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Effects of a Purported Aromatase and 5 α-Reductase Inhibitor on Hormone Profiles in College-Age Men

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The purpose of this study was to determine the effects of an alleged aromatase and 5-α reductase inhibitor (AI) on strength, body composition, and hormonal profiles in resistance-trained men. Thirty resistance-trained men were randomly assigned in a double-blind manner to ingest 500 mg of either a placebo (PL) or AI once per day for 8 wk. Participants participated in a 4-d/wk resistance-training program for 8 wk. At Weeks 0, 4, and 8, body composition, 1-repetition-maximum (1RM) bench press and leg press, muscle endurance, anaerobic power, and hormonal profiles were assessed. Statistical analyses used a 2-way ANOVA with repeated measures for all criterion variables ($p \leq .05$). Significant Group × Time interaction effects occurred over the 8-wk period for percent body fat (AI: –1.77% ± 1.52%, PL: –0.55% ± 1.72%; $p = .048$), total testosterone (AI: 0.97 ± 2.67 ng/ml, PL: –2.10 ± 3.75 ng/ml; $p = .018$), and bioavailable testosterone (AI: 1.32 ± 3.45 ng/ml, PL: –1.69 ± 3.94 ng/ml; $p = .049$). Significant main effects for time ($p \leq .05$) were noted for bench- and leg-press 1RM, lean body mass, and estradiol. No significant changes were detected among groups for Wingate peak or mean power, total body weight, dihydrotestosterone, hemodynamic variables, or clinical safety data ($p > .05$). The authors concluded that 500 mg of daily AI supplementation significantly affected percent body fat, total testosterone, and bioavailable testosterone compared with a placebo in a double-blind fashion.

Keywords: fenugreek, anabolic, resistance training

Athletes are continuously searching for ways to enhance performance, which has directed many to the use of anabolic steroids. Anabolic steroids are testosterone derivatives capable of inducing a positive nitrogen balance and increasing fat-free mass by stimulating protein synthesis and/or minimizing protein breakdown. Several studies have shown that administration of testosterone derivatives to younger (Bhasin et al., 1996) and older men (Ferrando et al., 2002; Schroeder, Terk, & Sattler, 2003; Snyder et al., 1999), as well as those classified as hypogonadal (Bhasin et al., 1997; Bhasin et al., 2000), increases muscle size and strength. This is in contrast to exercise-induced changes in testosterone that do not appear to have such a profound effect on muscle protein synthesis (West et al., 2009).

Testosterone is produced from its cholesterol substrate and almost exclusively binds to the blood proteins albumin (40%) and sex-hormone-binding globulin (40%). The remaining portion of testosterone that is not bound to blood proteins is the active constituent and labeled free testosterone. Exogenous testosterone can bind to an androgen receptor and promote intracellular transcriptional and translational events that ultimately increase fat-free mass (muscle hypertrophy). However, once bound to its receptor, testosterone can convert to dihydrotestosterone (DHT) and estradiol through enzymatic action of 5-α reductase and aromatase, respectively.

Because of the legal and ethical repercussions surrounding anabolic steroid use, nutritional supplement companies have designed prohormone compounds, or testosterone precursors, that are marketed to increase testosterone production similarly to anabolic steroids. Even though acute sublingual ingestion of androstenediol was effective in elevating free and total testosterone concentrations up to 180 min after intake (Brown, Martini, Roberts, Vukovich, & King, 2002), this protocol does not resemble the manner in which the supplement is purported to work. Other inquiries have established that prolonged supplementation with prohormone compounds over the course of weeks to months does not increase endogenous testosterone levels in conjunction with resistance training (Broeder et al., 2000; Brown et al., 2000; Brown et al., 1999).

In spite of this, nutritional supplement companies are continuing to try to develop products that have ergogenic potential comparable to that of anabolic steroids. The latest line of nutritional supplements fitting this category is aromatase inhibitors (AIs), which are proposed to suppress estrogen levels and thereby increase endogenous free testosterone levels (increased free testosterone:estrogen [Test:Est] ratio), resulting in increased fat-free mass and strength. It is assumed that

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these supplements will increase testosterone within normal physiological levels, but that is not clear at this point. AIs are not a new classification of drugs; they have been used as a medicinal preventive and treatment for breast cancer, and the effects of pharmacologic AIs such as anastrozole and exemestane on the Test:Est are well substantiated in both young and old men (Hayes, Seminara, Decruz, Boepple, & Crowley, 2000; Leder, Rohrer, Rubin, Gallo, & Longcope, 2004; Mauras et al., 2003; Taxel et al., 2001). Nevertheless, there are limited data to support the claims that nutritional companies make regarding AI supplementation.

