Training, Nutritional and Anabolic Steroid Practices During a Bodybuilder's Off-Season Phase and Their Effects on Muscle Strength, Hypertrophy, and Body Composition: A Case Study

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ABSTRACT

This case study documented the training and nutritional practices of a 21-year-old amateur male bodybuilder during a 9-week off-season period in combination with the use of anabolic androgenic steroids, and their effects on changes in body composition, muscle size and maximal strength. The assessments conducted included B-mode ultrasound measurements of muscle thickness, body composition via air displacement plethysmography, and strength testing via one-repetition maximum. The participant experienced significant increases in body mass (8.2 kg), fat-free mass (6.7 kg), and maximal strength (26.7% in squat, 13.2% in bench press, and 17.6% in deadlift) while maintaining a stable body fat percentage (18%). The study provides insights into the physical adaptations and hypertrophic effects associated with anabolic androgenic steroid use in combination with resistance training and a hypercaloric diet in an off-season bodybuilding phase, highlighting the distinct muscle growth and strength gains compared to drug-free athletes.

INTRODUCTION

Bodybuilding is a sport in which an athlete's physique is judged on muscularity, low body fat (BF) and overall physical symmetry (1). Competitive bodybuilders implement various training training modalities, including resistance training (RT) and aerobic training, while also adhering to a structured diet that varies in its macronutrient composition depending on the phase of their competitive season (1). The competitive cycle for physique athletes consists of an "off-season" phase that customarily includes an energy surplus and RT with the goal of increasing lean body mass while minimizing BF accrual, as well as an "in-season" preparatory phase (sometimes referred to as a 'contest preparation phase'), which typically consists of an energy deficit, RT, and aerobic activity to significantly decrease BF while preserving muscle mass (1).

In addition to training and diet, bodybuilders competing in non-tested federations often utilize anabolic androgenic steroids (AAS) to further enhance muscle mass gains and, secondarily, optimize fat loss (2). AAS enhance gains in muscle mass and strength by binding to androgen receptors, which increases the rate of protein synthesis and nitrogen retention in muscle cells (3). Haerinejad et al (4) surveyed 453 male bodybuilding athletes from 11 randomly selected gyms in Bushehr, Iran and found that 51.7% of bodybuilding athletes utilized multiple anabolic agents in their programs while other studies have explored the specific AAS use of competitive bodybuilders, including the dosages used during a competition preparatory period (5).

Competitive bodybuilding has attracted research interest throughout the years, mostly focusing on the training and nutrition practices of bodybuilders competing in drug-tested federations where AAS use is prohibited (1). Additionally, previous research has mostly focused on the pre-competition period, with a paucity of studies on the "off-season" phase.

Two questionnaire-based studies by Hackett et al (6, 7) on the training practices and ergogenic aids of male bodybuilders are among the few studies exploring the "off-season" routines of enhanced bodybuilders. The paucity of research in this area may be due to the legal status of AAS as they are illegal to possess without a prescription in many countries. For example, in the United States, AAS are classified as Schedule III controlled substances under the Controlled Substances Act, making unauthorized possession a criminal offense (8). Alternatively, in the United Kingdom it is permissible to possess AAS for personal use, although selling or distributing them without a license is prohibited (9). This disparity in legal status across countries complicates the ability to conduct research on anabolic steroid users and carrying out case studies can be particularly challenging, as individuals may be reluctant to participate due to the legal risks associated with admitting to possession or use in jurisdictions where it is considered a crime. However, given the widespread use of AAS in bodybuilders, it is important to understand their longitudinal effects in ecologically valid settings. Therefore, this case study aimed to explore the effects of an amateur male bodybuilder's off-season preparatory phase that included training, nutrition and self-reported use of AAS, on muscle hypertrophy, body composition, and maximal strength.

METHODS

Experimental approach to the problem

The participant was a 21-year-old male amateur bodybuilder based in the United Kingdom preparing for his first competition. This case study focused on his initial 9-week off-season training block, during which time he aimed to consume a surplus of energy while engaging in progressive RT and using AAS. Previously, he had engaged in RT for approximately 4 years but had not used AAS prior to commencing this 9-week off season period. The participant was not approached by the researchers to participate in the case study. Rather, he expressed interest in monitoring changes in muscle size and strength during his 9-week training block and it was retrospectively decided to present the data as a case study.

