Original Research

Psychophysiological Tracking of a Female Physique Competitor through Competition Preparation

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ABSTRACT

International Journal of Exercise Science 10(2): 301-311, 2017. Natural physique competitions are based on subjective judgments of how a competitor appears on show day. Prior to competition, there is a prolonged dieting phase referred to as contest preparation. The primary goal is to reduce body fat levels while maintaining skeletal muscle mass. The study tracked the physiological and psychological changes for a 24 year old female preparing for a physique competition. Purpose: The study was conducted to describe the physiological and psychological changes of a female physique competitor who engages in long-term contest preparation. Methods: Diet, body composition, blood work, energy expenditure, mood, and performance were evaluated through contest preparation. Results: The participant lost 10.1kg throughout contest preparation in a strong weekly linear pattern ($R^2=0.97$). Body fat was reduced from 30.45% to 15.85% while fat free mass was maintained. Mood for the participant remained stable until month five, when an observed variation occurred, with performance maintaining. Conclusions: Contest preparation was successful in reducing the body fat in the participant while having a minimum effect on both performance and fat free mass. For athletes looking to lose large amounts of body fat with minimal performance decrements a prolonged diet period with moderate exercise and food restriction can be an effective solution.

KEY WORDS: Adaptive thermogenesis, bodybuilding, body fat, figure, weight loss

INTRODUCTION

Natural physique competitions are based on subjective judgments of how a competitor appears on show day. In natural bodybuilding "natural" requirements include a drug free status. Urinalysis and polygraph testing are done on or before competition day in an effort to uphold the competitor's natural status. For example, the North American Natural

Bodybuilding Federation (NANBF) requires a minimum of seven years drug free, polygraph prior to competition day, and urinalysis on competition day to be considered natural.

Prior to stepping on stage on show day for the competition, there is a prolonged dieting phase referred to as contest preparation. The goal of contest preparation is to reduce the percentage of body fat (%BF) while sustaining skeletal muscle mass. Contest preparation phases have been recorded as short as two months in length with weight loss as high as 1.8 kg·wk^{-1} (10, 14). Energy intakes during the aforementioned studies are often reduced to minimal levels (under 900 kcal·d^{-1}) to further exacerbate negative effects of dieting (16). Other studies have reported binge eating and amenorrhea related to rapid weight loss (19, 23). The rapid weight loss and drastic caloric restriction is suggested to result in excessive fat free mass (FFM) losses (9). A more conservative approach to a contest preparation lasting two or more months hypothetically maintains FFM muscle mass to a greater degree (8). The longer approach to contest preparation hypothetically minimizes the negative effects of dieting by lowering the changes incurred when extensive fat loss is desired. FFM retention is integral to achieve success as the main goal of a physique competitor is subjective aesthetic appeal.

Recent case studies about natural physique competitions in males tracked diet, resistance training, aerobic exercise, body weight, fat mass, FFM, bone mineral density, blood pressure, heart rate, arterial stiffness, and cholesterol (13, 18). Rossow et al. (18) also tracked energy expenditure, hormonal, mood, and strength changes. Kistler et al. (13) additionally tracked relative VO$_2$ max, autonomic function, inflammation, and oxidative stress. Both of the aforementioned case studies followed a male participant throughout the contest preparation phase.

Despite the recent case studies tracking male bodybuilding contest preparation, we are unaware of any case reports tracking comprehensive physiological and psychological changes of a female during contest preparation. Therefore the purpose of the case study was to describe the physiological and psychological changes of a female physique competitor who engages in long-term contest preparation.

METHODS

Participants
The participant was a 24y white, female. Upon initiation of the five month study the participant was 171.5cm, 67.4kg, and 30.5%BF. Previous competition history included a fourth and fifth place finish in two separate competitions two years prior. The participant's training history included weight training 4-5 times per week for five years. The study was approved by the Minnesota State University, Mankato institutional review board for the protection of human participants. The participant was informed of all testing procedures of the study and signed an informed consent prior to beginning of the testing. The case study design tracked a single female participant throughout a contest preparation period. A comprehensive blood draw was taken to coincide with other physiologic changes such as body composition, energy

expenditure, and performance measures to determine the changes caused by the contest preparation period on the participant.

