

Activational Effects of Exogenous Steroid Hormones on Cognitive Performance:
A Study of Anabolic-Androgenic Steroids in Men

by

Sandra Jeanne Mish
B.A. (Hons.), Queens University, 1994
M.Sc., University of Victoria, 2001

A Dissertation Submitted in Partial Fulfillment of the
Requirements for the Degree of

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Abstract

Objective: Despite widespread drug testing in sports and warnings about the potential risks of using anabolic-androgenic steroids (AAS), non-medical use is prevalent among athletes, non-athletes, and disturbingly among adolescents. To date, most research has focused on the anabolic properties and short-term health risks of AAS use. In contrast, studies investigating the effects on cognitive function in men using high doses of multiple exogenous steroids are lacking. The primary purpose of this naturalistic study was to examine the effects of non-medical steroid use on sex-related cognitive abilities in male bodybuilders. The secondary purpose of the study was to evaluate the psychological functioning of male bodybuilders who use AASs.

Methods: Eight male bodybuilders who used high doses of AASs were matched with bodybuilding and aerobic controls who had never used AASs, according to age, education, and estimated verbal intelligence. AAS use of the bodybuilders appeared similar to reports in the literature of self-administered AASs regimens used by strength athletes. All groups underwent a battery of cognitive tests and self-report psychological inventories, and had serum total testosterone and binding proteins measured immediately after testing. Cognitive measures selected were those that have previously shown sex differences. The study examined four psychological domains: aggression, personality, body image, and eating-disordered attitudes/behaviours.

Results: Male bodybuilders who used AASs scored significantly lower than controls on mental rotations and on the WAIS-III Digit-Symbol Coding subtest. There were no other significant group differences on the cognitive tasks. A curvilinear (inverted U) relationship was identified between spatial ability and total testosterone in men who did not use AASs. As there were only a few AAS users in the current study, there was little power to demonstrate a linear or nonlinear relationship. Overall, there were no significant differences between groups on the psychological variables. AAS users exhibited elevated levels of antisocial personality traits, with 38% scoring in the clinically significant range. Bodybuilders reported some body weight concerns, specifically a drive for muscularity combined with a drive for a well-toned body, with no difference between AAS users and bodybuilding controls. Three AAS users and one bodybuilding control exhibited psychological disturbances, as evidenced by elevated scores on multiple psychological measures.

Conclusions: The results of this preliminary study provide some evidence that high doses of AASs in men might influence certain aspects of cognition, specifically reducing complex visuospatial skills and perceptual speed. The data also suggests that endogenous testosterone influences spatial ability in healthy men in a curvilinear fashion. Further research with larger samples of AAS users is required to quantify the cognitive effects of non-medical AAS regimens. The study also contributes to the growing literature on the psychological effects of bodybuilding and AAS use. Although many AAS users and bodybuilders might display minimal psychopathology, there is likely a subgroup of individuals who exhibit clinically significant psychological disturbances. Further research is necessary to identify the nature and severity of psychological symptomatology in this population, and effective modes of treatment.

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Dedications

To Grandma and Grandpa Black,
for your constant words of encouragement.

To Mom and Dad,
for being the loudest and most enthusiastic
cheering squad a kid could ask for!

&

To Shad,
my soulmate, my rock,
my anchor, and my best friend.

Introduction

During the 1950s and 1960s, many bodybuilders and strength athletes had begun using anabolic-androgenic steroids (AAS)¹ to increase lean muscle mass and strength, and to enhance athletic performance (e.g., Fair, 1988; Wade, 1972). Since that time, AAS use has spread to almost every sport, from wrestling to swimming to basketball (e.g., Franke & Berendonk, 1997; National Collegiate Athletic Association, 2001). Despite warnings about the potential adverse effects of these substances and widespread drug testing in sports, AAS use has increased substantially not only among collegiate, elite and professional athletes, but also among amateur athletes and other segments of the general population. For example, there is a public concern regarding the alarming increase in AAS use among adolescents and even elementary school-aged children. Adolescents are using steroids during a critical developmental period of maturation of the brain and the reproductive system (Sisk, Schulz & Zehr, 2003). Many women athletes are also using AASs despite their powerful virilizing effects (e.g., National Collegiate Athletic Association, 2001).

Lifetime steroid use was estimated to be more than one million people in the United States, with more than 300,000 having used AASs within the past year and a median age of initiation of 18 years (Yesalis, Kennedy, Kopstein, & Bahrke, 1993). Non-medical use of AASs remains a particular problem in sports today. Although AAS use is not rampant in all sports, higher prevalence rates have been reported among competitive athletes, particularly those involved in strength-intensive sports. Approximately 40 to 70% of male bodybuilders and powerlifters (Delbeke, Desmet, & Debackere, 1995; Wagman, Curry,

¹ For the sake of simplicity, the term anabolic-androgenic steroid (AAS) will be used throughout this paper to refer to exogenous testosterone and its synthetic derivatives.

& Cook, 1995; Yesalis et al., 1988), 30-70% of world class track and field athletes (Ljungqvist, 1975; Silvester, 1973), and 1-10% of U.S. college athletes in strength sports (National Collegiate Athletic Association, 2001) acknowledged current and/or previous use of AASs to enhance athletic performance. As there is a great deal of secrecy regarding AAS use among athletes, these prevalence rates may be an underestimation of the actual steroid use.

Studies estimate that approximately 3 to 12% of male adolescents and 1 to 5% of female adolescents in the United States have used AASs at some point in their life, some of whom simply use for cosmetic reasons (DuRant, Escobedo, & Heath, 1995; Grunbaum et al., 2004; Yesalis, Barsukiewicz, Kopstein, & Bahrke, 1997). Male high school athletes are more likely to use AASs as compared to non-athletes, specifically those involved in football and wrestling (Buckley et al., 1988; Gaa, Griffith, Cahill, & Tuttle, 1994; Terney & McLain, 1990). The use among high school females is even more alarming, as the national Youth Risk Behavior Survey noted a 140% increase in AAS use from 1999 (2.2%) to 2003 (5.3%) [Grunbaum et al., 2004; Kann et al, 2000]. A more recent report suggested a slight decline in AAS use among female adolescents (3.2%) [Eaton et al., 2006]. The use of AASs by adolescents is not limited to the United States, with prevalence rates ranging between about 1 to 4% in other countries such as Canada (e.g., Canadian Centre for Ethics in Sport, 1993; Melia, Pipe, & Greenberg, 1996), Australia (Handelsman & Gupta, 1997) and Norway (Pallesen, Jøsendal, Johnsen, Larsen, & Molde, 2006).

Endocrinology of Anabolic-Androgenic Steroids

AASs are a group of steroid hormones, which include exogenous testosterone and several synthetic derivatives of endogenous androgens. Testosterone is a 19-carbon

steroid hormone (androgen) synthesized from cholesterol. The four-ring chemical structure of cholesterol is preserved in the synthesis of testosterone. In adult men, testosterone is the principal circulating androgen in the body, which is produced primarily in the Leydig cells of the testes. About 5% of testosterone is produced by the adrenal glands (Wu, 1992). Plasma testosterone concentrations are much greater in adult men than in women and in prepubescent boys.

Testosterone production increases suddenly during puberty, and serum testosterone levels peak in early adulthood. The average adult male produces about 7 mg of testosterone per day, with circulating total testosterone levels ranging from around 10 to 35 nmol/L (Wu, 1992). An age-related decline in circulating testosterone levels has been identified in men, but there is great inter-individual variability (Tenover, 1994). Healthy men exhibit a gradual decline in serum testosterone levels during the third decade of life, with an associated increase in luteinizing hormone (LH), follicle-stimulating hormone (FSH), and sex-hormone binding globulin (SHBG) levels (e.g., Feldman et al., 2002; Gapstur et al., 2002; Gray, Feldman, McKinlay, & Longcope, 1991; Harman, Metter, Tobin, Pearson, & Blackman, 2001). Both free and bioavailable testosterone concentrations fall more steeply than total testosterone due to increases in SHBG levels with age (Swerdloff & Wang, 2004). Harman and colleagues (2001) also indicated that a significant percentage of men over 50 years of age have circulating testosterone concentrations in the hypogonadal range.

Diurnal and seasonal variations in circulating testosterone levels in young adult men have also been reported. Serum testosterone levels peak early in the morning and fall to approximately 43% of the morning peak value, reaching nadir concentrations between 4

and 8 p.m. (Diver, Imtiaz, Ahmad, Vora, & Fraser, 2003; Valero-Politi & Fuentes-Arderiu, 1996). In young adult men, the rise in testosterone is linked with the appearance of the first rapid-eye movement sleep episode (Luboshitzky, Zabari, Shen-Orr, Herer, & Lavie, 2001). The circadian rhythm in serum testosterone levels is blunted in healthy older men (e.g., Bremner, Vitiello, & Prinz, 1983; Plymate, Tenover, & Bremner, 1989).

Seasonal fluctuations in male testosterone levels have also been identified. In North America, men have higher testosterone levels in late autumn and early winter (when sperm counts are highest) than in the spring (Dabbs, 1990; Reinberg, Smolensky, Hallek, Smith, & Steinberger, 1988). Nonetheless, studies have demonstrated contradictory results (Meriggiola, Noonan, Paulsen, & Bremner, 1996; Svartberg, Jorde, Sundsfjord, Bønaa, & Barrett-Connor, 2003).

Production and secretion of testosterone in the male is regulated by a complex set of feedback loops of the hypothalamic-pituitary-gonadal axis. The hypothalamus synthesizes and secretes gonadotropin-releasing hormone (GnRH), which in turn stimulates the production and release of both LH and FSH from the anterior pituitary (Haymond & Gronowski, 2006). LH acts on testicular Leydig cells to stimulate the synthesis and secretion of testosterone, and FSH acts on the Sertoli cells to stimulate spermatogenesis, as well as the production and secretion of inhibin (Haymond & Gronowski, 2006). Circulating androgens (such as testosterone and DHT) act on target tissues, but also regulate gonadotropin secretion through negative feedback on the hypothalamus and anterior pituitary. For example, if plasma testosterone levels are elevated in the male, it signals the hypothalamus to inhibit secretion of LH and FSH. This

feedback also reduces the production of testosterone in the testes (Haymond & Gronowski, 2006).

Testosterone is not the sole inhibitor of gonadotropin secretion in men. Estrogens and peptide hormones (e.g., inhibin B, kisspeptin) also regulate gonadotropin secretion. Inhibin B, a gonadal glycoprotein hormone, has been shown to inhibit pituitary FSH secretion by negative feedback (Meachem, Nieschlag, & Simoni, 2001). Kisspeptin stimulates the release of GnRH by activating GnRH neurons (Dungan, Clifton, & Steiner, 2006). Kisspeptin receptors (G protein-coupled receptor, GPR54) have been found on the GnRH cell membrane. There is also some evidence that kisspeptin neurons are sensitive to steroid feedback (Dungan, Clifton, & Steiner, 2006).

Steroid hormones act as chemical messengers, and are transported in the bloodstream to target tissues. Free testosterone is a lipid-soluble steroid hormone, and thus can diffuse passively through extracellular membranes (Nelson, 2000). Once inside the target cell, testosterone binds tightly to inactive androgen receptors in the cytoplasm, causing the receptor to undergo a structural change into an active form (O'Malley & Strott, 1999). The activated steroid-receptor complex enters the cell nucleus where it binds directly to a specific DNA sequence (hormone response element) to regulate gene transcription and subsequent protein synthesis (Nelson, 2000; O'Malley & Strott, 1999). The physiological effects of testosterone (and AASs) are mediated through intracellular androgen receptors. However, there is evidence that some steroid hormone responses involve 'non-genomic' mechanisms of action, such as rapid cellular and behavioural responses to the steroid hormone (e.g., Foradori, Weiser, & Handa, 2008; Moore & Evans, 1999).

In healthy men, approximately 2-3% of testosterone circulates in plasma in unbound

form (free testosterone) [Haymond & Gronowski, 2006]. The remainder is bound to plasma proteins. Testosterone is bound primarily to SHBG and to a lesser and weaker extent to albumin (Haymond & Gronowski, 2006). Testosterone is bound tightly to SHBG, and thus is not biologically active. However, the free and weakly bound hormone fractions are available for tissue uptake (Pardridge, 1986). Bioavailable testosterone is the sum of albumin-bound testosterone plus free testosterone, and represents about 35% of total testosterone (Haymond & Gronowski, 2006).

Two primary pathways of peripheral metabolism of testosterone exist within the body. The liver is the main site for inactivation of androgens (Mooradian, Morley, & Korenman, 1987). Testosterone is converted to excretory metabolites, such as 17-ketosteroids, that are excreted primarily in the urine (Haymond & Gronowski, 2006). Urine testing for endogenous, as well as exogenous, steroids and their excretory metabolites has been the primary means for detecting steroid use in athletes. Circulating testosterone is also irreversibly metabolized in select target tissues to its more biologically potent products, specifically dihydrotestosterone (DHT) via the enzyme 5 α -reductase and to estradiol via aromatase (Haymond & Gronowski, 2006). Approximately 85% of the circulating estradiol in males is from aromatized testosterone, with the remainder secreted by the testes (MacDonald, Madden, Brenner, Wilson, & Siiteri, 1979).

Circulating testosterone exerts both direct and indirect effects on many different tissues in the body. It may act directly on kidney, skeletal and cardiac muscle, as well as some reproductive tissues, through binding with the androgen receptor (Mooradian et al., 1987). Aggression and sexual behaviour are in part mediated by testosterone (Rubinow &

Schmidt, 1996). Testosterone may exert indirect effects in peripheral tissues by converting to one of its active metabolites. For example, it is metabolized to DHT in androgen target tissues with high 5 α -reductase activity, such as the skin, hair follicles and prostate (Haymond & Gronowski, 2006; Mooradian et al., 1987). Although the actions of testosterone and DHT are mediated by the same intracellular androgen receptor, DHT binds to androgen receptors with a greater affinity than testosterone (Mooradian et al., 1987).

Testosterone also may exert some of its effects through estradiol. Peripheral aromatization of testosterone to estradiol occurs in adipose tissue, bone, and numerous sites in the brain (Mooradian et al., 1987). Aromatized testosterone presumably acts via the estrogen receptors to influence bone growth, male sexual behaviour, and other brain-related functions (Mooradian et al., 1987). Testosterone may also compete with estradiol for binding to estrogen receptors (Mooradian et al., 1987).

Androgen and estrogen receptors are selectively distributed in the brain, with some overlap in target locations. Nelson (2000) indicated that the distribution of estrogen receptors is more extensive in the brain than that of the androgen receptors. Animal studies have shown that androgen receptors are concentrated in the amygdala, hypothalamus, pituitary, septum, and preoptic area (McEwen, 1980). Aromatization of testosterone to estradiol occurs in different regions of the brain. Aromatase activity has been found in the amygdala, preoptic area, and hypothalamus, but was absent in the pituitary and cerebral cortex (McEwen, 1980).

Estradiol binds with two different types of estrogen receptors (ER α and ER β) in the brain. Based on localization studies of rodents, it has been found that both estrogen

receptor subtypes are generally expressed in a similar distribution throughout the brain (Maggi, Ciana, Belcredito, & Vegeto, 2004). However, the receptor subtypes are concentrated in different regions of the brain. For example, ER α is the predominant subtype in the hippocampus, preoptic area, and certain areas of the hypothalamus (e.g., Maggi et al., 2004; Orikasa, McEwen, Hayashi, Sakuma, & Hayashi, 2000; Pérez, Chen, & Mufson, 2003). Although the ER β is present in several brain regions where ER α is expressed (e.g., medial amygdala), it is also abundant in regions where ER α is sparse or absent such as the cerebral cortex and the cerebellum (Shughrue & Mercenthaler, 2001). Estrogens have an influence on mood, verbal memory and fine motor skills, and may play a neuroprotective role by limiting the extent of neurodegeneration induced by brain injury and neural disorders (Maggi et al., 2004). Steroid hormone actions in the male brain are likely due to a complex interplay of both direct and indirect effects on androgen and estrogen receptors.

Steroid hormone receptors are found throughout the body, such as skin, skeletal muscle, reproductive tissues, heart, liver, kidney, and the brain. The effects of steroid hormones vary depending on the type of receptors and enzymes present in target tissues. The diverse physical and behavioural effects often associated with AASs are related to the almost ubiquitous steroid receptor sites located in the body.

Anabolic and Androgenic Effects of Steroid Hormones

AASs produce both androgenic (masculinizing) and anabolic (tissue building) effects. However, they also possess biological actions on target tissues that are neither androgenic nor anabolic, such as those of the central nervous system. Androgenic effects are responsible for the normal growth and development of the male urogenital tract and

secondary sex characteristics (such as axillary, facial, and pubic hair growth, laryngeal enlargement, and sebaceous gland proliferation) [Mooradian et al., 1987]. Androgens are also necessary for spermatogenesis in men, as well as maintenance of the male accessory sex organs and sexual functions.

Testosterone also possesses highly anabolic effects. Early studies found that the injection of an androgen-containing extract from human male urine produced a strong positive nitrogen balance, with an increase in body weight in castrated dogs (Kochakian & Murlin, 1935). Shortly thereafter, the nitrogen retention ability of a synthetic steroid was documented in eunuchoid men (Kenyon, Sandiford, Bryan, Knowlton, & Koch, 1938). AASs have been shown to play a role in the growth and maintenance of muscle in humans, by stimulating positive protein metabolism and nitrogen retention. They also have a positive effect on bone mass and bone density (Shahidi, 2001). AASs stimulate the production of red blood cells by increasing erythropoietin levels and blocking the negative effects of catabolic hormones (cortisol) on protein metabolism (Basaria, Wahlstrom, & Dobs, 2001). The anabolic characteristics of AASs are the primary selling feature to bodybuilders and athletes.

Types of Anabolic-Androgenic Steroids

Unmodified testosterone is ineffective clinically when taken orally or by injection, as it is rapidly degraded by the liver and thus effective plasma levels are not sustained (Bagatell & Bremner, 1996; Wilson, 1988). To circumvent this problem, attempts were made to develop a steroid compound with prolonged biological activity (Shahidi, 2001). Specifically, modification of the chemical structure of the testosterone molecule was performed to slow the rate of absorption and to prevent rapid degradation in the body (Wu, 1992). Researchers were also interested in developing synthetic steroids with strong

anabolic relative to androgenic properties for therapeutic purposes, specifically for use with women and children. There are no purely 'anabolic' steroids, and all of the AASs retain sufficient androgenic activity to produce virilization (Wilson, 1988). Nonetheless, there are some synthetic steroids with more suitable anabolic-androgenic profiles for therapeutic use (Shahidi, 2001). In addition, women athletes interested in increasing anabolic support often choose AASs with lower androgenic properties to decrease the masculinizing effects.

Based on structural modifications to various regions of the testosterone molecule, three main classes of synthetically modified steroids have been developed. Type A steroids involve esterification of the 17β -hydroxyl group with various carboxylic acids, which increases lipid solubility of the molecule and extends its duration of action in peripheral tissues (Basaria et al., 2001; Wilson, 1988). To slow the rate of release of these compounds, they are primarily administered by intramuscular injection in oil. Lipid solubility and rate of absorption of testosterone esters depends on the length of the carbon chain, with longer chains resulting in slower release and a prolonged action in the body (Wilson, 1988). Testosterone esters are hydrolyzed to biologically active free testosterone, which possesses virtually the same biological effects on target tissues, and is metabolized by the same pathway as endogenous testosterone (Wu, 1992).

Type B derivatives entail alkylation at the 17α position, which slowed the rate of metabolic inactivation by the liver and permitted effective oral administration (Wilson, 1988). Alkylation alters the metabolic pathway, resulting in a longer half-life (Basaria et al., 2001). Type B derivatives are not converted to testosterone or its distinct metabolites,

but produce physiological effects by acting directly with the androgen receptor (Wilson, 1988).

Type C steroids involve alterations of the ring structure of the testosterone molecule (Wilson, 1988). Most derivatives contain a combination of structural changes of the ring (Type C) with either esterification (Type A) or alkylation (Type B) [Wilson, 1988]. These combined agents are available for both oral and parenteral use. Similar to the alkylated agents, they are not converted to testosterone in the body (Wilson, 1988).

Endurance and strength athletes who take AASs primarily use the oral and parenteral forms of steroids (Franke & Berendonk, 1997; Yesalis & Bahrke, 1995). Intramuscular injections of testosterone esters are often prescribed for clinical purposes; however, they pose potential undesirable side effects. Intramuscular injections can cause fluctuations in serum testosterone concentrations, with unphysiologically high levels within 24 to 48 hours after injection followed by a gradual decline to subnormal values before the next injection (Snyder & Lawrence, 1980; Wu, 1992). Fluctuations in serum testosterone levels can cause similar changes in energy, mood, sexual desire and activity (Bhasin & Bremner, 1997). The pharmaceutical industry has been interested in developing alternative testosterone preparations in order to stabilize testosterone levels and to improve side effect profiles.

Various alternative delivery systems have been developed, including transdermal scrotal and nonscrotal patches, dermatological gels, testosterone implants, and nasal sprays. Transdermal applications have become increasingly popular for clinical use as they maintain physiological testosterone levels and provide ease of application as compared to parenteral injections (Bhasin et al., 2006). Elite athletes also often use these

alternative delivery systems and other masking techniques before competitions to circumvent detection by drug testing (Franke & Berendonk, 1997).

Each AAS has a unique molecular structure that is similar to testosterone, and functions as a steroid hormone in the body. However, exogenous steroids possess different anabolic-androgenic ratios and have different effects within the body (e.g., some steroids are metabolized similar to endogenous testosterone, whereas other steroids are not converted to testosterone or its metabolites). The magnitude of anabolic-androgenic effects in the body also depends on route of administration, the dosage, as well as the frequency and length of usage. For example, intramuscular injections of testosterone esters require less frequent administration and are less likely to cause liver toxicity than oral AASs.

