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# Nutrition, Training, Supplementation, and Performance-Enhancing Drug Practices of Male and Female Physique Athletes Peaking for Competition

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**Abstract**

Escalante, G, Barakat, C, Tinsley, GM, and Schoenfeld, BJ. Nutrition, training, supplementation, and performance-enhancing drug practices of male and female physique athletes peaking for competition. *J Strength Cond Res* XX(X): 000–000, 2023—The purpose of this descriptive investigation was threefold: (a) to assess the nutrition, training, supplement, and performance-enhancement drug practices of male and female physique competitors 30 days before competition; (b) to examine the specific water and macronutrient manipulation performed by competitors during the last 3 days before competition; and (c) to assess physiological responses to precontest preparation including body composition, body fluids, resting heart rate, and blood pressure. Competitors reported performing moderately high volume, moderate to high repetition, split-body resistance training programs performed on most days of the week; the programs included the use of a variety of advanced training methods. A majority of competitors included cardio to expedite fat loss, and most reported performing cardio in a fasted state despite a lack of objective evidentiary support for the practice. Competitors substantially restricted calories and consumed protein in amounts well above research-based guidelines (>3 $g \cdot kg^{-1} \cdot d^{-1}$); carbohydrate and lipid intake were highly variable. Water was substantially reduced in the final 3 days before competition. Competitors used a variety of dietary supplements throughout the study period, many of which are not supported by research. Both male and female competitors reported using performance enhancing drugs (~48 and ~38%, respectively) including testosterone derivatives, selective androgen receptor modulators, and human growth hormone. More research is warranted to elucidate safer and more effective peak week practices for physique competitors.

**Key Words:** bodybuilding, figure, bikini, wellness, pre-contest, pre-competition, peak week

## Introduction

Physique competition for males and females has increased in popularity over the past several decades (21,22,45). In addition to bodybuilding, various categories within the umbrella of bodybuilding/physique competition have been established by bodybuilding/physique federations such as physique and classic physique for males and wellness, figure, physique, fitness, and bikini for females. Each division is judged differently for desired muscularity, leanness (often referred to as conditioning), and posing/presentation; however, a relatively small waistline with wider shoulders (creating a V-taper), muscle symmetry, and muscle proportion are desirable traits for all divisions.

To develop optimal proportions, competitors typically use a hypertrophy based "off-season" program that may last several months to several years, with training and nutrition practices geared toward maximizing muscularity in a symmetrical and balanced fashion (20,21). The "off-season" is typically followed by an 8–30 weeks "precontest" phase, with training and nutrition practices geared toward losing body fat while maintaining or gaining muscle mass (2,7,14,16,21,45). In a study on training practices and ergogenic aids used by bodybuilders, Hackett et al. (20) reported that total sets per muscle group decreased, reps per set increased, rest periods between sets decreased, and aerobic exercise volume increased between the "off-season" and "precontest" phases. A more recent study compared the training practices and ergogenic aids used by competitive male bodybuilders across training phases, and the results showed that ~85% of respondents use split routines, ~96% perform 4–7 training sessions per week, >50% train major muscle groups twice per week, and ~56% of respondents train between 60 and 90 minutes per session (21). The author of this study also reported that approximately 6 weeks before competition, there was a decrease in the number of muscle groups trained per session, a greater number of repetitions performed per set, and a significant increase in aerobic exercise volume (21). In addition to the nutrition and training practices used by physique competitors, the use of performance-enhancement drugs (PEDs) and dietary supplements has been reported during the 2 phases of physique competition (11,20,21).

Many studies and case reports have documented the nutritional, training, supplement, or PED practices of physique

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competitors at various time points in their preparation (6,7,10,11,16,20,21,28,30,35,40,45). Although several of these publications have focused on the "precontest" phase of competing, to the best of the authors' knowledge, none have assessed body composition and body fluids 1 day before competition along with investigating the nutrition, training, supplement, and drug practices 30 days before competition. Furthermore, measures of blood pressure and heart rate 1 day before competition, which may be altered due to dehydration, nerves, or supplement or PED usage, have not been previously documented to the best of the author's knowledge. The purpose of this descriptive investigation was threefold: (1) to assess the nutrition, training, supplement, and PED practices of male and female physique competitors 30 days before competition; (2) to examine the specific water and macronutrient manipulation performed by competitors during the last 3 days before competition; and (3) to assess physiological responses to precontest preparation including body composition, body fluids, resting heart rate, and blood pressure. The results of this investigation add to the limited body of literature of common nutrition, training, supplementation, and PED practices used by physique competitors 1 month before competing. Moreover, it will add insight into the safety and efficacy of peak week practices used by bodybuilders in the last few days before their competition.

## Methods

### *Experimental Approach to the Problem*

This descriptive study used a survey to assess the nutrition, training, supplementation, and pharmacological approaches of male and female physique competitors 30 days before competition. The survey also specifically asked subjects about their macronutrient and water intake in the 3 days before competition. Last, body composition, hydration status, body fluids, and vital signs (in a subset of subjects) of physique competitors were assessed 1 day before competition.

### *Subjects*

A total of 29 amateur physique athletes (male = 21 and female = 8; Age range 21-67 years) participating in nondrug tested bodybuilding/physique/figure/bikini national qualifier competitions in southern California, signed and informed consent and volunteered to participate in this study. For recruitment of the sample, investigators made arrangements with local bodybuilding competition promoters for permission to attend their events during the registration period 1 day before the competition. All competitions had divisions in bodybuilding, physique, classic physique, figure, and bikini. In addition, the competitions were considered national qualifying events where competitors who placed in the top 2 in their division qualified for national level competitions; top placing competitors at the national level competitions can then earn professional status in their respective divisions. The study was approved by the Institutional Review Board at California State University, San Bernardino (IRB-FY2018-148).

### *Procedures*

Competitors interested in participating in the study reviewed and signed an informed consent form explaining the benefits and risks of participation. Thereafter, each subject voided their bladder and provided a midstream urine sample for the assessment of specific gravity of urine (USG) by refractometry (Atago URC-NE, Atago USA Inc., Bellevue, WA). Next, the subjects' height was measured with a stadiometer (Seca 213, Seca North America, Chino, CA) and body mass with a digital electric scale (Tanita BWB-800S, Tanita Corporation of America Inc., Arlington Heights, IL). Resting heart rate and blood pressure were also measured in a subset of the subjects ($n$ = 14). Body composition was assessed with an IntelaMetrix BodyMetrix BX-2000 A-mode ultrasound (US) (CA) and total body water (TBW), intracellular water (ICW), extracellular water (ECW), and body composition were assessed with an ImpediMed SFB7 bioimpedance spectroscopy (BIS) device (CA). Given that data collection was performed in the afternoon 1 day before competition, it was not possible or practical to have subjects follow best practice standardized body composition testing conditions. As such, we recognize this as an inherent limitation, but nonetheless feel the data provide important insights into precontest preparation.

Assessment by the BodyMetrix A-mode US device was performed per the manufacturer recommendations. The US probe was attached to a USB port on a Microsoft Surface (Microsoft Corporation, Redmond, WA) that used the corresponding BodyView Professional software (IntelaMetrix, Livermore, CA) to estimate the body composition. The researcher inputted the height, body mass, age, and sex of the subject into the program and then obtained subcutaneous thickness measurements on the right side of the body using the 3-site locations according to Jackson et al. (25) while the participant was standing. The measurements included the triceps, suprailiac, and thigh for females and the chest, abdomen, and thigh for males. The trained researcher first placed gel on the head of the probe and then slid the probe $\pm$5 millimeters across the site while maintaining constant contact with the skin and ensuring minimal tissue deformation. Each site was measured 2–3 times based on the software's agreement between measurements; the average of these trials was used to identify the final subcutaneous thickness measurement. The BodyView software estimated the body fat percentage (BF%) using the 3 sites Jackson and Pollock equation option as previously reported in other investigations (32,47).

