Journal of
*Functional Morphology and Kinesiology*

MDPI

*Article*

# Biochemical Profile and Body Composition Alteration of Amateur Bodybuilders during the Pre-Contest Period

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Received: 19 March 2018; Accepted: 7 May 2018; Published: 8 May 2018


**Abstract:** The paper aims to analyze body composition and biochemical profile alterations in amateur bodybuilders during the cutting phase of a contest preparation, and to discuss them in light of scientific evidence. For the purpose of this study, bodybuilders and coaches provided details of drug administration, supplement use and training schedule. The four participants were two men competing in different Men's Physique categories, one woman in the Wellness category, and one woman competing in the Bikini category. Participants were evaluated for anthropometry and body composition before and after the cutting phase. There was an evident decrease in body fat for most of the participants during the cutting phase without evident loss of fat-free mass. In general, participants performed high volume resistance training combined with aerobic training. Regarding drug administration, participants used high doses of anabolic androgen steroids (AAS), combined with clenbuterol, thyroid hormone, and ephedrine. Blood analysis revealed alterations in lipid profiles, with increased total cholesterol and low-density lipoprotein (LDL), and reduced high-density lipoprotein (HDL) levels. There were marked alterations in markers of liver (aspartate aminotransferase) and cardiac (MB isoenzyme creatine kinase) damage. Our analysis suggests that the strategies adopted by bodybuilders during the pre-contest phase (high use of AAS and stimulant-based substances) may result in an increased risk of heart disease and liver dysfunction.

**Keywords:** ergogenic aids; muscle hypertrophy; fat loss; resistance training; aerobic exercise

## 1. Introduction

Bodybuilding contests involve the evaluation of aesthetic appearance and body composition. Participants are judged on aspects, such as muscle size, definition, and symmetry. Bodybuilding preparation is usually divided into two phases (bulking and cutting), and aims to increase muscle mass followed by decrease in body fat (BF) [1].

Specifically in the pre-contest or cutting phase, the participants often abruptly reduce their caloric intake and increase the total time spent on concurrent training, with high volume aerobic exercise [1]. During this period, high doses of anabolic androgen steroids (AAS) are used in association with stimulant-based substances [2–4]. However, most recommendations in this regard are not based on scientific evidence, and could lead to adverse health effects [5].

Long-term abuse of AAS is associated with cardiovascular and hepatic toxicity [6–8]. Some case studies call attention to the chronic use of anabolic androgen steroids (AAS) and the potential

risk for atherosclerotic disease, myocardial dysfunction, acute myocardial infarction (MI), and liver injury [9–12]. Moreover, the addition of stimulant-based substances in association with AAS during the pre-contest season may lead to additional risk of MI [11].

Regarding training recommendations, an increase in the volume of training is commonly observed during the pre-contest phase, with an emphasis on concurrent training. Strength training is often performed with high numbers of repetitions, combined with high volume moderate-intensity continuous exercise (60 to >120 min a day) in a fasting state [1–3]. Gentil et al. [2], and Viana et al. [3] suggest that these practices might impair morphological adaptations (loss of muscle mass) and/or lead to some adverse health effects.

Considering that bodybuilding is becoming increasingly popular, and many exercise enthusiasts might be likely to engage in it [13], it is important to provide some critical analysis of its procedures to better inform the general public. Therefore, the purpose this study is to describe alterations in the body composition and biochemical profile of amateur bodybuilders during the cutting phase of contest preparation, and to discuss these in light of scientific evidence.

## 2. Materials and Methods

### *2.1. Experimental Procedures*

This research is an observational study. All data comprises information provided by participants and their coaches. For the purposes of this study, bodybuilders and coaches provided details of drug administration, supplement use, and training schedules in both phases of preparation (bulking and cutting). Additional details were obtained directly from bodybuilders/coaches when necessary. The study protocol was approved by the Ethical Board of the Federal University of Goiás, and the participants provided written informed consent for the use of these data, in conformity with the Declaration of Helsinki.

### *2.2. Participants*

The four participants enrolled in the study were selected through convenience sampling and included two men competing in different Men's Physique categories (MP1 and MP2), one woman in the Wellness category (WW), and one woman in the Bikini category (WB). All participants were amateur competitors, and were competing in accordance with the standards of the International Federation of Bodybuilding and Fitness (IFBB). All participants had some experience as contests. MP1 and MP2 were 24 and 26 years old, and had 7 and 8 years of experience of resistance training, respectively, and both were competing in their third contest. WW was 34 years old, had 16 years of experience of resistance training, and was competing in her second contest. WB was 37 years old, had 9 years of experience of resistance training, and was competing in her fourth contest. It is important to point out that the participants were well ranked in the contest analyzed. MP1 and MP2 won in their respective categories, WW was placed fourth, and WB was placed second.