Testosterone deficiency in males is related to a considerable decrease in protein synthesis, decreased strength, decreased fat oxidation, and increased adiposity (Mauras et al., 1998), which are all regarded as negative physiological conditions. Elderly men exhibiting a state of hypogonadism were orally supplemented with the AI anastrozole for 12 weeks and effectively elevated bioavailable and total testosterone levels to a normal range, while estradiol was mildly suppressed (Leder et al., 2004). Similar results were seen in young, eugonadal men over the course of 10 days (Mauras et al., 2003), indicating that AIs have the potential to blunt estrogen concentrations while concomitantly increasing serum testosterone levels beyond normal levels.

Nutritional supplements designed with the purpose of inhibiting aromatase activity are alleged to work in the same mechanistic manner as AI drugs such as exemestane. One particular AI supplement (Novadex XT) increased total and free testosterone by 283% and 625%, respectively, while only slight increases in estrogen levels were observed in young, eugonadal men over 8 weeks (Willoughby, Wilborn, Taylor, & Campbell, 2007). Another investigation using an AI product concluded that aromatase activity was not completely blocked, even though increases were detected for free testosterone and Test:Est (Rohle et al., 2007). These findings demonstrate that AI nutritional supplements appear to provide some possible benefits to those interested in increasing their anabolic status. As noted previously, research is clear that supraphysiological levels of testosterone are capable of inducing myofibrillar hypertrophy and are vital in the regulation of muscle mass. It is possible that an herbal AI could increase testosterone significantly without increasing values over normal physiological levels and, according to recent research (West et al., 2009), may not be sufficient to induce appreciable change. However, neither of the previous studies examined the effects of the AI on performance measures, which are important variables of interest in athletic and physically active populations. In addition, no studies to our knowledge have investigated the performance benefits of an over-the-counter 5-α reductase inhibitor such as saw palmetto or willow bark. Therefore, it was our purpose to determine the effects of a commercially available product (Trigonella foenum-graecum [standardized for Grecunin]) purported to inhibit aromatase and 5-α reductase activity on strength, body composition, and hormonal profiles in resistance-trained men during an 8-week resistance-training program.

Methods

Participants

Thirty resistance-trained (>1 year of total-body resistance training) male participants (placebo [PL] n = 13, 21 ± 3 years, 180 ± 6.4 cm, 84 ± 15 kg, 18.3% ± 6.8% body fat; AI n = 17, 21 ± 2.8 years, 178 ± 5.8 cm, 85 ± 9.6 kg, 18.8% ± 4.8% body fat) participated in this study. Participants were not allowed to join this study if they had any metabolic disorder including known electrolyte abnormalities or heart disease, arrhythmias, diabetes, thyroid disease, or hypogonadism or a history of hypertension, hepatorenal, musculoskeletal, autoimmune, or neurologic disease; were taking thyroid, hyperlipidemic, hypoglycemic, antihypertensive, or androgenic medications; or had taken ergogenic levels of nutritional supplements that may affect muscle mass (e.g., creatine, HMB) or anabolic/catabolic hormone levels (androstenedione, DHEA, etc.) within 6 months before the start of the study. Participants were asked to maintain their normal dietary intake for the duration of the study and refrain from ingesting any dietary supplement with potential ergogenic benefits. Those meeting eligibility criteria were informed of the requirements of the study and signed informed-consent statements in compliance with the human participant guidelines of the University of Mary Hardin-Baylor and the American College of Sports Medicine.

Experimental Design

The study was conducted as a double-blind, placebo-controlled clinical trial using parallel groups matched according to total body weight. The independent variable was the nutritional supplements. Dependent variables included estimated dietary energy intake; body composition; upper and lower body one-repetition-maximum (1RM) strength, upper and lower body muscle endurance (80% of 1RM), anaerobic sprint power, and fasting clinical blood profiles (substrates, electrolytes, muscle and liver enzymes, red cells, white cells) and anabolic hormones (total testosterone, bioavailable testosterone, dihydrotestosterone, estradiol).

