Effects of androgenic-anabolic steroids on neuromuscular power and body composition

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Crist, Douglas M., Phillip J. Stackpole, and Glenn T. Peake. Effects of androgenic-anabolic steroids on neuromuscular power and body composition. J. Appl. Physiol.: Respirat. Environ. Exercise Physiol. 54(2): 366-370, 1983.—The effects of androgenic-anabolic steroids on neuromuscular power and body composition were studied in nine volunteers experienced with progressive-resistance weight training. By use of double-blind procedures, testosterone cypionate, nandrolone decanoate, and sesame oil (placebo) were administered in a repeated-measures design that counterbalanced treatment order. Duration of each treatment condition was 3 wk. Suplemental protein was provided, and dietary records were maintained throughout the study. Subjects were trained with progressive-resistance weight-training exercises. Isokinetic dynamometer testing revealed that peak torque output was not significantly changed between treatments in 7 out of 10 isolated-joint actions. The hydrostatic weighing results revealed insignificant differences in lean body mass and percent body fat. Significant changes in some treatment means of three peak torque output tests were insufficient to identify any treatment alterations. Since protein and caloric intake was sufficient to elicit anabolic effects from the steroid treatments and weight-training program, the lack of significant results could not be attributed to dietary considerations. Subjects reported subjective feelings of increased strength after administration of anabolic agents, which may partially account for their widespread use. In conclusion, anabolic steroids did not substantially change body composition or the objective power measurements used in this study.

ANDROGENS, including endogenously produced testosterone, are known to promote protein synthesis and growth of muscle and other tissues and are reputed to enhance muscular strength (12). Certain derivatives of androgens and androgen precursors are thought to have enhanced anabolic effects on protein synthesis and growth and strength of muscle and lessened effects on secondary sex characteristics (12). Bowers and Reardon (2) found increases in dynamic strength and biceps and forearm girths of anabolic steroid-treated subjects compared to untreated controls. These findings were confirmed by Johnson and O’Shea (9), who found increases in dynamic and static strength and five anthropometric measurements in anabolic steroid-treated subjects contrasted to untreated controls.

Other research indicates that androgenic-anabolic steroids are not beneficial to physical performance. Fowler et al. (7) conducted a double-blind study investigating the effects of unspecified physical conditioning and methandrostenolone on rugby players and untrained individuals. After 16 wk, no improvements were found in static strength, physical working capacity, or various anthropometric measurements. Other double-blind studies have found no significant effects on physical performance from androgenic-anabolic steroids. Stromme et al. (16) reported that high dosages of methandrostenolone, administered during 8 wk of weight training, did not change static strength, body weight, several anthropometric measurements, or aerobic power.

The present double-blind study was designed to give an unbiased determination of androgenic-anabolic steroid effects on objective measures of neuromuscular power by use of isokinetic dynamometry and body composition by use of hydrostatic weights. Self-report measures of muscular strength gain, if any, were solicited for each treatment condition to determine whether the subjects’ perception of the steroids’ effectiveness during training were similar to the objective findings.

METHODS

Nine healthy adults, aged 19-31 yr, volunteered as subjects for the study. Mean body weight, lean body mass, and percent body fat were 79.5 kg, 17.8 kg, and 9.5%, respectively. All subjects (8 males and 1 female), having had a mean of 2.7 consecutive yr of experience in weight training, were highly conditioned in such training. Six of the nine subjects, including the female subject,
were competitive weight lifters. Only one subject reported having used anabolic steroids previously.

These experienced subjects were selected for the study to achieve an increased degree of homogeneity in subject responsiveness to training, skill level, and motivational state. Also, it was felt that novice individuals might have a rapid rate of gain in strength from the training itself obscuring the effects, if any, from the steroids.

An informed consent, explaining the nature of the experiment and the risks involved and approved for use by the Human Research Review Committee at the University of New Mexico School of Medicine, was signed by each subject prior to participation in the study.

All subjects were exposed to three treatment conditions: placebo (sesame oil), testosterone cypionate, and nandrolone decanoate. Measurements of power and body composition were obtained 11-12 days following the last dose of each treatment condition (repeated-measures design). Some subjects had specific expectations concerning certain androgenic-anabolic steroids. Therefore, neither they nor the investigators were informed of the type of steroids used until termination of the study. This procedure avoided the effects of preconceived notions influencing a physical response to any of the treatments. Initially, subjects were randomly assigned to one of the treatment conditions and then systematically rotated throughout the remaining conditions. This was performed to counterbalance any treatment-order interaction.