Bioimpedance spectroscopy was used to obtain TBW, ICW, ECW, and body composition estimates. Bioimpedance spectroscopy uses Cole modeling (9) and mixture theories (23) to predict body fluids instead of regression equations used by bioimpedance analysis (BIA); it also uses 256 measurement frequencies ranging from 4 to 1,000 kHz (44). We acknowledge there are limitations to using BIS technology to estimate body fluids and body composition with this population since physique competitors have been reported to manipulate body fluids/food intake before competing in physique competitions (6,14). Regardless, we felt it was important to collect these data to help determine the effects of euhydration or hypohydration on BIS body composition and body fluid estimates for future research when hydration assumptions are violated.

For the BIS assessment, each subject remained supine for a minimum of 5 minutes on a nonconductive surface with the arms and legs not touching while the trained researcher prepped the subject's skin for electrode placement. Before placing the electrodes on the wrist/ankle, resting heart rate and blood pressure were measured on a subset of the subjects ($n$ = 14) in duplicate, and the average of those measurements were used for analysis. The resting heart rate was measured by the radial pulse, and blood pressure was measured using a standard stethoscope and manual sphygmomanometer. Next, 2 electrodes were placed on the right wrist: one on the midline of the ulnar styloid process on

the wrist and the distal electrode 5 cm downward toward the fingers. The other 2 electrodes were placed along the right ankle: one between the left medial and lateral malleoli and the distal electrode down toward the toes 5 cm apart. Finally, the researcher inputted the subject's height, body mass, age, and sex into the BIS system. Duplicate assessments were performed, with the values averaged for analysis. Assessments were reviewed for quality assurance through visual inspection of the Cole plots.

On completing the aforementioned assessments, subjects answered specific questions about their nutrition, supplement, training, and PED practices over the prior 30 days by a survey on Qualtrics.com. The survey was originally developed by 2 investigators (G.E. and B.J.S.) and was piloted with a group of 10 bodybuilders; written and verbal feedback was provided to an investigator (G.E.), and changes were implemented to improve the survey. The final survey was divided into 6 blocks including (a) informed consent confirmation (1 question); (b) demographics (6 questions); (c) sport and training (41 questions); (d) nutrition, supplements, drugs, coaching, and health (19 questions); (e) psychology and body image (31 questions); and (f) body measurements and body fluids (10 questions). Most of the survey had fixed multiple choice responses, but a part of the survey had open-ended questions; this was primarily the case in part of block 4 where subjects were specifically asked about their basic macronutrient/water intake over the prior 3 days and in block 6 where subjects entered their body measurements/body fluid data as measured by the researcher. The informed consent signed before participating in the study disclosed that all answers to the questions would remain strictly confidential and would not influence the outcome of their competition or have any other potentially negative consequences. The information for the psychology block from this survey is not discussed in this investigation as that is outside the aim of this study. A copy of the survey can be found in the Supplemental Digital Content (see Supplementary Files, http://links.lww.com/JSCR/A384).

### Statistical Analyses

Given the descriptive nature of this study, most responses are reported as a percentage derived from the number of responses divided by the number of subjects that answered a particular item. Respondent characteristics are reported as a mean ± *SD*. Relationships for select variables are also reported with correlations. Based on the unique physiological state at time of assessment, lack of criterion method, inability to fully standardize assessments, and small sample sizes, formal statistical comparisons of ultrasound and BIS body composition estimates were not warranted. Nonetheless, for descriptive purposes, individual data for relevant body composition and fluid variables are presented visually in figures and supplemental figures. Excel (Microsoft Corporation) and R (The R Foundation for Statistical Computing) were used for data analysis.

## Results

The 29 subjects in this investigation consisted of 21 males (age 32.1 ± 10.4 years) and 8 females (age 30.4 ± 3.6 years). The competitive categories of males included physique ($n$ = 13), classic physique ($n$ = 5), bodybuilding ($n$ = 2), and dual categorization as bodybuilding and classic physique ($n$ = 1). The competitive categories of females included figure ($n$ = 4), bikini ($n$ = 3), and physique ($n$ = 1). A total of 76% of the males (16/21) reported using a coach, but only 56% (9/16) of the coaches had a college degree and 69% (11/16) had a related certification. For the females, 88% (7/8) reported using a coach, but only 50% (4/8) of the coaches had a college degree and 88% (7/8) had a related certification. Subject competition experience information such as length of time competing, number of competitions entered, future plans for their next competition, and their competition level (amateur elite—national level competitor, amateur open—regional level competitor, and amateur novice—regional level competitor) are presented in Table 1.

### Body Composition, Body Fluids, and Vital Signs

The subjects' body composition, body fluid, and urine-specific gravity values are presented in Table 2. The relationships between BF% and fat-free mass estimates obtained by BIS and US are displayed in Figure 1. Associations between relative ECW and US skinfold thickness or relative TBW are displayed in Figure 2.

In a subset of the males ($n$ = 10), mean systolic blood pressure was 127.2 ± 17.6 mm Hg (range: 102–158), diastolic blood pressure was 81.8 ± 10.3 mm Hg (range: 62–98), and resting heart rate was 63.6 ± 9.1 beats per minute (BPM) (range: 62–78). In a subset of the females ($n$ = 4), mean systolic blood pressure was 107.5 ± 3.8 mm Hg (range: 102–110), diastolic blood pressure was 80.0 ± 2.3 mm Hg (range: 78–82), and resting heart rate was 70.5 ± 7.5 BPM (range 60–78).

### Resistance and Aerobic Training Practices of Subjects

Males performed an average of 5 resistance training sessions per week (range: 4 to 8+ sessions), spending an average of 61.9 minutes training per session (range: 30–90 minutes per session). Females performed an average of ~5.6 resistance training sessions per week (range: 5–7 sessions), spending an average of 90.7 minutes training per session (range: 60–120 minutes per session).

The number of sets per muscle group per session was highly variable for male competitors. For the upper-body musculature, they most commonly performed 4–6 sets per muscle per session (33–38%). For the lower-body and abdominal musculature, a majority of males reported performing either 1–3 sets (19–33%) or 4–6 sets (29–48%). With respect to upper-body volume for female competitors, subjects reported performing more sets per session for the shoulder, back, and chest muscles on average than for the biceps and triceps. Volume for the lower-body musculature in females varied to a greater extent than for the upper body, with somewhat higher volumes devoted to the gluteals. Data for training volume per muscle group per session are presented in Table 3.