### *2.3. Anthropometry and Body Composition*

Participants were evaluated for anthropometry and body composition before and after the cutting phase. Body mass was measured on a digital scale to the nearest 0.1 kg, with the individual barefoot and wearing light clothes. A portable stadiometer with an accuracy of 1 mm was used to measure height with the individuals in the Frankfurt position. Body composition was assessed by an experienced examiner using a whole-body tetrapolar bioimpedance analyzer (Inbody230, Biospace, Seoul, Korea) with an eight-point tetrapolar electrode system. The participants were oriented to stand upright, and to grasp the handles of the analyzer, thereby providing contact with eight electrodes (two for each foot and hand). Five segments (right and left arm, trunk, right and left leg) were independently analyzed using two different frequencies (20 kHz and 100 kHz). The input variables included the participants'

age, sex, height, and actual body weight. The percentage of body fat was computed through the proprietary algorithms, displayed on the analyzer's control panel, and recorded.

### 2.4. Biochemical Analysis

Whole blood samples were taken from the antecubital vein to determine the biochemical profile after the bulking and cutting phases. Participants were in the bulking phase for approximately 3 months, and were AAS users prior to preparation. However, they interrupted AAS administration 3–4 months prior to the bulking phase. Blood was collected after overnight fasting, and was immediately analyzed for the lipid profile (total cholesterol; high-density lipoprotein (HDL); low-density lipoprotein (LDL); triglycerides), aspartate aminotransferase (AST), alanine aminotransferase (ALT), MB isoenzyme creatine kinase (CK-MB), and cardiac troponin T (cTnT). The last blood sample was obtained 48–72 h prior to competition. Exercise was not well controlled prior to blood being drawn, and thus, some participants performed light workouts 24 h prior to or on the same day as blood collection. The lipid profile, ASTs, and cardiac damage markers were determined by colorimetric methods using commercial kits (DOLES® kit, Goiania, Brazil) specific to each parameter.

## 3. Results

The evaluations of the anthropometric measures and body composition of the participants before and after the cutting phase are described in Table 1. For each participant, the first date represents the beginning, and the second the end of the pre-contest phase. A decrease in body mass can be observed for most of the participants, with the exception of MP2, who gained 0.7 kg in two months. All participants lost a large amount of body fat. MP1, MP2, and WW were able to increase muscle mass during the cutting phase, while MB and WB present reductions of 6.67% and 3% of muscle mass, respectively.

**Table 1.** Characteristics of the participants.

| Participants | Date (Month/Day) | Height (cm) | Body Weight (kg) | Muscle Mass (kg) | Body Fat (%) |
|---|---|---|---|---|---|
| Men's Physique 1 | 07/18 | 170 | 76.3 | 38 | 13.3 |
| | 09/14 | | 77 | 39 | 4 |
| Men's Physique 2 | 09/20 | 178 | 87.8 | 42 | 17.4 |
| | 11/09 | | 80.4 | 42.4 | 8.6 |
| Wellness | 09/20 | 158 | 61.6 | 26.4 | 23.6 |
| | 11/10 | | 58.9 | 27.2 | 17.3 |
| Bikini | 08/22 | 171 | 68 | 33 | 18 |
| | 10/11 | | 58 | 32 | 8.9 |

Note: the first date is the beginning of the cutting phase and the second date is the last measurement taken before the competition at the end of the cutting phase.

The training schedules are available in Supplementary Material. In general, participants aimed to train each muscle group once a week through multiples sets of multi- and single-joint exercises, with the exception of calves and abdominals, which in some cases, were trained more times per week. During the bulking phase, MP1 performed sets of 6–10 repetitions with 2–3 min rest between sets for most muscle groups. During the cutting phase, the number of repetitions increased to 10–15 and the rest between sets decreased to 45–60 s. MP1 trained calves and abdominals twice a week, and performed 15–20 repetitions in both phases of preparation (bulking and cutting). In the cutting phase, MP1 stopped aerobic exercise. MP2, WW, and WB performed the same routines in both phases of preparation. MP2 and WW performed 12–20 repetitions with 1–2 min rest between sets. WB performed 8–20 repetitions with 1–2 min rest between sets. During the cutting phase, MP2, WW, and WB performed around 80–120 min aerobic exercise in a fed or fasting state every day. WB, in particular, undertook more than 2 h aerobic exercise every day prior to the contest.