All pre- and post-intervention muscle hypertrophy and body composition assessments were performed during the same visit in the following order: B-mode ultrasound (US) evaluation of muscle thickness (MT), anthropometric tape evaluation of arm circumference and body composition evaluation via air displacement plethysmography. For the US measurements, the participant was instructed to avoid strenuous physical activity or exercise 48-72 hours. For the body composition measurements, he was instructed to avoid food and drink at least 3 hours prior to the assessments. This protocol was implemented to help ensure that swelling in the muscles from training would not obscure the results and the participant would present a consistent hydration status and body temperature. As per the customs of our laboratory, the participant signed a standardized informed-consent form prior to testing.

In an effort to minimize interference with the participant's established training schedule, exercise performance testing sessions were conducted at the start and end of the bodybuilder's 9-week off-season block at approximately the same time of day but on different days than muscle hypertrophy and body composition assessments. Similar to the muscle hypertrophy and body composition assessments, the participant was instructed to avoid RT 48-72 hours prior to the testing. The participant provided self-collected data on his training (exercises, sets, reps, RPE) and nutrition (daily calories and macronutrients) practices as well as weekly AAS dosage.

Muscle Thickness. US measurements were taken at the thigh and upper arm on both the right and left side to determine muscle thickness (MT). A single US measurement was taken at each site, with all assessments made by the same researcher with the participant in the same position, and the same sites.

MT was measured using an M7 Diagnostic Ultrasound System (Shenzhen Mindray Bio-Medical Electronics Co. Ltd., China) and B-mode ultrasound imaging. The reliability and validity of ultrasound in determining MT is reported to be very high when compared to the "gold standard" magnetic resonance imaging (10). A 7.5MHz linear array transducer was used with a scanning head coated with a soluble transmission gel to improve imaging quality. A single transverse image was taken at each site and then digital calipers in the software was used to measure muscle thickness of the elbow flexors, elbow extensors, and quadriceps, assessed as the distance between the subcutaneous adipose tissue-muscle interface and the muscle-bone interface. For the upper arm, measurements were taken at 50% of the distance between the acromion process and the lateral epicondyle. The probe was positioned such that the flexors were most anterior and the extensors most posterior. The participant stood with his arm relaxed by his side during the measurement. For the thigh, measurements were taken at the most anterior position at 50% of the distance between the inguinal crease and the patella. The participant was positioned supine, with a pillow placed underneath the knee to support the limb and allow the knee extensors to relax.

Circumference. Circumference measurements of the upper arms were taken in both relaxed and flexed positions using an anthropometric tape measure (Seca Tape Measure, Seca, UK). Circumference measurements can detect resistance training-induced changes in muscle size that are comparable to those detected by US (11), though the magnitude of these changes may differ. However, circumference measurements are a practical, low-cost option and were used in this case study to provide a greater breadth of measurements.

Three circumference measurements were taken on each side, and the average of these measurements was calculated to obtain the final value. Left and right arm circumferences were obtained midway between the tip of the acromion and olecranon process. During the relaxed measurement, the participant stood with their elbow extended and forearm supinated. During the flexed measurement, the participant was instructed to perform elbow flexion with maximal effort while keeping their humerus parallel to the floor.

Body Composition. Fat-free mass (FFM), fat mass (FM), BF and BF percentage were all estimated using air displacement plethysmography (Bod Pod GS, Cosmed, Chicago, IL, USA), as previously described (12). In brief, the participant wore minimal clothing and a swim cap during the procedure. Prior to testing, the participant was weighed using a calibrated digital scale. The participant then sat in the Bod Pod for body volume measurement, breathing normally throughout the test. From the body mass measures, body volume measures and predicted thoracic lung volumes, the Bod Pod software estimated body density.

Strength. Strength was assessed via 1-repetition maximum (1RM) testing for 3 multi joint exercises: the barbell squat (SQ1RM), bench press (BP1RM), and deadlift (DL1RM). A sum of the best load from each exercise was formulated to obtain the participant's total (PLTotal). 1RM testing was performed in a competition-like setting, requiring the subject to test their SQ, BP and DL 1RM on the same day with 3 attempts allowed for each exercise. During strength testing, the participant warmed-up by gradually increasing load and decreasing repetitions as they approached a load approximately 10% lighter than their first attempt (13).

