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Fertility Outcomes in Men with Prior History of Anabolic Steroid Use

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Running Title: Fertility After Anabolic Steroid Use

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CAPSULE: A significant proportion of men with a prior history of anabolic steroid use continue to exhibit severe oligospermia, with approximately 50% failing to demonstrate substantial improvement even after undergoing a six-month treatment protocol.

ABSTRACT

OBJECTIVE: To study sperm parameters recovery and fertility outcomes in men with azoospermia or severe oligospermia caused by anabolic steroid use who underwent a standardized treatment regimen for spermatogenesis recovery.

DESIGN AND SUBJECTS: A retrospective analysis of a cohort of men with a prior history of anabolic steroid use and infertility complaints (between 2018 and 2022) was conducted.

EXPOSURE: The standardized treatment approach involved discontinuing testosterone replacement therapy and administering a combination regimen of clomiphene citrate and human chorionic gonadotropin for a minimum of 3 to 6 months.

MAIN OUTCOME MEASURES: The main outcome measures included changes in sperm parameters, predominantly sperm concentration, and subsequent pregnancy outcomes.

RESULTS: A total of 45 men (median age 37 years, IQR 32-45) met inclusion criteria for this analysis. Median duration of prior T use was 4 years (IQR 1.3-10), with the two most common modalities consisting of injection therapy (43.5%) and oral therapy (34.8%). Median initial sperm concentration was 0 million/cc (IQR 0-1.15), and 23 (51.1%) men initially presented with azoospermia.

The median duration of combination hCG/clomid therapy was 5 months (IQR 3-12). In initially azoospermic men (N:23), 5 were lost to follow-up, 6 (33.3%) progressed to severe oligospermia (<5 million/cc), 6 (33.3%) to oligospermia (<15 million/cc), 1 (5.6%) to normozoospermia (>15 million/cc), and 5 (27.8%) remained azoospermic following medical treatment for 6 months.

Among the 24 couples who responded to the follow-up call, a total of 9 (37.5%) achieved a successful subsequent pregnancy. Of these, 33.3% (3 couples) used assisted reproductive technology (ART), while 66.7% (6 couples) conceived naturally. On logistic regression analysis, no significant predictors for improved sperm parameters or successful pregnancy were identified.

CONCLUSION: Despite appropriate treatment regimens, a significant proportion of men with a prior history of anabolic steroid use continue to exhibit severe oligospermia, with more than half showing limited improvement in semen parameters after six months of treatment. Only a fraction of men achieves normozoospermia following treatment. Further research is needed to explore predictors for improved sperm parameters and successful pregnancy outcomes in men with a history of anabolic steroid use.

KEYWORDS: Anabolic Steroid Abuse, Infertility, oligospermia

INTRODUCTION

Anabolic-androgenic steroids (AAS) are Drug Enforcement Administration (DEA) schedule III regulated synthetic 17-a-alkyl or 17-b-ester derivatives of testosterone (1). AAS have been used historically as a treatment for weight loss and muscle wasting in advanced chronic diseases such as Human Immunodeficiency Virus (HIV) infection, male hypogonadism, osteoporosis, aplastic anemia, and child growth deficiency (2–4). The United States (US) Food and Drug Administration (FDA) approved indications for AAS use include delayed puberty, hypogonadotropic hypogonadism, primary hypogonadism, pituitary-hypothalamic dysfunction, primary testicular failure, and deficiency in gonadotropin and luteinizing hormone releasing hormone(1).

However, AAS have been increasingly abused for their anabolic-androgenic properties contributing to muscle growth, fat loss, and masculinization, particularly in Europe and the Americas(5). Globally, lifetime prevalence of AAS abuse (ASA) has been estimated at 6.4% for men and 1.6% for women(6). ASA is most commonly found in male weightlifters age 20-39, fighters, and security personnel, who utilize the synthetic derivatives to enhance their physical performance and appearance(7). The most commonly used steroids include testosterone, trenbolone, boldenone, methandrostenolone, nandrolone, oxandrolone, oxymetholone, and stanozolol (8,9).