A majority of both male and female competitors trained in what can be classified as a moderate repetition range (7–15 repetitions per set). Data for repetitions per set are presented in Table 4. About 38% of males reported taking less than 10% of their sets to muscular failure, but 5% trained to failure on all sets. The other competitors were fairly evenly dispersed, taking between 11 and 99% of sets to failure. Half of the females surveyed reported taking less than 20% of their sets to muscular failure. The other competitors took between 50 and 79% of sets to failure. Most males (81%) reported taking what can be considered relatively short rest periods between sets (30–90 seconds) for the upper-body musculature; the remaining 19% of male competitors reported resting 91–119 seconds between sets. For the lower-body musculature, a majority of males (72%) took relatively brief

**Table 1**
**Subject competition experience and future plans.**

| | Males | Females |
|---|---|---|
| Length of time competing | >5 y: 5%; 4–5 y: 0%<br>3–4 y: 5%; 2–3 y: 25%<br>1–2 y: 25%; <1 y: 40% | >5 y: 12.5%; 4–5 y: 0%<br>3–4 y: 37.5%; 2–3 y: 25%<br>1–2 y: 12.5%; <1 y: 12.5% |
| Number of competitions completed | >5: 25%; 4: 10%<br>3: 0%; 2: 25%<br>1: 15%; none: 25% | >5: 50%; 4: 0%<br>3: 25%; 2: 12.5%<br>1: 0%; none: 12.5% |
| Competition level | Amateur elite: 14%<br>Amateur open: 57%<br>Amateur novice: 29% | Amateur elite: 25%<br>Amateur open: 37.5%<br>Amateur novice: 37.5% |
| Next competition plans | <1 mo: 40%<br>1–3 mo: 30%<br>3–6 mo: 10%<br>7–12 mo: 5%<br>>1 y: 15% | <1 mo: 37.5%<br>1–3 mo: 62.5%<br>3–6 mo: 0%<br>7–12 mo: 0%<br>>1 y: 0% |

rest periods between sets (30–90 seconds); of the remaining competitors, 24% reported resting between 91 and 179 seconds and 5% reported resting >180 seconds. With respect to females, ~75% of competitors reported resting 30–90 seconds between sets for both upper-body and lower-body exercises; 12% reported taking very brief rest periods (<30 seconds), whereas 12% reported taking 120+ seconds rest.

On average, male competitors performed at least 10 minutes of cardio 5.6 times·wk$^{-1}$ (range 1–14), with cardio sessions lasting 36.2 minutes (range: 15–60+). With respect to aerobic intensity, males performed low-intensity cardio an average of 2.8 times·wk$^{-1}$ (range: 0–7), low-to-moderate intensity cardio 2.6 times·wk$^{-1}$ (range: 0–7), moderate-to-high intensity cardio 3.3 times·wk$^{-1}$ (range: 0–10), and high-intensity cardio 3.1 times·wk$^{-1}$ (range: 0–10). Fasted cardio was regularly performed by 43% (9 of 21) of male competitors, 19% (4 of 21) did not perform fasted cardio, and the remaining 38% (8 of 21) only performed fasted cardio occasionally. Weight training was performed in conjunction with their cardio by 43% (9 of 21) of the males, 23.8% (5 of 21) never combined weight training and cardio, and 33.3% (7 of 21) occasionally combined weight training and cardio.

Alternatively, female competitors performed at least 10 minutes of cardio 8.3 times·wk$^{-1}$ (range 5–14), with cardio sessions lasting 41.3 minutes (range: 25–50). With respect to aerobic intensity, females performed low-intensity cardio an average of 3 times·wk$^{-1}$ (range: 0–6), low-to-moderate intensity cardio 2.6 times·wk$^{-1}$ (range: 0–6), moderate-to-high intensity cardio 4.9 times·wk$^{-1}$ (range: 1–12), and high-intensity cardio 2.9 times·wk$^{-1}$ (range: 1–6). Fasted cardio was regularly performed by 75% (6 of 8) of female competitors, 12.5% (1 of 8) did not perform fasted cardio, and the 12.5% (1 of 8) only performed fasted cardio occasionally. Weight training was performed in conjunction with their cardio by 50% (4 of 8) of the females, 12.5% (1 of 8) never combined weight training and cardio, and 37.5% (3 of 8) occasionally combined weight training and cardio.

Approximately 24% of male competitors reported using periodization principles in their programming (block periodization = 19% and reverse periodization = 5%); the remaining 76% did not know if they used periodization principles. Similarly, 25% of female competitors reported using periodization principles (block periodization = 12.5% and daily undulating periodization = 12.5%). Male competitors used a variety of advanced training techniques at least once per week including supersets (43%), drop sets (19%), trisets/giant sets (14%), eccentric overload (10%), forced reps (10%), and variable resistance (5%). Only a small percentage of competitors included Olympic lifts in their routine (men = 5%; women = 12%).

**Table 2**
**Body composition, body fluid, and urine-specific gravity of subjects.***

| | Males ($n$ = 21) | | | | Females ($n$ = 8) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min | Max | Mean | SD | Min | Max |
| Height (cm) | 173.8 | 8.1 | 158.1 | 188.0 | 160.3 | 5.2 | 154.4 | 171.5 |
| Body mass (kg) | 80.8 | 9.0 | 63.7 | 97.7 | 58.5 | 6.7 | 49.1 | 69.6 |
| BIS | | | | | | | | |
| TBW (kg) | 51.1 | 6.8 | 38.8 | 63.2 | 34.2 | 4.3 | 28.2 | 40.7 |
| ICW (kg) | 31.2 | 4.6 | 22.8 | 40.4 | 21.0 | 3.4 | 15.7 | 26.1 |
| ECW (kg) | 19.9 | 2.6 | 15.5 | 25.0 | 13.3 | 1.2 | 11.6 | 15.2 |
| TBW (% of BM) | 63.1 | 4.8 | 55.9 | 69.9 | 58.5 | 2.8 | 54.2 | 62.4 |
| ICW (% of TBW) | 60.9 | 1.9 | 58.3 | 64.4 | 61.0 | 2.9 | 55.8 | 64.1 |
| ECW (% of TBW) | 39.1 | 1.9 | 35.6 | 41.7 | 39.0 | 2.9 | 35.9 | 44.2 |
| FM (kg) | 8.4 | 4.9 | 2.3 | 18.5 | 9.7 | 2.4 | 6.3 | 13.1 |
| FFM (kg) | 72.3 | 9.5 | 55.2 | 87.7 | 48.8 | 6.2 | 40.2 | 57.9 |
| BF% | 10.5 | 5.9 | 3.0 | 20.3 | 16.7 | 3.9 | 11.1 | 22.8 |
| US | | | | | | | | |
| Site 1[a] (mm) | 2.8 | 0.9 | 1.6 | 4.8 | 7.0 | 1.6 | 5.6 | 10.5 |
| Site 2[b] (mm) | 3.6 | 1.1 | 1.8 | 6.1 | 4.9 | 1.6 | 3.0 | 6.9 |
| Site 3[c] (mm) | 4.6 | 2.0 | 2.6 | 10.5 | 3.6 | 2.3 | 2.1 | 9.0 |
| Total thickness (mm) | 11.1 | 3.0 | 7.1 | 19.0 | 15.4 | 4.4 | 11.7 | 25.5 |
| FM (kg) | 5.5 | 1.9 | 3.0 | 9.8 | 8.2 | 2.4 | 6.4 | 13.4 |
| FFM (kg) | 75.3 | 8.5 | 59.8 | 88.3 | 50.3 | 5.6 | 42.0 | 59.7 |
| BF% | 6.8 | 2.0 | 3.7 | 11.3 | 13.9 | 3.1 | 11.6 | 21.1 |
| USG | 1.020 | 0.009 | 1.004 | 1.030 | 1.019 | 0.011 | 1.003 | 1.030 |

*BIS = bioimpedance spectroscopy; US = ultrasound; TBW = total body water; ICW = intracellular water; ECW = extracellular water; FM = fat mass; FFM = fat free mass; BF = body fat; USG = specific gravity of urine.
[a]Males: chest; females: triceps.
[b]Males: thigh; females: thigh.
[c]Males: abdomen; females: suprailiac.