Clinical Uses of Anabolic-Androgenic Steroids

When taken in controlled amounts, AASs have some valid clinical uses. AASs are primarily indicated and prescribed for male hypogonadism (Conway, Handelsman, Lording, Stuckey, & Zajac, 2000). The therapeutic goal of androgen supplementation is to maintain serum testosterone levels within the physiological range (Conway et al., 2000). In children with delayed puberty, testosterone replacement therapy also helps to advance sexual development and stimulate linear bone growth (Bagatell & Bremner, 1996). Androgen-deficient men experience diminished energy and sexual function, decreased lean muscle mass, strength, bone mineral density, hematocrit and hemoglobin concentrations, as well as a smaller prostate (Conway et al., 2000). Treatment with AASs has been shown to reverse these testosterone deficiencies (Bhasin et al., 1997; Conway et al., 2000; Snyder et al., 2000; Wang et al., 2000). Several testosterone regimens are available for treatment of androgen deficiency syndromes, such as long-acting

testosterone esters, transdermal formulations, and subdermal pellets (Hijazi & Cunningham, 2005; Kazi, Geraci & Koch, 2007).

There is an emerging trend to use AASs as hormone supplementation in healthy older men. Testosterone replacement therapy has been proposed to prevent or reverse symptoms associated with androgen deficiency in aging, including declines in energy, sexual dysfunction, muscle weakness and wasting, and osteopenia. Preliminary randomized, placebo-controlled studies have shown short-term benefits on body composition, bone mineral density, hematocrit and hemoglobin (Morley et al., 1993; Sih et al., 1997; Tenover, 1992). Nonetheless, the benefits of hormonal supplementation have not been adequately assessed in older men (Conway et al., 2000; Swerdloff & Wang, 2004).

Since AASs promote nitrogen balance and protein synthesis in the muscular system, these drugs have important clinical applications in the treatment of sarcopenia associated with chronic illnesses, such as severe burns, cancer, pulmonary disease, and renal failure (Basaria et al., 2001; Shahidi, 2001). AASs are also routinely used to fight muscle wasting associated with HIV and AIDS. Various studies have demonstrated increases in lean muscle mass and strength, as well as increases in libido, energy and mood with androgen supplementation in HIV patients (Basaria et al., 2001; Bhasin et al., 2000; Rabkin, Wagner, & Rabkin, 2000).

Testosterone and synthetic steroids have several other clinical applications. They have been used occasionally as an anti-estrogen to treat metastatic breast cancer (Basaria et al., 2001). These compounds have been used in the treatment of short stature (Turner's syndrome), wound healing and postoperative recovery, and hereditary angioedema

(Basaria et al., 2001; Shahidi, 2001). At one time, parenteral AASs were prescribed for the treatment of deficient red blood cell production, as seen in various anemias and bone marrow failure (Bagatell & Bremner, 1996; Basaria et al., 2001). However, due to the availability and effectiveness of recombinant erythropoietin in treating these conditions, androgen therapy is now rarely used.

Due to the shortcomings of existing methods of male contraception, efforts have been made to develop a reversible hormonal contraceptive method for men (Amory & Bremner, 2003). Several clinical studies have evaluated AASs alone or in combination with other agents as potential male contraceptives. Exogenous testosterone administration results in negative feedback suppression of gonadotropin secretion and normal testosterone production, as well as reduction in sperm production and fertility (Basaria et al., 2001). Clinical trials have shown that testosterone esters alone or in combination with other agents can induce fully reversible suppression of spermatogenesis to azoospermia with minimal side effects; however, sperm production was not entirely suppressed in all men (e.g., Bagatell, Matsumoto, Christensen, Rivier, & Bremner, 1993; Kamischke et al., 2002; Matsumoto, 1990; World Health Organization, 1996; Zhang, Gu, Wang, Cui, & Bremner, 1999).

Although AASs have been used for over 50 years to treat male hypogonadism, very little is known about the long-term effects of these drugs (Wu, 1992). Long-term outcomes of AAS use for therapeutic purposes need to be more fully evaluated. Side effects appear to be related to dose and route of administration. Safety hazards of AAS use are primarily available from studies conducted with athletes.

Non-medical Use of Anabolic-Androgenic Steroids

Performance-related AAS dosage depends on the sport and the particular needs of

the athlete (Yesalis, 2000). Endurance athletes use steroids primarily for their alleged catabolism-blocking effects, at doses typically at or slightly below physiological replacement levels (Yesalis, 2000). Bodybuilders, powerlifters, and other strength athletes, however, frequently use AASs in doses that far exceed those used for clinical purposes (supraphysiological levels). Based on their requirements to increase lean muscle mass and/or strength, these athletes often take doses that are 10 to more than 100 times greater than normal physiological levels (Brower, 2002; Franke & Berendonk, 1997). However, the actual amount and quality of the substances are often unknown because athletes typically obtain AASs from black market sources and/or use veterinary preparations (Brower, 2002).

Strength athletes often use different types of administration techniques to avoid tolerance and withdrawal symptoms, and to activate more androgen receptor sites (Brower, 2002; Yesalis, 2000). For example, athletes often combine ('stack') multiple oral and parenteral AASs at a time. To avoid plateauing, an athlete may stagger their use of AASs by taking different drugs in an overlapping pattern, or by stopping one AAS and starting another (Yesalis, 2000). Cycling is another technique used by bodybuilders; they alternate periods of AAS use with drug-free periods. Synthetic steroids are often used in cycles typically lasting for 6 to 12 weeks (Yesalis, 2000). However, some strength athletes take AASs on a continuous basis with few drug-free periods (Brower, 2002). Athletes might also use pyramid regimes during a cycle, where small doses are gradually increased to high doses and then tapered off toward the end of the cycle (Brower, 2002).

Bodybuilders, powerlifters, and other strength athletes often combine these various administration techniques. AASs are commonly used in conjunction with other drugs to

augment anabolic effects and to counteract adverse side effects, such as diuretics (to decrease fluid retention), ephedrine (to burn fat), anti-estrogens (to prevent gynecomastia), and human chorionic gonadotrophin (to prevent testicular atrophy) [Brower, 2002; Evans, 2004]. It is also important to note that athletes often combine strict diet regimes including dietary supplements (e.g., protein, vitamins, creatine) with their physical training and AAS use. Side effects experienced by athletes taking AASs might be the result of an interaction between AASs and other dietary supplements, diet, and intense physical training.

Athletes continue to use AASs despite their known ethical, legal, and health complications. Virtually all sport federations have banned the use of performance-enhancing drugs. Reasons for banning the use of drugs in sport have been based on various ethical and moral arguments, such as protection of the well-being of athletes, coercion to cheat, and unfair advantage over non-AAS using athletes (Yesalis, 2000). Yesalis (2000) argued that drug use “is morally wrong because it reduces sport to competition between biochemical machines” (p. 9). Testosterone and synthetic steroids are controlled substances in Canada and the United States, and are illegal for use without a physician’s prescription. A substantial portion of these drugs is obtained from black market sources for unapproved indications, such as for athletes or bodybuilders who use AASs for muscle building or performance enhancement (Yesalis, 2000). Beyond the dangers associated with AAS use, the purity and quality control of black market sources are an additional concern.

Effects of Anabolic-Androgenic Steroids

Non-medical use of AASs is a growing health problem, one that has an expanding list of negative side effects. Although the short-term health and psychological effects of

AAS use have been increasingly studied, the long-term risks of megadoses of AASs are not well known. In endurance and strength athletes, the benefits of AAS use, specifically the anabolic properties, appear to outweigh the risks (Yesalis, 2000).

Muscular strength and muscle mass. Bodybuilders, weightlifters and other strength athletes often take AASs to increase muscle mass and strength, reduce body fat, increase aggressiveness and/or reduce recovery time between workouts to allow them to increase training volume and intensity. Athletes consistently praise the anabolic effects of AASs. However, there is considerable debate about the efficacy of AASs for improving muscular strength and size. Some professionals have denied that AASs significantly increase muscle mass or improve athletic performance, arguing that any weight gain is primarily the result of water retention (e.g., Hervey et al., 1981; Wilson, 1988) or that any strength gain is largely psychological (Ariel & Saville, 1972).

Significant inconsistencies exist in the research literature with regards to the anabolic effects of AASs in normal men, with some studies demonstrating an increase in muscular strength (e.g., Alén & Häkkinen, 1987; Bhasin et al., 1996) and others failing to show a change in muscle strength (e.g., Crist, Stackpole, & Peake, 1983; Samuels, Henschel, & Keys, 1942). Part of the confusion stems from the lack of uniformity and questionable experimental designs, including lack of appropriate controls, different assessment criteria, varying doses of different steroids, and weight training history before the study period (Blue & Lombardo, 1999; Elashoff, Jacknow, Shain, & Braunstein, 1991; Wilson, 1988). In addition, studies that found positive effects on muscular strength generally used experienced weightlifters and/or high-doses of AASs.

In a meta-analysis study, Elashoff, Jacknow, Shain, and Braunstein (1991) examined

the effects of AASs on muscular strength. After elimination of several poorly designed studies, the investigators found no support for enhanced muscle strength with AAS use in untrained participants. On the other hand, previously trained athletes in the AAS group showed slightly greater improvements in strength compared to the trained athletes in the placebo group. Only three of nine studies of trained athletes provided adequate information to calculate effect sizes. Although a large overall effect size ($d = 1.0$, range = 0.22 to 2.3) was found for these three studies, Elashoff and colleagues (1991) indicated that the data were insufficient to allow any firm conclusions about the efficacy of AASs in enhancing overall athletic performance. It was also noted that these results should not be generalized to strength athletes using various AAS administration techniques as most of the published studies used low dosages of single steroid derivatives (Elashoff et al., 1991).

A recent well-designed study using supraphysiological doses of testosterone enanthate (600 mg/wk) demonstrated gains in muscle strength and muscle mass in healthy eugonadal men (Bhasin et al., 1996). Forty-three men, with previous weight training experience, were randomly assigned into four groups: testosterone with no exercise, testosterone with strength training, placebo with no exercise, and placebo with strength training. Among the no exercise groups, Bhasin and colleagues (1996) found that men given testosterone gained significantly more muscle size and strength than those given the placebo. However, the combined regime of (supraphysiologic) testosterone and strength training produced a greater increase in muscle size and strength than the other three groups (Bhasin et al., 1996).

Franke and Berendonk (1997) also shed some light on the performance enhancing

potential of AASs. From 1966 until the collapse of the German Democratic Republic, various physicians, scientists, and professors in this country performed doping research and administered AASs to thousands of male and female athletes. Based on well-documented observations and experiences of the athletes, Manfred Höppner (cited in Franke & Berendonk, 1997), the former deputy director and sports medical physician, concluded “The positive value of anabolic steroids for the development of a top performance is undoubted...[and] women have the greatest advantage from treatments with anabolic hormones with respect to their performance in sports” (p.1264).

Heavy resistance training (without AASs) also results in significant adaptive responses, such as muscle hypertrophy and increases in muscular strength (Häkkinen, Pakarinen, Alén, Kauhanen, & Komi, 1988; Kraemer et al., 1995). In the recent study by Bhasin et al. (1996), men in the placebo plus strength training group demonstrated significant increases in muscle strength and size as compared to the placebo group with no exercise. However, men who combine strength training (and balanced diets) with AASs experience increases in strength and muscle mass over and above those observed from resistance training alone (e.g., American College of Sports Medicine, 1987; Bhasin et al., 1996; Haupt & Rovere, 1984).

Physical health. A wide variety of detrimental effects of AASs have been documented in the literature. Health risks range from those that are minor and possibly inconvenient (acne) to those that are potentially lethal (liver tumours, cardiovascular disease). Adverse side effects can be temporary and persist for the duration of AAS use, last for a short duration after cessation of the drug, or can be permanent (Blue & Lombardo, 1999). The majority of side effects are short-term and reverse upon

discontinuation of the drug (Blue & Lombardo, 1999).

Potential adverse effects of AASs can be differentiated into four major areas: hepatic, cardiovascular, endocrine/reproductive, and psychological/behavioural. The negative side effects of AAS use depend on the age and sex of the individual, type of AAS used, dosage, and duration of steroid use (Wu, 1997). Psychological and behavioural effects will be detailed more extensively in a separate section.

AAS use has been associated with reversible elevations of liver enzymes and cholestatic jaundice, as well as rare but potentially life-threatening conditions such as peliosis hepatis and liver tumours (Wilson, 1988). This is not surprising because the liver is a target tissue for androgens and the principal site of steroid metabolism and clearance. In an extensive review of the literature, Haupt and Rovere (1984) found that approximately 50% of the athletes taking AASs displayed abnormal liver function tests. Intensive weightlifting alone is also associated with alterations in hepatic enzymes. Nonetheless, Kutscher, Lund, & Perry (2002) argued that AAS users are at greater risk of abnormal liver function. Hepatotoxicity is predominantly associated with the orally active 17 α -alkylated derivatives (Wilson, 1988).

It has been suggested that AAS use can increase risk factors associated with atherosclerotic cardiovascular disease and stroke (Blue & Lombardo, 1999). A significant adverse effect that has been clearly established is alteration of serum lipid levels. Research studies have identified that AAS administration reduces high-density lipoproteins (HDL) and elevates low-density lipoproteins (LDL) [e.g., Alén, Rahkila, & Marniemi, 1985; Glazer, 1991]. In a review of the literature, Glazer (1991) reported that AASs brought about profound suppression in serum HDL levels (52%) while

significantly increasing LDL levels by 36%. Route of administration is an important contributing factor, with the 17α -alkylated derivatives producing greater effects on serum lipid levels (Alén & Rahkila, 1988; Friedl, Hannan, Jones, & Plymate, 1990).

AAS use might also induce changes in the structure of the heart, such as enlargement and thickening of the left ventricular myocardium (Blue & Lombardo, 1999; Dickerman, Schaller, Zachariah, & McConathy, 1997; Sullivan, Martinez, Gennis, & Gallagher, 1998). However, Yeater, Reed, Ullrich, Morise & Borsch (1996) failed to detect a difference in left ventricular wall thickness between AAS-using and non-AAS using strength trained athletes, specifically men who lifted weights more than 10 hours/week.

AASs can also have dramatic effects on the endocrine and reproductive systems. The use of high doses of AASs results in decreased circulating concentrations of LH, FSH, and SHBG via the negative feedback loop of the hypothalamic-pituitary-gonadal axis (Alén & Rahkila, 1988; Alén, Rahkila, Reinilä, & Vihko, 1987). However, not all AASs have the same effects on endogenous hormones and reproductive functions. For example, administration of testosterone esters has been associated with immediate and temporary supraphysiological levels of serum testosterone and estradiol (Alén & Rahkila, 1988; Alén, Reinilä, & Vihko, 1985). Nonetheless, many synthetic steroids tend to decrease serum testosterone levels, and have no effect on estradiol levels.

Women and children are particularly susceptible to the virilizing and toxic effects of AASs (Franke & Berendonk, 1997; Wilson, 1988). Masculinizing effects are frequent and pronounced in female athletes; some of which appear to be permanent even when drug use is stopped. AAS use can lead to deepening of the voice, male pattern baldness, acne, facial and body hair, shrinkage of the breasts, an increase in libido, menstrual

irregularities, and significantly elevated serum testosterone levels (Franke & Berendonk, 1997; Korkia, Lenehan, & McVeigh, 1996; Strauss, Liggett, & Lanese, 1985). Synthetic steroids also have a profound capacity to promote premature masculinization and epiphyseal closure (resulting in short stature) in children of both sexes (Franke & Berendonk, 1997; Shahidi, 2001; Wilson 1988).

In normally virilized males, prolonged use of high and frequent doses of AASs can also lead to hypogonadotropic hypogonadism, which is associated with suppression of spermatogenesis, testicular atrophy, and infertility (Kutscher et al., 2002). Although disruption of sperm production and testicular atrophy appear to be reversible, several studies have noted that spermatogenesis may remain suppressed for several months to a year following cessation of the drugs (Alén, Reinilä, & Vihko, 1985; Jarow & Lipshultz, 1990). Feminization in men, such as development of gynecomastia, is most common after administration of aromatizable AASs (Alén, Reinilä, & Vihko, 1985; Franke & Berendonk, 1997). Other endocrine effects include acne and oily skin, and male-pattern baldness.

Research has also identified changes in the endocrine system with high-intensity resistance training in men who do not use AASs. The majority of studies have demonstrated acute increases in serum testosterone concentrations following a bout of heavy resistance exercise training (Fahey, Rolph, Moungmee, Nagel, & Mortara, 1976; Häkkinen & Pakarinen, 1995; Kraemer et al., 1991). Resting testosterone concentrations may remain unaltered by resistance training (Kraemer, 1988). However, Arce, De Souza, Pescatello, and Luciano (1993) noted lower resting testosterone levels in resistance-trained athletes compared to sedentary controls. Haskell (1994) also described other

physiological alterations related to regular exercise, including maintenance of bone density, decreased triglycerides, increased high-density cholesterol, and decreased levels of bodyfat.

Some indirect problems are also associated with AAS use, such as sharing of needles or syringes. Individuals who use unsanitary injection techniques put themselves at risk for contracting infections such as hepatitis and HIV/AIDS (Midgley et al., 2000). Administration of injectable AASs has also been associated with peripheral nerve damage (Perry, 1994) and abscesses (Khankhanian, Hammers, & Kowalski, 1992).

Psychological and behavioural effects. Psychological effects of AASs have been less extensively studied than their anabolic properties and health risks. Researchers have typically relied on case reports and naturalistic studies when drawing conclusions about the psychological effects of AASs in strength athletes. Clinical studies in the treatment of medical or psychiatric disorders, and laboratory studies with healthy male volunteers have only evaluated single agents of AASs, at doses much lower than those commonly used by athletic steroid users. Ethical reasons preclude execution of randomized controlled studies with healthy volunteers using doses and patterns of AAS administration comparable to illicit AAS users. This section will summarize the various types of studies that have evaluated the psychiatric effects of AASs.

Interestingly, during the 1930s to 1970s AASs were used successfully to treat clinical depression (Bahrke, Yesalis, & Wright, 1990). With the introduction of more efficacious pharmacological treatments and electroconvulsive therapy, the use of AASs rapidly lost favour as treatment of depressive disorders (Pope & Katz, 2003). A recent study has examined the antidepressant effects of testosterone supplementation. Pope,

Cohane, Kanayama, Siegel, & Hudson (2003) added a testosterone transdermal gel to the existing antidepressant regimens of men with treatment-resistant depression and low or borderline serum testosterone levels. These men exhibited significantly greater improvement in scores on the Hamilton Depression Rating Scale, particularly the vegetative and affective subscales (Pope et al., 2003).

Most clinical and laboratory studies have used only physiological or moderately supraphysiological doses of AASs. Testosterone esters have often been used for therapeutic purposes, including male hypogonadism in young men and treatment of muscle wasting associated with HIV/AIDS. Clinical treatment studies with hypogonadal men and men with HIV infection have often shown improvements in energy, libido and mood, with few, if any, reports of adverse psychiatric effects (Grinspoon et al., 2000; Rabkin et al., 2000; Wang et al., 1996). Similarly, laboratory studies that have administered physiological to “moderately” supraphysiological doses (e.g., 25 mg to 300 mg/week) of AASs to healthy young men have also shown minimal behavioural alterations (Anderson, Bancroft, & Wu, 1992; Bagatell, Heiman, Matsumoto, Rivier, & Bremner, 1994; Forbes, Porta, Herr, & Griggs, 1992; Matsumoto, 1990). However, the doses used in these studies are far lower than those used by most strength athletes.

In contrast to the subtle psychological effects noted in clinical and laboratory studies, naturalistic studies have often found prominent psychiatric manifestations in individuals taking supraphysiological levels of AASs (Trenton & Currier, 2005). Case reports suggest that AASs can produce a variety of psychological and behavioural disturbances, such as irritability, hypomania, psychotic symptoms, aggression, violent behaviour, as well as suicide (Annitto & Layman, 1980; Freinhar & Alvarez, 1985; Pope & Katz, 1987,

1990; Thiblin & Pärklö, 2002; Thiblin, Runeson, & Rajs, 1999).

Some investigators have assessed AAS users using either structured diagnostic interviews and/or rating scales to assess mood, aggression, and other variables. Non-AAS using athletes have served as controls, and in some cases, AAS users have served as their own controls (comparing periods of steroid use with periods of non-use). Bahrke, Wright, Strauss & Catlin (1992) found no significant differences on objective measures of mood and aggression between current/former AAS users and nonusers. Nonetheless, both the current and previous users described subjective increases in enthusiasm, irritability and aggression associated with AAS use. In another study, AAS-using weightlifters scored higher on depression, hostility, and paranoid ideation subscales of the SCL-90 than non-using weightlifters (Perry, Anderson & Yates, 1990), but there was not an increased incidence of major psychiatric disorders among the AAS users. On the other hand, some studies have found marked psychiatric manifestations in a few individuals. Irritability, hypomania, manic episodes, and psychotic symptoms were described during periods of AAS use (Malone, Dimeff, Lombardo, & Sample, 1995; Pope & Katz, 1988, 1994), although depressive symptoms have also been reported (Pope & Katz, 1994). Major depression and suicidal ideation have been associated with the discontinuation of AASs (Malone et al., 1995; Pope & Katz, 1988).