The placebo (control) condition consisted of 1 ml of sesame oil intramuscularly once weekly for 3 wk. The experimental treatments consisted of 100 mg of testosterone cypionate USP (100 mg/ml) or 100 mg of nandrolone decanoate NF (100 mg/ml) intramuscularly once weekly for 3 wk. The dosages of the experimental drugs exceeded those used in other studies that reported anabolic effects within a 3-wk treatment period (2, 9, 15). All injections were given in the gluteal muscles. Treatments were administered on a double-blind basis with neither the experimental subject nor the person administering the injections knowing which of the three treatments was being given.

An interval of 2 wk separated each treatment condition. This 2-wk interval was selected based on the results obtained by Stackpole (15), which showed that muscular strength continued to improve for 2 wk following 3 wk of anabolic steroid administration. Thereafter, muscular strength performance was unaffected by the steroid treatment. These results suggest that a 2-wk interval between steroid treatments is sufficient to avoid residual drug effects interfering with subsequent treatments.

At the time of each injection, 10 ml of blood were drawn from the median cubital vein and subjected to a multichannel blood chemistry screen (SMAC-20). This test included indices of hepatic function, which were monitored for adverse reactions. No pathophysiological reactions warranting subject termination from the study were observed.

Subjects were instructed to follow a weight-training routine developed by the researchers. These exercises trained the joint actions being tested, as well as other areas, so that lean body mass changes might be optimized. The routine consisted of 6-8 sets of 6-10 repetitions per body part. Increases in the resistance and repetitions of all exercises were constantly encouraged. Each subject’s training was intermittently monitored to ensure compliance with the training protocol.

Subjects supplemented their diet with 35 g, twice daily, of an 80% milk and egg protein preparation. This preparation supplied 56 g of protein, 4.7 g of carbohydrates, and 1.9 g of fat. Total caloric content was 261 kcal. Daily dietary records were maintained by each subject during all treatment conditions.

Neuromuscular power in elbow flexion, knee flexion, knee extension, ankle plantar flexion, and ankle dorsiflexion was measured with an electromechanical isokinetic dynamometer (Cybex Division of Lumex, Bay Shore, NY) using the recommended testing and joint-isolation procedures (5). Low- and high-velocity peak torque output were used to measure neuromuscular power. The velocities used for each joint action were elbow flexion (30 and 180°/s), knee flexion (60 and 180°/s), knee extension (60 and 180°/s), ankle plantar flexion (30 and 120°/s), and dorsiflexion (30 and 120°/s).

The subjects were first instructed to perform five submaximal contractions. A 30-s rest interval followed the warm-up bout. Subsequently, the subjects were instructed to perform three consecutive maximal contractions throughout the fullest range of motion possible in all areas being tested. Vocal encouragement was provided during the performance of each maximal effort.

Torque output was assessed throughout the range of motion, and peak torque was identified as the greatest force produced during contraction, regardless of the joint angle. The maximum obtainable torque of the three contractions was used to measure neuromuscular power. These procedures were implemented for both the high and low velocity. One week before beginning the study, subjects were tested on the isokinetic dynamometer to familiarize them with the equipment and testing protocol.

Lean body mass and fat weight were determined by hydrostatic weighing (3, 10). Underwater weight was assessed at total lung capacity. Total lung capacity was determined by indirect calculation of residual lung volume and direct spirometric calculation of vital capacity (4). Residual lung volume was determined through the helium-dilution technique of closed-circuit spirometry for obtaining functional residual capacity.

Each subject was weighed in air on a Detecto platform scale and underwater on a Challiton autopsy scale. Underwater weights were obtained from 10 total-body submersions. The two highest and two lowest underwater weights were deleted, leaving the mean of six trials to be used for the estimation of body density.

Each one of the three posttreatment testing sessions was conducted 11-12 days following the last treatment injection for each condition. Thus each treatment exceeded the 3-wk period previously shown to result in an ergogenic effect of anabolic steroids (14).

The results of the posttreatment tests were not revealed to the subjects until termination of the study. This avoided the possibility of exposing the placebo treatment.

At the conclusion of the study, subjects were required to rate each treatment from 1 to 10 on “total-body strength gain.” A score of 1 indicated very poor gains,
RESULTS

The results obtained from the female subject were comparable with some of those obtained from the male subjects and are presented separately in Table 1. Her data were grouped with those of the other subjects in the overall analyses.

There were no significant differences between means and a score of 10 indicated excellent gains. These data were collected confidentially before the treatments were revealed to the subjects.