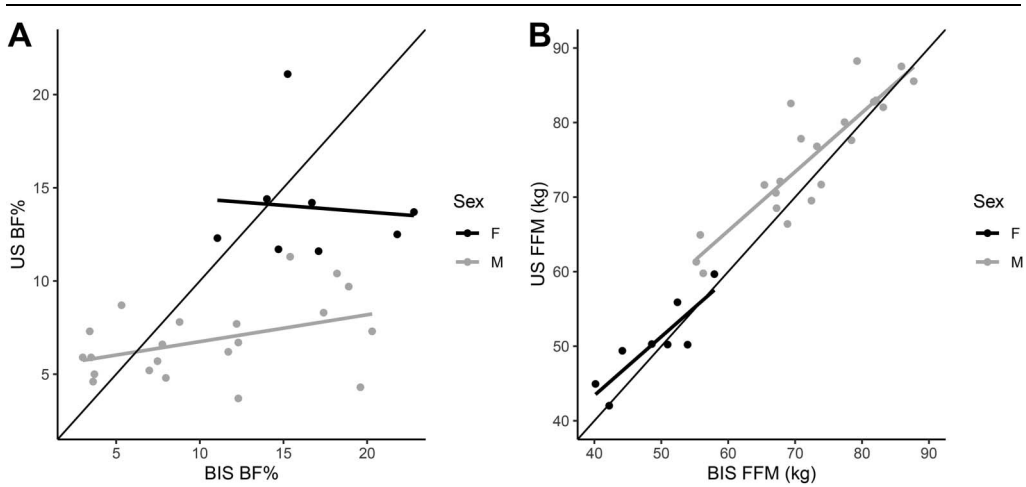


**Figure 1.** Relationship between body fat percentage (BF%) and fat free mass (FFM) estimated by US and BIS. A) total sample: significant correlation ($r = 0.52$, $p = 0.004$); males only: trend for correlation ($r = 0.42$, $p = 0.06$); females only: no correlation ($r = -0.09$, $p = 0.83$). B) total sample: significant correlation ($r = 0.96$, $p < 0.001$); males only: significant correlation ($r = 0.89$, $p < 0.001$); females only: significant correlation ($r = 0.87$, $p = 0.005$). US = ultrasound; BIS = bioimpedance spectroscopy.

### *Nutrition and Hydration Practices of Subjects*

Table 5 summarizes the nutrition and water intake of the subjects 3 days out from competition. The number of calories and macronutrients consumed per day for the final 3 days before competition for males and females were highly variable as noted by the relatively large *SD*s. In relation to the subjects' body mass, males consumed 22.6 kcal·kg$^{-1}$ and females consumed 21.4 kcal·kg$^{-1}$. Females also consumed ~26% more protein per day relative to body mass than males (males 3.07 g·kg$^{-1}$ vs. females 3.88 g·kg$^{-1}$). Over the course of the final 3 days, males consumed an average of 1.77 g·kg$^{-1}$ of carbohydrate per day and females consumed 1.18 g·kg$^{-1}$ of carbohydrate per day. Similar to the other macronutrients, fat intake was also highly variable between males and females (males 0–150 g·d$^{-1}$ vs. females 0–132 g·d$^{-1}$). Males consumed an average of 0.57 g·kg$^{-1}$ of fat per day, and females consumed an average of 0.8 g·kg$^{-1}$ of fat per day.

Similar to nutritional intake, water intake was also highly variable between subjects and sexes. On average, males reduced water intake from 5,082 ± 2,754 ml (range: 473–11,356 ml) 3 days before competition to 3,972 ± 2,521 ml (range: 237–9,464 ml) 1 day before competition (~22% reduction). Females reduced water intake more drastically than males from 4,835 ± 2,611 ml (range: 1,420–8,872 ml) 3 days before competition to 2,964 ± 2,595 ml (range: 709–8,872 ml) 1 day prior from competition (~39% reduction). One day out from competition, mean data demonstrated males and females consumed similar relative water intake (males ~49 ml·kg$^{-1}$ vs. females ~51 ml·kg$^{-1}$).

### *Supplementation Practices of Subjects*

Use of dietary supplements was common for males in the 30 days before competition. At least one dietary supplement was used by

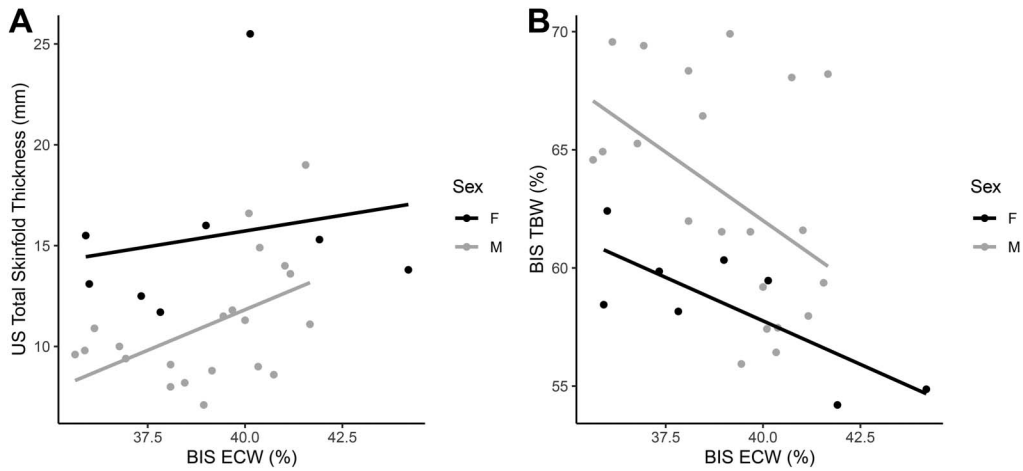


**Figure 2.** Relationship between US total skinfold thickness (3 sites) and BIS TBW% vs. BIS ECW%. TBW is % of body mass, but ECW% is % of TBW. A) total sample: no correlation ($r = 0.25$, $p = 0.20$); males only: significant correlation ($r = 0.50$, $p = 0.02$); females only: no correlation ($r = 0.21$, $p = 0.62$). B) total sample: significant correlation ($r = -0.44$, $p = 0.02$); males only: significant correlation ($r = -0.46$, $p = 0.03$); females only: significant correlation ($r = -0.78$, $p = 0.02$). US = ultrasound; BIS = bioimpedance spectroscopy; TBW = total body water; ECW = extracellular water.

**Table 3**
**Sets per muscle group per session.**

| | Sets per muscle group per session (% of subjects) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Muscle group** | **1–3** | **4–6** | **7–9** | **10–12** | **13–15** | **16–19** | **20+** |
| Men | | | | | | | |
| Chest | 19 | 38 | 10 | 5 | 5 | 14 | 10 |
| Shoulders | 14 | 33 | 10 | 5 | 5 | 19 | 10 |
| Back | 14 | 33 | 10 | 10 | 5 | 19 | 10 |
| Biceps | 24 | 38 | 5 | 19 | 0 | 10 | 5 |
| Triceps | 24 | 38 | 5 | 19 | 0 | 10 | 5 |
| Quadriceps | 19 | 48 | 5 | 10 | 0 | 10 | 10 |
| Hamstrings | 14 | 48 | 5 | 14 | 0 | 10 | 10 |
| Gluteals | 33 | 38 | 0 | 10 | 5 | 5 | 10 |
| Calves | 33 | 29 | 10 | 19 | 5 | 0 | 5 |
| Abdominals | 29 | 29 | 14 | 19 | 5 | 0 | 5 |
| Women | | | | | | | |
| Chest | 38 | 50 | 0 | 0 | 0 | 0 | 12 |
| Shoulders | 12 | 50 | 25 | 0 | 0 | 0 | 12 |
| Back | 12 | 50 | 25 | 0 | 0 | 0 | 12 |
| Biceps | 50 | 38 | 0 | 0 | 0 | 0 | 12 |
| Triceps | 50 | 38 | 0 | 0 | 0 | 0 | 12 |
| Quadriceps | 12 | 63 | 0 | 12 | 0 | 0 | 12 |
| Hamstrings | 12 | 63 | 0 | 12 | 0 | 0 | 12 |
| Gluteals | 12 | 50 | 12 | 12 | 0 | 0 | 12 |
| Calves | 63 | 25 | 12 | 0 | 0 | 0 | 0 |
| Abdominals | 50 | 38 | 0 | 0 | 0 | 0 | 12 |