Entry and Familiarization Session

Participants believed to meet eligibility criteria were then invited to attend an entry/familiarization session. During this session, they signed informed-consent statements and completed personal and medical histories. Participants meeting entry criteria were familiarized with the study protocol via a verbal and written explanation outlining the study design. This included describing the training program, familiarizing participants with the tests to be performed, and having them practice the bench-press and leg-press strength tests.

Testing Sessions

After the familiarization/practice session, participants recorded all food and fluid intake on dietary record forms

on 4 consecutive days before each experimental testing session to evaluate nutritional intake. Dietary intake was assessed using Food Processor nutrition software (ESHA, Salem, OR). Participants were instructed to refrain from exercise for 48 hr and fast for 12 hr before baseline testing (T1). They then reported to the human performance laboratory for body-composition and clinical assessments. Height was measured using standard anthropometry, and total body weight was measured using a calibrated electronic scale (Health o Meter, Electromed Corp., Flint, MI) with a precision of ±0.02 kg. Heart rate was determined by Polar (Finland) heart-rate monitor. Blood pressure was assessed in the supine position after participants had rested for 5 min, using a mercurial sphygmomanometer via standard procedures (Adams, 2002).

We then drew ~20 ml of fasting blood using venipuncture techniques of an antecubital vein in the forearm according to standard procedures. Blood samples were shipped to Quest Diagnostics (Dallas, TX) to run clinical chemistry profiles (glucose, total protein, blood urea nitrogen, creatinine, BUN:creatinine ratio, uric acid, AST, ALT, CK, LDH, GGT, albumin, globulin, sodium, chloride, calcium, carbon dioxide, total bilirubin, alkaline phosphatase, triglycerides, cholesterol, HDL, LDL) and whole blood cell counts (including hemoglobin, hematocrit, red blood cell counts, MCV, MCH, MCHC, RDW, white blood cell counts, neutrophils, lymphocytes, monocytes, eosinophils, basophils). Blood samples were collected, allowed to sit for 5 min, and then centrifuged at room temperature. Serum was extracted, aliquotted into microcentrifuge tubes, and stored at –20 °C for future analysis. Serum samples were then assayed in duplicate for free testosterone, total testosterone (Diagnostics Systems Laboratories, Webster, TX), DHT, and estradiol (Alpco Diagnostics, Windham, NH), using enzyme-linked immunoabsorbent assays (ELISA) and enzyme-immunoabsorbent assays using a Wallac Victor-1420 microplate reader (Perkin-Elmer Life Sciences, Boston, MA). The assays were performed at wavelengths of 450 and 405 nm, respectively, in the exercise and biochemical nutrition laboratory at Baylor University.

Participants then had body composition determined using hydrodensitometry. They reported to the underwater weighing tank in swimsuits, and body weight was determined out of water by an electronic scale. Body composition was analyzed using an Exertech (La Cresent, MN) body-density-measuring system. The Exertech consists of a shallow tank (4′ wide × 6′ long × 3′ deep) with a weighing platform with electronic (load cell) weighing system connected to a PC. Calibration is conducted daily by establishing linear interpolation from two known weights. Data points were recorded with data-acquisition software from the force transducer. Residual volume was estimated using standard procedures (Quanjer, 1983). Participants were submerged in warm water and asked to exhale a maximal amount of air, after which a signal from the force transducer produced a readable analog wave. The most stable waveform was selected, and the mean value was recorded. Participants performed this procedure until at least two trials were within a 0.10% difference or a total of seven trials had been completed. Body density was calculated after weight was recorded in and out of water, and the Siri equation was used to calculate percent body fat (Siri, 1993). Fat-free mass was also calculated from percent body fat (Siri, 1961).