Protocol
The participant started the contest preparation consuming a diet, which was followed for four weeks prior to beginning the study, of 305g/day carbohydrate, 150g/day protein, and 70g/day fat and had a higher macronutrient day twice weekly at 415g/day carbohydrate, 135g/day protein, and 60g/ day fat with a weekly average to begin the study of 2500kcals. The weekly diet consisted of a carbohydrate/protein/fat macronutrient ratio of 53%/23%/24%. At the end of contest preparation, the female participant consumed 70g/day carbohydrate, 150g/day protein, and 70g/day fat and had a higher macronutrient day of 300g/day carbohydrate, 135g/day protein, and 25g/day fat every five days. The weekly average was 1460kcals per day with a carbohydrate/protein/fat macronutrient ratio of 38%/40%/22%.

Macronutrient changes during the preparation period were under the guidance of a contest-preparation coach. A marked reduction in macronutrients, primarily from carbohydrates and fat, to the standard of approximately 100 calories was prescribed if weight loss rate slowed and insufficient visual changes coincided. During contest preparation, the participant remained within ±5g of each macronutrient daily. Daily supplementation of creatine monohydrate (5g/day), fish oil (3g/day), and a multi-vitamin (500mg/day) were consumed. No birth control or prescription medications were taken.

Bodyweight, macronutrients, training and menstrual cycle were tracked on a report that the participant filled out daily and sent to the researcher weekly. The competitor inputted numerically the weight and total macronutrients daily into the report. Training input would be recorded as the type and duration. Menstrual cycle was tracked with an affirmative or a negative indication as to whether menstruation was occurring.

Testing was conducted in the same order at 7:00am on Saturday every four weeks. The participant completed the blood draw, resting heart rate, blood pressure, resting metabolic rate (RMR), and underwater weighing in a fasted state. The participant then consumed a meal to reduce fasting effects on the mood questionnaire and performance (18). The participant completed the 3-minute all-out test (3MT) approximately 90 minutes after the meal.

Daily weighing was completed upon waking with similar styles of female underwear and sports bra and tracked to the nearest 0.1kgs on a weight scale (Taylor Precision Products, Las Cruces, NM). The same scale was used throughout the testing to reduce variability in measurements. At monthly lab visits total body weight was measured using a standard scale (Tanita, Arlington Heights, IL). Daily body weights were taken to determine the effectiveness of the nutrition and training regimen. The weights were a tool used to determine changes in nutrition and/or calories for the preceding week. Resting heart rate was taken with the participant in a seated position with feet flat on the floor, legs uncrossed. A Polar f6 heart rate

monitor (Polar Electro Inc, Lake Success, NY) was used to get the resting heart rate after a five minute rest.

Blood pressure was measured using an automatic blood pressure measuring device (Omron Healthcare Inc, Vernon Hills, IL). After five minutes at rest, two blood pressure measurements were taken. If the measurements were not within ±5mmHg the blood pressure reading was repeated. RMR was collected using indirect calorimetry. Before testing began, the participant sat quietly for 30 minutes (3). The participant lay in the supine position for the 20 minute duration of the test. The data reported represented the average of a 5 minute window with $V0_2$ deviation less than 5%. The RMR was calculated using the Weir equation with data from the metabolic cart (Parvo-Medics Inc, Sandy, UT) (24). RMR was used to determine the participant's baseline caloric needs and to determine if any adaptive thermogenesis occurred (4).

The Brozek equation was used to predict the body fat percent (BF%) and FFM from hydrostatic weighing (6). FFM was calculated by: FFM = (1-BF%) x Body weight. Water temperature was measured with a standard thermometer in degrees Celsius (°C). The hydrostatic weighing equipment was an Exertech™ Body Density Measuring System, including Flotaweigh™ Floating Wireless Underwater Weighing System (Exertech™ WD4 Software, Malvern, PA, USA). Three hydrostatic weighing trials were performed with the mean of the trials being considered the final value. Hydrostatic weighing was used to determine the effectiveness of the nutrition and training regimen in the preservation of FFM.

For determination of maximal oxygen consumption (VO_{2max}), critical power (CP), and anaerobic capacity (W') a cycle ergometer (Lode, Excalibur, Groningen, The Netherlands) 3MT was completed (22). Gas exchange during the 3MT was measured using a metabolic cart (Parvo-Medics Inc, Sandy, UT).