95% of males, and all of these subjects reported using ≥3 supplements simultaneously and 23.8% used ≥10 supplements (range: 10–16 supplements) simultaneously. The most commonly used supplements by males in the 30 days before competition were branched chain amino acids (71.4%), whey protein (52.3%), a fat burner (53.8%), vitamin C (47.6%), essential amino acids (42.8%), and caffeine (42.8%). Of the supplements reportedly consumed, the least commonly used (~5% of the participants) were taurine, chromium picolinate, glycerol, highly branched cyclic dextrin, creatine/forms of creatine, phosphatidic acid, fenugreek (Trigonella foenum-graecum), and tribulus terrestris.

Similarly, 75% of female competitors used at least one dietary supplement in the 30 days before competition, but of these subjects, 71.4% used ≥3 supplements simultaneously and 14.3% used ≥10 supplements simultaneously. The most commonly used supplements used by females in the 30 days before competition were caffeine (75%), branched chain amino acids (62.5%), a fat burner (62.5%), and a multivitamin (50%). The least commonly consumed supplements, each used by only 12.5% of the subjects, were a vitamin B complex, vitamin E, and zinc.

### *Performance Enhancement Drug Practices of Subjects*

Use of at least one PED was reported by 47.6% of male competitors. Of the competitors that reported using PEDs, 20% stacked 6 drugs together and 30% stacked 2–4 drugs together. The most commonly used PEDs were various types of selective androgen receptor modulators (SARMs) (19%) inclusive of ostarine, RAD140, S-23, and ligandrol; all individuals using these drugs used SARMs in isolation. Other PEDs used were human growth hormone (4.8%), testosterone propionate (9.5%), testosterone cypionate (14.3%), trenbolone acetate (14.3%), oxandrolone (14.3%), stanozolol (14.3%), drostanolone enanthate (4.8%), levothyroxine (4.8%), clenbuterol (14.3%), hydrochlorothiazide (4.8%), and spironolactone (9.5%). In females, use of at least one PED was reported by 37.5% of competitors. Of the competitors that reported using PEDs, 33.3% stacked 4 drugs together, 33.3% stacked 3 drugs together, and 33.3% used only 1 drug. The most commonly used PEDs were testosterone propionate (12.5%), oxandrolone (12.5%), stanozolol (12.5%), clenbuterol (12.5%), tamoxifen (25%), and spironolactone (25%). Table 6 shows the PED dosages and combinations used by male and female competitors.

## Discussion

The results of this investigation confirm the findings of previous studies that athletes partaking in physique competitions use a wide variety of "peaking" practices leading up to the show in an effort to present their most aesthetic physique on contest day (6,34). This may include changes to nutrition and fluid intake, supplements, resistance and aerobic training, or PEDs. Specific nutritional strategies can be used to increase muscle volume. For example, "fat loading" can be implemented to maximize intramuscular triglyceride stores and "carb loading" to maximize intramuscular glycogen stores (14). Furthermore, water manipulation is often used for multiple reasons or goals. For example, water loading/cutting may be used to aid with nutrient delivery, significantly reduce total body mass to make a weight class (37), or manipulate water/electrolyte balance with the goal to minimize interstitial fluid.

Our data demonstrate large variances in the approaches used by subjects and some differences between sexes in an attempt to peak for competition. Our results showed that a total of 76% of the males reported using a coach, but only 56% of the coaches had a college degree and 69% had a related certification. For the females, 88% reported using a coach, but only 50% of the coaches had a college degree and 88% had a related certification. Although a majority of the coaches had a certification related to the field of exercise science/nutrition, many of the coaches (44% of coaches for males and 50% of coaches for females) did not have a formal bachelor's degree in exercise science or a related field.

**Table 4**
**Repetitions per set.**

| | Repetitions per set (% of subjects) | | | | | |
|---|---|---|---|---|---|---|
| **Muscle group** | **1–3** | **4–6** | **7–9** | **10–12** | **13–15** | **16+** |
| Men | | | | | | |
| Chest | 0 | 0 | 14 | 48 | 19 | 19 |
| Shoulders | 0 | 0 | 10 | 43 | 33 | 14 |
| Back | 0 | 0 | 10 | 48 | 29 | 14 |
| Biceps | 5 | 0 | 5 | 48 | 24 | 19 |
| Triceps | 5 | 0 | 5 | 33 | 38 | 19 |
| Quadriceps | 0 | 0 | 10 | 38 | 38 | 14 |
| Hamstrings | 0 | 0 | 10 | 38 | 38 | 14 |
| Gluteals | 10 | 0 | 5 | 43 | 24 | 19 |
| Calves | 5 | 0 | 5 | 33 | 24 | 33 |
| Abdominals | 5 | 0 | 10 | 29 | 10 | 48 |
| Women | | | | | | |
| Chest | 12 | 0 | 0 | 38 | 50 | 0 |
| Shoulders | 12 | 0 | 0 | 38 | 50 | 0 |
| Back | 12 | 0 | 0 | 38 | 50 | 0 |
| Biceps | 12 | 0 | 0 | 38 | 38 | 12 |
| Triceps | 12 | 0 | 0 | 38 | 38 | 12 |
| Quadriceps | 12 | 0 | 0 | 50 | 25 | 12 |
| Hamstrings | 12 | 0 | 0 | 50 | 25 | 12 |
| Gluteals | 12 | 0 | 0 | 38 | 38 | 12 |
| Calves | 25 | 0 | 0 | 38 | 12 | 25 |
| Abdominals | 12 | 0 | 0 | 38 | 12 | 38 |

**Table 5**
**Nutrition and water intake summary of subjects 3 days out from competition.**

| | Male ($n$ = 21) | | | | Female ($n$ = 8) | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | *SD* | Max | Min | Mean | *SD* | Max | Min |
| Final 3 d caloric avg. (Kcals) | 1,823 | 1,045 | 3,500 | 1,000 | 1,250 | 614 | 1,500 | 800 |
| Protein last 3 d (g) | 248 | 169 | 700 | 145 | 227 | 166 | 504 | 140 |
| Carbs last 3 d (g) | 143 | 134 | 450 | 15 | 69 | 64 | 180 | 0 |
| Fat last 3 d (g) | 46 | 38 | 150 | 0 | 47 | 45 | 132 | 0 |
| Water—3 d out (ml) | 5,082 | 2,755 | 11,356 | 473 | 4,835 | 2,611 | 8,872 | 1,420 |
| Water—2 d out (ml) | 445 | 2,527 | 7,570 | 29 | 3,652 | 2,703 | 8,872 | 237 |
| Water—1 d out (ml) | 3,972 | 2,521 | 947 | 237 | 2,965 | 2,595 | 8,872 | 7,010 |

Previous research has reported that adequate knowledge in nutrition and exercise prescription is higher in individuals that hold a bachelor's degree in exercise science and possession of a certification by the American College of Sports Medicine or the National Strength and Conditioning Association as compared with those that only have field experience (29). Thus, the lack of common approaches to properly peak for competition may be partly explained by disparate guidance from arguably unqualified coaches. Importantly, the large variances in some of the observed practices should be interpreted with caution as they may be due to the relatively small sample size. They may also be due to the numerous unique strategies used by coaches and competitors during peak week due to the lack of evidence-based, safe, and effective practices to peak appropriately.