AAS inhibit the body's physiologic endogenous testosterone synthesis, and chronic ASA also has adverse effects on multiple organ systems(10). Adverse effects in men include sexual dysfunction, cardiovascular disease, endocrine abnormalities, psychiatric dysfunction, and hepatotoxicity(11–13). Impacts on sexual function include testicular atrophy, reduced sperm count, impotence, and infertility(14). Currently, both the American Urological Association and the Endocrine Society recommend against testosterone therapy in men who wish to preserve their fertility(15,16). Our study focuses on infertility after ASA.

Chronic AAS use suppresses pituitary gonadotropin secretion and consequently testosterone production and spermatogenesis, resulting in testicular atrophy(17). This induced hypogonadism may spontaneously resolve over months to years after discontinuation or persist permanently(18). Treatment involves cessation of steroid use and establishment of baseline serum testosterone, luteinizing hormone (LH), follicle stimulating hormone (FSH), estradiol, and semen analysis. Regimens consisting of clomiphene citrate (CC), which can promote FSH production, and intramuscular or subcutaneous human chorionic gonadotropin (hCG), which serves as a luteinizing hormone analog and can promote intratesticular testosterone production, can be given to promote spermatogenesis(19,20). If azoospermia persists and serum labs remain low after 3 months (total testosterone < 300ng/dL, and LH and FSH inappropriately compensating), CC can be stopped, and recombinant FSH and hCG can be taken for 3 more months. If there is still no resolution, testicular sperm extraction (TESE) or microdissection testicular sperm extraction (m-TESE) may be employed(19).

Previous studies have demonstrated high rates of recovery of spermatogenesis in men with prior history of testosterone use, ranging from 67 – 96% within 12 months(21,22). However, these

studies had relatively low sample sizes and employed varying treatment protocols based on physician preference. Furthermore, it is unclear how the recovery of fertility after ASA aligns with pregnancy outcomes. Given this lack of certainty, we aimed to perform a retrospective analysis of men presenting to the University of Miami with infertility after ASA and treated with a standardized treatment protocol. To further evaluate the potential for fertility recovery and the efficacy of standard treatment with CC and hCG, we analyzed outcomes in couples attempting pregnancy. Given the significant adverse impacts on male reproductive health associated with long-term ASA, we hypothesized that a majority of this cohort would not achieve successful pregnancy, and in those that did, most pregnancies would require assisted-reproductive technology (intrauterine insemination (IUI) or in vitro fertilization (IVF)).

METHODS

A retrospective analysis was conducted on a cohort of men with a documented history of anabolic steroid usage as reported by providers within their patient files, who sought infertility treatment at the University of Miami Men's Health clinic between 2018 and 2022 with a sperm concentration < 5 million/cc. A "documented history of anabolic steroid use" was self-reported by the patients themselves during their consultations for infertility. This self-reported documentation includes details regarding their anabolic steroid usage, such as the type of steroids used, duration of use, and administration route. This study aimed to evaluate the outcomes of a standardized treatment protocol in improving sperm concentrations and fertility outcomes in men with a prior history of ASA. We aimed to assess the longitudinal trends in sperm concentrations, determine the proportion of men achieving normozoospermia, and evaluate the subsequent partner pregnancy rates in this specific population. Additionally, we sought to identify potential predictors for improved semen parameters and successful pregnancy outcomes.

Men included within the study received a standard treatment protocol which involved the discontinuation of testosterone replacement therapy (TRT) and the initiation of a combination regimen comprising CC (50 mg PO every other day) and hCG (2000 U SQ three times weekly). All included patients underwent and completed this combined treatment approach, that was administered consistently for a minimum of 3 to 6 months during the time period from 2018 to 2022. Following the completion of the treatment period, men were contacted via telephone call in March 2023 to gather up-to-date information on pregnancy outcomes. When called, patients were asked the following questions: (1) Did you and your partner achieve pregnancy?; (2) How long did you receive fertility treatment until pregnancy?; (3) How many pregnancies have you and your partner had since treatment?; (4) How many live births have you and your partner have?; (5) Did your partner receive fertility treatment? If yes, IVF or IUI, and how many cycles of treatment; (6) Did you restart testosterone use after infertility treatment, and if so, how long after completion of treatment?