Drug use is presented in Table 2. MP2 reported no use of AAS during the bulking phase. In general, participants used supratherapeutic doses of AAS in different combinations. Stimulant-based substances were added during the cutting phase.

**Table 2.** Drug administration during bulking and cutting phases (mg/week).

| Drug | MP1 | MP2 | WW | WB |
|---|---|---|---|---|
| Bulking | | | | |
| Testosterone Enanthate | 500 | - | - | - |
| Testosterone Propionate | - | - | - | 600 |
| Nandrolone Decanoate | 400 | - | - | - |
| Boldenone Undecylenate | 200 | - | - | 400 |
| Trenbolone Acetate | 225 | - | - | - |
| Methandrostenolone | - | - | - | - |
| Metenolone Enanthate | - | - | 300 | 200 |
| Cutting | | | | |
| Testosterone Propionate | 300 | 300 | - | |
| Trenbolone Acetate | - | 300 | - | |
| Drostanolone Propionate | 300 | - | 300 | 300 |
| Stanozolol | 300 | 300 | 150 | 200 |
| Oxandrolone | 140–210 | 280 | - | 140–280 |
| Clenbuterol | - | 140 | 280–420 | 280–420 |
| T3 | 87.5–262.5 | 140 | 87.5–262.5 | 87.5–262.5 |
| T4 | 175–525 | 140 | 175–525 | 175–525 |
| Ephedrine | 105–315 | - | - | |
| Aspirin | 1750–5250 | - | - | |

All participants were supplemented with whey protein isolate, chromium picolinate, omega 3 fatty acids, branched chain amino acids (BCAA), vitamin C, vitamin D, vitamin E, poly-vitamins, and glutamine in both phases of preparation. During the cutting phase, high doses of caffeine were added to nutritional supplements, with doses in the range 420–960 mg/day.

Blood was analyzed before and after the cutting phase, and the results are shown in Table 3. There were changes in the lipid profiles of all participants. Total cholesterol and LDL increased after the cutting phase for MP2 and WW, and decreased for the other participants. HDL decreased for all participants after the cutting phase, and triglycerides increased only for WB, but decreased for the other participants. Regarding aminotransferases, the AST level increased for all participants after the cutting phase, while ALT increased for MP2 and both women, but decreased for MP1. Most participants presented increased CK-MB levels after the cutting phase, with the exception of MP2. After cutting, cTnT levels increased only for WW, did not change for MP2, and decreased for the other participants.

**Table 3.** Biochemical profile of the subjects.

| Participants | Date (Month/Day) | Cholesterol (mg/dL) | HDL (mg/dL) | LDL (mg/dL) | Triglyceride (mg/dL) | AST (U/L) | ALT (U/L) | CK-MB (ng/mL) | cTnT (ng/mL) |
|---|---|---|---|---|---|---|---|---|---|
| Men's Physique 1 | 07/18 | 165 * | 30 | 122.6 * | 62 * | 41 | 26 * | 2.8 * | 0.006 * |
| | 09/14 | 148 * | 19 | 121.8 * | 36 * | 61 | 61 | 7.1 | 0.005 * |
| Men's Physique 2 | 09/20 | 193 * | 35 | 149.8 * | 41 * | 78 | 61 | 14.3 | 0.006 * |
| | 11/09 | 204 * | 16 | 181 | 35 * | 68 | 59 | 9.4 | 0.006 * |
| Wellness | 09/20 | 230 * | 40 * | 171 | 93 * | 36 * | 14 * | 2.6 * | 0.003 * |
| | 11/10 | 262 | 38 | 212.4 | 58 * | 38 * | 27 * | 4.7 * | 0.005 * |
| Bikini | 08/22 | 294 | 24 | 260.8 | 46 * | 31 * | 27 * | 3.2 * | 0.008 * |
| | 10/11 | 264 | 11 | 240.8 | 61 * | 34 * | 36 | 7.3 | 0.005 * |

Note: The first date is the beginning of the cutting phase and the second date is the last measurement taken before the competition at the end of the cutting phase. HDL = high-density lipoprotein; LDL = low-density lipoprotein; AST = aspartate aminotransferase; ALT = alanine aminotransferase; CK-MB = MB isoenzyme creatine kinase; cTnT = cardiac troponin T. * Value in normal reference range.

## 4. Discussion

This study aimed to describe the practices adopted by four amateur bodybuilders during contest preparation, and their biochemical profile and body composition. In line with the findings of previous studies [1–5], the pre-contest involved high doses of AAS, use of stimulants, severe caloric restriction, and high volume resistance training and aerobic exercise. However, as previously noted, most recommendations in this regard are not supported by scientific evidence, and may lead to certain metabolic alterations and increase the risk of adverse health effects [2,3,5].