The large variances in precontest peaking practices between males and females may also be partly explained by the differences in the level of leanness and muscularity required to be successful across the divisions in physique competition. For example, the standard of leanness to be successful in the nonbodybuilding female divisions (e.g., bikini and figure) often call for higher body fat levels and less muscularity as compared with bodybuilding and physique categories for males (14). As such, different approaches to peak for competition are required. Moreover, as previously stated, there is a lack of evidence-based practices and qualified coaches to properly guide competitors, as well as a paucity of research on many precompetition practices to objectively guide prescription.

Various approaches were reported in the nutritional intake and fluid consumption of the competitors in the final 3 days approaching competition day. In regards to overall caloric consumption in the 3 days before competition, males consumed ~22.6 kcal·kg$^{-1}$, whereas females consumed ~21.4 kcal·kg$^{-1}$. These quantities were significantly lower than previous reports in male (32.6 kcal·kg$^{-1}$) and female (30.9 kcal·kg$^{-1}$) bodybuilders (8). This was likely slightly below their resting energy expenditure (33), and extended their contest preparation diet phase (i.e., a caloric deficit), which should not be the goal of peak week, nor enable them to truly "peak" their physique (14). It has been well demonstrated that carbohydrate (CHO) loading to maximize glycogen stores can increase intracellular water content (43), muscle thickness (10,40), and lean body mass (3). In addition, data suggest that athletes need to consume ~10 g CHO per kg of total body mass to properly restore muscle glycogen (4), and part of our group (Escalante, Barakat, Schoenfeld) recommended that physique athletes should consume at least 4 g·kg$^{-1}$ of CHO for peak week (14). Despite the high individual variability, on average, the subjects of this observational study reported consuming significantly lower amounts of CHO than required to adequately replenish skeletal muscle glycogen stores. Indeed, males and females, respectively, consumed just 1.77 g CHO·kg$^{-1}$ and 1.18 g CHO·kg$^{-1}$; this is well below the recommended minimum of 4 g CHO·kg$^{-1}$ to CHO load during peak week (14). Dietary fat intake was also relatively low for both males and females, especially considering CHO intake was also low during this time period. Previous data suggest athletes require ~2 g of dietary fat per kg of body mass to adequately restore intramuscular triglycerides (IMT) if fat loading (12), and it has been recommended for physique athletes to consume ~0.5 g of fat per kg during peak week while carbohydrate loading and up to 2 g·kg$^{-1}$ of fat when CHO intake is lower (14). Although the male and female physique athletes observed in this study, respectively, consumed 0.57 g·kg$^{-1}$ and 0.8 g·kg$^{-1}$ of fat in the last 3 days before competition,

**Table 6**
**Performance enhancement drug dosages and combinations used by male (M) and female (F) competitors.**

| | M1 | M2 | M3 | M4 | M5 | F1 | F2 | F3 |
|---|---|---|---|---|---|---|---|---|
| Growth hormone | 7 mg·wk$^{-1}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Testosterone propionate | 0 | 0 | 100 mg·wk$^{-1}$ | 0 | 200 mg·wk$^{-1}$ | 30 mg·wk$^{-1}$ | 0 | 0 |
| Testosterone cypionate | 600 mg·wk$^{-1}$ | 400 mg·wk$^{-1}$ | 100 mg·wk$^{-1}$ | 0 | 0 | 0 | 0 | 0 |
| Trenbolone acetate | 300 mg·wk$^{-1}$ | 0 | 100 mg·wk$^{-1}$ | 0 | 200 mg·wk$^{-1}$ | 0 | 0 | 0 |
| Oxandrolone | 560 mg·wk$^{-1}$ | 500 mg·wk$^{-1}$ | 0 | 140 mg·wk$^{-1}$ | 0 | 0 | 140 mg·wk$^{-1}$ | 0 |
| Stanozolol | 280 mg·wk$^{-1}$ | 250 mg·wk$^{-1}$ | 0 | 0 | 0 | 0 | 140 mg·wk$^{-1}$ | 0 |
| Drostanolone enanthate | 0 | 0 | 0 | 0 | 200 mg·wk$^{-1}$ | 0 | 0 | 0 |
| Levothyroxine | 0 | 1,400 mcg·wk$^{-1}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Clenbuterol | 420 mcg·wk$^{-1}$ | 100 mcg·wk$^{-1}$ | 0 | 200 mcg·wk$^{-1}$ | 0 | 600 mcg·wk$^{-1}$ | 0 | 0 |
| Tamoxifen | 0 | 0 | 0 | 0 | 0 | 50 mg·wk$^{-1}$ | 280 mg·wk$^{-1}$ | 0 |
| Spironolactone* | 0 | 225 mg·wk$^{-1}$ | 0 | 0 | 0 | 0 | 75 mg·wk$^{-1}$ | 50 mg·wk$^{-1}$ |
| Hydrochlorothiazide* | 0 | 0 | 0 | 0 | 150 mg·wk$^{-1}$ | 0 | 0 | 0 |

*Used only within the last 7 days from the competition.

they did not simultaneously consume a relatively large quantity of CHO as previously recommended with this relatively low fat intake (14).

In regard to protein intake, males and females, respectively, consumed 3.07 $g \cdot kg^{-1}$ and 3.88 $g \cdot kg^{-1}$ per day in the last 3 days before competition. This amount is much higher than the usual recommendation of 1.6–2.2 $g \cdot kg^{-1}$ of protein to maximize protein synthesis (38) but is not uncommon among physique competitors (7). However, such a high protein intake in the last few days before competition may partially explain why the subjects in this cohort consumed lower quantities of CHO and fat. Indeed, one potentially viable strategy of altering protein intake during peak week is to keep protein intake relatively high at ~2.5–3.5 $g \cdot kg^{-1} \cdot d^{-1}$ during the initial ~ 3 days of glycogen depletion portion of a CHO loading strategy, followed by a relatively lower protein intake of ~1.6 $g \cdot kg^{-1} \cdot d^{-1}$ during a high CHO diet for 1–3 days, finishing at least 24 hours before the scheduled competition (14). However, more research is required to test the effectiveness of this strategy.

Similar to previous findings (6), water intake was tapered down as competition day approached. On average, males consumed ~63 $ml \cdot kg^{-1}$ of fluids 3 days out from competition and reduced consumption by ~22%–~49 $ml \cdot kg^{-1}$ 1 day out of competition. On average, females consumed ~83 $ml \cdot kg^{-1}$ of fluids 3 days out from competition and reduced consumption by ~39%–51 $ml \cdot kg^{-1}$. Although data are limited as to the best water intake practices for physique athletes, Reale et al. (37) prescribed 100 $ml \cdot kg^{-1}$ of water for consecutive days followed by a "water cut" of just 15 $ml \cdot kg^{-1}$ for 1 day for combat athletes seeking to make weight. This may be applicable for bodybuilders seeking to make a weight class or to intentionally create a hypohydrated state with the aim of losing water within the interstitial spaces to enhance muscle definition (14). Further research is needed to improve our understanding on the safety and effectiveness of this practice as well as other water loading/cutting strategies.