Participants then performed 1RM lifts on the isotonic bench press and leg press to assess strength and then muscle endurance. All strength/exercise tests were supervised by laboratory assistants experienced in conducting strength/anaerobic exercise tests using standard procedures. Participants warmed up (two sets of 8–10 repetitions at approximately 50% of anticipated maximum) on the bench press. They then performed successive 1RM lifts starting at about 70% of anticipated 1RM and increased by 5–10 lb until reaching 1RM. They then rested for 10 min and performed a muscle-endurance test at 80% of their 1RM. Participants then rested for 10 min and warmed up on the 45° leg press (two sets of 8–10 repetitions at approximately 50% of anticipated maximum). They then performed successive 1RM lifts on the leg press starting at about 70% of anticipated 1RM and increased by 10–25 lb until reaching 1RM. Participants then rested for 10 min and performed a muscle-endurance test at 80% of their 1RM. Both 1RM protocols were followed as outlined by the National Strength and Conditioning Association (Baechle & Earle, 2008).

After the strength assessments and 15 min of rest, participants performed a 30-s Wingate anaerobic capacity test using a Lode computerized cycle ergometer (Groningen, The Netherlands). Cycle-ergometer measurements (seat height, seat position, handlebar height, and handlebar position) were recorded and kept identical for each participant across testing sessions to ensure test-to-test reliability. Before leaving the laboratory, participants were randomly assigned to a supplement group based on their body weight and given a training regimen. Participants repeated all testing after 4 (T2) and 8 (T3) weeks of training and supplementation.

Supplementation Protocol

Participants were matched into one of two groups according to total body weight. They were then randomly assigned in a double-blind manner to ingest capsules containing 500 mg of placebo (maltodextrin; PL) or 500 mg of T. foenum-graecum (standardized for Grecunin; AI; Indus Biotech, India). The doses investigated represent the current recommended doses sold in nutritional supplements. Participants ingested the assigned capsules once per day in the morning on nontraining days and before their workout on training days for 8 weeks. The supplements were prepared in capsule form and packaged in generic bottles for double-blind administration by Indus Biotech. Supplementation compliance was monitored by having research assistants watch participants take the supplements before supervised workouts and by having the participants return empty bottles of the supplement at the end of 4 and 8 weeks of supplementation. Participants

reported to a research assistant on a weekly basis throughout the study to answer a questionnaire regarding side effects and health status.

Training Protocol

Participants underwent a periodized 4-day/week resistance-training program, split into two upper and two lower extremity workouts per week, for a total of 8 weeks. This training regimen has been shown to increase strength and lean body mass without additive dietary or supplementary interventions (Kerksick et al., 2009). The participants performed an upper body resistance-training program consisting of nine exercises (bench press, lat pull, shoulder press, seated rows, shoulder shrugs, chest flies, biceps curl, triceps press-down, and abdominal curls) twice a week and a seven-exercise lower extremity program (leg press, back extension, step-ups, leg curls, leg extension, heel raises, and abdominal crunches) twice a week. They performed three sets of 10 repetitions with as much weight as they could lift per set during Weeks 1–4 and three sets of eight repetitions during Weeks 5–8, also with as much weight as could be lifted per set (typically 60–80% of 1RM). Rest periods between exercises lasted no longer than 3 min, and rest between sets, no longer than 2 min. Training was conducted at the Mayborn Campus Center at the University of Mary Hardin-Baylor under the supervision of trained research assistants, documented in training logs, and signed off to verify compliance and monitor progress.

Statistical Analysis

Analysis of variance (ANOVA) for repeated-measures univariate tests was used to analyze data. Data were considered statistically significant when the probability of Type I error equaled .05 or less. All statistical procedures were analyzed using SPSS (Statistical Package for Social Science) version 16.0. All data are reported as $M \pm SD$.

Results

Medical Monitoring, Dietary Analysis, and Training Volume

Although a few cases of gastrointestinal discomfort were reported, no participants experienced any major clinical side effects related or unrelated to the study. All participants completed the training protocol without any complications. No significant differences ($p > .05$) between groups were detected for total daily caloric intake, macronutrient intake, or training volume.

Hematological Variables

There were no significant Group × Time interactions ($p > .05$) or main effects for time ($p > .05$) for red blood cell count, white blood cell count, triglycerides, cholesterol variables, liver enzymes or proteins, or markers of kidney function or muscle damage.