The primary objective was to retrospectively assess the effectiveness of the treatment in improving semen analysis parameters. The secondary objective was to assess rates of subsequent successful pregnancies among the study participants' partners and utilization of assisted reproductive technology (ART). We conducted logistic regression analysis to examine two models: The first assessed the improvement in sperm concentration from initially less than <5 million/cc to greater than >15 million/cc, excluding men whose initial sperm concentration was greater than >5 million/cc. This model aimed to identify potential predictor variables associated with this improvement, such as age, ethnicity, body mass index, previous testis size, duration of anabolic steroid use, initial serum testosterone levels, and initial sperm concentration values.

The second logistic regression model focused on the improvement from initially being azoospermic to non-azoospermic (presence of sperm at any concentration above zero), excluding men whose initial sperm concentration was non-azoospermic. Similarly, this model aimed to identify potential predictor variables associated with this improvement, considering the same set of variables as in the first model.

Statistical analysis was performed using SPSS version 28.0.0.0. The statistical significance level was defined as $p < 0.05$.

The study was reviewed and approved by the University of Miami, Institutional Review Board (IRB) (Protocol Number: 20170849) and monitored by a data and safety monitoring board.

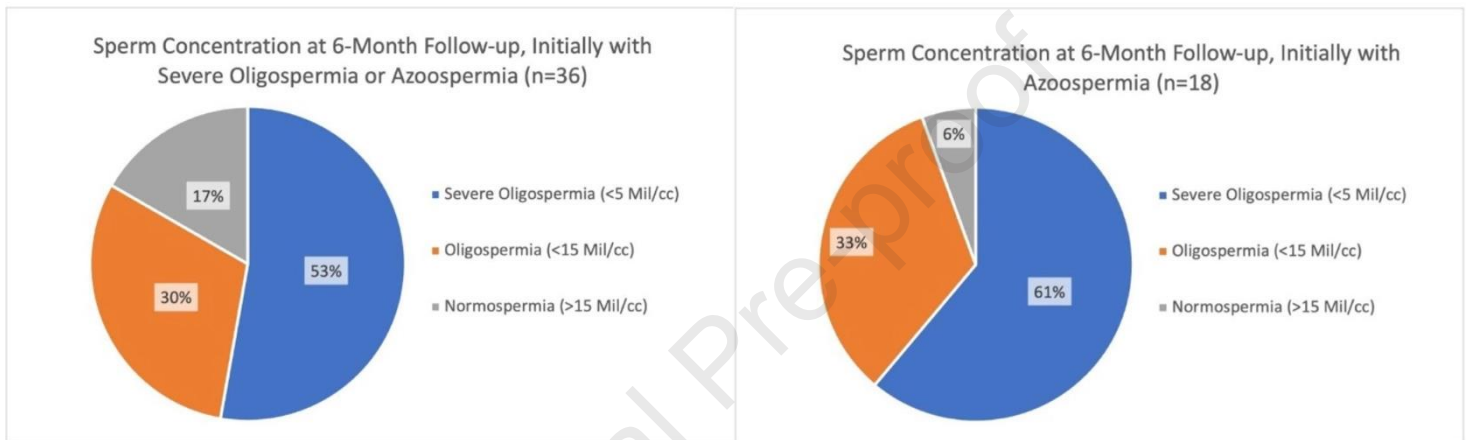
RESULTS

A total of 45 men (with a median age of 37 years, IQR 32-45) were included in this analysis (Table 1). The median duration of prior TRT use was 4 years (IQR 1.3-10), with the two most common modalities consisting of injection therapy (43.5%) and oral therapy (34.8%). The median initial sperm concentration was 0 million/cc (IQR 0-1.15), and initially 23 (51.1%) men presented with azoospermia. The median duration of hCG/clomid therapy administered was 5 months (IQR 3-12). At the 3-month follow-up, the median testosterone (T) level was 328 ng/dL (IQR 229-683). The median follicle-stimulating hormone (FSH) level at this time point was 3.7 mIU/mL (IQR 1.4-15), and the median luteinizing hormone (LH) level was 2.5 mIU/mL (IQR 0.35-6.23) (Table 2).