The precontest training programs of competitors had notable similarities and differences, both within and between the sexes. Consistent with previous research (21), the session frequency of the programs was relatively high for all competitors, with an average of ~5 training sessions performed per week. The duration of sessions tended to be longer for women compared with men (90.7 vs. 61.9 minutes, respectively). These practices seemingly helped to support the relatively high training volumes used by competitors, although the total set volume was somewhat lower than that generally reported during the off-season period (20,21). The most apparent difference in training volume between the sexes was in the lower-body musculature, with females devoting a greater amount of volume to training the gluteals compared with male competitors. Conceivably, this inconsistency is due to the fact that the criteria for judging female competitors, particularly the figure and bikini divisions, places a greater emphasis on gluteal development than in the male competitions.

Consistent with previous survey data (20,21), competitors trained predominantly in a moderate-to-high repetition range, with the vast majority of sets performed using ≥7 repetitions. Repetitions were generally higher for the abdominal and calf musculature than other muscles, perhaps based on the anecdotal belief that these muscles require a more endurance-based training approach. Females tended to use higher repetition schemes than males, with most of their sets performed using ≥10 repetitions; reasons for this discrepancy are not clear and may simply be related to the lower sample of female competitors. Anecdotally, bodybuilders often consider higher repetition schemes more appropriate for "cutting" cycles (20); however, there is no objective evidence this holds true in practice. Alternatively, there is compelling evidence that similar gains in muscle mass can be achieved across a wide spectrum of loading zones (39), and thus, the approach does not seem detrimental to precompetition goals.

Rest intervals tended to be relatively short, with competitors taking ≤90 seconds between most of their sets as previously observed (20,21); minimal differences were observed between sexes on this variable. This strategy is typically used to help expedite fat loss (20), which is a primary goal during the precontest period. It should be noted that research indicates shorter rest periods may compromise muscle development (17), perhaps making the strategy ill-advised for precontest physique competitors.

Intensity of effort varied greatly between physique athletes. Most competitors trained to failure on some of their sets, but few took all sets to failure. Males generally trained with a higher intensity of effort than females; no female competitor reported taking >80% of sets to failure, whereas 18% of male competitors trained to failure on >80% of sets. Current evidence indicates that training to failure does not elicit superior hypertrophy provided sets are relatively challenging to the neuromuscular system (18). However, the paucity of research on the topic in physique competitors, particularly during periods of energy restriction, precludes the ability to generalize findings to the studied population in a precontest setting.

All competitors supplemented their resistance training programs with cardio exercise. Physique athletes commonly use this practice during the precontest period given the need to reduce body fat to extremely low levels on competition day (20). Compared with males, females tended to perform a higher number of weekly cardio sessions (5.6 vs. 8.3 $times \cdot wk^{-1}$) for a somewhat greater per session duration (36.2 vs. 41.3 minutes). Both male and female competitors included high-intensity interval training methods to further expedite fat loss. Contrary to previous evidence (15), recent meta-analytic data suggest that performing cardio may not interfere with muscle development (42); however, studies are lacking in highly trained physique athletes with low body levels, and both the duration and intensity of the exercise likely influences results (41). A majority of competitors reported performing cardio in a fasted state, despite a paucity of evidence that this strategy is not superior for fat loss as compared with fed cardio (19). However, members of our group (Escalante and Barakat) recently discussed that no current research has specifically examined if fasted cardio is superior to fed or protein-enhanced cardio in the physique population where athletes have to achieve extremely low levels of body fat and often begin their fat loss program 16+ weeks before the competition date with relatively low body fat levels in comparison with the populations previously studied on the topic where the intervention lasts only ~4 weeks (13).

In agreement with previous survey research (20,21), a large percentage of physique athletes used dietary supplements to prepare for competition. Hackett et al. (21) recently reported that 95.7% of male bodybuilders used dietary supplements, and the results of our study showed similar results. At least one dietary supplement was used by 95% of males, and 100% of these subjects reported using ≥3 supplements simultaneously, whereas 23.8% used ≥10 supplements simultaneously. Similar to the results reported by Hackett et al. (21), fat burners and caffeine were

some of the most commonly used supplements by male competitors as they got closer to competing; however, in our study, males also frequently consumed branched chain amino acids, whey protein, vitamin C, and essential amino acids, whereas participants in the Hackett et al. study (21) frequently used yohimbine and preworkout supplements. Interestingly, only 1 competitor in this study reported using a preworkout supplement during the last 30 days of competition. Although a smaller percentage of female competitors used dietary supplements as compared with males (males: 95% vs. females 75%), 71.4% of the females using dietary supplements used ≥3 supplements simultaneously and 14.3% used ≥10 supplements simultaneously. Similar to the males, caffeine, branched chain amino acids, and fat burners were the most frequently used dietary supplements by females in this study. Many of the supplements reportedly consumed by competitors lack objective evidentiary support, and some have been shown to be ineffective (31).

Also in agreement with previous research of competitors entering untested bodybuilding competitions, male and female physique athletes in this study reported using PEDs. In a case report of 6 physique competitors by Gentil et al. (16), all of the subjects (4 males and 2 females) reported using various types of PEDs inclusive of testosterone propionate, testosterone enanthate, stanozolol, oxandrolone, drostanolone propionate, ephedrine, hydrochlorothiazide, and theophylline. Similarly, Hackett et al. reported that 53.6% of respondents competing in competitions not sanctioned as "natural" and 2.4% of respondents competing in natural bodybuilding events used PEDs (21). In this study, use of at least one PED was reported by 47.6 and 37.5% of male and female competitors, respectively. Of the male competitors that reported using PEDs, 20% stacked 6 drugs together and 30% stacked 2–4 drugs together. Female PED users also stacked drugs, with 66.6% taking at least 3 drugs simultaneously. Similarly, Hackett et al. reported that a median of 6 drugs were used by the competitors that used PEDs in his study (21). The most commonly used PEDs by males in this study were various types of SARMs, human growth hormone, testosterone propionate, testosterone cypionate, trenbolone acetate, oxandrolone, stanozolol, drostanolone enanthate, levothyroxine, clenbuterol, hydrochlorothiazide, and spironolactone. Like males, females reported to use testosterone propionate, oxandrolone, stanozolol, clenbuterol, and spironolactone; however, they also reported using the estrogen blocker tamoxifen. Similar to this study, Hackett et al. (21) reported bodybuilders used similar drugs (e.g., drostanolone propionate, stanozolol, clenbuterol, trenbolone acetate, and oxandrolone) during the 6 weeks before competing.

One concern with the abuse of PEDs, specifically androgenic–anabolic steroids (AASs), is the negative cardiac and metabolic effects they may have on the body such as elevated levels of low-density lipoprotein (LDL), low levels of high-density lipoprotein (HDL), potentially elevated systolic/diastolic blood pressure, left ventricular hypertrophy, and secondary erythrocytosis (1,36). The cardiovascular concerns with abuse of AAS can become more concerning when combined with some of the water/sodium manipulation practices often used by bodybuilders during the final days before competition. Specifically, reaching a point of significant (USG 1.021–1.030) or severe (USG > 1.030) dehydration (5) from cutting water or use of diuretics, which was reached by 66.7% (14/21) of males and 50% (4/8) of females, may lead to relative erythrocytosis (26,27). The increased blood viscosity as a result of the elevated red blood cell count from use of AAS (secondary erythrocytosis), combined with an elevated hematocrit from the decreased plasma volume as a result of dehydration (relative erythrocytosis), may lead to an increased risk for venous thromboembolism, myocardial infarction, and cerebrovascular accidents (36). It would be beneficial for future research in this population to investigate hematocrit levels, HDL, LDL, and other blood biomarkers in the "off-season" and "precontest" season.