A successful attempt was defined according to standard powerlifting criteria (14). For the SQ, the lifter had to descend until the hips were below the knees and then rise to a fully upright position without any downward movement of the bar, maintaining control throughout the lift without assistance. In the BP, the bar had to touch the chest, pause briefly, and then be pressed upward to full arm extension without any downward movement, while the feet, buttocks, and head remained in contact with the floor and bench. For the deadlift, the lifter had to pull the bar from the floor to a fully erect position with shoulders back and knees locked, in a continuous motion without hitching or downward movement. The highest successful lift in each exercise was summed to determine the lifter's total (PLTotal). The participant was allowed to rest 3-5 minutes between each attempt, with a 15-20 minute break provided between each exercise.

Statistical Analysis

Pre- and post- values and percentage difference (Δ%) were reported for all measures regarding MT, circumference, body composition and strength.

RESULTS

The participant's training program was divided into six distinct workout configurations: push; pull; squat-focused legs; shoulders, back and biceps; chest and triceps; and, deadlift-focused legs. Each major muscle group was trained with approximately 12 to 16 sets per week, spread across multiple exercises. The participant performed a total of 6 training sessions per week, which was consistent throughout the 9-week period, with no considerable variation from one week to another. The exercises were performed in a repetition range of 6 to 20, with set repetitions-in-reserve (RIR) ranging from 1-3 and an average of 2 RIR. The participant's training program can be found in Table 1.

Table 1 - Participant Training Program

Training Session	**Exercises**	**Sets**	**Reps**	**RIR**
Push	Rear delt flies, barbell bench press*, incline dumbbell press, flat cable flies, behind-the-neck barbell shoulder press, dumbbell lateral raises, cable tricep extensions, dumbbell French press, and dips	3-4	6-15	0-3
Pull	Standing cable pullover, barbell row, lat pulldown, dumbbell row, narrow pulldown, seated cable pullover, alternate dumbbell screw curl, alternate dumbbell hammer curl, and cable curl.	3-5	6-15	1-3
Legs (SQ emphasis)	Barbell back squat*, leg extension, leg press, dumbbell walking lunges, abductor machine, adductor machine, standing calf raises, and seated calf raises	3-5	8-20	1-3
Shoulders, back & biceps	Cable face pulls, cable lateral raise, seated dumbbell shoulder press, high-low cable row, chest supported dumbbell row, dumbbell pullover, cable curl, dumbbell preacher curl, and dumbbell curl	3-4	8-12	1-3
Chest & triceps	Standing cable flies, barbell bench press*, incline barbell press, seated cable fly, cable kickback, skull crushers, and underhand cable extension.	3-4	8-15	1-3
Legs (DL emphasis)	Deadlift*, hamstring curl, static reverse barbell lunge, leg extensions, seated calf raise, and standing calf raise.	3-5	6-20	0-3

*Repetitions averaged 6 to 8 per set for a approximately 3-6 sets per week for the SQ, BP and DL

The participant consumed an average of 3555 calories per day with a protein intake of 1.75-2.3 grams per kilogram (g/kg) of bodyweight, a carbohydrate intake of 3.5-5.5 g/kg and a fat intake of 0.75-1.25 g/kg. In regard to dietary supplementation, the participant consumed 5 g of creatine monohydrate daily throughout the 9 week period. A detailed breakdown of the participant's nutritional intake can be found in Table 2.

Table 2 - Participant Macronutrient Intake

Week	Carbohydrate (g/kg of bodyweight)	Fat (g/kg of bodyweight)	Protein (g/kg of bodyweight)	Caloric Intake (Kcals)
1	4.5	1.25	1.95	3100
2	4.4	1.15	2.0	3400
3	4.2	1.1	1.9	3200
4	3.8	0.9	1.85	3000
5	3.6	1.15	1.8	2900
6	3.7	1.25	1.85	3100
7	3.7	1.0	1.95	3700
8	5.2	1.1	2.35	4800
9	4.5	1.2	2.0	4000

The participant exclusively used testosterone enanthate, methandrostenolone, and anastrozole during the 9-week period. The participant's AAS usage is shown in Table 3.

Table 3 - AAS Usage

Week	AAS	Dosage (mg)
1	Testosterone Enanthate / Methandrostenolone	500 / 210
2	Testosterone Enanthate / Methandrostenolone	500 / 210
3	Testosterone Enanthate / Methandrostenolone	500 / 240
4	Testosterone Enanthate, Methandrostenolone/ Anastrozole	500 / 280 / 1
5	Testosterone Enanthate / Methandrostenolone	250 / 40
6	Testosterone Enanthate	250
7	Testosterone Enanthate	500
8	Testosterone Enanthate	750
9	Testosterone Enanthate	500

Over the 9-week assessment period, SQ1RM increased by 26.7% (40 kg), BP1RM increased by 13.2% (15 kg), DL1RM increased by 17.6% (30 kg), while PLTotal increased by 19.3% (87.5 kg). The participant's strength changes can be found in Table 4.