Four placebo-controlled studies have investigated the psychological effects of moderately supraphysiological doses of AASs in healthy male volunteers (Pope, Kouri, & Hudson, 2000; Su et al., 1993; Tricker et al., 1996; Yates, Perry, MacIndoe, Holman, & Ellingrod, 1999). Collectively, these studies showed that most men exhibited minimal alterations in mood and aggression. However, a few men displayed marked psychiatric

symptoms. For example, 4.6% (5 of 109 men) exhibited prominent hypomanic or manic symptoms during administration of high doses of AASs (Pope & Katz, 2003). In addition, one individual developed marked depressive symptoms after discontinuation of AASs (Su et al., 1993). This prevalence rate might underestimate the 'true' prevalence of hypomanic and manic symptoms among AAS users.

The most commonly cited psychiatric effect of AASs in athletes is increased hostility and aggressive behaviour. Anecdotal evidence suggests that megadoses of AASs might result in highly aggressive behaviour and violence, which is defined as "roid rage". The validity of this claim is questionable; however, as most of the evidence supporting this behaviour is based on single case reports or correlational studies (Basaria et al., 2001).

It is widely believed that testosterone is an important determinant of aggression. Animal models provide strong evidence to support the assertion that endogenous testosterone levels directly mediate dominance and aggressive behaviour in male adult animals (Bahrke et al., 1990). In addition, exposure to exogenous testosterone increases aggressive behaviour in rodents (e.g., Farrell & McGinnis, 2003; Lumia, Thorner, & McGinnis, 1994; Melloni, Connor, Hang, Harrison, & Ferris, 1997). Conclusions drawn from animal studies should be applied cautiously to humans.

The effects of androgens on human aggression have not been firmly established (Archer, 1991). Some evidence suggests that testosterone may play a role in expression of aggressive behaviours. For one, there are clear sex differences in steroid hormone levels and aggressive behaviour in humans. These sex differences appear at an early age, with boys more likely to engage in rough-and-tumble play than girls (Hines, 1982). Males are also involved in more delinquent acts and violent crimes than females. Some

studies have found a positive relationship between endogenous testosterone levels and aggressive behaviour in boys and men (Archer, 1991; Christiansen & Knussman, 1987a; Gladue, 1991; Olweus, Mattsson, Schalling, & Low, 1980). However, this relationship has not been consistently shown (Archer, Biring, & Wu, 1998). The expression of aggressive behaviour is likely related to not only hormonal influences, but also environmental factors, such as socialization and learning (Gladue, 1991).

Cross-sectional studies have examined hostility and aggressive behaviour using standardized rating scales in athletes using AASs. Many researchers have found significantly higher levels of self-rated hostility and aggression in athletes while using AASs (e.g., Choi & Pope, 1994; Choi, Parrot, & Cowan, 1990; Lefavi, Reeve, & Newland, 1990; Moss, Panazak, & Tarter, 1992; Parrot, Choi, Davies, 1994; Yates, Perry, & Murray, 1992). Based on these findings, some researchers have proposed a causal relationship between AAS use and aggression. However, Sharp and Collins (1998) argue that psychosocial factors, such as expectancy, modelling, and subculture values, might also have an influence on aggressive behaviour.

Research on aggression and AASs has typically focused on the negative aspects of aggression. Nonetheless, an aggressive attitude is valued in many strength sports, such as football, powerlifting, and wrestling (Yesalis, 2000). Increased feelings of aggressiveness may facilitate the performance of more frequent training sessions, and thus result in greater gains in athletic performance.

Very few studies have investigated personality characteristics among male athletes using AASs. Cooper, Noakes, Dunne, Lambert & Rochford (1996) examined the effects of AAS use on personality traits in male bodybuilders. Personality traits of users before

the onset of AAS use, as assessed retrospectively, were not significantly different from those of the control group. Nonetheless, AAS users demonstrated more abnormal personality traits, such as antisocial and narcissistic, during AAS use compared to the control group (Cooper et al., 1996).

Yates, Perry, & Andersen (1990) evaluated personality disorders in a group of AAS-using weightlifters and compared them to three control groups (weightlifters not using AASs, alcoholics, and non-weightlifting community controls). AAS users demonstrated an increased risk of personality psychopathology, with particular elevation of Cluster B personality traits, compared with community controls. Similar to the alcoholic group, AAS users (45%) also demonstrated significant antisocial personality traits. Of note, weightlifter controls also had higher rates of Cluster B traits than community controls. Yates et al. (1990) noted that weightlifter group membership partially explained the increased prevalence of Cluster B traits among AAS users.

Researchers have also focused on AAS dependence and withdrawal symptoms. A recent review of the literature documented 165 cases of AAS dependence among dedicated weightlifters and bodybuilders who chronically took supraphysiological doses of AASs (Brower, 2002). Brower (2002) proposed a two-stage model of AAS dependence. In stage one, high-dose AASs are used for their muscle-building properties, in conjunction with intensive weight training and strict diet regimes, to improve body image or enhance athletic performance (Brower, 2002). The AAS user often becomes preoccupied with their goal-directed activities (weight training, diet, and AAS use), which may take on a compulsive quality. At this stage, the primary reinforcing actions of AASs are derived from their muscle-building effects. Some AAS users may reach stage

two dependence. Chronic megadoses of AASs are believed to activate brain reward systems, similar to other drugs of abuse (Brower, 2002). During the second stage, steroid users are likely administering AASs not only for their muscle-building effects but also for their psychoactive effects (to avoid withdrawal symptoms).

Some athletes have experienced withdrawal symptoms upon discontinuation of AASs. The withdrawal syndrome is primarily depressive in nature and includes symptoms of fatigue, insomnia, restlessness, depressed mood, anorexia, decreased libido, and a desire (craving) to take more AASs (Brower, 2002). Although withdrawal symptoms may only last for a few weeks, some individuals may experience severe and persistent depression with suicidal thoughts (Malone et al., 1995). Withdrawal symptoms might be due to psychological dependence. However, depressed mood might also stem from the rapid decrease in muscular size and strength from discontinuation of AASs. Physiological alterations in hormone levels are also likely to contribute to and exacerbate withdrawal symptoms.

Although there are contradictory findings in the literature, there is convincing data to suggest that AASs can produce profound psychological and behavioural disturbances in some individuals who take these substances (Pope & Katz, 2003). It appears that psychological effects are dose-related. A recent controlled naturalistic study investigated the psychological effects of AAS abuse patterns in athletes (Pagonis, Angelopoulos, Koukoulis, & Hadjichristodoulou, 2006). They recruited a substantial group of AAS-using athletes (160 current users) and controls (80 users administering placebo drugs, 80 athletes who were not using any substances), and controlled for the effects of weight training and diet regimens. On the Symptom Checklist-90 and the Hostility and Direction

of Hostility Questionnaire, AAS users reported significantly higher levels of hostility and psychopathological symptoms during their cycle, while the scores for the control groups remained stable over time. Of note, stratification of athletes according to severity of abuse showed that hostility and psychological side effects increased as the abuse progressed from light into heavier consumption patterns (Pagonis et al., 2006). Although the AAS users exhibited elevated levels of psychological symptoms as compared to non-using athletes, a structured diagnostic interview would have helped clarify the nature and severity of their symptoms.

In summary, based on findings from clinical, laboratory and naturalistic studies, physiological or moderately high dosages of AASs (300 mg or less/week) rarely produce psychological symptoms. However, individuals who take much larger doses of AASs (900 mg or more/week) are more likely to exhibit psychiatric manifestations, such as manic episodes, clinical depression and even psychotic symptoms (Pope & Katz, 2003). There is also evidence to support that AAS dependence and withdrawal symptoms may develop among strength athletes who chronically administer supraphysiological dosages of AASs (Brower, 2002).

Popular belief is that exercise and physical activity promotes positive mental health in individuals who do not use AAS. Anecdotally, individuals often report that they “feel better” following exercise. There is evidence supporting the beneficial effects of regular physical activity on psychological and mental health (Arent, Landers, & Etnier, 2000; Stephens, 1988). In a cross-sectional population based study, increases in physical activity were associated with positive mental health, as measured by the absence of anxiety and depressive symptoms, positive mood, and general psychological well-being

(Stephens, 1988). Paffenbarger, Lee, and Leung (1994) found an inverse relation between physical activity and the risk of depression. Physically active men were less likely to develop clinical depression, with the lowest risk noted in the most active group (28%), as compared to their inactive peers.

Short bouts of physical activity are associated with positive psychological benefits, such as a sensation of well being or euphoria, and reductions in state anxiety (Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991; Raglin & Morgan, 1987). Anxiolytic effects occur in the immediate post-exercise period, and may persist for 1 to 2 hours following vigorous aerobic activity (Raglin & Morgan, 1987). Chronic exercise programs are also associated with improvements in trait anxiety (Petruzzello et al., 1991).

Most of the literature has focused on the benefits of aerobic exercise on overall mental health and affect. In comparison, there is a paucity of research regarding the effects of anaerobic exercise (strength or resistance training) on psychological states. Acute bouts of resistance training have not been found to be associated with reductions in 'state' anxiety, and in some cases, resulted in elevations in anxiety immediately post-exercise (Koltyn, Raglin, O'Connor, & Morgan, 1995; Petruzzello et al., 1991; Raglin, Turner, & Eksten, 1993). However, the limited outcome studies on resistance training and mental health are plagued with methodological problems, such as different operational definitions of psychological states and poor control of training variables. A recent study examined the effects of three different resistance-training intensities (40%, 70% and 100% of 10-repetition maximum) on positive and negative moods, and anxiety (Arent, Landers, Matt, & Etnier, 2005). A curvilinear dose-response relationship between intensity of resistance training and post-exercise affective change was identified, with

moderate intensity training (70%) producing the greatest overall improvements in affect and anxiety.

Although habitual physical activity is often associated with positive psychological mental health, exercise can be potentially harmful when it becomes excessive and uncontrollable. Exercise dependence is a craving for physical activity that results in compulsive exercise behaviour and manifests in physiological (tolerance, withdrawal) and/or psychological symptoms (depression, anxiety) [Hausenblas & Symons Downs, 2002a]. A sudden deprivation of chronic physical activity can also lead to sleep disturbances, fatigue, and negative mood states, such as irritability, anxiety, and depression (Hausenblas & Symons Downs, 2002a). Researchers have often found a positive relationship between exercise dependence and certain personality characteristics, such as perfectionism (Hausenblas & Symons Downs, 2002c) and obsessive-compulsiveness (Spano, 2001). Hausenblas and Giacobbi (2004) recently examined the relationship between normal personality characteristics and exercise dependence symptoms. Both extraversion and neuroticism were positively correlated and agreeableness was negatively correlated, with exercise dependence (Hausenblas & Giacobbi, 2004).

In summary, although psychological and behavioural effects might be associated with AAS use, weightlifting may also contribute to changes in mood and personality (Bahrke & Yesalis, 1994). Dedicated weightlifters that exhibit exercise dependence are likely to develop persistent psychological and social problems. Psychological changes associated with AAS use might be due in whole or in part to the compulsive nature of weight training (Bahrke and Yesalis, 1994). In addition, psychological disturbances

might be due to a synergistic effect between AASs and weightlifting.

Body image and eating behaviours. The research literature on eating disorders and body image has historically focused on women. Eating disorders, such as anorexia nervosa and bulimia nervosa (American Psychiatric Association, 1994), as well as body image disturbances (Garner, 1997), are more prevalent among female adolescents and adults. Researchers have identified a positive relationship between body dissatisfaction and disordered eating in females (e.g., Cash & Deagle, 1997; Cooley & Toray, 2001; Killen et al., 1996). The literature also suggests an increased risk of disordered eating attitudes and behaviour among female athletes, particularly those involved in sports that emphasize leanness and/or aesthetics (Hausenblas & Carron, 1999; Sundgot-Borgen, 1994).

Considerably less is known about body image and disordered eating in men. However, a growing body of literature has described body image dissatisfaction and disordered eating in male adolescents and adults. Body image is one component of self-esteem, which is defined as one's subjective perceptions and attitudes about his or her body and physical appearance. Body image is a multidimensional concept involving perceptual, affective, cognitive, behavioural, and subjective evaluation processes (Thompson, 2004). In contemporary Western societies, the aesthetic idealized body for males is a mesomorphic (lean, muscular) physique.

Body image concerns in males appear to be linked with their desire to attain the mesomorphic ideal body type (McCreary & Sasse, 2000; Morrison, Morrison, Hopkins, & Rowan, 2004). Pope, Gruber and colleagues (2000) found that men would like an ideal body that is 13 kg more muscular than their current body. The literature suggests that

male's perceptions of their current level of muscularity are related to their psychological well-being (McCreary & Sasse 2000; Olivardia, Pope, Borowiecki, & Cohane, 2004). Thus, the greater the difference between the actual and ideal body type, the greater the likelihood of body image disturbances. Large scale survey studies have revealed that the prevalence of body image dissatisfaction has increased nearly threefold in males from 1972 (15%) to 1996 (43%) [Berscheid, Walster, & Bohrnstedt, 1973; Garner, 1997].

The research literature has demonstrated conflicting findings regarding levels of body image dissatisfaction and eating disorders among male athletes. Based on the results of a recent meta-analysis, Hausenblas & Symons Downs (2001) found that male athletes have a more positive body image compared to non-athletes, although the magnitude of this effect was small ($ES = 0.31$). In another meta-analytic study, male athletes in aesthetic and weight-dependent sports (e.g., diving, wrestling) reported more bulimic and drive for thinness symptomatology compared to non-athletes (Hausenblas & Carron, 1999). Of note, these studies did not evaluate body image in bodybuilders and weightlifters.

Bodybuilding, in particular, espouses the mesomorphic sociocultural ideal body type for men. To develop a muscular and lean physique, a bodybuilder engages in intensive weight training and often follows a strict diet of high protein and low carbohydrates to develop the 'ripped' look. Competitive male bodybuilders frequently experience one or more large weight gain and loss cycles per year, which often includes dietary restrictions, use of weight loss substances (e.g., diuretics, herbal supplements), and preoccupation with food and their physique [Andersen, Bartlett, Morgan, & Brownell, 1995]. Approximately 30 to 50% reported feelings of irritability, fatigue, anxiety, depression,

and anger in the week prior to competition (Andersen et al., 1995).

Bodybuilders walk a very fine line between safe and pathogenic attitudes and weight control behaviours. A bodybuilder's drive to develop a leaner and hypermesomorphic physique might foster increased preoccupation and criticism of one's physical appearance, possibly leading to body dissatisfaction and abnormal eating patterns. Some individuals may not recover from the temporary disordered attitudes and eating practices associated with competitive bodybuilding, and thus develop long-lasting body image disturbances and eating disorders (Andersen et al., 1995).

Blouin and Goldfield (1995) examined the relationship between body image, and eating-related attitudes and behaviours among male bodybuilders as compared to runners and martial artists. Bodybuilders showed greater body image dissatisfaction, with a higher drive for muscle bulk and thinness relative to the other athletes. There was also evidence of abnormal eating practices (bulimic tendencies), and elevated feelings of ineffectiveness and perfectionism among the bodybuilders (Blouin & Goldfield, 1995). Forty-four percent of men in the bodybuilding group reported using AASs; and these men reported greater drive for bulk and bulimic tendencies than the non-AAS using weightlifters. Disordered eating attitudes and behaviours are associated with AAS use among bodybuilders (Blouin & Goldfield, 1995; Brower, Blow, & Hill, 1994).

Pope, Katz, and Hudson (1993) described a "reverse anorexia nervosa" syndrome in men, where the affected individual believes that they are physically small even though they are highly muscular. This belief was associated with many abnormal behaviours and cognitions, such as compulsive exercising, dieting, and profound distress about having their bodies seen in public (Pope et al., 1993). Reverse anorexia nervosa was found

exclusively among AAS users (Pope & Katz, 1994; Pope et al., 1993). This term was recently changed to “muscle dysmorphia”, a subtype of body dysmorphic disorder, as affected individuals develop pathological preoccupations with their muscularity (Pope, Gruber, Choi, Olivardia, & Phillips, 1997). Male weightlifters with muscle dysmorphia differed significantly from nonclinical comparison weightlifters in terms of body dissatisfaction, eating attitudes, prevalence of AAS use and lifetime prevalence of mood, anxiety and eating disorders, with nonclinical weightlifters demonstrating little pathology (Choi, Pope, & Olivardia, 2002; Olivardia, Pope, & Hudson, 2000). Interestingly, elite-level bodybuilders also reported more body image dissatisfaction, greater dietary manipulation, and greater use of muscle-enhancing substances in comparison to elite-level powerlifters (Lantz, Rhea, & Cornelius, 2002).

The research literature suggests that many bodybuilders may not exhibit elevated levels of psychopathology. However, a subgroup of bodybuilders may be at great risk for developing body image disturbances and associated pathological behaviour.

Cognitive effects. Research on the cognitive functioning in athletes who use high doses of exogenous testosterone and/or synthetic steroids is lacking. Based on a previous placebo-controlled study group (Su et al., 1993), Daly and colleagues (2003) further investigated the neuroendocrine and behavioural effects of AAS administration. Male volunteers receiving moderately high doses of methyltestosterone (240 mg/day) reported increased distractibility and forgetfulness. The cognitive cluster (distractibility, forgetfulness) correlated significantly with changes in endogenous testosterone levels ($r = .52, p = .02$). Daly et al. (2003) indicated that they did not observe any systematic effects of methyltestosterone on objective measures of cognition. However, it is uncertain what

cognitive measures were administered as this information was not published.

In a meta-analysis examining the relationship between physical activity and cognitive functioning, Etnier and colleagues (1997) found that exercise has a small overall positive effect on cognition ($g = 0.25$). Involvement in physical activity for a long period of time has a greater impact on cognitive functioning than an acute bout of exercise ($g = 0.33$, $g = 0.16$), respectively. Etnier and colleagues (1997) proposed various mechanisms to explain the beneficial effects of physical exercise on cognitive abilities. Investigators have found links between cerebral blood flow and moderate to high physical exercise. Thus, enhanced cognitive performance might be related to an increase in essential nutrients to the brain, such as glucose and oxygen (Etnier et al., 1997). Acute and chronic physical activity may also have an influence on brain neurotransmitter levels, such as norepinephrine, serotonin, and endorphins (Etnier et al., 1997). Another theory is that physical exercise may result in permanent structural changes in the brain, as illustrated in some animal studies (e.g., Black, Isaacs, Anderson, Alcantara, & Greenough, 1990).

Sex-Related Differences in Cognition

The topic of sex-related differences in cognition has intrigued researchers for centuries, and has engendered heated debates among scientists, philosophers, and the public. Many assume that the study of cognitive sex differences will be inherently harmful to women because the data will demonstrate that females are inferior to males (Halpern & Ikier, 2002). However, this fear is unwarranted and has not been supported by the research literature. For some cognitive abilities there are (on average) sex differences between men and women, while for other abilities there are no sex differences (Halpern & Ikier, 2002). The cognitive sex differences sometimes favour women and

other times favour men, depending on the specific cognitive ability being evaluated (Halpern & Ikier, 2002).

The nature (biological influences) versus nurture (environmental influences) argument is central to the study of sex differences. Although most researchers and clinicians recognize that both heredity and environmental factors contribute to our behaviour, research often does not take into account the complex interplay between biological, psychological, and social determinants of behavioural differences.

In the research literature, sex differences refer to average differences between men and women. As there is great variability in cognitive performance within the sexes, performance on cognitive tasks overlaps to a large degree between men and women (Halpern, 2000). Although the sex difference literature has been plagued by inconsistent findings and contradictory theories, there are some real and stable differences between males and females (Halpern & LaMay, 2000). Men, on average, outperform women on certain aspects of spatial ability and mathematical problem solving, whereas women excel on certain language-based tasks, perceptual speed, and memory for object locations (e.g., Collaer & Nelson, 2002; Halpern & LaMay, 2000; Kimura, 1999; Voyer, Voyer, & Bryden, 1995).

Many researchers assert that there are no clinically significant sex differences on measures of intelligence, such as the Wechsler scales of intelligence and Raven's Progressive Matrices (Colom, Juan-Espinosa, Abad, & Garcia, 2000; Court, 1983; Halpern & LaMay, 2000; Mackintosh, 1996). Sex differences are of small or negligible magnitude on measures of general intellectual ability. Nonetheless, Lynn (1994) has challenged the widely held opinion that there are no sex differences in general

intelligence, demonstrating an adult male advantage of approximately 4 IQ points. It is important to note that standardized intelligence tests were constructed to ensure that there was no significant overall difference between males and females (Halpern & LaMay, 2000).

Longman, Saklofske and Fung (2007) examined sex differences on the United States and Canadian standardization samples of the Wechsler Adult Intelligence Scale-Third Edition (WAIS-III). Results indicated that males scored higher than females by 2.4 to 4 points on Verbal IQ (VIQ), 0.5 to 1 point on Performance IQ (PIQ), and 1.7 to 2.8 points on Full-Scale IQ, with smaller and nonsignificant sex effects for the Canadian normative sample. However, a significant female advantage was identified for the Processing Speed Index [$d = .19$ (Canadian sample), $d = .31$ (U.S. sample)]. Although sex differences are small on standard measures of overall intelligence, sex differences are more notable on a few subtests of the WAIS-III. Medium to high effect sizes were noted on three subtests; women scored higher on the Digit Symbol-Coding subtest and men scored higher on both Information and Arithmetic (Kaufman & Lichtenberger, 2006; van der Sluis et al., 2006).

Although researchers suggest negligible differences in general intelligence between men and women, sex differences are well documented in some of the cognitive domains that underlie intelligence measures. Women and men display different cognitive strengths, and thus different patterns of ability (Kimura, 2002). A brief summary of commonly reported sex differences in spatial abilities, verbal abilities, and perceptual/motor speed will follow, as well as a recent documented difference in working memory.