Body Composition

Baseline total body weight was not significantly different ($p = .809$) between AI and PL groups. A significant main effect for time ($p = .034$) was observed for total body weight for AI (T1= 85.13 ± 9.69 kg, T2 = 85.74 ± 10.59 kg, T3 = 85.31 ± 10.68 kg) and PL (T1 = 84.02 ± 15.21 kg, T2 = 85.04 ± 15.73 kg, T3 = 85.63 ± 16.07 kg) groups, although no between-groups differences ($p = .083$) were noticed over the 8-week study period. Significant main effect for time ($p = .001$) and interaction ($p = .048$) effects for mean body-fat percentage occurred between AI (T1 = 18.87% ± 4.87%, T2 = 17.91% ± 4.98%, T3 = 17.09% ± 5.04%) and PL (T1 = 18.37% ± 6.85%, T2 = 17.59% ± 7.04%, T3 = 17.82% ± 7.19%) groups (Figure 1). In addition, a significant main effect for time ($p < .001$) was noticed for fat-free mass (AI: T1 = 68.81 ± 6.30 kg, T2 = 70.06 ± 6.57 kg, T3 = 70.40 ± 6.45 kg; PL: T1 = 67.91 ± 8.28 kg, T2 = 69.33 ± 8.27 kg, T3 = 69.55 ± 8.06 kg).

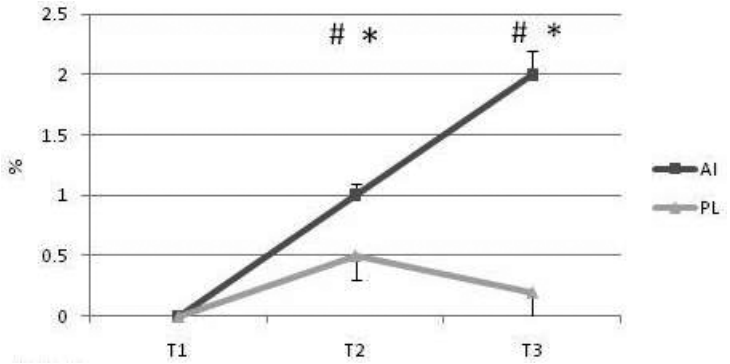

Figure 1 — Body-fat changes from baseline testing (T1) through Week 8 (T3), mean Delta ± SD. #Significant Group × Time interaction ($p < .05$). *Significant main effect for time ($p < .05$) over baseline at T2 (after 4 weeks) and T3.

Training Adaptations

A significant main effect for time was detected for AI and PL groups for bench-press 1RM ($p < .001$; AI: T1 = 108.55 ± 24.98 kg, T2 = 112.97 ± 24.84 kg, T3 = 114.04 ± 23.39 kg; PL: T1 = 95.10 ± 26.89 kg, T2 = 100.17 ± 28.89 kg, T3 = 102.10 ± 29.29 kg) and leg-press 1RM ($p < .001$; AI: T1 = 329.15 ± 61.20 kg, T2 = 371.12 ± 68.20 kg, T3 = 398.53 ± 74.33 kg; PL: T1 = 295.80 ± 71.25 kg, T2 = 332.17 ± 80.72 kg, T3 = 355.77 ± 81.53 kg) over the 8-week resistance-training program, despite no between-groups differences for 1RM tests (Table 1). No significant interactions were noted for muscle-endurance repetitions on the bench press ($p = .328$) or leg press ($p = .184$) or Wingate peak ($p = .343$) and mean power ($p = .679$; Table 2) between AI and PL groups.

Table 1 Bench-Press and Leg-Press One-Repetition-Maximum Values From Baseline Testing (T1) Through Week 8 (T3), kg

Group and time point	Bench press	Leg press
Aromatase and 5-α reductase inhibitor		
T1	108.55 ± 24.98	329.15 ± 61.20
T2	112.97 ± 24.84*	371.12 ± 68.20*
T3	114.04 ± 23.39*	398.53 ± 74.33*
Placebo		
T1	95.10 ± 26.89	295.80 ± 71.25
T2	100.17 ± 28.89*	332.17 ± 80.72*
T3	102.10 ± 29.29*	355.77 ± 81.53*

Note. Values are $M \pm SD$. No significant interactions ($p > .05$) occurred.
*Significant difference from baseline.

Table 2 Wingate Power Measures From Baseline Testing (T1) Through Week 8 (T3), W

Group and time point	Peak power	Mean power
Aromatase and 5-α reductase inhibitor		
T1	1,145 ± 185	599 ± 81
T2	1,178 ± 167	606 ± 79
T3	1,178 ± 167	605 ± 91
Placebo		
T1	1,311 ± 828	561 ± 76
T2	1,143 ± 182	556 ± 84
T3	1,151 ± 172	572 ± 79

Note. Values are $M \pm SD$. No significant interactions ($p > .05$) occurred.