Table 4 - Changes in Strength

Characteristic	**Pre**	**Post**	**Δ(%)**
1RM Squat(kg)	150	190	26.7
1RM Bench Press(kg)	135	150	13.2
1RM Deadlift(kg)	170	200	17.6
Powerlifting Total(kg)	452.5	540	19.3
Wilks Score	278.88	322.49	15.6

The participant's body mass increased by 26.7% (8.2 kg), his FFM increased by 8.4% (6.7 kg), his FM increased by 6.9% (1.2 kg), and his BF% decreased by 2.3% (0.4 kg). Increases were also observed in circumference measures. Left arm circumference increased by 7.6% (3 cm) and 1.9% (0.8 cm) in the relaxed and flexed conditions, respectively. Right arm circumference increased by 3.5% and 2.9% (1.4 cm and 1.2 cm) in the relaxed and flexed conditions, respectively. The participant's changes in body composition can be found in Table 5.

Table 5 - Changes in Body Composition

Characteristic	**Pre**	**Post**	**Δ(%)**
Body Mass (kg)	97.0	105.2	26.7
FFM (kg)	80.0	86.7	8.4
FM (kg)	17.3	18.5	6.9
BF (%)	18	17.6	-2.3

Figure 1

Figure 1. Before and after body composition of a 21-year-old amateur bodybuilder following a hypercaloric diet combined with AAS. The "after" image shows increased muscle mass and reduced body fat. Note: differences in lighting between the images may accentuate the visual changes.

As it pertains to MT, the participant's right and left triceps brachii increased by 7.58% (0.5 cm) and 11.76% (0.74 cm) respectively. Right and left quadriceps femoris increased by 14.5% (0.87 cm) and 12.58% (0.78 cm) respectively. Right and left biceps brachii both decreased by 2.33% (0.1 cm) respectively. The participant's changes in muscle thickness can be found in Table 6.

Table 6 - Changes in Muscle Thickness

Characteristic	Pre	Post	Δ(%)
Right Bicep Brachii(cm)	4.30	4.20	-2.3
Left Bicep Brachii(cm)	4.30	4.20	-2.3
Right Tricep Brachii(cm)	6.60	7.10	7.5
Left Tricep Brachii (cm)	6.29	7.03	11.7
Right Quadriceps Femoris(cm)	6.00	6.87	14.5
Left Quadriceps Femoris(cm)	6.20	6.98	12.5

DISCUSSION

Over the 9-week off-season phase, the participant generally increased his fat-free mass and muscle size while decreasing his BF% – changes that have been previously observed, albeit in different magnitudes, in individuals receiving supraphysiological doses of testosterone while engaging in RT (15). The participant's nutritional intake reflect the practices of competitive bodybuilders previously reported in the literature (6, 16), as well as evidence-based guidelines that recommend bodybuilders consume 1.6–2.2 g/kg of protein, 2–5 g/kg of carbohydrates and a minimum of 0.7 g/kg of fat daily (16). The participant's training practices also align with previous studies that have characterized the training practices of bodybuilders, as well as with evidence-based RT guidelines for maximizing muscle hypertrophy (17).

To our knowledge, no previous study has assessed body composition changes in bodybuilders following a hypercaloric diet while using AAS; thus, we can only draw comparisons from previous research on AAS-free resistance-trained individuals adhering to a hypercaloric diet and regimented RT routine. The participant substantially increased his body mass and FFM with small corresponding gains in fat mass and no perceptible change in BF% . Although previous research indicates that beginner trainees can substantially increase FFM while losing BF (18), the FFM increases experienced by the participant were nearly threefold of those previously reported in AAS-free athletes engaging in RT while following a hypercaloric diet (19). Additionally, despite achieving a 26% increase in body mass, the participant's FM increased by only 7.5% - an increase lower than previously reported in AAS-free resistance trained individuals following a hypercaloric diet who only experienced a 3-4% body mass increase over a similar timeframe (19, 20).