Latin square design (LS-3) was applied to all 10 measures of peak torque output and the two body composition measures to determine if the treatments and the order in which they were presented had significant effects (Ref. 11, p. 151-169). One-way analysis of variance (CR-3) was applied to subject self-evaluations of total-body strength gain and caloric and protein intake. These analyses performed on posttreatment data were consistent with the study design (11). Tukey's HSD (highly significant difference) test identified the source of treatment effects (Ref. 11, p. 88-90).

DISCUSSION

The results obtained in this investigation support studies reporting no significant androgenic-anabolic steroid-
EFFECTS OF ANABOLIC STEROIDS

induced changes in measures of body composition and neuromuscular power or strength (6, 7, 16). Percent body fat, lean body mass, and 7 of 10 tests measuring single-joint peak torque output were not significantly altered between placebo, testosterone cypionate, and nandrolone decanoate treatment conditions. Although three power tests demonstrated significant differences between treatments, they had no consistent pattern of change. This inconsistent pattern suggests that the effects were not sufficient to identify any specific treatment alteration.

Since protein and caloric intake might influence the anabolic actions of androgenic steroids, these variables were monitored so that dietary intake could be evaluated before conclusions were reached regarding the effectiveness of the steroid treatments. This was necessary because the loss of appetite is a potential adverse reaction associated with administration of these drugs (1). Also, subjects highly experienced in weight training tend to alter the composition of their diets during training.

The dietary findings revealed that there was more than adequate protein (13) ingested in each treatment condition, and there was no significant between group differences in this variable. No critical caloric deficiency was present during the three treatment periods. Within the limitations of self-report dietary records, it appears that dietary intake was sufficient to obtain anabolic effects from the treatments employed. Such monitoring is indicated, since others (2, 9, 14) have reported improvements in muscle strength with protein supplementation, weight training, and anabolic steroid administration. Despite these previous findings, even under dietary conditions conducive to anabolic metabolism the androgenic-anabolic steroid treatments did not produce significant improvements in neuromuscular power or body composition in the present study.

The possibility does exist that the dosage or duration of steroid administration might have been inadequate to achieve significant improvements in the performance measurements of this study, especially since we determined that dietary intake was adequate for such purposes. The dosages of androgenic-anabolic steroids used in this study, which amounted to approximately 14 mg/day for 3 wk, exceeded those used in similar studies that reported anabolic effects within a 3-wk treatment period (2, 9, 13). Personal correspondence with numerous competitive weight lifters known to have taken anabolic steroids revealed that, on the average, they reported noticing anabolic effects in 10-14 days with the administration of 10-15 mg/day. These findings and those of Stackpole (15) indicate that our treatment protocol was sufficient to obtain significant anabolic effects.

Since we used individuals experienced in weight training, there was a possibility that previous administration of anabolic steroids would produce a tachyphylactic reaction that could interfere with the dosages used in our study. Since only one subject reported having used an anabolic steroid previously, such an effect would not be expected in the present study.

In contrast to the objective findings of this study, the results of the self-report measures of total-body strength gain revealed that the subjects felt that significant differences existed between the steroid treatments and placebo treatment. Since the subjects were unaware of a placebo treatment, this increased the validity of their evaluations. This subjective impression may account for the acceptance of androgenic-anabolic steroids, by athletes, in attempts to improve physical performance.

Of interest are the findings of Fahey and Brown (6), who reported similar effects on isokinetic strength and lean body mass while administering one of the anabolic agents (nandrolone decanoate) employed in the present study. These results suggest that, under similar experimental conditions, androgenic-anabolic steroids do not significantly influence objective measurements of isokinetic strength or body composition. However, these results offer little explanation for the discrepancy between the objective results and the double-blind subjective self-report evaluations of steroid induced strength gain.

The reported feeling of increased strength during androgenic-anabolic steroid administration was not confirmed with isolated-joint testing using the isokinetic dynamometer. It is plausible that single-joint isolation and/or accommodative resistance testing are not sufficiently sensitive for accurate assessment of neuromuscular power gains produced from standard multiple-joint weight-training exercises. This method of isolated-joint testing, however, offers an objective and precise approach to the assessment of neuromuscular power.

In summary, subjects treated with testosterone cypionate, nandrolone decanoate, and placebo (sesame oil) did not exhibit mean treatment condition differences in 7 of 10 tests measuring peak torque output, lean body mass, and fat weight. Significant changes in some treatment means of three power tests were insufficient to identify any consistent treatment alterations. Since dietary intake was sufficient to elicit anabolic effects from the steroid treatments and weight-training program, the lack of significant results could not be attributed to dietary considerations. The subjects reported feelings of increased strength after steroid administration, which differed from the objective findings of this study.

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