Forty-five men were initially presented with severe oligospermia or azoospermia. Of these, 9 were lost to follow-up. Of the remaining 36, 18 were azoospermic and 18 were severely oligospermia prior to onset of medical therapy. Of the 36 severely oligospermic or azoospermic men, 11 (30.1%) progressed to oligospermia, 6 (16.7%) to normozoospermia, and 19 (52.3%) remained azoospermic or severely oligospermic following medical treatment for 6 months. Of the 18 azoospermic men, 6 (33.3%) progressed to severe oligospermia (<5 million/cc), 6 (33.3%) to oligospermia (<15 million/cc), 1 (5.6%) to normozoospermia (>15 million/cc), and 5 (27.8%) remained azoospermic following medical treatment for 6 months. (Figure 1).

Among the 24 couples who responded to the follow-up call, a total of 9 (37.5%) achieved a successful subsequent pregnancy. Of these, 33.3% (3 couples) used ART to achieve pregnancy, while 66.7% (6 couples) conceived naturally. On logistic regression analysis, no significant predictors for recovery of sperm in azoospermic men or optimization of sperm concentration in oligospermic men were found. (Table 3)

Figure 1.



DISCUSSION

This study aimed to address a significant clinical challenge in the management of infertility: the impact of prior anabolic steroid use on male fertility and longitudinal pregnancy outcomes. Anabolic steroid use is prevalent among athletes and bodybuilders, but its consequences on reproductive health are not fully understood. The overarching hypothesis of this study was that a standardized treatment protocol could improve sperm concentrations and fertility outcomes in men with a history of anabolic steroid use. By examining this hypothesis, we sought to fill the gap in knowledge regarding the effectiveness of treatment interventions for this specific population.

The major gap in understanding that this work addresses is the limited knowledge of optimal management strategies for infertility in men with a history of anabolic steroid use. While previous studies have provided insights into the potential for recovery of spermatogenesis after testosterone use, there is a lack of comprehensive research focusing specifically on the effectiveness of

standardized treatment protocols and the subsequent fertility outcomes in this population. In prior work, Liu et al. demonstrated in an analysis of 30 studies that in eugonadal men with short-term T use as a hormonal contraceptive (21), up to 67% will recover spermatogenesis at 6 months. Wenker et al. evaluated HCG-based combination therapy for recovery of spermatogenesis after T use, and found that return of spermatogenesis for azoospermic men or improved counts in men with severe oligospermia was documented in 47/49 men (95.9%) (22). Our study demonstrated improvement in sperm concentration in 17/36 (47%) men; however, only 6% of azoospermic men progressed to normozoospermia at the 6-month treatment mark. Furthermore, in this cohort, only 17% achieved normozoospermia in the 6-month treatment window, and a significant proportion were normozoospermic at baseline despite anabolic steroid use, which excluded them from the analysis. This suggests that men with higher initial sperm concentrations are likely to have improved fertility outcomes relative to men with initially low sperm concentrations or presentation with azoospermia. This is further highlighted in a study by Kohn et al. which found that only 64.8% of azoospermic men with prior T use treated with hCG and selective estrogen receptor modulator (SERM) therapy achieved a total motile sperm count > 5 million at 12 months, compared to 91.7% of cryptozoospermic men (23).

We created a logistic regression model to determine potential predictors of improved sperm concentrations during the treatment window. Kohn et al. showed that both advanced age and increased duration of prior T therapy had negative effects on time to recovery of spermatogenesis (23). However, we found no significant predictors in our analysis.

In our cohort of 24 couples who responded to the follow-up call, about 38% achieved a successful pregnancy, with one third of those through ART and two thirds through natural pregnancy. This highlights a significant concept, in that many of these couples required ART for successful pregnancy. As demonstrated in this cohort, only 1/5 of the men achieved normozoospermia despite 6 months of adequate treatment. Therefore, discussion of the possible need for ART should be initiated with couples early on in counseling.

Strengths of this study include a large study cohort relative to prior studies and the employment of a standardized treatment regimen, which allowed for proper analysis of outcomes. Furthermore, to the best of our knowledge, this is the first study to assess fertility outcomes including pregnancy rates and use of ART utilizing this standardized treatment regimen.