Visual-spatial abilities. Most studies have identified a male advantage in visual-

spatial abilities. Linn and Petersen (1985) conducted a meta-analysis of spatial abilities, and found that sex differences vary in magnitude depending on the type of spatial ability assessed. Significant sex differences were identified on tasks of mental rotation ($g = 0.73$) and spatial perception ($g = 0.44$); however, sex differences failed to reach significance for spatial visualization ($g = 0.13$). Linn and Peterson (1985) defined mental rotation as the ability to quickly visualize two- or three-dimensional figures that have to be rotated or manipulated mentally in space. Spatial perception was defined as the ability to determine spatial relations while ignoring distracting information. Lastly, Linn & Peterson (1985) defined spatial visualization as the ability to manipulate complex spatial information when several stages are required to produce the correct solution.

A more recent meta-analysis found a significant overall sex difference favouring males in spatial abilities ($d = 0.37$) [Voyer et al., 1995]. However, effect sizes varied considerably from test to test, likely due to measures tapping different spatial abilities. Certain spatial tasks were found to produce robust sex differences (Mental Rotations Test, $d = 0.67$), whereas others did not show a significant effect (Paper Folding, $d = 0.12$). Procedural factors also had an influence on effect sizes for particular tasks. For example, the magnitude of the sex difference is larger when the Mental Rotations Test is scored out of 20 ($d = 0.94$) than when it scored out of 40 ($d = 0.70$). Voyer et al. (1995) suggested that giving credit for each correct choice (2 correct items on 20 trials) allows guessing to have a greater influence on the final score.

Mental rotations, specifically the three-dimensional Vandenberg & Kuse version (1978) yields the largest and most consistent sex difference [Linn & Petersen, 1985; Peters et al., 1995; Voyer et al., 1995]. Silverman and colleagues (2007) recently

demonstrated the universality of sex differences on the mental rotation task; men scored significantly higher than women across multiple countries and ethnic groups ($d = 0.48$).

Verbal abilities. The research literature has often supported the assertion that females, on average, possess better verbal abilities than males. Sex differences in verbal skills are among the first to appear developmentally (Halpern, 2000). Speech and language skills appear to mature more rapidly in girls. For example, girls on average articulate earlier, produce longer mean utterances and develop larger vocabularies than boys (e.g., Bornstein, Hahn, & Haynes, 2004; Lutchmaya, Baron-Cohen, & Raggatt, 2002). Furthermore, boys demonstrate a higher prevalence of stuttering, developmental language disorders, and reading disabilities than girls (APA, 1994).

Although adult women are thought to have better verbal abilities than men, sex differences vary with the type of ability being assessed. For example, there are no substantial sex differences in vocabulary (Hyde & Linn, 1988; van der Sluis et al., 2006). The research literature is equivocal concerning verbal fluency abilities, which is the production of words, phrases, or sentences according to certain rules within a specified time limit. Some studies have found little evidence for sex differences on phonemic and semantic tasks (e.g., Brickman et al., 2005; Tombaugh, Kozak, & Rees, 1999; Yeudall, Fromm, Reddon, & Stefanyk, 1986), whereas others have reported a female advantage on these tasks. Sex differences favouring females are small to moderate on letter fluency ($d = 0.15$ to 0.59) [e.g., Barr, 2003; Herlitz, Airaksinen, & Nordström, 1999; Rahman, Abrahams, & Wilson, 2003] and moderate to large on category fluency ($d = 0.5$ to 1.12) [Acevedo et al., 2000; Rahman et al., 2003]. A recent study reported a large effect size ($d = 1.05$) favouring heterosexual females on a synonym generation task (Rahman et al.,

2003). Verbal fluency tasks involve rapid retrieval of verbal information from long-term memory (Halpern & Tan, 2001).

Researchers have also identified sex differences in verbal memory abilities, with women obtaining higher scores on many episodic memory tasks. It has been shown that adult women often outperform men on recall indices of list learning tasks, such as the Auditory Verbal Learning Test and California Verbal Learning Test (e.g., Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Gale, Baxter, Connor, Herring, & Comer, 2007; Geffen, Moar, O'Hanlon, Clark, & Geffen, 1990; Kramer, Delis, & Daniel, 1988; Van der Elst, van Boxtel, van Breukelen, & Jolles, 2005). Adult women were also more likely to use a semantic organizational strategy during recall. However, no sex differences were identified on the recognition task (Kramer et al., 1988). List-learning memory tests have shown the largest effect sizes favouring females ($d = 0.58$ to 0.97) [Chipman & Kimura, 1999]. Kramer and his colleagues (1997) identified that sex differences on a verbal learning task were evident from age five. On some research studies, women have also outperformed men on story recall tasks (Hultsch, Masson, & Small, 1991; Zelinski, Gilweski, & Schaie, 1993).

Speeded perceptual and motor skills. Reliable sex differences have also been found on tasks requiring perceptual speed and accuracy, as well as some perceptual-motor tasks. Females typically outperform males on tasks that require rapid matching, symbol-digit substitution tasks, and clerical speed (Barr, 2003; Droege, 1967; Snow & Weinstock, 1990; van der Sluis et al., 2006). Similar to the WAIS-III, females scored significantly higher on the processing speed index of the Woodcock-Johnson (WJ-III) cognitive battery, with the largest difference in the adolescent sample ($d = .55$) [Camarata &

Woodcock, 2006]. A female advantage has also been found on tasks of fine-motor dexterity, such as Grooved Pegboard (Bornstein, 1985; Bryden & Roy, 2005; Ruff & Parker, 1993; Schmidt, Oliveira, Rocha, & Abreu-Villaça, 2000).

Working memory. Duff and Hampson (2001) investigated whether there are sex-related differences in working memory in adult humans. This study identified significant sex differences in favour of females on a novel multitrial spatial working memory task (similar to the game Memory) and a verbal working memory task (digit ordering). Females made fewer working memory errors than males, with medium effect sizes for the spatial task ($d = 0.63$ to 0.76) and the verbal task ($d = 0.59$). Duff and Hampson (2001) noted that the sex difference in working memory was not accounted for by differences in general intellectual ability, perceptual speed, attention, incidental memory, or speed of verbal access. These research findings suggest that some prefrontal functions might be sexually differentiated in adults (Duff & Hampson, 2001).

Mechanisms underlying the observed cognitive sex differences are poorly understood. However, several researchers have suggested that cognitive abilities are the combined product of biological and psychosocial factors. Biological explanations have typically focused on neuroanatomical and hormonal sex differences (Kramer et al., 1997). Much of the recent research literature has focused on the role of organizational and activational effects of steroid hormones on cognitive performance (Collaer & Hines, 1995).

Endogenous Steroid Hormones, Brain, and Behaviour

Animal research has established that steroid hormones are responsible for the sexual differentiation of both the structure and function of the brain via two related processes,

organizational and activational effects (Arnold & Breedlove, 1985; Phoenix, Goy, Gerall, & Young, 1959). Steroid hormones promote growth and induce permanent structural and chemical changes during critical periods of prenatal development (Nyborg, 1994; Phoenix et al., 1959). Once the critical period has passed, steroid hormones cannot exert permanent effects (Arnold & Breedlove, 1985). These organizational effects shape the brain in male or female directions, and support the expression of sexually differentiated behaviours (Arnold & Breedlove, 1985; Nyborg, 1994). Activational effects of steroid hormones occur during adulthood and involve transient, reversible actions in previously established steroid-responsive neural circuits. Gross reorganization of neural pathways is not expected to occur with daily fluctuations in steroid hormone levels (Arnold & Breedlove, 1985). However, circulating androgens and estrogens have been shown to modulate sexually differentiated neural pathways and functions.

Organizational influences. Males and females differ in their prenatal exposure to steroid hormones, and sex differences arise indirectly as a function of steroid hormones secreted by the gonads (Breedlove, 1992). During a critical period of brain development, the presence or absence of testosterone induces sexual differentiation of the brain and behaviour. The classic model of gonadal hormone effects proposes that exposure to testosterone and its metabolites in utero acts to masculinize and defeminize the body and the brain, resulting in development of male-typical behaviours (Woodson & Gorski, 1999). If androgens are absent, it results in feminine morphology and development of female-typical characteristics (Arnold & Breedlove, 1985).

The underlying mechanisms of how steroid hormones act on the developing brain to produce sex differences in neuronal organization are not fully understood (Arai, 1999). It

has been suggested that testosterone acts directly via androgen receptors to organize neural pathways during early development (Phoenix et al., 1959). Nonetheless, testosterone might also play a significant role in sexual differentiation of the brain through its aromatization to estradiol and consequent activation of estrogen receptors (Cooke, Hegstrom, Villeneuve, & Breedlove, 1998).

Animal studies and studies conducted in humans with hormone abnormalities suggest that early exposure to steroid hormones plays a critical role in brain organization and sexually differentiated cognitive functions. Prenatal hormone manipulation in animals has demonstrated hormonal effects on sexually dimorphic cognitive abilities. Isgor and Sengelaub (1998) investigated prenatal androgen and estrogen exposure on spatial learning in adult rats. Results indicated that prenatal steroids had significant effects on water maze performance. Specifically, untreated male rats performed better than male rats prenatally-treated with flutamide (an androgen receptor blocker), while female rats treated prenatally with estradiol benzoate or androgens (testosterone propionate or dihydrotestosterone propionate) performed better than untreated female rats (Isgor & Sengelaub, 1998). A recent study examined the influence of prenatal hormone manipulations on visual-spatial memory, as assessed by the radial arm maze, in adulthood (Lund & Lephart, 2001). Results suggested that visual-spatial memory was inhibited in the flutamide-treated male rats and enhanced in the testosterone-treated female rats. Female rodents and nonhuman primates exposed to high levels of androgens prenatally or neonatally also showed increases in male-typical behaviours, such as rough play and mounting (e.g., Goy, Bercovitch, & McBair, 1988; Williams & Meck, 1991).

Hormone manipulation studies are not possible in humans because of ethical considerations. However, a natural model for examining hormone influences on neurobehavioural development has come from studying individuals who were exposed to atypical hormone environments in utero. The most compelling evidence for prenatal hormonal influences on human behaviour comes from females with congenital adrenal hyperplasia (CAH) [Kimura, 2002]. Due to an enzymatic defect, females with CAH (an autosomal recessive genetic disorder) produce higher than normal levels of adrenal androgens early in gestation. The overproduction of androgens leads to variable degrees of masculinization of the external genitalia at birth (Collaer & Hines, 1995). Behavioural studies also suggest that females with CAH exhibit more male-typical behaviours as compared to control females, such as a preference for boys' toys and activities (Berenbaum, 1999; Berenbaum & Snyder, 1995).

Research on cognitive abilities in females with CAH has produced inconsistent findings. Some studies have found that girls with CAH perform better than unaffected community or sibling controls on some visuospatial tasks (Hampson, Rovet, & Altmann, 1998; Hines et al., 2003; Resnick, Berenbaum, Gottesman, & Bouchard, 1986), while other studies have found no differences (Helleday, Bartfai, Ritzen, & Forsman, 1994; Hines et al., 2003; McGuire, Ryan, & Omenn, 1975) or impaired performance (Helleday et al., 1994). Hampson et al. (1998) found a double dissociation among cognitive abilities; girls with CAH performed significantly better on a spatial relations task than unaffected female siblings, but scored significantly lower on a perceptual speed test. Nonetheless, most studies have typically found no differences on female-typical skills,

such as verbal fluency and perceptual speed (Helleday et al., 1994; McGuire et al., 1975; Resnick et al., 1986).

Further evidence that androgens might influence cognitive development comes from clinical studies investigating individuals with idiopathic hypogonadotropic hypogonadism (IHH). Congenital IHH is marked by decreased activity of the testes during early postnatal development, resulting in incomplete virilization and low levels of androgens. Hier and Crowley (1982) found that men with IHH had reduced visuospatial ability as compared to unaffected community controls. In addition, androgen replacement therapy in adulthood did not improve spatial performance in men with IHH (Hier & Crowley, 1982).

Studies have also provided convergent evidence for a relationship between prenatal testosterone levels and cognitive functions in normal children. Grimshaw, Bryden, and Finegan (1995) examined the relationship between prenatal testosterone levels in second trimester amniotic fluid and cerebral lateralization in 10-year old children. Girls with higher prenatal testosterone levels demonstrated stronger left-hemisphere specialization for language, suggesting a male-typical pattern of cerebral lateralization. In another study, second-trimester prenatal testosterone concentrations were related to mental rotation performance at seven years of age (Grimshaw, Sitarenios, & Finegan, 1995). A significant positive correlation ($r = 0.67$) was found between prenatal testosterone levels and performance on the mental rotation task in girls.

Research with normal healthy twins also provides an opportunity to investigate prenatal effects of androgens on brain and behaviour (Cohen-Bendahan, Buitelaar, Van Goozen, & Cohen-Kettanis, 2004). Animal research has shown that exposure to

androgens in utero is influenced by the intrauterine position of the fetus and the litter sex-ratio, which can affect adult spatial performance. For example, a female fetus positioned between two males has higher concentrations of testosterone than a female situated between two females (vom Saal, 1989). Studies have also shown that female animals born into male-biased litters performed better on spatial tasks than those born into predominantly female litters (Galea, Ossenkopp, & Kavaliers, 1994; Williams & Meck, 1991). A recent study by Cohen-Bendahan and her colleagues (2004) investigated the potential effect of prenatal exposure to testosterone and functional cerebral organization in same-sex and opposite-sex twin girls. Opposite-sex twin girls demonstrated a more masculine pattern of functional cerebral lateralization, as reflected by right-ear superiority for processing verbal-auditory stimuli (Cohen-Bendahan et al., 2004).

Prenatal hormone manipulation studies with animals, and studies conducted with humans with abnormal and normal prenatal levels of testosterone, has provided evidence to support the organizational effects of steroid hormones on sexually differentiated cognitive functions. Activational effects have also been shown to influence cognition during adulthood.

Activational influences. Accumulating evidence suggests that adult steroid hormones might also modify cognitive patterns. Researchers have had to rely on natural hormonal fluctuations to study the activational effects of steroid hormones. The menstrual cycle provides a natural paradigm for studying the activational effects of naturally occurring variations in steroid hormones (Hampson, 1995). Researchers have found that sex-related cognitive abilities fluctuate in a cyclical fashion during phases of the menstrual cycle. Enhanced performance on tests of verbal fluency, speeded

articulation and manual skills were noted during the midluteal phase (high levels of estrogen and progesterone) than at menses (low levels of estrogen and progesterone) [Hampson, 1990a, 1990b; Hampson & Kimura, 1988; Hausmann, Slabbekoorn, van Goozen, Cohen-Kettenis, & Güntürkün, 2000]. In contrast, women obtained lower scores on spatial tasks during the midluteal phase, relative to performance during menstrual phase of the cycle.

Diurnal and seasonal variations in serum testosterone concentrations have been associated with changes in spatial performance in males. Men performed worse on spatial tasks in early morning, when testosterone levels were higher, as compared to late morning when testosterone levels were lower (Moffat & Hampson, 1996). Men also show seasonal variations, with higher testosterone levels in autumn than in spring. Kimura and Hampson (1994) found that spatial skills were correspondingly lower in autumn and higher in the spring.

Since secondary sex characteristics are influenced by androgens in males, there have been some attempts to investigate the relationship between physical manifestations of sex hormones and cognitive performance (e.g., Broverman, Broverman, Vogel, Palmer, & Klaiber, 1964; Peterson, 1976). For example, Peterson (1976) found that males with less masculine body types were relatively better at spatial tasks than fluent production tasks, whereas the more physically masculine males showed the reverse cognitive pattern. However, using physical characteristics is an indirect and likely imprecise method of assessing androgen levels.

Several researchers have also examined the relationship between circulating testosterone levels and cognitive abilities in men and women. Gouchie & Kimura (1991)

did not find any consistent relationships between salivary testosterone concentrations and performance on tasks of perceptual speed, verbal articulation, and vocabulary. However, Christiansen & Knussman (1987b) found a significant negative relationship between androgen levels and some verbal tasks in healthy young males. Research studies are also inconsistent concerning the relationship between testosterone and spatial ability.

McKeever, Rich, Deyo, & Conner (1987) failed to find a significant association between testosterone and spatial visualization tests in both men and women. Some studies have found a positive relationship between circulating androgen levels and spatial ability in men (Christiansen & Knussmann, 1987b; Christiansen, 1993; Janowsky, Oviatt, & Orwell, 1994), whereas others have suggested an inverted U-shaped curvilinear relationship across sexes (e.g., Gouchie & Kimura, 1991; Moffat & Hampson, 1996; Ostatníková, Putz, Celec, & Hudosa, 2002; Shute, Pellegrino, Hubert, & Reynolds, 1983). Specifically, adult males with low (physiological range) testosterone levels performed better on spatial tasks than males with higher levels, whereas females with higher testosterone levels performed better than females with lower levels. Decreased spatial performance in males with IHH as compared to healthy adult males is also consistent with this curvilinear hypothesis (Hier & Crowley, 1982). Taken together, these findings suggest that intermediate levels of testosterone, within the physiological range in men might be associated with optimal spatial performance (Moffat & Hampson, 1996).

Although the organizational-activational dichotomy has proved to be a useful model to understanding hormonal influences, it may be a bit too rigid (Arnold & Breedlove, 1985). The human brain maintains a high degree of neuroplasticity, with hormones modulating behaviour throughout the lifespan. Under certain conditions, steroid

hormones might cause permanent changes in brain morphology or behaviour in adults. For example, brain injury and chronic stress have been shown to cause permanent changes in neural organization.

Administration of prolonged or high-doses of exogenous steroid hormones might also exert permanent, possibly detrimental effects on neural reorganization. Hormone-induced sexual differentiation of brain and behaviour serves as a model to consider the potential ramifications of androgen supplementation, particularly the non-medical use of supraphysiological dosages of AAS in athletes.

Exogenous Hormone Administration

Exogenous hormone administration provides some evidence on the potential activational or modulatory effects of hormones on cognitive functioning and brain plasticity in adulthood. Hormone manipulation studies have typically administered physiological levels of anabolic steroids, usually for therapeutic purposes.

Several randomized placebo-controlled studies have investigated the cognitive effects of short-term testosterone supplementation in healthy older men. Healthy older men received weekly intramuscular injections of 100 to 150 mg of testosterone (T) enanthate (Cherrier et al., 2001; Cherrier et al., 2005; Janowsky, Chavez, & Orwell, 2000) or scrotal patches containing 15 mg testosterone (Janowsky et al., 1994). Cherrier and colleagues (2005) also randomly assigned some participants to receive T enanthate plus anastrozole, an aromatase inhibitor, to block conversion of testosterone to estradiol. Both serum testosterone and estradiol levels increased with intramuscular injections; however, the scrotal patch and T enanthate plus anastrozole raised testosterone levels but suppressed estradiol production. Results suggested improvements in spatial ability (Cherrier et al., 2001; Janowsky et al., 1994) and visuospatial memory (Cherrier et al.,

2001; Cherrier et al., 2005), and visuospatial working memory (Janowsky et al., 2000). Only men with elevated estradiol levels, those who received T enanthate alone, demonstrated verbal memory improvements (Cherrier et al., 2001; Cherrier et al., 2005). Of note, Cherrier et al. (2005) did not find any improvements in visuospatial working memory. Although the Self-Ordered Pointing Test was administered in both studies (Janowsky et al., 2000; Cherrier et al., 2005), discrepant findings might be related to different administration procedures.

These results suggest that steroid hormones can modulate certain aspects of cognition in older men. It is uncertain whether improvements in cognition might be related to increased levels of testosterone and/or estradiol. However, findings from Cherrier et al.'s study (2005) suggest that improvements in verbal memory might depend on aromatization of testosterone to estradiol, whereas improvements in spatial memory might occur in the absence of increases in estradiol.

Effects of cross-sex hormone treatment provide tentative support for the activational effects of steroid hormones on cognition. Administration of estrogens (ethinyl-oestradiol; 50 µg/twice a day) and antiandrogens (cyproterone acetate; 50 mg/twice a day) to male-to-female transsexuals resulted in a shift towards a female-typical pattern of cognitive performance, specifically verbal fluency increased whereas visuospatial ability decreased (Van Goozen, Cohen-Kettenis, Gooren, Frijda, & Van de Poll, 1995). In contrast, female-to-male transsexuals receiving androgen treatment (e.g., testosterone esters, 250 mg once every two weeks; or Andriol, 40 mg/twice a day) showed the reverse pattern (Van Goozen et al, 1994, 1995). Female-to-male transsexuals demonstrated an increase in visuospatial ability and a decline in verbal fluency performance. These studies suggest

that hormones may exert a differential effect on sex-related cognitive abilities, such that as one function improves, the other deteriorates.

Despite the substantial increase in anabolic steroid use, research regarding the effects of supraphysiological doses of AASs on cognitive functioning in men is lacking. A recent randomized controlled study investigated the effects of administration of moderately supraphysiological doses of exogenous testosterone on cognitive abilities in healthy men. O'Connor, Archer, Hair and Wu (2001) investigated the effects of short-term administration of testosterone enanthate (200 mg/week) on cognitive functions in healthy eugonadal men. Researchers found a differential effect on sex-related cognitive abilities in response to exogenous testosterone, such that an increase in verbal fluency was accompanied by a decrease in spatial ability (O'Connor et al., 2001). Based on combined results of this study in conjunction with studies on interindividual variations in endogenous testosterone, evidence suggests a curvilinear relationship between testosterone levels and sex-related cognitive abilities. O'Connor and colleagues (2001) argue that intermediate levels of testosterone are necessary for optimal performance on both spatial and verbal tasks. However, sub-optimal and supraphysiological levels of testosterone are associated with a decline in visuospatial ability and an increase in verbal fluency.

Rationale for the Present Study

Illicit use of AASs is a growing health concern. Athletes continue to use AASs despite their known health and psychological risks. Hormone supplementation studies using physiological or moderately supraphysiological doses of AASs have demonstrated some alterations in cognitive performance. However, they do not capture the effects of

steroid regimens commonly used by bodybuilders, such as multidrug combinations, supraphysiological doses, and chronic use of AASs.