The high use of supratherapeutic doses of AAS by bodybuilding participants to improve body composition is well known [14,15]. The amounts of AAS used by the participants in this present study are similar to those previously reported [2,3], and are many times greater than endogenous testosterone production, which is around 2.5–11 mg/day for men and 0.25 mg/day for women [16]. Long-term abuse of AAS is associated with cardiomyopathy and atherosclerotic vascular disease caused by detrimental lipid changes [15,17]. A recent retrospective study reinforced the association between long-term abuse of AAS and premature cardiovascular disease (CVD) [7]. High total cholesterol and LDL cholesterol contributes to vascular endothelial dysfunction, and represents an important risk factor for coronary heart disease [18]. Moreover, lower HDL cholesterol levels are associated with premature mortality [19].

All participants presented suboptimal lipid profile values. After the cutting phase, HDL decreased for all participants, followed by an increase in total cholesterol and LDL for MP2 and WW. Both women competitors presented high total cholesterol, while MP2, WW, and WB presented high LDL cholesterol after the cutting phase [6]. CK-MB and cTnT are specific markers for myocardial damage. Increases in these markers are associated with histological myocardial changes and represent sensitive indicators for MI or myocardial dysfunction [20]. Recently, several studies have called attention to AAS abuse and the risk of adverse cardiovascular events [7,10,12,17,21,22]. In this study, most of the participants presented high levels of CK-MB after the cutting phase, with the exception of WW, who presented borderline values. Although cTnT is a more sensitive marker for cardiac damage, CK-MB is more effective during pre-procedural monitoring, and its elevation is a significant predictor of adverse cardiac effects [23]. However, considering that CK-MB is a marker of muscle damage, as well as an indicator of cardiac damage [20], the lack of adequate control for training prior to blood collection may be a potential confounder in using this marker. In contrast, cTnT remained at normal levels for all participants in both phases of preparation. Regarding AAS use, it is important to highlight the reversible effect for most markers when AAS use is interrupted, while continued use may increase the risk of adverse effects [24].

In addition to AAS, the participants used several stimulant-based substances, mainly during the pre-contest season, which is similar to findings previously reported [2,3]. In this study, the participants reported using ephedrine, caffeine, clenbuterol, and synthetic thyroid hormones (T3 and T4) during the cutting phase. Considering that during the pre-contest phase there is an abrupt reduction in nutrients and caloric intake [2–4,21], the rationale for the use of stimulant-based substances during this phase is thought to be to avoid the reduced performance and increased perception of effort observed during severe caloric restriction [21,25]. However, the cost–benefit of this practice might be addressed critically, since the use of AAS might increase catecholamine release and β-adrenergic receptor expression [12], which might potentiate the harmful effects of stimulants. Indeed, the association of AAS with stimulants has been shown to give rise to an additional risk of MI [11].

Another adverse effect associated with long-term use of AAS is hepatotoxicity. The hepatotoxic effect induced by AAS use has been associated with an increase in oxidative stress in the hepatic cells through androgen receptor activation [8]. These harmful liver alterations could be determined by an increase in aminotransferases [26]. In this study, MP1 and MP2 presented high AST values after the cutting phase. High values were also observed for ALT, with exception of WW. The alterations observed in aminotransferases suggest a potential risk of liver injury, in agreement with Schwingel et al. [27], who suggest an association between chronic use of AAS and incidence of non-alcoholic fatty liver

disease, which is commonly associated with metabolic syndrome and could progress to cirrhosis [28]. Furthermore, it has been reported that chronic use of AAS might result in cholestasis, peliosis hepatis, and hepatocellular carcinoma, or adenoma [8,29].

All participants in this study reported use of oral AAS during the cutting phase. This is particularly alarming considering that orally active 17-α-alkyl steroids have been shown to be particularly dangerous to the liver [8], and to promote increases in cholesterol due to hepatic triglyceride lipase stimulation [30].

The potential harm associated with chronic use of AAS seems to be dose-dependent [15]. Whilst we agree that it might be difficult to become competitive in bodybuilding without drug use, it is necessary to provide strategies that could provide better results and reduce the reliance on drug abuse to help, in turn, to reduce the potential deleterious effects on the health of bodybuilders, as previously discussed [2,3,5].