The participant pedaled at a moderate intensity for five minutes followed by five minutes of recovery. The participant then pedaled all-out against a resistance predetermined by the investigators (22). The software for the cycle ergometer is programmed to provide 30 second lead-up time at 50 watts (W). Within the last few seconds of the lead-up time, the participant was instructed to increase the pedaling rate to prohibit starting from a dead start. The test was terminated at 3min 5s for the full 3min sample to be gathered. In order to be valid the 3MT ending cadence had to be within 10 rpm of preferred cadence, and minimal fluctuation of the power data.

A square wave verification bout was performed after the 3MT to verify the VO2max values were accurate (2). Software was programmed to provide a 3-min recovery at 50W. Based on the data from the 3MT a value of 10% above CP was calculated. The power output of the cycle was set to 10% above CP. Cadence was initially selected at the participants preference with the test being terminated when the selected cadence decreased by 10rpm for 10s. Previous research indicates that participants should reach VO2max in ~2 to 3 min if true CP was

determined. W' was calculated by subtracting the average power output during the first 150 seconds from the CP and multiplying the number by 150 (22).

VO2max was used to determine the participant's maximum volume of oxygen that can be used. CP is the maximum work rate the participant can maintain for an extended period of time (22). W' is the anaerobic work capacity.

Blood sampling was obtained through venipuncture of the median cubital vein by a physician. Blood samples were sent to Quest Diagnostics for analysis. Three different blood panels were drawn from a blood sample each month, comprising of lipid, metabolic and hormonal panels. The lipid panel included total cholesterol, high density lipoproteins (HDL), triglycerides (TG). The metabolic panel included glucose, blood urea nitrogen (BUN), creatinine, BUN/creatinine ratio, sodium (Na), potassium (K), chloride (Cl), carbon dioxide (CO_2), and calcium (Ca). Lastly, the hormonal panel included thyroid stimulating hormone (TSH), leptin, estradiol, cortisol, and testosterone.

Mood assessment was with the activation deactivation adjective checklist (AD ACL) (21, 20). The 20 activation adjectives were rated by the participant to describe one's immediate feelings on a Likert scale (1: definitely feel, 2: feel slightly, 3: cannot decide, 4: definitely do not feel). The four subscales within the AD ACL include energy, tension, tiredness, and calmness.

The participant began contest preparation performing five weight training sessions per week, targeting each muscle group two times; one with a moderate weight (60-80% 1RM) and volume and one with a higher weight (85%+ 1RM) and lower volume. Additionally, there were no cardiovascular training sessions for the two months prior to the contest preparation. Cardiorespiratory training sessions were broken into two categories based on their intensity; moderate intensity steady state (MISS) and high intensity interval training (HIIT) (9). MISS training was done on a cycle or an elliptical while HIIT was only completed on a cycle. Throughout contest preparation, increases in cardiorespiratory frequency and duration occurred to maintain caloric deficit and weight loss. Recommendations for training and cardiorespiratory exercise were at the discretion of the contest-preparation coach. Typical weekly adjustments of cardiorespiratory exercise included an increase of 15 minutes MISS and/or 5 minutes of HIIT. At the time of competition, the participant was doing the same weight training as described previously with the addition of 185 minutes of MISS with three 12 minute HIIT sessions.

Statistical Analysis
Microsoft Excel (Microsoft, Redmond, WA) was used to determine coefficient of determination (R^2) for weight loss.

RESULTS

Highlighted changes during competition preparation were; small fluctuations in FFM and RMR, strong weekly linear weight loss (R^2=0.97), and a decline in energy intake of 1040 kcals

(Figure 1, Table 1).   The menstrual cycle remained consistent for the initial four months of competition preparation.   However, month five and six of testing resulted in a delayed cycle (four and five days respectively).

