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Actual and Perceived Effects of Anabolic Steroid Use on Maximal Strength Performance: A Brief Review

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Anabolic steroids (AS) have been repeatedly identified as an effective way to increase muscle size, strength, and plasma free-testosterone levels with or without exercise [1]. Improving these variables can give athletes a performance advantage in competitive sports. Steroid use is generally a taboo subject around athletes, and as such, it represents a powerful psychological tool as much as it acts physiologically. The expectancy effect of AS is so powerful that even administration of a "steroid placebo" can significantly increase one repetition maximum (1RM) in advanced powerlifters and varsity athletes over a short intervention [2,3]. The motivational and self-efficacy components of believed AS usage can improve strength at a significantly faster rate than high intensity resistance training alone [2,3]. Not only do AS work physiologically to increase muscle size and strength [1], but AS administration may alter intensity perception, resulting in notable strength improvements [2,3].

Bhasin., *et al*. [1] examined the effects of AS on muscle size and strength in normal men. The researchers investigated whether 600 mg of injected testosterone would substantially increase fat free mass (FFM), muscle size, and strength, relative to a placebo. Parameters consisted of both exercise and non-exercise conditions and utilized an isocaloric, protein-matched diet throughout the intervention. The researchers recruited 43 resistance trained males, of whom 40 completed the entire study. The subjects all had weightlifting experience and had never taken AS prior the study. The subjects were divided into four groups: placebo with no exercise, Testosterone with no exercise, placebo plus exercise, and Testosterone plus exercise. The training protocol began with a 4-week control period, where no subjects engaged in weight or endurance training, followed by a 10-week treatment period and a 16-week recovery period. Energy and protein intake were standardized at 36 kcal/kg bodyweight and 1.5g protein per kg bodyweight. The Testosterone injection consisted of a weekly 600 mg dose for 10 weeks. The training groups followed the same protocol of 3 nonconsecutive day: weekly training sessions at light intensity (70% 1RM), moderate intensity (80% 1RM), and high intensity (90% 1RM). The men performed 4 sets of 6 repetitions regardless of load, increasing to 5 sets for the second 5-week training block [1].

The researchers measured FFM, muscle size via magnetic resonance imaging (MRI) and muscle strength based on observed 1RM [1]. Serum concentrations of free Testosterone, Luteinizing Hormone (LH), Follicle Stimulating Hormone (FSH) were all measured. A Multidimensional Anger Inventory with 38 questions assessed mood and emotional stability pre, during, and post treatment. Serum Testosterone increased significantly in the two testosterone groups but not the placebo groups ($p < 0.05$), while LH and FSH did not notably differ. Bodyweight increased significantly in the Testosterone groups, but not the placebo groups. FFM increased by 3.2 kg in Testosterone without exercise group, 1.9 kg in the placebo plus exercise group, and 6.1 kg in the Testosterone plus exercise group. Mean cross sectional area significantly increased in the arms and legs in both Testosterone groups but not the placebo groups. Squat strength increased by 19% in the Testosterone alone group, 21% in the placebo plus exercise, and 38% in Testosterone plus exercise. Bench press strength also increased by 10%, 11%, and 22%, respectively. No significant changes in mood were observed between groups [1].

The researchers concluded that supraphysiologic doses of Testosterone, particularly when combined with strength training, increases FFM, muscle size, and strength in resistance trained males. Strength and muscle size gains were similar in the placebo exercise group and Testosterone non-exercise group, but greatest in the Testosterone plus exercise group. The 600mg dose of Testosterone used in this study was the greatest in the literature at the time, and the researchers proposed a dose-dependent relationship between Testosterone and both muscle size and strength. Short term administration of androgens was shown to be an effective, but not necessarily justified, method to improve performance. The authors suggest the practical use of injectable testosterone in space travel, cancer-related cachexia, HIV, or any other muscular wasting disorder [1].

Ariel and Saville [2] investigated the physiological effects of an AS placebo on male varsity athletes. The researchers sought to determine the effectiveness of the motivational aspect of AS with a double-blind study. Previous literature noted in the study indicated that AS significantly increases strength in healthy subjects, but no study had yet to investigate the motivational aspect of AS [2]. The researchers recruited 15 college-aged, varsity male athletes for the study. The subjects all had a minimum of 2 years of intense resistance training experience, 5 days per week. For the 4 months prior to data collection, the subjects were told that those who improved the most would be selected to take Dianabol, a potent androgenic anabolic agent. Eight subjects were selected to receive the AS placebo. The exercises performed and tested were the seated press, military press, bench press, curl, and squat. The 8 chosen subjects were briefed on the positive effects of AS and cited studies on reported strength gains. After initial screening, 2 were excluded, so 6 were given the 10 mg Dianabol AS placebo [1].