Hormones

Significant Group × Time interaction effects were observed for serum total testosterone ($p = .018$; AI: T1 = 14.76 ± 3.97 ng/ml, T2 = 15.38 ± 3.19 ng/ml, T3 = 15.73 ± 3.62 ng/ml; PL: T1 = 15.80 ± 4.91 ng/ml, T2 = 14.38 ± 5.11 ng/ml, T3 = 13.70 ± 3.27 ng/ml; Figure 2) and bioavailable testosterone ($p = .049$; AI: T1 = 10.77 ± 4.11 ng/ml, T2 = 11.65 ± 3.59 ng/ml, T3 = 12.09 ± 4.16 ng/ml; PL: T1 = 11.80 ± 5.41 ng/ml, T2 = 10.99 ± 5.35 ng/ml, T3 = 10.11 ± 3.29 ng/ml; Figure 3) between AI and PL groups. No main effect for time was noted for total or bioavailable testosterone ($p > .05$). A significant main effect for time was noted for estradiol ($p < .001$; Figure 4). No significant interaction effects transpired over the 8-week study period for free testosterone ($p = .900$) or DHT ($p = .422$; Figure 5).

Discussion

The purpose of this study was to determine the effects of a commercially available product (T. foenum-graecum [standardized for Grecunin]) purported to inhibit aromatase and 5-α reductase activity on strength, body composition, and hormonal profiles in resistance-trained men during an 8-week resistance-training program. No adverse side effects were reported by any of the participants, nor were any clinical safety markers or hematological variables significantly altered ($p > .05$), demonstrating that within the study parameters and the experimental supplement dosage tested, the product appears safe when taken over an 8-week time period.

Over the allotted 8-week supplemental time frame, no changes were seen in any of the hormonal variables of interest in the PL group. It is noted, however, that the AI group underwent average increases of 6.57% and 12.26% for total testosterone and bioavailable testosterone, respectively ($p < .05$). Moreover, we did not see a decrease in serum estradiol and DHT levels, as would be expected from the AI; instead we observed nonsignificant increases ($p > .05$) of 26.62% and 6.10%, respectively. Even though our results demonstrate that the experimental AI increased endogenous testosterone levels, it did not completely block aromatase and 5-α reductase activity. Our results are in concurrence with those of others (Rohle et al., 2007; Willoughby et al., 2007) who found marginal increases in estradiol after supplementing with an aromatase-inhibiting supplement for 8 weeks.

Aromatase inhibits the conversion of testosterone to estradiol, which subsequently sends feedback to the hypothalamus and pituitary to promote testosterone production (Hayes et al., 2000). Therefore, estradiol levels would likely decrease to see testosterone levels inversely elevate. Our data agree with this; estradiol decreased 9.64% from Week 0 to Week 4 before rising above baseline values by the conclusion of the 8-week study. Because of a significant increase in total and bioavailable testosterone without a corresponding increase in estradiol and DHT, we conclude that the experimental

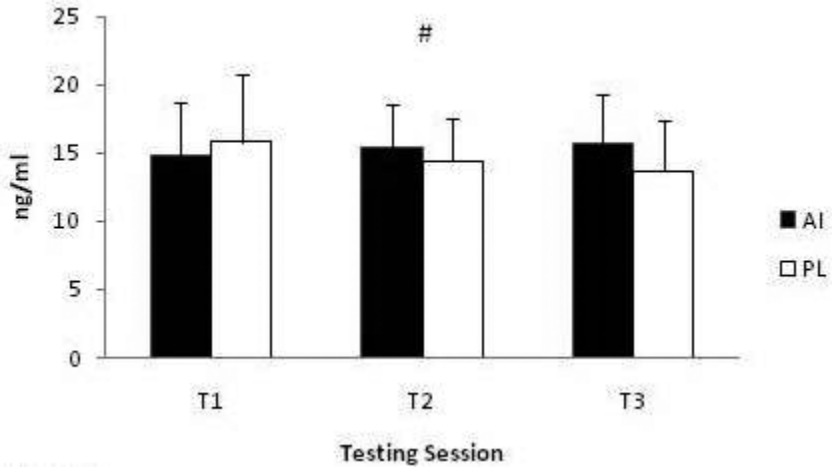

Figure 2 — Serum total testosterone changes from baseline testing (T1) through Week 8 (T), *M* ± *SD*. #Significant Group × Time interaction ($p < .05$).