The aerobic fitness as measured metabolically using VO2max and CP remained consistent, however relative VO2max increased due to the decline in body mass (Table 2). The anaerobic work capacity as measured by W' remained relatively stable with slight changes occurring throughout contest preparation.   The cycle ergometer was broken on month four; therefore a graded exercise test on a Monarch Ergomedic was completed to determine VO2max.   There was a decline in observed maximal heart rate (Table 2).
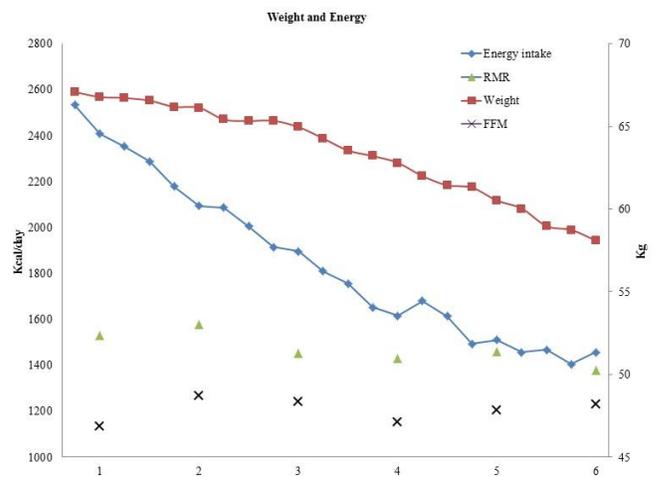

Figure 1. Contest preparation weight and energy requirement fluctuations. Legend: ♦ Energy intake, ▲ Resting metabolic rate, ■ Weight, x Fat free mass.

Table 1. Monthly assessed variables

	Month	1	2	3	4	5	6
Height	Cm	171.5	171.5	171.5	171.5	171.5	171.5
Weight	Kg	67.4	66.0	65.0	62.3	60.5	57.3
HR_{rest}	Bpm	64	63	62	56	54	53
BP	mmHg	120/76	118/64	112/62	115/67	110/75	112/58
Body Fat	%	30.5	26.2	25.6	24.3	20.9	15.9
FFM	Kg	46.9	48.7	48.3	47.1	47.8	48.2
RMR	Kcal/day	1531.1	1577.5	1452.6	1429.1	1460.3	1376.4

Abbreviations: HR_{rest}: resting heart rate; BP: blood pressure; FFM: fat free mass; RMR: resting metabolic rate

Table 2. Monthly performance measures.

	Month	1	2	3	4	5	6
HR_{max}	bpm	183	178	179	180	179	170
VO_{2max}	$L \cdot min^{-1}$	2.7	2.9	2.5	2.5	2.6	2.3
VO_{2max}	$ml \cdot kg^{-1} \cdot min^{-1}$	39.9	43.5	38.0	40.5	43.7	40.7
CP	W	136	134	139		129	124
W'	kJ	8.3	8.4	6.4		9.3	6.1

HR_{max}: maximal heart rate; VO_{2max}: maximum oxygen uptake; *CP*: critical power; *W'*: finite work capacity >*CP*.

The lipid panel was largely unaffected throughout the contest preparation. Total cholesterol initially was below reference ranges and remained low throughout contest preparation. No other lipid panel values changed outside of reference ranges. The metabolic panel also was unaffected through the contest preparation period. Thyroid stimulating hormone was initially high and out of reference range, but after the first week returned to normal ranges. Hormonal panel values of estradiol and leptin were affected throughout the preparation. Estradiol was elevated the last two testing dates as the participant's menstrual cycle was delayed. Leptin slowly dropped throughout the preparation period until leveling off the last two months. Table 3 outlines the blood draws taken every four weeks throughout the contest preparation period.
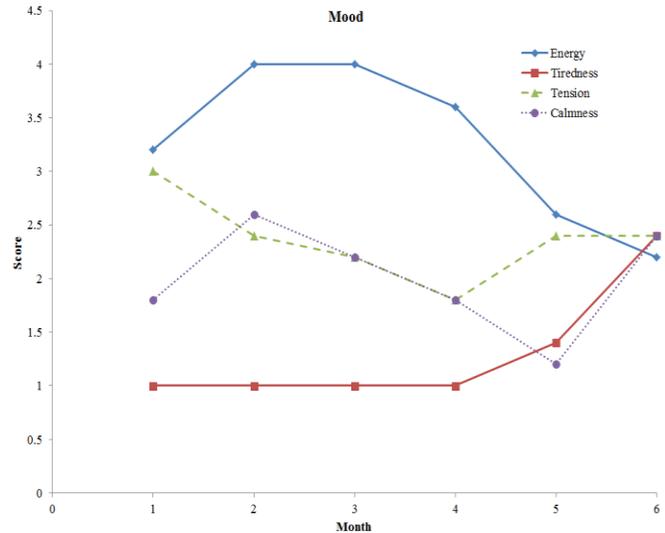

Figure 2. Mood alterations during competition preparation with a score of 4 being high and 1 being low for the corresponding mood. Legend: ♦ Energy, ■ Tiredness, ▲ Tension, ● Calmness

Table 3. Blood work variables during contest preparation.