The researchers collected data for 7 weeks during the pre-placebo (PP) period and 4 weeks during the placebo period (P) [1]. Significant strength gains were made during both the PP period and the P period ($p < 0.01$), but the gains made in the P period were significantly greater than those made in the PP period ($p < 0.01$). In the military press, subjects had no significant gain in the PP period, but demonstrated significant improvement in the P period. In the seated press, subjects elicited similar significant gains in PP and P, with no significant difference between periods. Lifts improved by 4.54, 0.73, 2.27 and 2.65 kg, respectively for the bench press, military press, seated press and squat in PP by 13.28, 7.59, 5.3 and 18.94 kg after the P period, respectively [2].

Apart from the seated press, subjects made significantly greater improvements in the P period compared to the PP period [2]. These results could be potentially attributed to neuromuscular fatigue from exercise order, as the seated press was performed after the military press. Despite the shorter training time frame of P (4 weeks), subjects made significantly more gains than during PP (7 weeks). It appeared that that the psychological enhancing effects of AS can powerfully enhance strength gains, even in varsity level trainees [2].

Maganaris., *et al*. [3] investigated the effects of anabolic steroid (AS) expectancy on strength training in a population of competitive powerlifters. The researchers sought to identify whether the expectancy effects of AS would improve strength through the administration of a placebo. Previous literature indicated that cognitive factors of AS may play a significant role in motivation and self-efficacy, leading to improvements in physical performance. The researchers hypothesized that administration of an AS placebo would lead to substantial increases in performance, and once the placebo was revealed, performance gains would return to baseline [3].

The researchers recruited 11 nationally competitive powerlifters for the study [3]. None had reported to ever consume any substances banned by the International Olympic Committee, and all subjects abstained from supplement use during the study, to protein and amino acids. For the placebo, subjects were informed that the saccharin placebo being consumed was a fast-acting, oral anabolic steroid with no health risks. The subjects tested a baseline one repetition maximum (1RM) test on the squat, bench, and deadlift and began taking the placebo after the first test. Of note, these powerlifters were already at an advanced level, with 1RM ranges from 182.5 - 230 kg on the bench press, 237.5 - 277.5 kg on the squat, and 240 - 280 kg on the deadlift. All subjects reported increased vigor within the first week, lifting heavier weight or performing more repetitions [3].

During trial 1, just 1 week after taking the AS placebo (saccharin), all subjects increased individual 1RM from a range of 5 kg - 12.5 kg on the bench press, 10 - 15 kg on the squat, and 7.5 - 12 kg on the deadlift [2]. Body mass and daily energy intake did not notably change throughout the study. After Trial 1, 5 of the 11 subjects were told that the supplement was a placebo (AS/P). The AS/AS group maintained or improved strength gains through Trial 2, 1 week later, whereas the AS/P group lost between 2.5 - 14.5 kg off the Trial 1 lifts and returned to baseline values, despite Trial 1 performances [3].

The researchers concluded that the beliefs about the effectiveness of AS were successful at promoting a substantial increase in the squat, bench press and deadlift of each of the subjects [3]. The degree of improvement experienced was enough to bring the powerlifters from a national to an international level. The researchers report that such a cognitive manipulation intervention can demonstrate the

power of cognitive perception in skeptical athletes [2]. The findings suggested the effectiveness of efficacy-oriented instruction in increasing performance, even in advanced athletes.

Anabolic steroid usage can act both physiologically and psychologically to improve markers of strength [1-3]. Actual AS injections can improve strength, muscle cross sectional area, and fat-free mass [1], but even the administration of an AS placebo can significantly improve 1RM strength in advanced powerlifters and varsity athletes [2,3]. It appears that AS possess a powerful psychological component that may account for some of these results, due to expectancy effects alone [2,3]. While this deceptive strategy is effective, it may be limited in application. Coaches may share the findings of these studies to demonstrate the power of confidence and the mind.

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