There are several limitations to this study to note. This was a retrospective review and subject to confounding variables which cannot be controlled for. Compliance with the treatment regimen, age of first steroid use, and recency of steroid use was not specifically evaluated and may have affected outcomes. Similarly, we do not have standard data on social history, such as alcohol use, tobacco use, occupational exposure, and exercise regimens, all of which may potentially influence outcomes. Furthermore, we found no significant predictors for improved sperm concentration on

logistic regression analysis; however, this may be in part to a small study sample which was not powered enough to detect statistically significant differences. Regarding the inclusion of BMI as a predictor, we note that BMI is not a great measure of adiposity, especially in a population of men who use steroids potentially for increasing muscle mass. Other measurements of adiposity such as waist circumference or body fat percent, data which is not available to us, would be a better indicator of adiposity. Lastly, with respect to fertility outcomes, our results may be affected by responder bias, in that those with successful fertility outcomes were more likely to respond to a follow-up call. On the same note, another limitation is not having comprehensive data on the types of ART used by the couples. We understand the value of such analysis and its implications for understanding the outcomes of men who achieved normozoospermia.

Future work should continue to investigate factors that may predict successful fertility outcomes in men with prior history of anabolic steroid use. In addition, sperm concentration was the main focus of this study; however, further analysis is required to assess effects of treatment protocols on other semen parameters, such as volume and motility. Lastly, this study evaluated one standardized treatment regimen for treatment of men with anabolic steroid use and future studies should investigate potential alternate treatment regimens with subsequent fertility outcomes.

In conclusion, our study contributes important insights into the management of infertility in men with a prior history of anabolic steroid use. Despite the implementation of appropriate treatment regimens, a significant proportion of men with a prior history of anabolic steroid use continue to exhibit severe oligospermia, with approximately 50% failing to demonstrate substantial improvement in their semen parameter even after undergoing a six-month treatment protocol. While the standardized treatment protocol resulted in improvements in sperm concentrations for many individuals, a substantial proportion of the men still faced challenges in achieving normozoospermia. Furthermore, the chances of achieving pregnancy through natural conception alone were found to be quite low, emphasizing the importance of ART procedures in assisting couples in this population. These findings underscore the need for comprehensive fertility counseling and personalized treatment approaches for men with a history of anabolic steroid use who are seeking to achieve parenthood.

Author contributions: BL, JW, AM and RR designed research; BL, AM, AW, GV, JT and MN performed research; BL, AW, AM, RR analyzed data; and BL, AW, JW, AM, and RR wrote the manuscript.

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TABLES AND FIGURES LEGENDS

Table 1. Descriptive statistics of our cohort.

Table 2. Fertility Descriptive Statistics of our cohort.

Table 3. Logistic Regression Models

TABLES AND FIGURES

Table 1.

Descriptive Statistics (45 original participants with initial azoospermia or severe oligospermia)			
	N	Mean	Std. Deviation
Age	45	38.80	8.330
BMI	37	28.2568	3.46996
Female Partner Age	40	32.50	6.243
Initial Testis Size (cc)	19	13.16	3.287
Serum T at time of initial assessment	33	586.952	439.6164
Duration of time on T prior to initial assessment	30	77.933	84.3425
Sperm concentration at time of initial assessment	45	0.7787	1.20543
Sperm concentration at first follow-up	29	9.7234	31.09473
Serum T at time of first follow-up	21	474.048	370.7388
FSH at time of first follow-up	23	7.574	7.3054
LH at time of first follow-up	24	4.225	4.5737
Sperm concentration at second follow-up	19	9.3789	18.15071
Serum T at time of second follow-up	12	431	257.759
LH at time of second follow-up	11	5.218	4.0824
FSH at time of second follow-up	11	9.864	9.1555

BMI= Body Mass Index

T= Testosterone

FSH = follicle stimulating hormone

LH = luteinizing hormone

Table 2.