The dose response of training has recently been debated [31,32] and it seems that the amount of resistance training performed by the participants is over the recommended limit for obtaining optimal results. Moreover, the performance of resistance training concurrently with high volume aerobic training might also negatively impact muscle mass [33]. While the practices adopted might be considered successful as some participants increased muscle mass and lost body fat, it is important to consider the extent to which it would be possible to reach similar, or even better results, while decreasing the amount of drugs used. For example, Pardue et al. [21] observed a drop in resting metabolic rate, reduced T3 and T4 hormones, and an increase in cortisol in natural bodybuilders during the pre-contest phase. Considering that an excessive amount of training combined with a restricted diet could lead to a catabolic state and decreased resting metabolic rate, one might question if the abuse of AAS is a means of counteracting erroneous practices in both exercise and nutrition.

Regarding resistance training, during the cutting phase, participants performed a weekly number of 10–20 sets for the main muscle group. Despite some authors proposing additional benefits for muscle hypertrophy using more than 10 sets per week [34], there is a paucity of consistent data to support this conclusion [31,32]. Furthermore, Wernbom et al. [35] suggest there is a plateau in hypertrophy gain after a certain point, with a risk of muscle loss when the number of sets is carried beyond the point of plateau. For example, Ostrowski et al. [36] observed similar gains for muscle hypertrophy comparing 3- and 12-per-week sets for muscle groups after 10 weeks. However, the authors reported a trend for hormonal imbalance, suggesting a catabolic state for the high-volume group [36]. Recently, Viana et al. [3] reported a case of an amateur bodybuilder who experienced loss of muscle mass during the pre-contest period, despite the use of AAS. It is plausible that high volume training plus inadequate nutrition was responsible for this outcome. With this in mind, adjusting training volume to the reduced energy intake often used during the pre-contest phases might be necessary to avoid a catabolic state.

One option for adjusting training volume is to review exercise choice, as proposed by Gentil et al. [2] and Viana et al. [3]. In accordance with previous studies, training using multi-joint or single-joint exercise has been shown to result in similar muscle activation, strength, and muscle size gains in upper limbs [37]. Thus, performing multi-joint exercise can be a strategy for reducing the number of sets and avoiding adverse training effects (overuse and/or overtraining). Another alternative strategy is based on the high effort paradigm: high intensity training is a time-efficient strategy and promotes the same muscle gains with a reduced training volume [38]. Performing repetitions until momentary failure plays a key role in low volume resistance training [39]. In this regard, performing multi-joint exercises with an incentive for competitors to perform sets to the point of failure, as previously defined by Steele et al. [40], might be an optimal stimulus for promoting muscle hypertrophy with reduced training volume, which could help to prevent a catabolic state during the cutting phase.

In addition to resistance training, MP2, WW, and WB performed a high volume (>80 min) of aerobic exercise every day during the cutting phase, which is in agreement with the findings of previous studies [1–4]. However, a high volume and high frequency of concurrent aerobic training

may increase catabolic state-led impairment of muscle gains [33]. Thus, reducing the volume of aerobic exercises by performing high intensity aerobic exercises with reduced frequency, and utilizing cycling instead of running, might contribute to preserving muscle mass [41]. In addition, MP2 performed aerobic exercise in a fasting state. Although this seems to be a common practice in bodybuilding, it brings no additional benefits in terms of fat loss [42], and might reduce energy expenditure and fat oxidation, and induce a catabolic state [43,44].

By analyzing the current practices adopted by bodybuilders, it is possible to suggest that the high use of AAS and stimulants during the cutting phase seems to be a strategy adopted to counteract the potential deleterious effects of some aggressive practices. However, the abuse of these substances might cause detrimental alterations in the lipid profile, transaminases, and markers of cardiac damage. Based on this, we highly recommend that bodybuilders adjust their training and nutritional strategies to reduce their reliance on drug use.

One possible limitation in this study is the lack of nutritional data during the cutting phase. Notwithstanding, we believe that this limitation does not prevent conclusions being drawn from the study.

## 5. Conclusions

These results suggest that the high use of AAS and stimulant-based substances may be necessary to counteract the deleterious effects of inadequate training strategies adopted by amateur bodybuilders during pre-contest preparation. However, our analysis shows that these strategies result in deleterious effects on the lipid profile and alteration of transaminases, increasing the risk of atherosclerotic heart disease and liver dysfunction.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2411-5142/3/2/26/s1.

**Author Contributions:** P.G. and J.A.B.S. study design; J.A.B.S. and D.M.S. data acquisition; D.C.S. and P.G. manuscript drafting; D.C.S., J.A.B.S., D.M.S. and P.G. data analysis and manuscript revision.

**Conflicts of Interest:** The authors declare no conflict of interest.

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