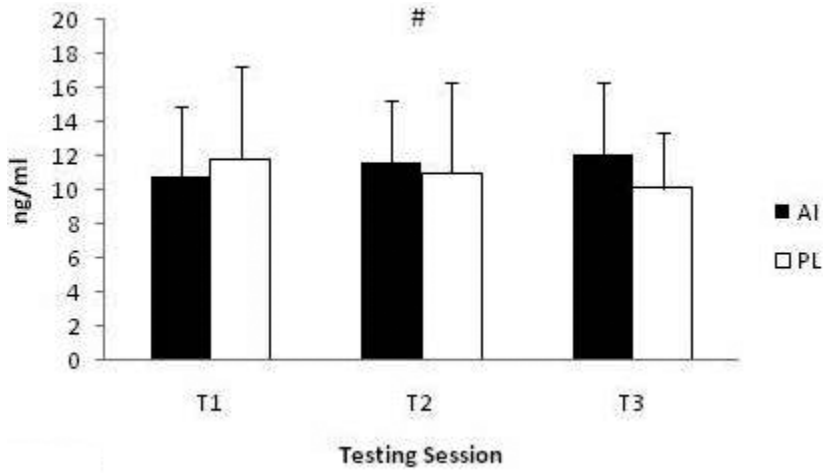

Figure 3 — Serum bioavailable testosterone changes from baseline testing (T1) through Week 8 (T), *M* ± *SD*. #Significant Group × Time interaction ($p < .05$).

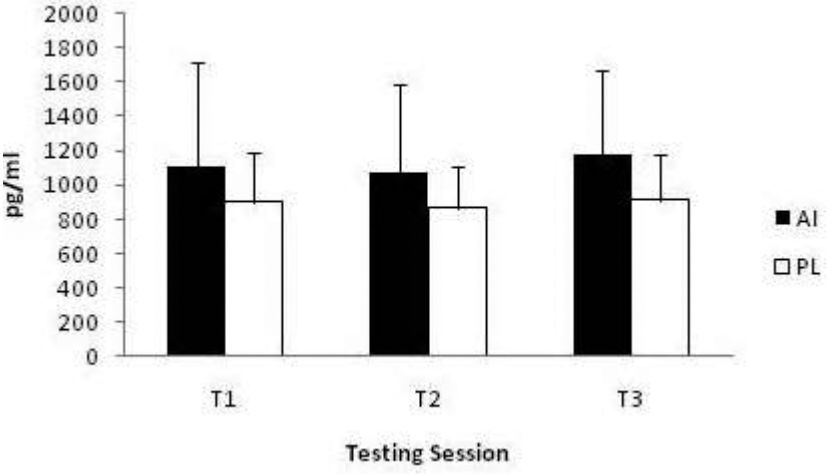

Figure 4 — Serum dihydrotestosterone changes from baseline testing (T1) through Week 8 (T), *M* ± *SD*. No significant changes were noted.

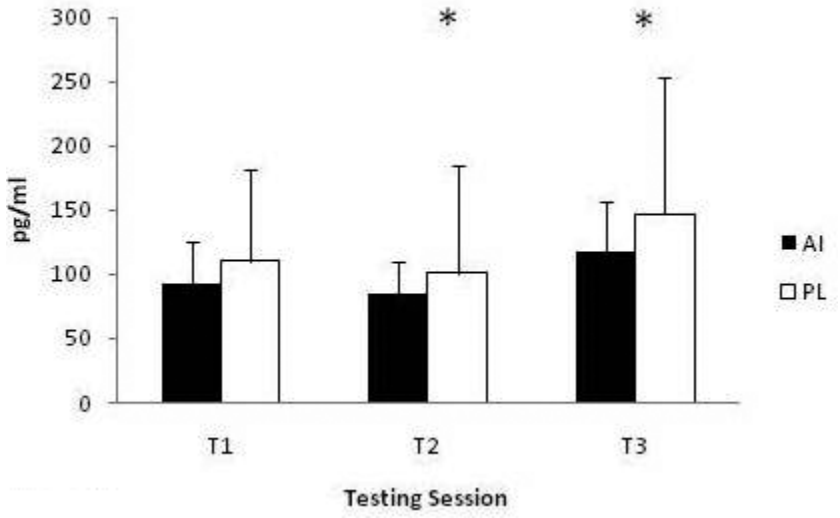

Figure 5 — Serum estradiol changes from baseline testing (T1) through Week 8 (T), $M \pm SD$. *Significant linear increase over baseline.