This study examined the effects of exogenous steroid hormones on sex-related cognitive abilities and psychological functioning. Review of the literature suggests that this is the first study to investigate the potential activating effects of AASs on sex-related cognitive abilities in illicit AAS users. The psychological effects of exogenous steroid supplementation have also been less extensively researched than the anabolic properties and short-term health risks of AAS use.

The primary purpose of this naturalistic study was to examine whether male bodybuilders who use supraphysiological doses of AASs (i.e., greater than 500 mg/week) demonstrate differential performance on cognitive tasks as compared to non-AAS using controls (male bodybuilders and men involved in primarily aerobic activities). This study investigated specific cognitive domains with documented sex differences. It is difficult to predict with certainty the pattern of differences in cognitive abilities between groups. For one, each synthetic steroid has a very different effect within the body. Some AASs (testosterone esters) result in supraphysiological testosterone levels and are available for conversion to DHT and estradiol, whereas others result in sub-normal testosterone levels, with no conversion to DHT and estradiol. In addition, bodybuilders often combine multiple oral and parenteral derivatives at a time.

The secondary purpose of the study was to build on the small body of research investigating psychological characteristics of male bodybuilders who use AAS. It is difficult to draw firm conclusions from previous studies, as researchers have often used different measures and examined only a few psychological variables. In addition, several

studies have not included an appropriate control group for comparison. Although research findings have been inconsistent, some psychological disturbances have been reported in male bodybuilders who use AAS, such as increased levels of aggression, body dissatisfaction, disordered eating attitudes and practices, and certain personality traits (e.g., antisocial, narcissism). Studies that have comparatively examined psychological characteristics in AAS-using and non-AAS using male bodybuilders also suggest some similarities in psychological functioning.

A small but growing body of research has investigated the pursuit of the idealized mesomorphic physique and unhealthy behaviours in men. Since male bodybuilders espouse the hypermesomorphic body ideal, an increased drive for muscularity might lead to excessive exercise, body dissatisfaction, and abnormal eating behaviours. Some research has found that male bodybuilders exhibit a psychological profile similar to individuals with eating disorders and body dysmorphic disorder, such as a preoccupation with weight and shape, body dissatisfaction, disordered eating behaviours (i.e., bulimic tendencies), and personality traits (e.g., perfectionism, neuroticism, obsessive-compulsive, and narcissism). Some of these behaviours might be more prominent among male bodybuilders who use AASs.

Cognitive hypotheses

Based on available evidence from previous hormone studies investigating interindividual variations in serum testosterone levels and exogenous testosterone administration, it was hypothesized that the male bodybuilders who used AASs would demonstrate a shift towards a female-typical pattern of cognitive performance (e.g., with stronger abilities on verbal tasks than spatial tasks). In contrast, it was hypothesized that the two matched control groups of men who did not use AASs would demonstrate a

male-typical pattern of performance on sex-related cognitive tasks (e.g., with stronger abilities on spatial tasks than verbal tasks). Heavy resistance training was not expected to have an effect on hormone levels or cognitive performance in male bodybuilders who did not use steroids.

The primary cognitive hypotheses tested in this study are the following:

H1: The AAS group will show weaker visuospatial abilities, as evidenced by a significantly lower score on the mental rotation task, relative to the control groups.

H2: The AAS group will demonstrate stronger verbal fluency skills, as evidenced by significantly higher scores on the phonemic and semantic fluency tasks, relative to the control groups.

H3: The AAS group will show enhanced verbal memory abilities, as evidenced by significantly higher scores on the total recall and delay trials of the verbal memory test, than the control groups.

H4: The AAS group will perform better on speeded perceptual and motor tasks, as evidenced by a significantly higher score on the Digit Symbol-Coding subtest and faster latency scores on the Grooved Pegboard task, than the control groups.

H5: The AAS group will demonstrate stronger visuospatial working memory, as evidenced by significantly fewer errors on the Self-Ordered Pointing Test, than the control groups.

H6: The AAS group will display stronger verbal working memory, as evidenced by a significantly higher score on the Letter-Number Sequencing subtest, than the control groups.

Exploratory analyses for cognitive measures. Given the evidence that testosterone supplementation improves spatial memory in healthy older men, hormones might also have an effect on visuospatial memory performance in AAS users. Thus, this study was also interested in exploring whether AAS users demonstrated differential performance on visuospatial memory tasks as compared non-AAS using individuals. It was hypothesized that males who used AASs would perform better on the visuospatial memory task, specifically the total recall and delay trials, relative to the control groups.

Lastly, this study explored the association between hormone levels and cognitive performance. As the research literature has suggested a curvilinear relationship between cognitive abilities and testosterone levels, it was hypothesized that testosterone levels within the normal physiological range would be related to a male-typical pattern of performance on cognitive tasks (e.g., higher spatial abilities and lower verbal abilities). However, subnormal or supraphysiological testosterone levels were expected to be related to a decline in visuospatial abilities and improvements on verbal tasks (fluency, memory), working memory, and speeded perceptual-motor tasks. To investigate the association between hormone levels and cognitive abilities, the investigator collapsed all three participant groups and included additional control participants who were not included in the matching process to increase the range of hormone levels from slightly below the physiological range to supraphysiological levels.

Psychological hypotheses

This current study was also interested in determining whether psychological differences exist between AAS users and non-AAS users, specifically men who are bodybuilders. The psychological comparison of bodybuilding groups represents an

important component to the present study, as the expression of psychopathology might be related in part to a bodybuilding group effect. Although much of the information gained from the interview and questionnaires was used for descriptive purposes, the study investigated various aspects of psychological functioning, including aggression, personality characteristics, body image, and eating-related pathology.

The primary psychological hypotheses tested in the current study were the following:

H1: The AAS group will exhibit elevated levels of aggression as compared to both control groups.

H2: The AAS group will exhibit elevated levels of specific personality traits (i.e., antisocial, narcissism, neuroticism, and obsessive-compulsive) as compared to both control groups.

H3: The AAS group and the bodybuilding control group will exhibit greater body image dissatisfaction and abnormal eating attitudes and practices than the aerobic control group.

Method

Participants

Recruitment. The current study was conducted from June 2005 to October 2006, and August 2007 to December 2007. The study received ethical approval from the University of Victoria's Human Research Ethics Board (HREB) [Protocol number: 07-05-106g]. Due to the requirements for anonymity surrounding illegal use of AASs, the HREB agreed to the use of verbal informed consent in this study. Signed informed consent was not used because it would likely decrease participation of AAS users, and might lead to a breach of confidentiality. Refer to Appendix A and B for the approved Information Letter and Consent Form for the current study, respectively. After obtaining permission, the investigator recruited participants through the various procedures described below.

Male adults were recruited from various cities in British Columbia, specifically Victoria, Duncan, Cobble Hill, Nanaimo, and the lower mainland (e.g., Vancouver, Langley, Port Coquitlam, and Surrey). Extensive recruitment procedures occurred through advertisements posted in various gymnasiums, health and fitness centres, recreational facilities, and on various internet websites (e.g., bodybuilding, steroid forums) and bulletin boards at the University of Victoria; as well as advertisements distributed at athletic events (e.g., bodybuilding competitions, road races, and triathlons) and by athletic clubs/teams, athletic stores, and nutritional supplement companies. Gym owners, athletic event planners, coaches of athletic teams, etc. were initially contacted about the research study, and they provided support through distribution of research advertisements. Individuals interested in participating in the current study initiated contact with the investigator.

Description of study criteria. To be eligible for inclusion in the study, all participants had to be men between the ages of 20 and 50. Firstly, only men were included in the current study because AAS use is more prevalent in males than females. Secondly, this age range was selected to minimize potential age-effects on hormone levels and cognitive performance. Adolescents were not included in the study as they experience hormonal fluctuations during puberty. An age cut-off of 50 years was used to ensure minor age-related declines in testosterone concentrations and cognitive performance (particularly speeded tasks). Furthermore, all men had to be right-handed to avoid potential effects of handedness on brain organization and cognitive abilities. Non-smokers were preferable; however, no more than a social smoker (less than a pack/week) was accepted as a participant.

Additional exclusionary criteria included the following: a history of learning disabilities (LD) or Attention-Deficit/Hyperactivity Disorder (ADHD), pre-existent neurological, endocrine or metabolic abnormalities, history of significant mental health problems, current alcohol or substance abuse (aside from AAS use for the experimental group), and a primary language other than English. All elite athletes were also excluded from participation, as well as interested individuals that did not meet physical activity criteria. Participants, who completed blood testing on a different day than their testing session, were not included in any of the statistical analyses. Lastly, control men who exhibited high or subnormal physiological levels of endogenous hormones were not used in the matching process. Table 1 summarizes the number of men excluded based on the study criteria.

Table 1. Number of men excluded based on study criteria

Exclusion criteria	# of men excluded (<i>N</i> = 123)
Multiple factors (e.g., medical & mental health history)	19
Declined participation	18
Medical history (e.g., traumatic brain injury, hypothyroidism)	12
Mental health history (e.g., depression, anxiety)	11
English as a second language	9
Left-handed	9
Current substance abuse and/or regular tobacco smoking	8
Physical activity criteria (e.g., elite athlete, overtraining)	8
Recent use of prohormones and AASs	8
Testing variables (e.g., fatigue, decreased effort)	8
Testosterone levels outside reference range	5
Age (outside range of 20-50 years)	3
Unable to participate (e.g., work commitments)	3
Learning disabilities	1
Pilot study	1

To control for the effects of physical activity and drugs on endogenous steroid hormone levels, cognition and mood, the principal investigator implemented the following restrictions for study participation. All participants were required to refrain from all types of sexual activity, as well as any aerobic or anaerobic exercise, for at least 15 hours prior to testing. They were also required to refrain from ingesting caffeinated products (i.e., coffee, tea, soda pop, chocolate) and nicotine for at least three hours, and alcohol and illicit drugs for at least 15 hours prior to testing. Based on self-report during the testing session, all participants included in the primary statistical analyses followed these study restrictions. In addition, participants were instructed not to change their

current diet, eating patterns, and dietary supplements. However, they were encouraged to eat immediately prior to or at the beginning of the testing session to ensure adequate energy levels for cognitive testing, and decrease the possibility of negative side-effects of blood testing (e.g., shakiness). A fasting state was not mandatory for hormone testing.

Initially, the study proposed classifying bodybuilders as individuals who engaged in weight training to maximize muscle hypertrophy with no more than one aerobic session each week. Thus, athletes who focused on weight training for strength purposes, or combined weight training and multiple aerobic activities, were initially excluded from study participation (i.e., Olympic weightlifters). These restrictions on training history were to ensure that participants focused primarily on resistance training for bodybuilding purposes.

Based on findings during recruitment, classification criteria were altered for the bodybuilding groups. Firstly, participants in both groups typically endorsed more than one aerobic activity each week, often to decrease body fat. Secondly, the principal investigator had difficulties recruiting a sample of competitive bodybuilders (i.e., those who have been involved in bodybuilding competitions). To address these issues, a broader definition was developed to increase sample size. In the current study, a 'bodybuilder' was defined as an individual who performed resistance-training exercises primarily to increase muscle mass and/or strength. Thus, this definition included recreational and competitive bodybuilders, powerlifters, strongman competitors, and Olympic weightlifters. Men could also include aerobic exercise in their weekly training schedule, such as cardiovascular activity and recreational sports; however, weight training had to be their primary focus. For acceptance in the bodybuilding groups, these

participants had to weight train at least four times a week for a minimum of three consecutive years.

Minimum aerobic activity guidelines of the American College of Sports Medicine (ACSM) were used to help classify aerobic activity in the study groups. The ACSM recommends at least 20 minutes of vigorous-intensity aerobic activity (e.g., jogging, swimming continuous laps) at least three times per week, or at least 30 minutes of moderate-intensity aerobic activity (e.g., brisk walking, biking) five times per week. The principal investigator applied stringent criteria for calculating aerobic sessions; only those of moderate intensity lasting at least 20 minutes were included. Thus, warm-up and cool-down sessions, as well as walking or biking for transportation, were not included in the calculations unless the participant identified that the activity was designed to promote aerobic fitness.

The second control group consisted of healthy active males who were involved in aerobic activities. To be eligible for this group, individuals had to be involved in moderate-intensity aerobic exercise for at least 30 minutes, three times weekly for a minimum of one year. Initially the study was designed to include only aerobic exercisers (i.e., runners, cyclists, triathletes) who did not include weights in their training schedule. However, most of the men classified as aerobic exercisers reported including at least one strength training session in their weekly schedule. As a result, men who included weight training in their weekly aerobic training schedule, where weight training for muscle hypertrophy was not their primary focus alike the bodybuilding groups, were included in the second control group.

Screening and Matching Process: A visual flowchart of the screening and matching process of the current study is provided in Figure 1. One hundred and sixty-six men were screened for study eligibility during a brief telephone interview. Based on exclusion criteria or non-interest in study participation, 107 men were identified as potential participants for the research study. Of these 107 men, one was used as a pilot for the study, 18 declined participation in the study (i.e., ‘no show’ or withdrawal), and eight testing sessions were discontinued. Eighty participants completed the full battery of tests. However, strict inclusion criteria were applied for the final matching process, resulting in 35 potential controls. Almost two thirds of the 80 participants (those that completed the testing) responded to postings in gyms, health clubs or recreational facilities. Other participants were recruited through advertisements posted or distributed by athletic teams/clubs, websites, or at athletic events (16%), word of mouth through friends, family members, and co-workers (10%) or the investigator (6%), and from advertisements distributed by athletic or nutritional supplement companies (4%).

It is important to note that only 15 male bodybuilders who self-disclosed use of AASs contacted the principal investigator. Of these 15 men, two decided not to participate in the study and one did not live in British Columbia. The investigator excluded three additional men who used AASs, two of whom had a history of current substance abuse and one described an atypical pattern of AAS use (1 to 2 week cycles). Thus, nine AAS users completed the full battery of tests. As admission to the final group was stringent, another AAS user was excluded due to a diagnosis of a previous traumatic brain injury and resultant cognitive sequelae.

From a surplus of 35 control participants who met inclusion criteria, each of the AAS

users were matched closely with two controls (one participant in the bodybuilding group, one participant in the aerobic group) for age, education, and estimated verbal intelligence. Since IQ is correlated with various cognitive abilities, statistically controlling for any significant differences between the groups was imperative. The WAIS-III Vocabulary subtest was used to estimate verbal intellectual ability (described in more detail below in

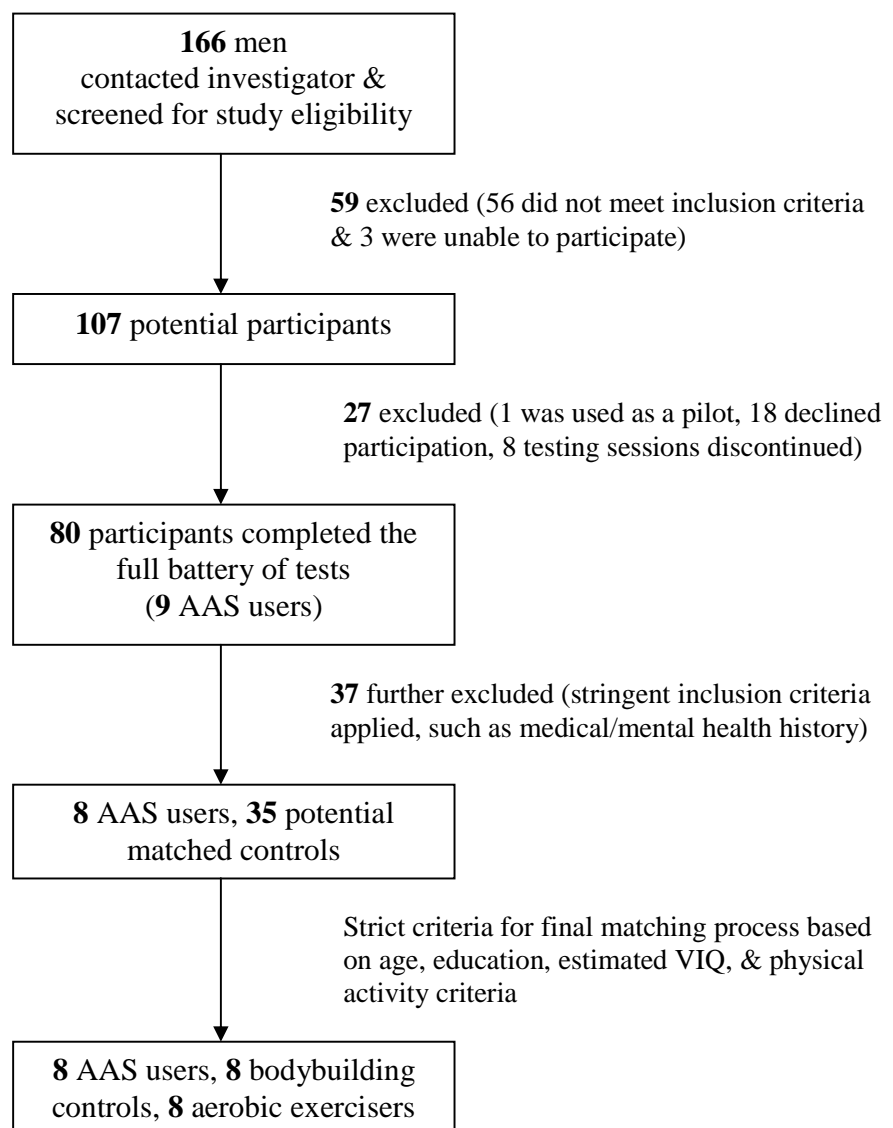


Figure 1. Flowchart of the exclusion and matching process.

the “Materials” section). Due to difficulties matching on the three variables, a discrepancy of up to 8 years was accepted for age, up to 2 years for education, and up to two scaled score points for estimated verbal intelligence between matched cases.

Description of study sample. The final sample consisted of 24 healthy active men, ranging in age from 20 to 48 ($M = 33.33$, $SD = 9.63$). Participants were divided into three groups; (i) male bodybuilders who admitted to current AAS use ($n = 8$), (ii) male bodybuilders who denied any current or previous use of AASs ($n = 8$), and (iii) male aerobic exercisers who also denied any AAS use ($n = 8$). The bodybuilding control group was included to control for potential effects of resistance training on endogenous hormone levels, cognition, and psychological status. The control group of primarily ‘aerobically trained’ men was included to provide a basis of comparison to the study group of AAS users.

The following description of the sample pertains only to the 24 participants whose data were included in the final analyses. All participants included in the study reported English as their first language. Based on handwriting preference identified during the screening interview, all participants were classified as right-handed. Men were predominantly Caucasian (91.7%), except for three individuals in the AAS group who reported mixed ethnicity. Concerning family status, five AAS users (62.5%), 4 bodybuilding controls (50%), and 4 aerobic exercisers (50%) were married or common-law. All other participants were unmarried (i.e., single or divorced). Two participants in each of the control groups were university students; all of the other participants were employed in either part-time or full-time work.

Table 2 summarizes the frequency of various health-related behaviour variables.

Based on self-report, participants did not report any current alcohol or drug abuse. The groups did not differ in terms of current consumption of alcohol, cigarettes, cannabis, and other illicit substances. Overall participants reported occasional use of these substances within the past 30 days. However, one individual in the AAS group reported smoking an average of 20 cigarettes per week in the past month. Lifetime use of alcohol, cigarettes, and cannabis also did not differ between groups. Besides cannabis, a greater number of participants in the AAS group and the aerobic group reported lifetime use of other illicit drugs. Of note, two individuals in the AAS group reported frequent use of illicit drugs in the past. Based on self-report, none of the matched controls had ever used AASs. However, two participants indicated that they were seriously considering the use of AASs.

Eleven of 24 participants reported experiencing a mild traumatic brain injury, or one or more concussions in the past. This finding is not surprising, as there is a higher incidence of concussions and mild traumatic brain injuries among males. A few resulted in a brief loss of consciousness with reportedly no lasting cognitive effects of these injuries. Two participants described prior clinical diagnoses of depression and/or anxiety; one was related to issues of loss and the other was related to teenage obesity. Lastly, one participant in the bodybuilding control group reported a diagnosis of adult Attention Deficit Disorder (ADD), although he has not taken any stimulant medications.

Participant demographic characteristics are presented in Table 3. One-way ANOVAs indicated that the groups did not differ significantly in age, education, and estimated verbal intelligence. As these groups did not differ reliably in terms of matching variables, these measures were not considered a potential confound requiring statistical control. In

addition, the groups did not differ on measures of height, positive affect, negative affect, global psychological distress, or exercise dependence symptoms. However, the bodybuilders who used AASs were heavier than both the bodybuilding and the aerobic controls, but the latter of the two groups did not differ from each other.

Table 2. Frequency of health-related behaviours per group

	AAS users (<i>n</i> = 8)	Bodybuilders (<i>n</i> = 8)	Aerobic controls (<i>n</i> = 8)
Alcohol consumption			
Past 30 days	5	6	5
Lifetime	7	8	8
Tobacco smoking			
Past 30 days	1	1	1
Lifetime	3	4	4
Cannabis			
Past 30 days	1	1	1
Lifetime	6	7	6
Illicit substance use			
Past 30 days	1	1	0
Lifetime	6	2	6
Concussion	3	4	4
Previous mental health diagnoses (e.g., depression, anxiety)	1	1	0
Attention Deficit Disorder	0	1	0

All bodybuilders met group-specific physical activity criteria. The majority of men in the bodybuilding groups had been weight training for greater than 7 years (62.5%), with all of the other men having trained for at least 3 years. Most male bodybuilders reported weight training for at least 4 days per week (range = 3.5 to 6 days). Sessions lasted on

average 76.69 minutes ($SD = 27.47$) and 75.63 minutes ($SD = 19.72$) for the AAS group and the bodybuilding control group, respectively. Aside from two individuals in the AAS group, all other bodybuilders included some aerobic training in their weekly schedule.