Month		1	2	3	4	5	6
TC	mg·dL⁻¹	109*	106*	113*	95*	98*	105*
HDL	mg·dL⁻¹	48	51	49	45	50	54
TG	mg·dL⁻¹	44	41	39	37	37	52
LDL	mg·dL⁻¹	52	47	56	43	41	41
Chol/HDL ratio	mg·dL⁻¹	2.3	2.1	2.3	2.1	2	1.9
Glucose	mg·dL⁻¹	84	86	94	78	84	82
BUN	mg·dL⁻¹	16	11	13	16	14	14
creatinine	mg·dL⁻¹	0.7	0.71	0.82	0.74	0.75	0.77
GFR	mL·min·1.73m2⁻¹	121	119	100	113	112	108
BUN/Creatinine		22.9	15.5	15.9	21.6	18.7	18.2
Sodium	mmol·L⁻¹	140	137	137	138	139	136
Potassium	mmol·L⁻¹	4.6	4.5	4.6	4.5	4.7	4.5
Chloride	mmol·L⁻¹	107	101	105	103	103	103
Carbon dioxide	mmol·L⁻¹	21	25	23	24	23	22
Calcium	mg·dL⁻¹	9.4	9.5 9.4	9.3	9.7	9.8	
TSH	mIU·L⁻¹	5.27*	5.05 3.78	4	3.36	2.5	
Leptin	ng·mL⁻¹	12	6.1 5.9	3.1	1.6	1	
Estradiol	pg·mL⁻¹	35	34 41	35	136	127	
Cortisol	mcg·dL⁻¹	9.4	14.4 10.8	9.5	9.2	12.6	
Testosterone	ng·dL⁻¹	23	20 27	25	29	28	

TC = total cholesterol, HDL = high density lipoprotein, TG = triglyceride, LDL = low density lipoprotein, BUN = blood urea nitrogen, GFR = glomular filtration rate, TSH = thyroid stimulating hormone
*Value not within normal, healthy limits of the measure.

Mood was relatively unaffected until month five (Figure 2). Month five and six each had a decline in energy and an increase in tiredness. The change in energy was in an inverse relationship with the change in tiredness. No discernable trends were seen in tiredness and calmness.

DISCUSSION

Weight loss was observed in a consistent linear fashion throughout contest preparation (R^2=0.97). A surprising finding was the female participant successfully lost half of her initial body fat while maintaining FFM. Previous studies on male participants found FFM losses throughout the preparation period (13, 18). A high protein diet and a moderate weight loss rate per week could explain the body fat loss without a concomitant FFM loss (8). However, differences in FFM retention could be related to varied body composition methods between studies (two and four compartment models).

Another finding was the small change in RMR despite the drop in calories (1040kcal) and bodyweight (10.1kg). Unlike the male counterpart in a previous case study, the female participant had a less pronounced decrease in RMR (160kcal decrease compared to 1000kcal) (18). Despite the male in the aforementioned study remaining relatively consistent with calorie intake throughout the preparation, the participant suffered adaptive thermogenesis possibly due to the decreased body fat (13, 18). The female did not seem to incur much adaptive thermogenesis related to the fat loss and caloric restriction throughout the preparation phase. While adaptive thermogenesis differs in comparison to other recent contest preparation studies, the slow rate of weight loss was found to be similar to that of athletes' losing weight while preserving FFM (7). The participant's FFM was unaffected throughout the competition preparation and the RMR decreased by 10%. The data conflicts with Johannsen et al. study which found the participant's RMR decreased 29.4% while fat free mass remained relatively the same (11). The conflict could be due to the large caloric restriction and time-intensive exercise regimens given to the participant's compared to the gradual changes of calories and exercise in the present study. Also the participant's in Johannsen et al. lost 30-50% of their initial body weight compared to the present study's loss of 15% could explain the discrepancy (11).

