the habitually-consumed diet with the aim of achieving a specific health and/or performance benefit” [19]. Supplementation may also be used by powerlifters outside of the pre-exercise timeframe and for a variety of purposes beyond training performance that may include medicinal, general health and well-being, and sponsorship reasons. These reasons and their prevalence require future exploration. Survey data generally indicate that supplement usage is more common in males than females, and usage increases with the level of training/performance and age [19,52]. In the current study, there were no subgroup differences reporting yes/no to specific attention to supplementation in the hours preceding training. SJ + J more often than O + M reported using supplementation occasionally for easy sessions in addition to all key sessions. This may reflect a greater frequency of use across all training sessions for younger powerlifters, although this subgroup difference was a weak association (φ_c = 0.145) and should be interpreted with caution. Females generally report using supplementation for health purposes; whereas, males more often report supplementation to enhance performance [52]. This agrees with the findings of the present study, as males reported using pre-exercise supplements for the purpose of training better at that specific training session more often than females.

It should be noted that while most powerlifters using supplementation did report a source of information informing their practice (*n* = 152, 64.1%), a minority reported *sport nutritionist* (*n* = 39, 16.2%) or *dietician* (*n* = 17, 7.2%) guidance in their decision making, with no subgroup differences (i.e., age, sex, and weight class, or competitive caliber) for nutrition professional informed decisions. Some supplements may contain underdosed active ingredients [19], or excessive doses of potentially toxic ingredients [53]. Indeed, adverse health effects associated with supplementation have been reported in the literature [54,55]. In addition, anabolic androgenic steroids, ephedrine, and stimulants (or metabolites thereof) have been reported in dietary supplements [56,57], and are highly prevalent in commercial sport nutrition supplements [58], which may increase the risk of inadvertent doping and a violation of antidoping rules for powerlifters competing in drug-tested federations. Given these risks, the costs and benefits of supplementation need to be carefully weighed and lower risk supplements may wish to be sought. Third-party, independent testing (e.g., ConsumerLab, Informed Sport, Banned Substances Control Group) of supplements, identified by seals/markers on the product of the third-party company used, may provide some assurances regarding lower risk products [22]. There are also numerous online resources available for athletes, such as those established in the UK (http://sport.wetestyoutrust.com/), Germany (http://www.koelnerliste.com/), the Netherlands (http://macho.nl/nzvt), Australia (http://hasta.org.au/), and U.S. (http://info.nsf.org/Certified/dietary/). In addition, the “high risk list” curated by the U.S. Anti-Doping Agency provides examples of supplements that pose an antidoping risk (http://www.usada.org/athletes/substances/supplement-connect/high-risk-list/). Overall, dietary supplementation is not free of risk for the powerlifter but can be minimized with education and guidance from nutrition professionals.

Limitations

The current study has several limitations. Firstly, the analysis relies on self-reported nutrition practices that could be subject to recall errors and participant bias. Indeed, previous research on endurance athletes has observed discrepancies between participant reported dietary trends and actual intake [59,60]. In addition, we were not able to assess reliability due to the anonymous nature of the survey. Secondly, we did not define all terms used in the questionnaire for the participants (e.g., supplementation or fasting), nor were quantities defined for potential answers (e.g., what constitutes a CHO/protein/fat rich food), although some examples were given. Participants were required to be at least 18 y old to be eligible for inclusion in the present survey, which excluded subjunior powerlifters who were not yet 18 y old (14−17 y old). While we have pooled subjunior (at least 18 y old) and junior (19−23 y old) powerlifters for the analysis, it should be noted that the results may not generalize to subjunior powerlifters less than 18 y old. The large, international sample enabled subgroup analysis of sex, age, and weight class and competitive caliber. Most respondents (84%) resided in North America and Europe, which limits the generalizability of the results to different regions as various influences, such as cultural and socioeconomic factors, could contribute to different food choices [61]. However, we note that the sample was convenience based and our analysis should be considered descriptive and exploratory, rather than confirmatory. Only 21% of participants (*n* = 65) were female, which may limit the generalizability of the findings. Given the disparity in the number of female and male (*n* = 240) respondents, the subgroup analyses for weight class (i.e., W63-, W72+, M83-, and M93+) and competitive division (male or female) need to be interpreted with caution as these results may be spurious (i.e., false positive) or of limited practical significance.

Conclusion

The current study is the first to characterize the self-reported periworkout nutrition practices of competitive powerlifters. The key findings were that competitive powerlifters rarely practiced fasted training and commonly use pre- and intraexercise nutrition strategies that emphasize CHO ingestion to aid training performance and boost energy levels. Most powerlifters reported paying attention to postexercise nutrition and emphasizing protein rich foods. The most common reasons for postexercise nutrition practices included recovering better for the day, enhancing the benefits of training, attenuating hunger, and helping to build/retain muscle mass. Supplementation in the hours before training was reported by most powerlifters, of which a source of caffeine (preworkout formula, energy drink, caffeine pills, coffee) or creatine was most common. Given the prevalence of the use of formulated foods and multi- and single-ingredient products as supplements, competitive powerlifters should consider third-party tested supplements to minimize the risk of potential contamination with banned substances and underdosing of ergogenic ingredients. Overall, the findings suggest that competitive powerlifters implement nutrition strategies around their training sessions that are supported by current sport nutrition guidelines/recommendations.

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.

CRediT authorship contribution statement

Andrew King: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kedric Kwan:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Ivan Jukic:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Caryn Zinn:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Eric Helms:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Disclosure statement

The authors have no relevant financial or nonfinancial interests to disclose.

Data availability statement

The dataset and analysis code are available on the Open Science Framework: https://osf.io/xdu7s/

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.nut.2024.112389.

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