Table 3. Characteristics of the study population

Variable	AAS users		Bodybuilders		Aerobic controls		$F(2,21)$
	M	SD	M	SD	M	SD	
Age (years)	33.50	8.12	32.50	11.23	34.00	10.56	0.05
Education (years)	14.00	1.77	14.38	1.77	14.75	1.17	0.44
Vocabulary (scaled score)	11.38	2.39	12.38	2.07	12.13	2.03	0.46
Height (cm)	179.39	7.33	179.71	7.41	181.07	5.38	0.14
Weight (kg)	107.68 _a	12.19	91.16 _b	13.70	79.07 _b	9.29	11.71***
WT sessions/week	4.63 _a	0.74	4.88 _a	0.99	2.25 _b	1.13	17.85***
AT sessions/week	2.19 _a	2.79	2.28 _a	1.71	5.69 _b	1.58	7.23**
BDS Social Dependence ^a	18.00 _a	5.32	14.88 _a	4.45	8.14 _b	3.53	9.09**
PANAS Positive Affect	39.00	3.55	38.88	6.51	39.75	5.60	0.06
PANAS Negative Affect	22.38	8.88	18.88	4.85	21.75	7.92	0.51
SCL-90-R GSI	0.59	0.42	0.57	0.57	0.58	0.16	0.01
EDS Total Score	82.25	29.89	70.00	17.78	65.00	14.36	1.34

Note. Groups with different letter subscripts are significantly different ($p < .05$) based on Tukey's honestly significant difference post hoc test. Vocabulary = Vocabulary subtest from Wechsler Adult Intelligence Scale-Third Edition; WT = Weight training; AT = Aerobic training; BDS = Bodybuilding Dependence Scale; PANAS = Positive and Negative Affect Schedule; SCL-90-R GSI = Global Severity Index for the Symptom Checklist-90-Revised; EDS = Exercise Dependence Scale.

^a Twenty-three participants filled out this measure; one aerobic exerciser did not weight train.

** $p < .01$, *** $p < .001$.

All of the bodybuilders reported weight training for primarily hypertrophy or strength purposes. Additional reasons included aesthetics and health. The majority of the men in the bodybuilding groups were recreational bodybuilders, those who had never competed in a bodybuilding competition and had no plans to compete in the next twelve months. Competitive bodybuilders were defined as men who either had participated in at least one bodybuilding competition in the past or were preparing for a competition within the next year. Seven men were classified as competitive bodybuilders; four men in the AAS group and one man in the bodybuilding control group had competed in amateur bodybuilding competitions. Two of the recreational bodybuilders (one in each group) had plans of entering a bodybuilding competition in the future. One of the bodybuilding controls was also a strongman competitor.

Men in the aerobic control group also met group-specific physical activity criteria. All men had been physically active since childhood or adolescence, with most reporting at least 15 years involvement in their current aerobic activities (62.5%). These men were involved in aerobic activities at least 4 times per week (range = 4 to 9 sessions), for an average 63.13 minutes ($SD = 18.31$) per session. Six aerobic exercisers included some weight training in their weekly schedule. Primary reasons for weight training were to promote fitness, physical health, maintenance, and/or increase strength for their sport. Although some individuals reported weight training to increase muscle mass, this appeared to be related to enhancing fitness or for sports-related performance (e.g., running).

To provide evidence of correct classification of bodybuilders and aerobic exercisers, the principal investigator looked at group differences in terms of weight training, aerobic

activities, and bodybuilding dependence. As expected, there were significant group differences on all these measures. Post hoc comparisons revealed that the aerobic controls completed more aerobic sessions per week than both of the bodybuilding groups. On the other hand, AAS users and bodybuilding controls weight trained more often than aerobic exercisers, and showed more dependence on the social aspects of bodybuilding training. These findings provided support for the validity of the current classification of bodybuilding and aerobic groups.

Since supplementation with nutritional aids is common in bodybuilders and athletes (Brill & Keane, 1994; Morrison, Gizis, & Shorter, 2004; Nieman et al., 1989), participants were asked about their current weekly consumption of various products. Only three participants in the aerobic group used dietary supplements. Vitamins/minerals, protein powders/bars, joint repair products, energy drinks, and stimulants were the only products used by these individuals. On the other hand, all participants in AAS group and seven participants in the bodybuilding control group endorsed using dietary supplements. Of note, six AAS users and five bodybuilding controls reported using greater than four different supplements each week. Vitamins/minerals and protein powder were the most popular supplements used by the bodybuilding groups. The next most frequently reported supplements were essential fatty acids, glutamine, creatine (for bodybuilding controls), and other amino acids (AAS group). Seventeen percent of the total sample consumed stimulants at least once per week, such as ephedrine, caffeine pills, and guarana. Although most individuals ingested caffeinated products (e.g., coffee, tea, soda), these were not included in the calculation for stimulants. The frequency of current supplement use for each group is outlined in Table 4.

Table 4. Frequency of current nutritional supplementation per group

Type of supplements	AAS users (n = 8)	Bodybuilders (n = 8)	Aerobic controls (n = 8)
Vitamins / Minerals / Antioxidants	7	7	2
Protein powder / bars	7	5	1
Essential fatty acids	5	4	0
Glutamine	4	4	0
Creatine	2	4	0
Other amino acids	4	2	0
Joint repair products	3	2	1
Energy drinks	2	2	1
Sleep aids	2	0	0
Fat burners	1	0	0
Stimulants	1	2	1
Other	3	1	0

AAS group. Due to the expense of urinalysis, steroid use was based solely on self-report. Some research studies have found no inconsistencies between self-reported AAS use and urinalysis, suggesting that self-report is a reliable measure in this context (Bond, Choi, & Pope, 1995; Pope and Katz, 1994). In addition, measurement of total testosterone, estradiol and SHBG through blood specimen collection provided indirect confirmation of current steroid use (see Table 8)

Participants in the AAS group followed individualized regimens of self-obtained steroids; all of the drugs were used independently of this study. The majority of the drugs

reportedly came from the black market and underground laboratories. Aside from one bodybuilder (who will be discussed separately), most of the men were experienced users. Seven of the bodybuilders had been using steroids for an average of about 10 years (range = 5 to 18). Steroid use started during adolescence or their 20's ($M = 20.86$, range = 15 to 27). Participants reported use of various administration techniques, such as cycling (on and off periods of AAS use), stacking (use of two or more AAS at a time), and pyramiding (tapering doses toward the end of a cycle). These men often used a number of different drugs within a cycle, but not necessarily all at the same time. For example, some of the bodybuilders staggered their drugs, by taking them in an overlapping pattern or by stopping use of one drug and then starting another. For five of the participants, AAS were taken in cycles with on-periods lasting about 4 to 16 weeks. Based on participant approximations, the average number of lifetime cycles totalled 15.7 (range = 10 to 20). Of note, two bodybuilders reported using AAS on a relatively continuous basis (8 months to 3 years) with very few off-periods (maximum of 1 to 2 weeks off).

Table 5 summarizes the lifetime use of different types of performance-enhancing substances and other drugs by the AAS group. Since starting steroids, these seven bodybuilders have used several different types of oral and injectable agents. Participants 'cycling' steroids reported stacking a maximum of three to four different steroids at the same time, with a stack of more than five reported by those who have used continuously. Similar to reports from the literature, the most commonly used injectable agent by participants was Deca-Durabolin (nandrolone decanoate), which has a reputation for increasing size and strength. Polypharmacy was also common among the participants. AAS were often used with a number of other performance-enhancing drugs (e.g.,

Table 5. Types of AAS and other substances used by the AAS group

Generic name / Category of drugs (Brand name)	# of users (<i>n</i> = 8)
<i>Types of AAS</i>	
Nandrolone decanoate (Deca-Durabolin [®])	8
Methandrostenolone (Dianabol)	7
Stanozolol (Winstrol [®] tabs & depot)	7
Trenbolone (Finaplix, Parabolan)	7
Methenolone acetate / enanthate (Primobolan tabs & depot)	6
Testosterone enanthate	6
Testosterone blends (Omnadren, Sten, Sustanon)	6
Drostanolone propionate (Masteron)	5
Oxandrolone (Anavar)	5
Oxymetholone (Anadrol [®])	5
Testosterone cypionate	5
Testosterone propionate	5
Boldenone undecylenate (Equipoise)	4
Fluoxymesterone (Halotestin)	3
Mesterolone (Proviron)	2
Testosterone suspension (Aquaviron)	2
Nandrolone phenylpropionate (Durabolin [®])	1
Norethandrolone (Nilevar)	1
Oral-Turinabol	1
Denistenil	1
<i>Other drugs commonly used in combination with steroids</i>	
Anti-estrogens / aromatase inhibitors (e.g., Arimidex, Clomid, Femera)	5
Clenbuterol	5
DHEA / Tribulus terrestris	4
Growth hormone & peptide hormones (e.g., hGH, insulin, IGF-1)	4
Dexedrine	2
Diuretics (e.g., Aldactone, Dyazide, Hydrodiuril, Lasix)	2
Human chorionic gonadotropin	2
Liothyronine sodium (Cytomel)	2

Note. hGH = Human Growth Hormone; IGF-1 = Insulin-like Growth Factor; DHEA = dehydroepiandrosterone.

clenbuterol, human growth hormone) and nutritional supplements. Therapeutic substances were also often used to counteract the side effects of AAS (e.g., anti-estrogens).

Table 6 presents the types and dosages of all agents used in the current steroid cycles, as well as the number of bodybuilders using the specified substances. The current cycles of seven of the men consisted of a combination of multiple oral and/or injectable formulations of different agents, used in supraphysiological doses over several weeks. The majority were stacking two or three steroids at the time of testing, with one man using four AASs. All AAS users administered at least one injectable agent (one man consumed the substance orally), up to a total of three. Additionally, three men used between one to two oral agents at the time of testing. The current cycles varied in length from 6 to 16 weeks.

One of the bodybuilders in the current study started using steroids at the age of 45. He has only used two different types of injectable steroids. These agents were used separately in two cycles, lasting between 9 to 10 weeks. His current steroid regimen consisted of a maximum of 600 mg/week of the injectable agent. Of note, this individual also served as his own control in the bodybuilding group. As a bodybuilding control, he was tested about 7 months after his first cycle ended. The principal investigator tested him again 1.5 years later during his second cycle.

At the time of testing, their current steroid regimens consisted of an average of 986 mg/week (range = 450 to 1800) of oral and/or injectable agents. For drugs with approved clinical indications, dosages of oral and injectable steroids were typically greater than those used for therapeutic purposes. Other researchers have also described similar

patterns of AAS use in athletes and non-athletes (e.g., Fudala, Weinrieb, Calarco, Kampman, & Boardman, 2003; Pagonis, Angelopoulos, Kououlis, & Hadjichristodoulou, 2006; Perry, Lund, Deninger, Kutscher, & Schneider, 2005).

Table 6. Types of substances used in the current steroid regimens of the AAS users

Generic Name	Clinical dose	Dosage	# of users (<i>n</i> = 8)
Oral agents (mg/day)			
Methandrostenolone	5-10 mg	25 mg	1
Oxandrolone	10-20 mg	50 mg	1
Oxymetholone	50-100 mg	75-150 mg	1
Stanozolol	2-16 mg	50 mg	1
Injectable agents (mg/week)			
Nandrolone decanoate	30-100 mg every 3 to 4 wks	200-600 mg	3
Testosterone enanthate	100 mg/wk to 400 mg/4 wks	250-1000 mg	3
Testosterone cypionate	100 mg/wk to 400 mg/4 wks	250-400 mg	2
Testosterone propionate	50-100 mg	300-375 mg	2
Testosterone blend (Sustanon)	50-125 mg	250-1000 mg	2
Trenbolone acetate	not used clinically	200-300 mg	2
Stanozolol (liquid oral)	not used clinically	150 mg	1

Note. Clinical doses were estimated based on information obtained from product monographs and clinical research studies.

Procedure

An initial phone interview was conducted to determine whether each interested individual met inclusion criteria. Inability to meet the criteria excluded participation in the current study. Specific restrictions for study participation were discussed extensively with potential participants (i.e., refrain from sexual activity and physical activity for at

least 15 hours prior to testing, etc.). Information about protection of anonymity and confidentiality were also discussed during the phone interviews. The principal investigator emphasized to participants that under no circumstances would they be required to provide their real name. Several participants provided a pseudonym. All participants also received an identification number, and only this number was recorded on data forms. For potential participants who met inclusion criteria, a personal information sheet was developed at the time of the phone interview, which included their identification number, telephone number, and in some cases their address and a pseudonym (if these were provided). This information was recorded to have a means to contact participants during the study (i.e., to mail the package when necessary, reschedule testing sessions for cancelled appointments, and to provide feedback about their blood test results).

Prior to the scheduled testing session, participants either picked up or were mailed a package that included a letter of information about the research study, a history form, and some self-rating inventories (i.e., Exercise Dependence Scale, Bodybuilding Dependence Scale, Drive for Muscularity Scale, and Multidimensional Body-Self Relations Questionnaire). Participants were encouraged to bring their completed history form and questionnaires to the scheduled testing session. As noted on the information letter, the return of completed questionnaires indicated that the participant was providing consent to participate in the research study.

Most participants were tested individually in a research laboratory at the University of Victoria. The University testing environment consisted of two different rooms; the main room used for completion of the non-computerized and physiological tasks, and a

second room used briefly to complete the computerized task. As many interested individuals lived in other regions of British Columbia, 3 of the 24 study participants (2 AAS users, 1 bodybuilder control) were tested individually in a quiet location outside Victoria (e.g., meeting rooms booked at libraries or recreational facilities). The principal investigator and a research assistant (a graduate student in the Clinical Psychology program) conducted testing in Victoria, both of whom were not blind to group status of the participants. However, only the principal investigator conducted testing sessions outside of Victoria.

Testing occurred during one session lasting approximately 2.5 to 3.5 hours, dependent on participants' speed of task completion. Although the examiners offered breaks during testing, most participants chose to complete the sessions without breaks. At the outset of the testing session, the examiners again described the nature of study and reviewed the informed consent procedures. Each participant provided verbal consent prior to starting the research tasks. Verbal consent was documented in a book, with participant's identification number and date of consent.

After informed consent, the examiners asked specific questions to ensure that individuals had followed the necessary restrictions for study participation (e.g., sexual and physical activity, alcohol/drug use, etc.). Prior to task completion, men were familiarized with instructions on the cognitive tasks and self-report inventories. The tasks were administered to participants in the order outlined in Table 7. A brief interview was conducted during the testing session to follow-up on information provided in the history form. The Eating Disorder Inventory-3 (EDI-3) and the Aggression Questionnaire (AQ) were also administered during the memory delays, specifically after the WAIS-III Digit-

Symbol Coding task and prior to WAIS-III Letter-Number Sequencing. To ensure a delay of approximately 5 minutes between the two mental rotation sets, physiological measurements and final follow-up questions were administered during this delay period.

Table 7. Test administration order

Cognitive measures and self-rating scales
Positive and Negative Affect Schedule (PANAS)
Symptom Checklist-90-R (SCL-90-R)
OMNI Personality Inventory (OMNI)
Bodybuilder's Survey (only completed by the AAS group)
Weschler Adult Intelligence Scale –Third Edition (WAIS-III), Vocabulary
-----BREAK-----
Rey Auditory Verbal Learning Test (RAVLT)
Brief Visuospatial Memory Test-Revised (BVM-T-R)
Grooved Pegboard
WAIS-III, Digit Symbol-Coding
RAVLT (delay trials)
BVMT-R (delay trials)
-----BREAK-----
WAIS-III Letter-Number Sequencing
Self-Ordered Pointing Test (SOPT)
Phonemic Fluency (FAS)
Animal Naming
Mental Rotation

After participants completed their testing session, they went directly to a local medical laboratory for blood specimen collection. Measurement of serum hormone levels occurred in the afternoon, as soon as possible after cognitive testing. All participants who

completed the full battery of tests and blood sampling received a t-shirt and \$40 for their participation. In cases where testing sessions were discontinued, participants were reimbursed with a t-shirt and \$20 for their time. Costs for blood testing, participant reimbursement, and research assistance were paid through small grants from the Canadian Institute for Health Research, Lions Gate Healthcare Research Foundation, and Michael Smith Foundation for Health Research.

The investigator contacted participants via telephone to provide general information about their blood test results (fell within the ‘normal physiological range’ and/or ‘fell outside the normal physiological range’). As the medical laboratory service employed for this study has an obligation to communicate abnormal results to patients, the company requested that the principal investigator provide this information to the study participants. Thus, participants were provided with a copy of their abnormal blood test results and were encouraged to follow-up with their family physician. After providing feedback to participants, their personal information sheets were immediately shredded. In cases where the investigator was unable to contact a participant, this information was shredded after one month.

Measures

Questionnaires for demographic and descriptive variables. During the initial phone interview, basic demographic and health-related information was gathered for screening and descriptive purposes. The Screening Questions form (see Appendix C) and the Drug History Questionnaire (DHQ; Sobell, Kwan, & Sobell, 1995) were administered during the phone interview. The DHQ is a brief standardized screening questionnaire of past and current substance use. It assesses the extent and frequency of use for different

drug categories (i.e., alcohol, cannabis, stimulants, etc.). Test-retest reliability coefficients of 20 drug abusers in treatment were moderately high ($r = .53$ to $.93$; $ICC = .54$ to $.93$) for the variables “*number of years used*” and “*frequency of past use in a typical month*” (Sobell et al., 1995).

Additional information was collected from questionnaires completed before and during the testing session. The Health History Form, a self-report questionnaire developed for this study, provided information about demographics (e.g., marital status, occupation, race/ethnicity), medical and mental health history, substance use, physical activity, nutrition/diet, and use of nutritional supplements (see Appendix D). To protect anonymity, participants were only asked general information about their employment status (i.e., student, part-time and/or full-time work). A brief assessment of nutritional supplementation was included to provide a summary of use among bodybuilders and aerobic exercisers. Exercise questions were aimed at identifying how often participants engaged in sports and physical activity, such as aerobic training and weight training. AAS use was assessed solely on self-report by identifying the types of steroids used, doses and durations used, and age at which AAS use started. Bodybuilders who used AAS were asked several questions regarding history of anabolic steroid use in the Health History Form, as well as the Bodybuilder’s Survey (see Appendix E).

The following self-rating scales and questionnaires were used for descriptive purposes; the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988); Symptom Checklist-90-R (SCL-90-R; Derogatis, 1994), Bodybuilding Dependence Scale (BDS; Smith, Hale, & Collins, 1998), and the Exercise Dependence Scale (EDS; Hausenblaus & Symons Downs, 2001b). A detailed summary of these

measures is included in the Psychological Measures section.

Physiological measures. Measurements of height (in) and weight (lb) were obtained from each participant, and converted to the respective International System equivalents (cm, kg). Body weight was measured in light clothing, without shoes and with empty pockets. Body mass index (BMI), a simple height-to-weight ratio, was not calculated in this study. It is an inappropriate measurement of body composition particularly for muscular men, as it does not account for weight attributable to muscle mass. For example, if a man were heavier due to increased muscle mass, a high score on the BMI would falsely suggest obesity. Although it would have been desirable to calculate fat-free mass index (FFMI), as it takes into consideration muscularity, this measurement was not included in the current study due to time constraints.

Hormone measurements. A private clinical medical laboratory company (LifeLabs, formerly MDS Metro Laboratory Services) was contracted to be responsible for the coordination of support services for blood specimen collection and hormone analyses for the current study. The medical company followed strict industry-standard procedures and protocols on blood specimen collection, serum preparation, assays, transport of samples, and waste disposal. No more than 12 ml was taken from each participant. Although blood specimen collection is recommended in the morning due to daytime biological variations of testosterone and SHBG, all blood samples were collected in the afternoon when testosterone levels are lower. To protect anonymity, requisition forms for hormone testing provided only the participant's study identification number and a 'default' date of birth (e.g., use same day of the month for each participant). Blood samples were not used for any other purpose than those outlined in the study, and were disposed of within 7 days

of faxing the blood test results to the principal investigator.

Serum total testosterone, total estradiol, SHBG, and albumin concentrations were measured directly from blood samples collected from participants. Free and bioavailable testosterone were calculated using the quadratic equations developed by Vermeulen and colleagues (1999). The contracted laboratory company established the following references ranges for males: total testosterone, 10 to 30 nmol/L; total estradiol, 0 to 220 pmol/L; SHBG, 10 to 70 nmol/L; and albumin, 35 to 50 g/L.

A lab representative provided information on assays used in the current study (K. Dooley, personal communication, January 11, 2008). Serum total testosterone was measured directly on the ADVIA Centaur[®] (Siemens Healthcare Diagnostics, Deerfield, IL), an automated chemiluminescent enzyme immunoassay. The assay measures testosterone concentrations up to 52 nmol/L with an analytical sensitivity of 0.35 nmol/L. Based on in-house studies, mean inter-assay coefficients of variation were less than 10%. However, the intra-assay coefficients of variation ranged from 4.3% to 27.2%. Quantitative measurement of SHBG in serum was measured directly on the IMMULITE 2000[®] (Siemens Healthcare Diagnostics, Deerfield, IL). The SHBG assay is a solid-phase, two-site chemiluminescent immunoassay. Based on in-house studies, the within-run and between-run coefficients of variation were 3.6 to 5.1% and 5.4 to 6.2%, respectively. The assay has an analytical sensitivity of 2 nmol/L with a range up to 180 nmol/L. Serum albumin concentration was measured on the VITROS[®] by using dry-slide technology (Ortho-Clinical Diagnostics, Rochester, NY).