Similar to previous case studies in males (13, 18) the participant maintained VO2$_{max}$ and critical power throughout the contest preparation. For anaerobic performance, despite losing a significant amount of body mass and body fat, the female participant was able to achieve the highest W' in month five of testing. The data is in contrast to the Rossow et al. (18) study where the male participant consistently reduced W' throughout the contest preparation. A possible explanation for the discrepancy is the unreliable nature of the W' for test-retest reliability reported previously (12).

Surprisingly, K, BUN, creatinine, GFR, Na, Cl, CO2, and Ca for the participant remained within normal values throughout the contest preparation. Remarkably GFR, BUN, and

creatinine remained within normal limits with the %kcals from protein increasing throughout the competition preparation. Similar to previous data from Knight et al. (15) which also found no change in renal function with increasing levels of protein intake in normal renal functioning participants. The lipid panel fluctuated each month but did not show a trend towards increasing or decreasing. Estradiol was low as menstruation began 1-3 days prior to monthly blood testing with exception of the last two testing dates in which menstruation occurred after testing and the estradiol was high. Cortisol and testosterone fluctuated but did not have any discernable trend towards decreasing or increasing unlike Rossow et al. (18) which had cortisol increase and testosterone decrease. Leptin incurred a substantial decrease between the first two testing dates and subsequently continued to decrease through month six. The drops in leptin follow the drops in calories which would be expected as decreases in leptin occur during caloric restricted periods (25). TSH decreased consistently during the competition preparation. As the TSH and leptin dropped consistently during contest preparation there may be an energy impact on TSH as well. No large changes were observed with testosterone, cortisol, lipids, and estradiol with weight loss. The data is consistent with past studies showing a prolonged weight loss phase emphasizing minimal changes weekly can delay/prevent negative objective markers of weight loss (7, 13, 18).

Notably, the participant's mood was unaffected through the competition preparation period until the final two months of testing. The energy and calmness decreased and the tiredness and tension increased suggesting, despite the changes in BF%, calories, and training amount mood may not be affected until a certain threshold is reached.

Further studies should be done evaluating female physique competitors at increased levels of leanness. There was a change in the leanness and body composition of the current subject, but the current subject did not achieve states of leanness in proportion to the male study counter parts which could be why there are differences in mood and RMR.

A study with an increased number of subjects should be done. However, the difficulty of this task is compounded by each subject's specific needs to achieve a state of leanness to compete. This is evident in the previous two studies on males which resulted in each subject using varying intensities of caloric restriction and increased energy expenditure to achieve their stage leanness (13, 18).

The contest preparation was successful for the participant in removing body fat while preserving FFM to promote a positive aesthetic appearance while ensuring minimal negative psychophysiological effects. Negative adaptations throughout the preparation period included a reduction in energy, calmness, and leptin, as well as an increase in tiredness. As a whole, the contest preparation period was effective in improving aesthetic appearance while minimizing negative physiologic adaptations.

The results of the present study suggest that female athletes looking to improve body composition or reduce weight for an improvement in sport performance could experience

fewer physiological and psychological disturbances with a prolonged dieting period. Based on this study's data, the diet of the athlete should be consistent throughout with a high protein intake to preserve FFM (1). Planning ahead aids in adequate construction of a manageable weight loss program for the athlete leading into a competition.

ACKNOWLEDGEMENTS

REFERENCES

1. Churchward-Venne TA, Murphy CH, Longland TM, Phillips SM. Role of protein and amino acids in promoting lean mass accretion with resistance exercise and attenuating lean mass loss during energy deficit in humans. J Amino Acids 45(2): 231-240, 2013.

2. Clark IE, Murray SR, Pettitt CD, Kernozek TW, Pettitt RW. Alternative Procedures For The 3-Min All-Out Exercise Test. Med Sci Sports Exerc 45(5): 686, 2013.

3. Dalbo VJ, Roberts MD, Stout JR, Kerksick CM. Effect of gender on the metabolic impact of a commercially available thermogenic drink. J Strength Cond Res 24(6):1633-1642, 2010.

4. Doucet E, St-Pierre S, Alméras N, Després J, Bouchard C, Tremblay A. Evidence for the existence of adaptive thermogenesis during weight loss. Br J Nutr 85(6): 715-723, 2001.