The participant also experienced increases in MT across all sites except for the elbow flexors, where he experienced a 2.3% decrease. The relative increases experienced across the other two sites are similar to what has previously been reported in studies of a similar duration where resistance-trained individuals engaged in high volume RT programs (21, 22). The decrease in MT of the right and left elbow flexors was a curious finding given that the participant experienced an increase in arm circumference. Since arm circumference assesses the girth of the upper arm as a whole, it is possible that the growth of the triceps brachii overrode small reductions in biceps brachii size, resulting in a net-positive increase in overall arm size. It also is possible that the participant may have experienced an increase in overall muscle mass of the elbow flexors, but the changes went undetected because the elbow flexor MT was only assessed at one site. Alternatively, we cannot rule out the possibility that the decrease recorded for the MT measurement of the right and left elbow flexors could be due to measurement error given that only a single measurement was obtained at each site.

The participant's strength increases were 5 times greater than what powerlifting athletes and coaches generally regard as a meaningful increase across a 6-12 week training period (14). The substantial strength increases experienced by the participant may be partially explained by his use of AAS while sustaining an energy surplus; however, it is important to note that the participant's starting strength was comparable to that of AAS-free powerlifters who are classified as beginner-intermediate lifters (23). Additionally, his PLTotal at the end of the 9-week off-season period is better or equal to ~32% of AAS-free powerlifters competing in the under-105kg category in drug tested powerlifting federations across the world (24). Of note, the participant did not formally engage in powerlifting-focused training (ie: frequent training close to 1RM in the SQ, BP and DL exercises) during or before the case study, which underscores the potential synergistic effect AAS and a hypercaloric diet on 1RM strength, even in the absence of 1RM strength-specific training.

Several limitations of the present case study warrant consideration. First, we did not collect blood samples and thus do not have data regarding the participant's hormonal values, which prevents us from drawing conclusions between testosterone levels and the magnitude of adaptations. Anecdotally, the magnitude of the participant's use can be classified as relatively modest by competitive bodybuilding standards. Bodybuilders typically "stack" AAS, combining multiple different types of substances to maximize anabolic effects (7). For example, self-reported AAS use in a case study of a competitive bodybuilder included weekly administration of methylandrostenediol, stanozolol, mesterolone, metenolone enanthate, trenbolone acetate nandrolone laurate and drostanolone propionate (25). Moreover, many bodybuilders combine AAS use with additional anabolic agents such as insulin and growth hormone, among others, to further promote anabolism (26); the participant in the present case study reported no administration of anabolic agents other than AAS. Therefore, the participant's results cannot necessarily be generalized to other competitive bodybuilders. Second, we did not have information on whether the participant obtained the AAS from a medical provider or from an unverified source, which limits our ability to determine whether the self-reported AAS compounds and dosages truly reflect the participant's AAS use. Counterfeit anabolic agents are prevalent on the black market, which can negatively affect purity and thus compromise effects (27). Third, measurements were only obtained immediately before and after the 9-week off-season phase. Thus, we cannot make determinations as to the time course of changes that occurred, and whether results may have plateaued or perhaps even regressed toward the end of the study period. Fourth, the training, AAS, and nutrition data were all self-reported, so there is a possibility that the participant may not have reported them accurately. Fifth, body composition changes were assessed via the BodPod, which has not been validated in bodybuilders, including those using AAS. This is a limitation as AAS use can cause water retention (28), which could have affected the body composition measurement. Finally, as previously noted, MT was only assessed at a single site along the length of each muscle. Evidence indicates that the magnitude of hypertrophy can vary substantially along the length of a muscle (29), which makes it possible that the participant experienced regional changes in muscle size that were not observed in our assessment.

CONCLUSIONS

Overall, the combination of RT, a hypercaloric diet and AAS led to substantial increases in MT, FFM and 1RM strength with minimal fat gain over a 9-week off-season bodybuilding period. In contrast, studies involving AAS-free resistance trained individuals engaging in RT while following a hypercaloric diet of a similar magnitude typically show more modest changes in FFM with greater increases in FM (30). However, the MT changes experienced by the participant in this case study appear to be similar to those observed in AAS-free, resistance-trained individuals over a 6-8 week period (30, 21, 22). It is important to interpret these findings with caution, as this case study involves a single participant who self-reported relatively modest AAS use without hormonal evaluations to confirm their effects. Further research with larger sample sizes is needed to fully understand the impact of different AAS dosages combined with resistance training and a hypercaloric diet on muscle strength, hypertrophy, and body composition outcomes.

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