Lastly, the ADVIA Centaur[®] Estradiol-6 III (Siemens Healthcare Diagnostics, Deerfield, IL), a competitive immunoassay using direct chemiluminescent technology,

was used to measure serum estradiol levels. Based on in-house studies, coefficients of variation were in the range of 5.2 to 9.0% (between-run) and 7.1 to 7.7% (within-run), respectively. As per the manufacturer, the assay has a linear range up to 3670 pmol/L with an analytical sensitivity of 25.7 pmol/L. However, the precision of the assay was noted to be sufficiently poor for values below 100, and thus all these values were reported as <100 pmol/L.

Cognitive measures. Six cognitive measures were selected as they typically show sex-related differences, albeit of variable size. These included measures of spatial ability (mental rotation), verbal fluency (phonemic and semantic fluency tasks), verbal memory (list learning task), and speeded perceptual and fine-motor tasks (Digit Symbol-Coding, Grooved Pegboard). Measures of visual and verbal working memory were also included, as recent reports have identified sex differences on complex working memory tasks (Duff & Hampson, 2001). A visual memory measure was added to explore whether sex steroid hormones would have a general effect on memory performance.

1. Vocabulary subtest from the WAIS-III (Wechsler, 1997). Vocabulary was used as an estimate of verbal intellectual ability. Based on factor analytic studies, the Vocabulary subtest is the best measure of general intelligence, with an average loading of .83 (Sattler & Ryan, 1999). Vocabulary also has a high correlation with the Full Scale (FSIQ; $r = .80$) and the Verbal Scale (VIQ; $r = .83$), and has consistently high split-half reliability for all age groups ($r = .93$, range = .90 to .95) [The Psychological Corporation, 1997]. Since vocabulary is a hallmark measure of crystallized intelligence (i.e., acquired knowledge), and there are also no notable sex differences on this task (Kaufman, McLean, &

Reynolds, 1988; van der Sluis et al., 2006), no changes on account of AAS administration were expected.

On the Vocabulary subtest, participants defined words of increasing complexity. If they were unable to define six consecutive words accurately, the test was discontinued. Scores of 0, 1, or 2 were assigned for each item according to criteria outlined in the WAIS-III manual. Performance on this task was presented as age-based scaled scores, which have a mean of 10 and a standard deviation of 3.

2. Mental Rotations Test (MRT; Peters, 1995). This test was included in the current study because it has shown the largest sex difference, with a strong male advantage. The MRT is a redrawn paper-and-pencil version (Peters et al., 1995) of the original Mental Rotations Test figures of Vandenberg & Kuse (1978), which in turn was based on cube stimuli from the Shepard and Metzler paradigm (1971). The redrawn version of the Vandenberg and Kuse designs was reported to have high internal consistency for a group of 377 participants ($\alpha = .86$) [M. Peters, personal communication, January 4, 2008]. Based on a large-scale internet study designed to investigate sex differences (Reimers, 2007), a six-item MRT (drawn from Peters et al. (1995) revised version) showed a moderate correlation with a line angle judgement task ($r = .26, p < .0001$) [M. Peters, personal communication, January 4, 2008].

Each participant was given the MRT-A version, which was comprised of 24 problems involving mental manipulation of figures around the vertical axis under timed constraints. For each problem, there was a target figure with four block figures to the right of the target figure. Participants were required to correctly identify both of the block figures (only 2 of 4 figures were correct rotated versions) that matched the target figure.

The test was presented in two sets of 12 problems each, with 3 min for each set, separated by a 5 min rest period. To control for guessing, no credit was given for single correct answers. Thus, a single point was given only if both correct figures were identified, for a maximum score of 24. The summary score on this task was the total number of problem sets answered correctly within the time limit.

3. Verbal fluency. Measures of phonemic fluency [FAS; Spreen & Benton, 1977] and semantic fluency (Animal naming) were included in the test battery, as sex-related differences favouring women have been identified on verbal fluency tasks (e.g., Herlitz et al., 1999; Rahman et al., 2003). Internal consistency has been found to be high for FAS ($\alpha = .83$) [Tombaugh et al., 1999]. Phonemic fluency (FAS) scores correlate moderately well with category fluency (Animals) scores ($r = .52, p < .01$) [Tombaugh et al., 1999].

For the phonemic fluency task, participants were asked to spontaneously generate as many different words beginning with a specified letter in three respective 60 s trials. Performance on the phonemic fluency task was evaluated by summing the total number of correct words generated for the three trials. For the semantic fluency task, participants were required to name as many different animals in 60 s. Performance on this task was evaluated by summing all the acceptable words for the semantic category. A separate summary score was generated for the phonemic fluency and the semantic fluency tasks. In the interest of parsimony, only the phonemic fluency total score was used in the statistical analyses.

4. Rey Auditory-Verbal Learning Test (RAVLT; Schmidt, 1996). The RAVLT is a standardized measure of verbal learning and memory. This task was included because previous studies have found sex differences favouring females on the RAVLT (e.g.,

Bleecker et al., 1988; Gale et al., 2007; Geffen et al., 1990; Van der Elst et al., 2005).

Small to moderate levels of convergent validity have been previously reported (Crossen & Wiens, 1994; Johnstone, Vieth, Johnson, & Shaw, 2000).

Participants were read a list of 15 unrelated words, and were then asked to recall as many items as possible across five learning trials. Words were presented in the same order for the five consecutive trials. After completion of the fifth trial, a new list of 15 words was presented, followed by a free-recall trial for this list. Participants were then asked to recall words from the first list, but without further presentation of those words. After a delay of about 20 min, they were again required to recollect words from the first list. Finally, a word list recognition trial using a yes-no format was administered. The scores of interest in this study were the Total score (sum of Trial 1 to 5), which is the best index of overall performance, and the Trial 7 score, a measure of delayed recall.

5. Digit Symbol-Coding subtest of the WAIS-III (Wechsler, 1997). This timed task involves complex visual scanning, attention, and psychomotor speed. The Digit Symbol-Coding subtest has high test-retest reliability for the different age groups ($r = .84$, range = $.81$ to $.87$), and correlates moderately with FSIQ ($r = .75$) Performance IQ (PIQ; $r = .62$), and the Processing Speed Index (PSI; $r = .65$) [The Psychological Corporation, 1997]. A sex-related difference on this task has been identified for children, adolescents and adults, with females typically outperforming males (e.g., Barr, 2003; Snow & Weinstock, 1990; van der Sluis et al., 2006).

Participants were asked to quickly copy symbols into the empty boxes, by matching each number with its respective symbol provided in the key at the top of the page. The key consisted of boxes containing a number from 1 to 9 and a symbol. Each number was

paired with a different symbol. The outcome score was based on the total number of correctly drawn symbols completed within the 2-min time limit.

6. Grooved Pegboard (Heaton, Grant, & Matthews, 1991). This test evaluates complex fine-motor dexterity and motor speed in the dominant and nondominant hands. Several researchers have identified a sex difference, favouring women, on the Grooved Pegboard task (Bornstein, 1985; Bryden & Roy, 2005; Ruff & Parker, 1993; Schmidt et al., 2000). The pegboard consisted of a 5 by 5 matrix of slotted holes angled in different directions. The holes in the pegboard were grooved and each peg had a ridge on its side. Participants were asked to place all 25 pegs into the holes as quickly as possible, matching the ridge of the pegs to the groove in the holes, first with their dominant hand then with their nondominant hand. The measures obtained from this task were the latency scores (time to completion) for the dominant hand and the nondominant hand. In the interest of parsimony, only the latency score for the dominant hand was used in the statistical analyses.

7. Self-Ordered Pointing Test (SOPT; Petrides & Milner, 1982). The SOPT is an experimental test measuring visual-spatial working memory processes and strategic memory. This task was chosen because a recent study identified a large sex effect, favouring woman, on a complex spatial working memory task (Duff & Hampson, 2002). Another recent study also found that testosterone supplementation improved working memory, as assessed by the SOPT, in older men (Janowsky et al., 2000). Low internal consistency (i.e., average inter-trial correlations) was reported for the abstract-design version (Ross, Hanouskova, Giralda, Calhoun, & Tucker, 2007). Thus, Ross and

colleagues (2007) suggested that the total error score (a measure of performance across all trials) should be utilized.

A computerized version of the original SOPT was developed for the present study, and was structured identically to the paper version. Participants either touched the designs on a computer screen or clicked them with a mouse. Although Petrides and Milner (1982) used four different tasks (i.e., abstract designs, representational drawings, high-imagery words, and low-imagery words), only abstract designs were used in the current study as they are more difficult to label verbally. The principal investigator developed new abstract designs for this measure.

Similar to the original version, there were four different sections in the current study, each of which consisted of a different number of abstract designs (i.e., 6, 8, 10, and 12). In the first section, an array of six designs was presented in a different spatial arrangement on each page (i.e., six pages in each set). Participants selected one design on every page with the restriction that they should choose a different design each time. Three consecutive trials of the six-item set were administered. Abstract designs for the six-item set are presented in Figure 2.

Administration of sections two through four was identical to section one, except that they consisted of 8, 10, and 12 abstract designs. A different set of abstract designs was used for each of the four sections. Of note, the 6-item set was always presented first, followed by the 8-, 10-, and then 12 item sets, respectively. Only the total error score (number of errors across all trials) of the SOPT was used in the statistical analyses.

A participant made an error when he pointed to a design previously selected in a set. Thus, participants were expected to monitor their performance by 'holding in mind'

previously selected designs while planning a future response. To increase the working memory demand on this task, the computer program was set-up to stop participants from responding consistently to the same location on each trial (Petrides & Milner, 1982).

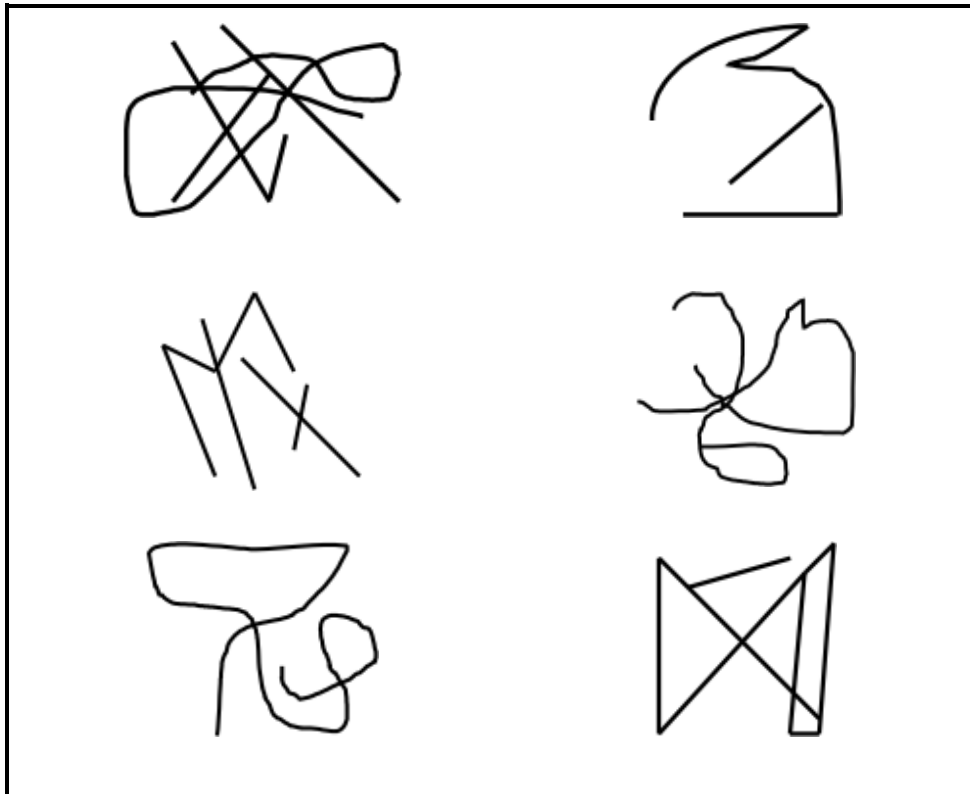


Figure 2. Abstract designs for the six-item set of the Self-Ordered Pointing Test (SOPT).

Of note, although computerizing a task might affect comparability of the results to the original version, this issue was considered to have a negligible influence on the dissertation results. There was no reason to assume that displaying the designs on a computer would significantly alter the task demands relative to displaying the items in paper form. Furthermore, since all participants received the same task and the groups

were matched by age, years of education, and estimated verbal intelligence, any artefacts from computerizing the task would affect both groups equally.

8. Letter-Number Sequencing subtest of the WAIS-III (Wechsler, 1997). This subtest is a measure of verbal working memory. Letter-Number Sequencing has high split-half reliability for the different age groups ($r = .82$, range = .75 to .88), and has a moderate correlation with FSIQ ($r = .64$), VIQ ($r = .62$), and the Working Memory Index (WMI; $r = .64$) [The Psychological Corporation, 1997]. Duff & Hampson (2002) found a large sex difference on a complex verbal memory task (digit ordering), with women outperforming men. However, more recently van der Sluis and colleagues (2006) did not find a sex effect on the Letter-Number Sequencing task.

Based on standard administration instructions, participants were initially read a combination of numbers and letters. After hearing a combination, participants repeated them by saying the numbers first in ascending order followed by the letters in alphabetical order. Participants completed five practice trials before starting the task. There were three trials per string length. The test was discontinued after failure on all three trials containing an identical number of digits and letters. The summary measure for this task was the total number of trials answered correctly.

9. Brief Visuospatial Memory Test-Revised (BVMT-R; Benedict, 1997). This measure was chosen as it provides a detailed assessment of visuospatial learning and memory, and is similar to the RAVLT (i.e., has multiple learning trials). High interrater reliability has been reported ($r > .90$) [Benedict, 1997]. The Total Recall and Delayed Recall scores from the BVMT-R have moderate to high correlations with other visual ($r =$

.66 to .80) [Benedict, Schretlen, Groninger, Dobraski, & Shpritz, 1996] and verbal memory tasks ($r = .35$ to $.74$) [Benedict et al., 1996; Gale et al., 2007].

Based on the original normative sample, sex does not reportedly influence aspects of recall on the BVMT-R (Benedict, 1997), thus indicating that hormone levels do not have an impact on this measure. However, a recent study investigating sex differences in the elderly found that women obtained higher scores than men on the BVMT-R Total Recall ($d = 0.27$) and Delayed Recall ($d = 0.15$) trials, but not on the Recognition trial ($d = 0.00$) [Gale et al., 2007]. In addition, young males with high (normal range) levels of estradiol performed better on some visual memory tasks than those with lower levels (Kampen & Sherwin, 1996). These findings, in addition to sex-related differences between hormone levels and verbal memory performance, and moderate-to-high correlations between the BVMT-R and verbal memory tasks, suggest that hormones might have an influence on this task. This measure was added to explore whether steroid hormones would have a general effect on memory performance.

Participants were shown a display of six geometric designs for three learning trials, and were asked to draw as many of the designs in their correct location as they appeared on the display. After a 25 min delay, participants reproduced the array of designs. The delayed recall trial was followed by a recognition trial using a yes-no format. The outcome scores were the Total Recall (sum of Trials 1 to 3) and Delayed Recall scores.

Psychological measures. Participants completed several self-report inventories assessing the following concerns: screening for overall affect, psychological distress, and exercise dependence (Positive and Negative Affect Schedule, Symptom Checklist-90-R, Bodybuilding Dependence Scale, Exercise Dependence Scale), aggression (Aggression

Questionnaire), disordered eating attitudes and body image (Eating Disorder Inventory-3, Drive for Muscularity Scale, Drive for Tone scale, Multidimensional Body-Self Relations Questionnaire), and personality (OMNI Personality Inventory).

1. Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) is a widely used self-report measure of affect. It contains two 10-item scales, the Positive Affect scale (e.g., *alert, active*) and the Negative Affect scale (e.g., *afraid, ashamed*), which assess the two dominant dimensions that consistently emerge in factor analytic studies of self-rated affect (Watson & Tellegen, 1985). The scales can be used as state or trait measures of affect by using different time instructions, such as rating how you feel today vs. how you have felt within the past year. Low correlations between the two scales ($r = -.12$ to $-.23$) suggest that the positive and negative affect scales measure relatively distinct constructs (Watson et al., 1988). These two scales have shown adequate internal consistency ($r > .83$) for the different time instructions [Watson et al., 1988; Watson & Walker, 1996], and high convergent validity as demonstrated in factor analysis studies ($r > .90$) [Watson et al., 1988]. Good predictive validity of both affect scales was shown across an extended time span, as evidenced by significant correlations between initial scores on the PANAS scales and measures of current anxious and depressive symptomatology that were completed 4.5 to 7.5 years later (Watson & Walker, 1996).

As noted earlier, this measure was used for descriptive purposes in the present study. Participants were asked to rate the extent to which they had experienced certain feelings during the past week on a five-point Likert scale, ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). Total scores on the Positive Affect scale and Negative Affect scale were reported. High scores indicated high levels of affect.

2. Symptom Checklist-90-R (SCL-90-R; Derogatis, 1994). The SCL-90-R is a widely employed, self-report inventory designed to screen a broad range of psychological problems and symptoms of psychopathology. It is comprised of 90 items that cluster into nine symptom domains (Anxiety, Depression, Hostility, Interpersonal Sensitivity, Obsessive-Compulsive, Phobic Anxiety, Paranoid Ideation, Psychoticism, and Somatization), and three global indices of distress (Global Severity Index, Positive Symptom Distress Index, and Positive Symptom Total). The SCL-90-R is appropriate for use with several ethnic and cultural groups (e.g., Bonicatto, Dew, Soria, & Seghezze, 1997).

High split-half reliability, as estimated by the Spearman-Brown formula, and internal consistency (coefficient alpha) of the Global Severity Index (GSI) have been reported ($r = .94, .96$), respectively [Bonicatto et al., 1997; Brophy, Norvell, & Kiluk, 1988]. Internal consistency of the nine symptom dimensions ranged from .62 to .90, with the lowest coefficients on the Paranoid Ideation and Psychoticism subscales (Bonicatto et al., 1997; Derogatis, Rickels, & Rock, 1976; Horowitz, Rosenberg, Baer, Ureño, & Villaseñor, 1988). On the other hand, validity of the nine symptom dimensions has been questioned. Convergent validity is acceptable for certain clinical subscales on the SCL-90-R. For example, the SCL-90-R Depression dimension was most highly related to the BDI ($r = .73$) and the Depression scale of the MMPI ($r = .55$) [Brophy et al., 1988]. However, evidence for discriminant validity is inconclusive, as each of the SCL-90-R dimensions were significantly correlated with the BDI and all of the MMPI clinical scales (Brophy et al., 1988). Some factor analysis studies have also failed to replicate the nine symptom dimensions (Brophy et al., 1988; Cyr, McKenna-Foley, & Peacock, 1985). Based on

these results, researchers have argued that the overall SCL-90-R score should only be used to measure global psychological distress.

As per standard administration, participants were asked to rate the severity of psychological symptoms experienced during the past week on a 5-point scale, ranging from 0 (*not at all*) to 4 (*extremely*). The SCL-90-R was used for descriptive purposes to provide a measure of overall psychological adjustment. As the GSI provides the best summary measure for current level of distress, only this score was reported in the current study. The GSI was calculated by summing all items and dividing by the total number of responses.

3. Exercise Dependence Scale (EDS; Hausenblas & Symons Downs, 2002b). This multidimensional measure was used for descriptive purposes to assess exercise dependence symptoms. Based on DSM-IV criteria for substance dependence, the EDS-21 conceptualizes exercise dependence as a cluster of cognitive, behavioural, and physiological symptoms leading to clinically significant impairment or distress (Hausenblas & Symons Downs, 2002c). It is comprised of 21 items that cluster into seven clinical symptoms: Tolerance, Withdrawal, Intention Effects, Lack of Control, Time, Reduction in Other Activities, and Continuance. The EDS has satisfactory psychometric properties. Internal consistency (coefficient alpha) for the total EDS score ($r = .93$) [Hausenblas & Giacobbi, 2004] and the seven subscales ($r = .67$ to $.93$) was above acceptable limits [Hausenblas & Fallon, 2002; Symons Downs, Hausenblas, & Nigg, 2004]. During initial development and validation, the EDS was also shown to be significantly related to the Exercise Dependence Questionnaire ($r = .69$) and the

Obligatory Exercise Questionnaire ($r = .75$), which suggests adequate convergent validity (Hausenblas & Symons Downs, 2002c).

In the present study, participants were asked to rate how well each item reflected their current exercise beliefs and behaviours that have occurred in the past three months on a 7-point Likert scale from 1 (*never*) to 7 (*always*). Higher total and subscale scores suggest more exercise dependence symptomatology. As the measure was mistakenly altered to a 7-point Likert scale (original EDS is a 6-point scale), only the overall score of exercise dependence symptoms was reported in the current study. The total EDS score was calculated by summing all 21 items.

4. Bodybuilding Dependence Scale (BDS; Smith et al., 1998). The BDS was developed to assess both biomedical (e.g., withdrawal) and psychosocial (e.g., interference with social and occupational functioning) aspects of dependence. This 9-item rating scale consists of three subscales relevant to compulsive weight lifting; Social Dependence (i.e., the need to be in the bodybuilding social environment), Training Dependence (i.e., the compulsive need to engage in weight training), and Mastery Dependence (i.e., the need to exert control over training schedules) [Smith et al., 1998].