	Percentage (n)
Race	

Black	5.3% (1)
White	94.7% (18)
Ethnicity	
Hispanic	66.7% (28)
Non-Hispanic	33.3% (14)
Female partner infertility abnormality	
Present	18.4% (7)
Absent	81.6% (31)
Pre-T Varicocele	
Present	39.1% (9)
Absent	60.9% (14)
Route of T prior to assessment	
Oral	34.8% (8)
Gel	8.7% (2)
Injection	43.5% (10)
Testopel	8.7% (2)
Other	4.3% (1)
On clomiphene at time of initial assessment	
Present	15.9% (7)
Absent	84.1% (37)
On HCG at time of initial assessment	
Present	15.9% (7)
Absent	84.1% (37)
Natural Conception Achieved	
Present	6.5% (2)
Absent	93.5% (29)
IUI Attempted	
Present	19.4% (6)
Absent	80.6% (25)

IVF/ICSI Attempted	
Present	26.7% (8)
Absent	73.3% (22)
Surgical procedure for male fertility	
Present	24.2% (8)
Absent	75.8% (25)
Testosterone Restarted	
Present	25% (7)
Absent	75% (21)
Route of T Restarted	
Injection	60% (3)
Other	40% (2)
Pregnancy Achieved	
Present	37.5% (9)
Absent	62.5% (15)

T=Testosterone

IUI=Intrauterine insemination

IVF/ICSI=in vitro fertilization/intracytoplasmic sperm injection

Table 3.

	Model 1			Model 2		
	Odds Ratio	95% Confidence Interval	P Value	Odds Ratio	95% Confidence Interval	P Value
Age	1.020	0.918-1.133	0.716	0.915	0.795-1.054	0.219
Ethnicity	0.950	0.148-6.115	0.957	0.667	0.080-5.537	0.707
BMI	1.236	0.946-1.615	0.121	1.200	0.772-1.867	0.418

Previous Testis Size	1.115	0.725-1.714	0.620	-	-	-
Duration of ASA	1.002	0.984-1.021	0.820	1.013	0.985-1.041	0.373
Initial Serum Testosterone	1.000	0.997-1.003	0.919	1.004	0.998-1.009	0.169
Initial Sperm Concentration	1.265	0.675-2.372	0.463	-	-	-

BMI= Body Mass Index

ASA = Anabolic steroid abuse

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Table 2. Demographics and Fertility Descriptive Statistics

	Percentage (n)
Race	
Black	5.3% (1)
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Gel	8.7% (2)
Injection	43.5% (10)
Testopel	8.7% (2)
Other	4.3% (1)
On clomiphene at time of initial assessment	
Present	15.9% (7)
Absent	84.1% (37)
On HCG at time of initial assessment	
Present	15.9% (7)
Absent	84.1% (37)
Natural Conception Achieved	
Present	6.5% (2)
Absent	93.5% (29)
IUI Attempted	

Present	19.4% (6)
Absent	80.6% (25)
IVF/ICSI Attempted	
Present	26.7% (8)
Absent	73.3% (22)
Surgical procedure for male fertility	
Present	24.2% (8)
Absent	75.8% (25)
Testosterone Restarted	
Present	25% (7)
Absent	75% (21)
Route of T Restarted	
Injection	60% (3)
Other	40% (2)
Pregnancy Achieved	
Present	37.5% (9)
Absent	62.5% (15)

Table 3. Logistic Regression Models

	Model 1			Model 2		
	Odds Ratio	95% Confidence Interval	P Value	Odds Ratio	95% Confidence Interval	P Value
Age	1.020	0.918-1.133	0.716	0.915	0.795-1.054	0.219
Ethnicity	0.950	0.148-6.115	0.957	0.667	0.080-5.537	0.707
BMI	1.236	0.946-1.615	0.121	1.200	0.772-1.867	0.418
Previous Testis Size	1.115	0.725-1.714	0.620	-	-	-
Duration of ASA	1.002	0.984-1.021	0.820	1.013	0.985-1.041	0.373
Initial Serum Testosterone	1.000	0.997-1.003	0.919	1.004	0.998-1.009	0.169
Initial Sperm Concentration	1.265	0.675-2.372	0.463	-	-	-

BMI= Body Mass Index

ASA = Anabolic steroid abuse