Although blood samples were not collected in this study, blood pressure (BP) and resting heart rate were 2 physiological biomarkers that were assessed in 14 of the 29 subjects (10 males and 4 females). Resting heart rate fell within normal ranges with a mean HR of ~64 BPM and ~71 BPM for males and females, respectively. By contrast, mean BP for males and females in this study are considered stage 1 hypertension (diastolic 80–89 mm Hg) per the American College of Cardiology and the American Heart Association (48) with a mean BP of ~ 127/82 mm Hg for males and ~108/80 mm Hg for females. The results of the BP may be at least partly explained by the small sample size where some subjects reported to use caffeine, fat burners, and PEDs along with the measurement of BP 1 day before competition where stress/anxiety levels are likely high. Given the relatively minor observed mean elevations in BP, the findings should be interpreted with circumspection. However, future research in this area is necessary to draw more definitive conclusions.

For body composition, competitors were generally successful in achieving low relative body fat, as evidenced by multiple body composition estimation techniques. As estimated by the US, BF % in male competitors exhibited a mean of 6.8% (range: 3.7–11.3%) the day before competition. In female competitors, mean US BF% was 13.9% (range: 11.6–21.1%). Bioimpedance spectroscopy BF% estimates were higher than US BF% estimates in 71% (15/21) of male competitors and 63% (5/8) of female competitors (Figure 1A). Accordingly, mean BIS BF% was 10.5% (range: 5.9–20.3%) in male competitors and 16.7% (range: 11.1–22.8%) in female competitors. A cursory examination of BF% values emphasizes that US and BIS assess fundamentally different parameters to estimate relative body fat. As expected, the apparent agreement between US and BIS for fat-free mass was superior than for BF%, primarily due to the larger absolute quantities, larger spread of values, and more direct incorporation of body mass estimates (Figure 1B). In addition to individual physiological differences and varying success of the precompetition preparation phase, the disparate leanness requirements in different competitive categories may have contributed to the observed ranges of BF%. Furthermore, both technical and biological errors were present for both US and BIS, particularly given the inability to perform fully standardized assessments (46).

A large range of relative TBW values was observed (males: 55.9–69.9% of body mass; females: 54.2–62.4% of body mass). It would be expected that, due to greater fat-free mass, physique competitors would exhibit higher relative body water values. However, the utilization of a bioimpedance, rather than a dilution technique, as well as the nonstandardized assessment and the intentional manipulation of body fluids by competitors, could have contributed to this finding.

For body fluid distribution, the reference man possesses ~57% of TBW as ICW and ~43% as ECW (24). In this study, male physique competitors exhibited slightly greater mean ICW (60.9%) and correspondingly slightly lower mean ECW (39.1%). Furthermore, 100% of male competitors exhibited lower ECW and higher ICW than the reference man, although methodological

differences should again be noted. The reference woman is ascribed ~60% of TBW as ICW and ~40% of TBW as ECW (24). In the female physique competitors, mean values were very similar (ICW: 61.0% and ECW: 39.0%), with the reference woman values sitting near the midpoints of the observed ranges (ICW: 55.8–64.1% and ECW: 35.9–44.2%). In competitors of both sexes, a general trend for higher ECW% (i.e., ECW/TBW) in those with lower TBW% (i.e., TBW/BM) was observed, indicating that those with higher relative TBW content may possess higher relative ICW content (Figure 2B).

Interestingly, one of the primary goals of CHO loading and water/sodium manipulation among physique competitors is to minimize the extracellular interstitial fluid (specifically subcutaneous water) that surrounds the muscles while maintaining or increasing the intramyocellular ICW to maximize the appearance of muscle size and leanness (14). Although there is a paucity of research on the safety and effectiveness of the strategies implemented by physique competitors to accomplish these goals, the slight differences observed in the ICW to ECW ratios between male and female competitors in this study in relation to reference values is intriguing. Both males and females reported a relatively low CHO intake in the 3 days before competition (males: 1.77 g CHO·kg$^{-1}$; females: 1.18 g CHO·kg$^{-1}$), so CHO intake likely did not favorably influence the ICW to ECW ratio due to the low quantity of CHO consumed in relation to the minimum recommendation of 4 g CHO·kg$^{-1}$ to help increase muscle glycogen levels (14). Water intake was similar between males and females 1 day before competition (males: 49 ml·kg$^{-1}$; females: 51 ml·kg$^{-1}$), but compared with 3 days before competition, males reduced water intake less than females (males: 22% reduction; females 39% reduction); thus, reducing water intake past a certain point (especially when combined with low CHO consumption) may negatively affect the ICW to ECW ratio. Last, 25% of females used prescription diuretics (e.g., spironolactone and hydrochlorothiazide), and only 4.7% of males used prescription grade diuretics; hence, use of prescription grade diuretics, even potassium sparing diuretics such as the ones used by competitors in this study, may negatively affect the ICW to ECW ratio. As previously mentioned, the findings of body fluids should be interpreted with caution as we acknowledge that using BIS to assess TBW/ICW/ECW, the nonstandardized assessment of body fluids, and the intentional manipulation of body fluids by competitors may have influenced our findings; however, future research in this area is warranted. Furthermore, we must also recognize that although the ICW/ECW ratios between males and females were different in relation to reference values, they were rather similar between each other (males: ICW = 60.9%, ECW = 39.1%; females: ICW = 61.0%, ECW = 39.0%). Similarly, mean hydration levels as determined by USG were also similar between the sexes (males: 1.020; females: 1.019). The relationship between distinct variables that theoretically influence the appearance of leanness, such as ECW content and skinfold thickness, is not fully clear. A possible relationship between higher ECW% (i.e., ECW/TBW) and greater US total skinfold thickness was observed, particularly in males (Figure 2A), but further research is needed to establish the veracity and importance of this observation.

As mentioned throughout this article, the results of this observation study must be interpreted with caution due to the small sample size of 29 physique athletes. Although we attended several bodybuilding events and spoke to over 500 competitors, only ~6% of the subjects volunteered to be part of our study. Since our data collection took place 1 day before the competition, we had to work around athlete meetings, weigh-ins, tanning appointments, competitor eating schedules, and other similar "day before a show" priorities that competitors have to navigate. That said, this study adds value to the body of literature on the nutrition, training, supplement, and PED practices used by physique athletes at nontested events 30 days before their competition, including the peak week. It also provides insight into body composition and body fluid measures of physique competitors 1 day before competition.

## Practical Applications

Although there is a lack of research on the safety and efficacy of physique competitors' practices to peak for competition, current data demonstrate large interindividual differences regarding their nutrition, training, supplement, and PED methodologies. Since these variables are interrelated and their manipulations can elicit different responses among different individuals, specific prescription recommendations cannot be made. However, due to the researchers' experience as coaches or athletes in conjunction with the information available, we recommend instituting at least one "mock peak week" 2–4 weeks before competing to assess how variables may need to be altered to optimize individual results. In addition, we suggest the following: If working with a coach, consider his/her educational background in conjunction with practical experience. Use a nutritional strategy with the aim of restoring previously depleted energy reserves (i.e., IMT and glycogen) to maximize muscle fullness during peak week. Use water intake as a potential tool to improve physique aesthetics by nutrient delivery and fluid balance or to aid in making a weight class. Abstain from supplemental or drug protocols where there is a limited understanding of their efficacy, potential benefits, and more commonly ignored health risks.

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