5. Dulloo AG, Jacquet J, Montani J, Schutz Y. How dieting makes the lean fatter: From a perspective of body composition autoregulation through adipostats and proteinstats awaiting discovery. Obes Rev 16(S1): 25-35, 2015.

6. Fleck SJ. Body composition of elite american athletes. Am J Sports Med 11(6): 398-403, 1983.

7. Garthe I, Raastad T, Refsnes PE, Koivisto A, Sundgot-Borgen J. Effect of two different weight-loss rates on body composition and strength and power-related performance in elite athletes. Int J Sport Nutr Exerc Metab 21(2): 97-104, 2011.

8. Helms ER, Aragon AA, Fitschen PJ. Evidence-based recommendations for natural bodybuilding contest preparation: Nutrition and supplementation. J Int Soc Sports Nutr 11(1): 20, 2014.

9. Helms E, Fitschen PJ, Aragon A, Cronin J, Schoenfeld BJ. Recommendations for natural bodybuilding contest preparation: Resistance and cardiovascular training. J Sports Med Phys Fitness 55(3): 164-178, 2014.

10. Hickson JF Jr, Johnson TE, Lee W, Sidor RJ. Nutrition and the precontest preparations of a male bodybuilder. J Am Diet Assoc 90(2): 264-267, 1990.

11. Johannsen DL, Knuth ND, Huizenga R, Rood JC, Ravussin E, Hall KD. Metabolic slowing with massive weight loss despite preservation of fat-free mass. J Clin Endocrinol Meab 97(7): 2489-2496, 2012.

12. Johnson TM, Sexton PJ, Placek AM, Murray SR, Pettitt RW. Reliability analysis of the 3-min all-out exercise test for cycle ergometry. Med Sci Sports Exerc 43(12): 2375-2380, 2011.

13. Kistler BM, Fitschen PJ, Ranadive SM, Fernhall B, Wilund KR. Case study: Natural bodybuilding contest preparation. Int J Sport Nutr Exerc Metab 24(6): 694-700, 2014.

14. Kleiner SM, Bazzarre TL, Litchford MD. Metabolic profiles, diet, and health practices of championship male and female bodybuilders. J Am Diet Assoc 90(7): 962-967, 1990.

15. Knight EL, Stampfer MJ, Hankinson SE, Spiegelman D, Curhan GC. The impact of protein intake on renal function decline in women with normal renal function or mild renal insufficiency. Ann Intern Med 138(6): 460-467, 2003.

16. Lamar-Hildebrand N, Saldanha L, Endres J. Dietary and exercise practices of college-aged female bodybuilders. J Am Diet Assoc 89(9): 1308-1310, 1989.

17. Maclean PS, Bergouignan A, Cornier MA, Jackman MR. Biology's response to dieting: The impetus for weight regain. Am J Physiol Regul Integr Comp Physiol 301(3): R581-600, 2013.

18. Rossow LM, Fukuda DH, Fahs CA, Loenneke JP, Stout JR. Natural bodybuilding competition preparation and recovery: A 12-month case study. Int J Sports Physiol Perform 8(5): 582-592, 2013.

19. Steen SN. Precontest strategies of a male bodybuilder. Int J Sport Nutr 1(1): 69-78, 1991.

20. Thayer RE. Activation-deactivation adjective check list: Current overview and structural analysis. Psychol Rep 58(2): 607-614, 1986.

21. Thayer RE. Factor analytic and reliability studies on the activation-deactivation adjective check list. Psychol Rep 42(3): 747-756, 1978.

22. Vanhatalo A, Doust JH, Burnley M. Determination of critical power using a 3-min all-out cycling test. Med Sci Sports Exerc 39(3): 548-555, 2007.

23. Walberg JL, Johnston CS. Menstrual function and eating behavior in female recreational weight lifters and competitive body builders. Med Sci Sports Exerc 23(1): 30-36, 1991

24. Weir JB. New methods for calculating metabolic rate with special reference to protein metabolism. J Physiol 109(1-2): 1-9, 1949.

25. Yadav A, Kataria MA, Saini V, Yadav A. Role of leptin and adiponectin in insulin resistance. Clinica Chimica Acta 417: 80-84, 2013.