AI successfully, but incompletely, inhibited aromatase and 5-α reductase activity.

In the current study, the purported aromatase and 5-α reductase inhibitor had no effect on fat-free mass but was an effective stimulus for decreasing fat mass by 1.77%, compared with 0.55% in the PL group ($p < .05$). Our data are supported by our previous work (Willoughby et al., 2007), which also found a decrease in fat mass (3.5%) without changes in fat-free mass during an 8-week resistance-training program in conjunction with an aromatase-inhibiting supplement.

Increased serum androgen concentrations related to hypergonadism can accelerate lipolysis via activation of hormone-sensitive lipase (Hossain & Hornick, 1994), while a state of hypogonadism is correlated with a diminished fat-oxidation efficiency and a subsequent reduction in resting energy expenditure (Hayes, 2000). We observed significant increases in total and bioavailable testosterone levels, without any noticeable change in estradiol between AI and PL, thus indicating a possible connection between increased androgen levels and decreased fat mass, even though no markers of lipolysis were assessed.

For the evaluated performance measures, the AI group increased bench-press and leg-press 1RM strength 8.04% and 21.08%, respectively, but no differences were seen between groups ($p > .05$), which signifies that the experimental supplement had no effect on overall body strength. Previous research has shown that supplementation with anastrozole for 10 weeks did not affect strength, although total testosterone increased 58% and estradiol declined 50%. Our previous work (Rohle et al., 2007; Willoughby et al., 2007) experimenting with aromatase inhibitors marketed by nutritional supplement companies did not analyze strength in young, eugonadal men. However, the effects of testosterone derivatives coupled with resistance training vastly improve muscle strength across all populations (Bhasin et al., 1996; Bhasin et al., 1997; Bhasin et al., 2000; Ferrando et al., 2002; Schroeder et al., 2003; Snyder et al., 1999). These training adaptations would appear to be a result of supraphysiological doses of testosterone, because exercise-induced changes in testosterone do not appear to significantly affect muscle protein synthesis (West et al., 2009). After its release into the blood, testosterone can circulate to a desired muscle cell, translocate and bind to an androgen receptor, and promote intracellular transcriptional and translational events that ultimately increase fat-free mass (muscle hypertrophy). Because muscle cross-sectional area is linearly related to strength potential (force-production potential; Ratamess, 2008), the effects of supraphysiological doses of testosterone derivatives on muscle strength are clearly understood.

AIs marketed by nutritional supplement companies claim that these products increase androgen levels similarly to anabolic steroids while simultaneously suppressing estrogen levels. The current data, along with those from our previous work (Willoughby et al., 2007), support this notion to some extent, because we saw increases in total and bioavailable testosterone accompanied with minimal change in DHT and estradiol. Conversely, as our data suggest, an increase in endogenous testosterone levels does not always translate to an increase in muscle hypertrophy and strength. It is likely that the increase in endogenous testosterone levels from the experimental supplement did not affect androgen-receptor expression or the interaction between testosterone and an androgen receptor, which provides a possible explanation of why fat-free mass and strength did not increase more than in the PL group in our investigation. Thus, these data support the notion that elevated levels of testosterone within physiological levels have no influence on muscle strength in strength-trained young men.

AI drugs have been around for some time and have successfully been used as medicinal treatments for various types of cancer. However, AIs marketed as nutritional supplements are relatively new to the fitness industry, and there are limited data on their alleged benefits as

advertised by supplement companies. The results of this study indicate that 8 weeks of supplementation with a commercially available AI incompletely inhibited aromatase and 5-α reductase activity while significantly increasing total and bioavailable testosterone levels, as well as decreasing percent body fat, in conjunction with a resistance-training program. No changes between Al and PL were noted for upper and lower body strength, hematological variables, or clinical safety data.

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