Preliminary research on the BDS by Smith and colleagues (1988) indicated acceptable internal consistency coefficients for each subscale ($\alpha = .76, .75, .78$), respectively. Convergent validity of the Social Dependence subscale was evidenced by moderate correlations with the Social Identity ($r = .66$) and Exclusivity subscales ($r = .71$) of Athletic Identity Measurement Scale. Convergent validity of the two other subscales was inconclusive. However, a more recent study provided support for convergent validity of all three subscales, specifically moderate correlations were shown

with the Interference with Social/Family Life, Positive Reward, Withdrawal Symptoms, and Exercise for Social Reasons subscales of the Exercise Dependence Questionnaire ($r = .36$ to $.71$) [Smith & Hale, 2004]. Smith et al. (1998) also found that bodybuilders scored significantly higher on the BDS Social Dependence scale than Olympic weightlifters and individuals who weight trained for fitness purposes. There was also no difference in scores between the AAS-using bodybuilders and the non-AAS using bodybuilders.

The BDS was used for descriptive purposes to assess bodybuilding dependence. In the current study, the measure was only administered to participants who included weight-training sessions in their weekly schedule. Participants were asked to rate how well each item reflected their attitudes about bodybuilding on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). Higher total and subscale scores suggest more exercise dependence symptomatology. As previous research identified a significant difference in Social Dependence scores between bodybuilders and fitness trainers, this subscale was reported to provide further evidence of appropriate classification of the control groups.

5. Aggression Questionnaire (AQ; Buss & Perry, 1992). The AQ was administered to evaluate aggression in the current sample. It is a psychometrically improved and updated version of the Buss-Durkee Hostility Inventory (BDHI; Buss & Durkee, 1957), a widely used measure for assessing aggression and hostility. The most recent version, a 34-item rating scale, was used in the current study (Buss & Warren, 2000). It consists of several original items from the Buss & Durkee (1957) version, as well as seven new items, that cluster into five subscales (Physical Aggression, Verbal Aggression, Anger, Hostility,

and Indirect Aggression. The AQ provides a tripartite model of aggression describing behavioural (Verbal Aggression, Physical Aggression, Indirect Aggression), affective (Anger) and cognitive components (Hostility).

For the entire normative sample, internal consistency coefficients were acceptable for the AQ Total score ($\alpha = .94$) and for the five subscales, ranging from .71 (Indirect Aggression) to .88 (Physical Aggression) [Buss & Warren, 2000]. These measures are consistent with those reported on the first version of the AQ (Total score = .89; $r = .72$ to .85 for subscales), although of note, the Indirect Aggression scale was not included [Buss & Perry, 1992]. Overall, convergent validity was adequate, as evidenced by higher correlations with constructs purported to be measured by each AQ scale (e.g., $r = .73$ for Physical Aggression subscale of AQ and Angry Behavior of Novaco Anger Scale) [Buss & Warren, 2000]. Factor analytic techniques were utilized in the development of the first version of the questionnaire (Buss & Perry, 1992), which resulted in four factors: Physical Aggression, Verbal Aggression, Anger, and Hostility. Indirect aggression did not appear as a separate factor. Based on a principal component factor analysis of the standardization sample, Buss and Warren (2000) found that the most recent version provides support for the relative independence of the Physical Aggression, Verbal Aggression, and Hostility subscales. However, Anger and Indirect Aggression items displayed associations with all three of those factors.

As per standard administration, each participant was asked to rate how well each item described him on a five-point Likert scale ranging from 1 (*not at all like me*) to 5 (*completely like me*). Based on evaluation of the Inconsistent Responding Index, all participants demonstrated a valid profile. In the interest of parsimony, only the AQ total

score was used in the data analyses. It is a good summary measure of general aggression and anger.

6. OMNI Personality Inventory (OMNI; Loranger, 2001). The OMNI is a self-report inventory that provides a comprehensive assessment of normal and abnormal personality traits. The 375-item measure contains 25 normal personality traits (Normal scales) and 10 abnormal personality traits (Personality Disorder scales). The OMNI Personality Disorder scales are based on the Axis II diagnostic categories of the Diagnostic Statistical Manual – Fourth Edition (DSM-IV). The OMNI also contains seven broad factor scales (Agreeableness, Conscientiousness, Extraversion, Narcissism, Neuroticism, Openness, and Sensation Seeking) that represent an integration of traits across the normal and abnormal scales. Five of these factors were similar to those often referred to as the “Big Five” traits in the literature (McCrae & John, 1992). Two validity scales are also available to determine the consistency of responding.

Based on the original and replication samples, coefficient alphas for the Normal scales were moderate to high ($\alpha = .53$ to $.86$) [Loranger, 2001], and were similar to those obtained from other measures of normal personality traits (e.g., Costa & McCrae, 1992). Acceptable internal consistency was also shown for the Personality Disorder scales ($\alpha = .62$ to $.84$) and the Factor scales ($\alpha = .79$ to $.94$). Lastly, acceptable convergent validity was found, as evidenced by significant correlations between the 25 normal scales on the OMNI and similar scales on other personality tests (Loranger, 2001).

Prior to administration, the examiners indicated that the test was divided into three separate sections, each with its own set of instructions (Loranger, 2001). On the first section, participants were asked to indicate how well each item described them or their

opinions during the past 5 years on a 7-point Likert scale from 1 (*definitely agree*) to 7 (*definitely disagree*). On the second set of items, participants were asked to rate how often something had been occurring during the past 5 years on a 7-point scale (1 = *always* to 7 = *never*). The last section, which was included as a validity indicator (Current Distress), focused on participant's experiences within the past 7 days on a 7-point scale (1 = *always* to 7 = *never*).

The primary measures of interest for this study were two of the OMNI Factor scales (Narcissism, Neuroticism), as well as two Personality Disorder scales (Antisocial and Obsessive-Compulsive). Total raw scores for each scale were presented.

7. Eating Disorder Inventory-3 (EDI-3; Garner, 2004). The EDI-3 was administered in the current study to assess disordered eating attitudes and behaviour. The original Eating Disorder Inventory (EDI; Garner, Olmstead, & Polivy, 1983) and the Eating Disorder Inventory-2 (EDI-2; Garner, 1991) have been widely used in research and treatment of eating disorders. The updated version was developed to improve the psychometric properties and conceptual framework of this measure, thus several EDI-2 scales have been refined or created to measure psychological constructs that are more consistent with modern theories on eating disorders (Garner, 2004). Although the original items have been retained in the EDI-3, the new 91-item version includes the original three eating disorder subscales (Body Dissatisfaction, Bulimia, Drive for Thinness), as well as nine other psychological subscales (Asceticism, Emotional Dysregulation, Interoceptive Deficits, Interpersonal Alienation, Interpersonal Insecurity, Low Self-Esteem, Maturity Fears, Perfectionism, and Personal Alienation). The inventory also includes six composite scores (General Psychological Maladjustment, Affective

Problems Composite, Eating Disorder Risk Composite, Ineffectiveness Composite, Interpersonal Problems Composite, Overcontrol Composite) and three validity indicators (Inconsistency, Infrequency, Negative Impression).

Based on the U.S. and international adult clinical samples of the EDI-3, overall moderate to high internal consistency ($r > .70$) was reported for the 18 clinical and 6 composite scales, with lower reliability estimates ($r < .70$) for the Bulimia subscale for the Anorexia Nervosa-Restricting type in the U.S. sample (Garner, 2004). However, the EDI-3 does not provide internal consistency coefficients for the nonpatient comparison groups. For the U. S. adult clinical sample, the EDI-3 clinical scales have their highest correlations with the corresponding EDI-2 subscales ($r = .73$ to $.98$). In addition, the Drive for Thinness and Body Dissatisfaction scores have the highest correlations with the Eating Attitudes Test-26 total score (EAT-26; $r = .72$ and $.52$), and Bulimia and Drive for Thinness scores have the highest correlations with the Bulimia Test-Revised Total score (BULIT-R; $r = .81$ and $.77$) [Garner, 2004]. These provide some support for convergent validity. Of note, very little research has been conducted regarding reliability and validity of the measure with men. Nonetheless, the EDI/EDI-2 has been used to assess disordered eating attitudes and behaviour in men with suspected eating disorders.

Participants rated how well each item reflected their current attitudes, feelings, and behaviours on a six-point scale from *Always* to *Never*. As per standard administration, a 0 to 4 scoring system was used. A score of 4 was assigned for the extreme response in the symptomatic direction (*Always* or *Never*, depending on whether the item is positively or negatively keyed), a score of 3 for the immediately adjacent response (*Usually* or *Rarely*), and a score of 2 for the next response (*Often* or *Sometimes*), and a score of 1 for

the next response (*Sometimes* or *Often*). The two responses in the asymptomatic direction were given a score of 0 [Garner, 2004]. Clinical scale scores were computed by summing all items for that specific scale.

Outcome measures for the present study were limited to the Drive for Thinness, Bulimia, and Perfectionism subscales of the EDI-3. The Body Dissatisfaction subscale was not reported in this study, as it assesses site-specific satisfaction of body regions (i.e., buttocks, hips, stomach, thighs) of greatest concern to females and eating disorder populations. However, a modified version of the Body Dissatisfaction subscale has been developed for men. Blouin and Goldfield (1995) found higher scores on these measures in male bodybuilders as compared to male runners or martial artists. In this same study, male bodybuilders who used AASs endorsed significantly higher scores than non-using bodybuilders on the Bulimia and Drive for Bulk (adapted Body Dissatisfaction scale) subscales. In another research study (Cole, Smith, Halford, & Wagstaff, 2003), although current and ex-AAS male users obtained higher scores on the Drive for Thinness subscale and the modified version of the Body Dissatisfaction, only the ex-AAS users scored higher on the Bulimia and Perfectionism subscales than non-using male bodybuilders and aerobic trainers.

To address aspects of men's body image (e.g., desire for increased muscularity and reduced body fat), the Drive for Bulk and Drive for Tone scales were included in the current study (Blouin & Goldfield, 1995; Goldfield, Blouin, & Woodside, 2006). The six-item Drive for Bulk scale (i.e., a desire to increase muscle mass) is a modification of the Body Dissatisfaction scale of the EDI. The direction of items was reversed on this scale (e.g., "too big" was changed to "too small"), and references to specific body parts were

adapted to be more appropriate for males (i.e., arms, back, chest, legs, and shoulders). The Drive for Tone scale is comprised of five items that evaluate the desire to achieve a leaner and more toned body (e.g., “ripped” and “cut”). Although Goldfield et al. (2006) used the EDI-2 scoring system; the current study used the 0 to 4 scoring system for the Drive for Bulk and Drive for Tone scales in order to keep it consistent with the EDI-3 clinical scales. The psychometric properties of these two measures have not been investigated.

Other questionnaires were included in the study to assess men’s body image, such as the Drive for Muscularity Scale (McCreary & Sasse, 2000) and the Multidimensional Body-Self Relations Questionnaire (Cash, 2000). For a description of these measures, please refer to their respective sections.

8. Drive for Muscularity Scale (McCreary & Sasse, 2000). The DMS is a self-report measure designed to evaluate an individual’s desire for a more muscular body. It is one of the few measures developed using samples of both men and women. The original inventory consisted of 15 items; however, results of a factor analysis indicated that one item (“*I think about taking anabolic steroids*”) did not load significantly on any factor and showed very little variability in responses (McCreary, Sasse, Saucier, & Dorsch, 2004). Both the 15-item version and 14-item version (after removal of the AAS question) have consistently shown good reliability among men and women. Moderately high internal consistency coefficients on the total DMS score and the two subscale scores have been found for male respondents, ranging from .81 to .88 (McCreary & Sasse, 2000; McCreary et al., 2004). Exploratory factor analyses revealed two factors, muscularity-oriented body image (attitudes) and muscularity behaviour, for the men but not the

women (McCreary et al., 2004). A single-factor structure for the DMS also emerged for both men and women. Thus, these results suggest that the overall DMS score is appropriate for use with both men and women, but the two subscales should only be used with men (McCreary et al., 2004). Acceptable convergent validity was also found in a sample of men and women, as evidenced by a significant correlation between the DMS total score and the Swansea Muscularity Attitudes Questionnaire total score ($r = .83$) [Wojtowicz & van Ranson, 2006].

The participants were asked to rate each item on a six-point scale ranging from 1 (*always*) to 6 (*never*). All of the DMS items are reverse-coded prior to scoring so that higher scores reflect a greater drive for muscularity (McCreary & Sasse, 2000). As the AAS item loaded weakly on the lower order factors (McCreary et al., 2004), this item was removed from the scale in the current study. The total DMS score (sum of all 14 items) was the measure of interest in the present study.

9. Multidimensional Body-Self Relations Questionnaire (MBSRQ; Cash, 2000). The current study administered this self-report inventory as it has been used extensively in body image research. In addition, it is one of the few measures developed from a large normative sample of men and women of various ages representative of the U.S. population (Cash, Winstead, & Janda, 1986). The MBSRQ is a multidimensional attitudinal assessment designed to assess affective, cognitive, and behavioural components of the body image construct. The 69-item inventory is comprised of the revised Body-Self Relations Questionnaire (54 items, seven subscales), Body Areas Satisfaction Scale (9 items), Overweight Preoccupation (4 items), and the Self-Classified Weight subscale (2 items).

A principal-components factor analysis of the original database supported the conceptual framework of the 54-item Body-Self Relations Questionnaire, with six subscales reflecting two attitudinal dimensions (evaluation, orientation) for each of the three somatic domains (appearance, fitness, and health) [Brown, Cash, & Mikulka, 1990]. An additional factor (illness orientation) also emerged. This study identified the same seven factors for both males and females (Brown et al., 1990). The reliability coefficients of the subscales ranged from .70 to .91, which suggests moderately high levels of internal consistency (Brown et al., 1990; Cash, 2000). Adequate convergent validity of the Appearance Evaluation ($r = -.47$ to $-.67$), Appearance Orientation ($r = .28$ to $.58$) and Body Parts Satisfaction ($r = -.53$ to $-.71$) subscales with other attitudinal measures of body image has been shown [Mayville, Williamson, White, Netemeyer, & Drab, 2002; Rosen, Jones, Ramirez, & Waxman, 1996].

Three subscales from the MBSRQ were of primary interest in this study, as these measures were sensitive in identifying body image concerns in male weightlifters with muscle dysmorphia (Choi, Pope, & Olivardia, 2002). The Appearance Evaluation subscale (seven items) assesses attitudes about general physical appearance, with higher scores reflecting greater satisfaction with overall appearance. The Appearance Orientation subscale (12 items) evaluates the cognitive-behavioural investment in or concern with physical appearance, with higher scores indicating more importance and attention placed on looks and more engagement in grooming behaviours. The Appearance Evaluation and Appearance Orientation subscales measure different aspects of body image (Thompson, Altabe, Johnson, & Stormer, 1994). On these two subscales, participants were asked to rate each item on a five-point Likert scale from 1 (*definitely*

disagree) to 5 (*definitely agree*). On the Body Areas Satisfaction subscale (nine items), participants rated their level of satisfaction of discrete body areas or attributes on a five-point scale (0 = *very dissatisfied* to 5 = *very satisfied*), with higher scores suggesting contentment with most areas of their body. Although it is possible measure body image satisfaction by analyzing each separate body area, this research only examined the total score in the interest of parsimony. Moderate correlations for men ($r = .66$) and women ($r = .61$) have been shown between the MBSRQ Appearance Evaluation subscale and the Body-Parts Satisfaction subscale (Keeton, Cash, & Brown, 1990). As per the MBSRQ scoring instructions, summary scores for these three subscales were calculated by taking the mean of its corresponding items (Cash, 2000).

Power Analysis

Within the greater Victoria and Vancouver regions, it was estimated that there would be at least 100 male bodybuilders who use AASs. Although there were over 1000 viewings of the study advertisement on bodybuilding/steroid forums on the internet as well as support from owners of gyms, nutritional supplement companies, and bodybuilding federations, participant recruitment of AAS users still proved to be a difficult task.

An a priori power analysis using G*Power (Faul & Erdfelder, 1992) was conducted to determine the required sample size. Based on the sex difference literature, it was expected that there would be a great deal of overlap between groups in terms of cognitive scores. Nonetheless, it was anticipated that AAS users would exhibit a different cognitive pattern on sex-related measures than the control groups, with control groups showing similar performance. A moderate effect size was anticipated on cognitive measures. With

a moderate effect size ($f = 0.30$) and a conservative alpha level ($p < .05$), a total sample size of 111 participants (i.e., 37 participants per group) would be needed to produce a significant finding. The power for the resulting test would be 0.80. Another a-priori power analysis was run to determine the required sample size for a large effect size ($f = 0.40$). In this case, the large effect size necessitated a smaller sample size of 22 participants per group to detect group differences with a minimum power of .80. Although there were more AAS users interested in participating in the current study, as well as several more controls who participated in the study, the final sample had 8 participants per group due to stringent inclusion and exclusion criteria for the reasons previously mentioned.

Statistical Analyses

The primary cognitive hypotheses assessed group differences on a battery of sex-related cognitive tests of spatial ability, verbal fluency, verbal memory, verbal and visual working memory, perceptual and motor speeded tasks. Since participants were matched closely on age, education, and estimated verbal intelligence, results were analyzed using analysis of variance (ANOVA) matched-group design. Matched-group ANOVAs were used to enhance statistical power due to a small sample size. Given similar testosterone levels for the control groups, cognitive performance on each task was averaged for matched controls. Thus, matched-group ANOVAs were run with two orthogonal planned comparisons; (1) the AAS group compared to the averaged control group and (2) the bodybuilding controls compared to the aerobic controls. As this is an exploratory study with a small sample size, an alpha level of .05 was selected for all planned comparisons. Further matched-group ANOVAs were run to investigate differences in cognitive performance between the AAS group and each separate control group (bodybuilders and

aerobic exercisers). A more conservative alpha level of .025 was selected for these additional comparisons to reduce the probability of a Type I error. Group differences in visuospatial memory were also explored using matched-group ANOVAs. Effect sizes (eta squared, η^2) are presented, and according to Cohen's criteria (1988), .01 is indicative of a small effect, .06 a medium effect, and greater than .14 a large effect size.

For exploratory analyses of the bivariate relationships between total testosterone and the various cognitive tasks, alpha level was set to .05. Pearson correlation coefficients were used; correlations of .30 to .50 were considered moderate in size and those above .50 were viewed as large (Cohen, 1988). Lastly, since a female-typical pattern of performance was expected for the AAS group, the cognitive profile of two men with the highest total testosterone levels were examined graphically and compared to the average scores of the controls. All raw scores were converted to z-scores, with higher scores suggesting better performance on the tasks.

The primary psychological hypotheses investigated group differences in three domains: aggression, personality, and body image/disordered eating practices. A series of one-way ANOVAs were performed. For the aggression and personality variables, one-way ANOVAs were run with the following orthogonal planned comparisons; (1) the AAS group and the averaged control group and (2) the bodybuilding controls compared to the aerobic controls. Two planned comparisons were also conducted to investigate group differences in body image and eating disorder variables; (1) the aerobic group compared to the averaged bodybuilding group (AAS users and bodybuilding controls) and (2) the AAS users compared to the bodybuilding controls. An alpha level of .05 was set for all planned comparisons and .025 for all post hoc comparisons.

Results

Data were statistically analysed using the software package, SPSS Graduate Pack 15.0 for Windows (SPSS, 2006). Although a large amount of data was collected in the current study, the data analyses do not include every possible variable. The following results were designed to test the principal hypotheses for the cognitive and psychological outcome measures, rather than address all data collected.

Data Screening

The principal investigator rescored all of the outcome measures to ensure scoring accuracy. Prior to analyses, recommended procedures for screening grouped data were employed (Tabachnick & Fidell, 2001). Outcome measures were examined for correct entry of data and missing values. Although there was no missing data for the cognitive measures, a few random items on the questionnaires were not completed. The principal investigator did not omit cases with missing data due to a small sample size, instead implemented methods outlined in the respective manuals to deal with missing values. Based on examination of potential univariate outliers which was identified as cases with z-scores in excess of 3.29 (Tabachnick & Fidell, 2001), all data were within acceptable limits with two exceptions. One bodybuilding control had an unusually high score on a descriptive variable, the SCL-90-R Global Severity Index ($z = 3.32$). In addition, inspection of box plots indicated that there was one unusually low score when mental rotation was averaged for the control groups. Marked intraindividual variability on cognitive tests is common in normal adults, thus these outliers were not discarded from the study (Schretlen, Munro, Anthony, & Pearlson, 2003).

Data were also examined to ensure that the variable distributions met statistical assumptions of the planned analyses. Although some of the variables were not normally

distributed with some deviations in skewness and/or kurtosis, no substantial violations were uncovered. Transformations were attempted on three descriptive variables (GSI, estradiol, and testosterone) and for some, but not all variables, transformations resulted in non-significant tests for normality and homogeneity of variance. Due to similar results from transformed and untransformed data analyses, only the results from untransformed raw scores will be presented. Of note, ANOVAs are relatively robust to violations of normality and heterogeneity of variance. In cases where F_{max} for equality of variances was greater than six [set at a lower value than recommended by Tabachnick & Fidell (2001) due to a small sample size], F tests for unequal variances were reported.

Hormone Measurements

Participant hormone and protein measurements are presented in Table 8. ANOVAs revealed significant differences between the three groups on total testosterone, total estradiol, and SHBG levels.² As expected, men who used AAS had higher serum total testosterone and total estradiol levels, and lower SHBG concentrations than the bodybuilding and aerobic control groups, whereas the control groups did not differ on these measures. On the other hand, albumin levels did not differ among the groups.

Free and bioavailable testosterone were also calculated in the present study. Based on information provided by the contracted medical laboratory company, calculated free and bioavailable testosterone can only be reliably computed when total testosterone falls within 0.5 to 52 nmol/L and when SHBG falls within 2 to 180 nmol/L. Of note, three men in the AAS group had total testosterone levels falling well above the 52 nmol/L limit

² As the assumption of homogeneity of variance was not met for these variables, Welch ANOVAs and Games-Howell test of posthoc comparisons were utilized in these analyses. Significant group differences were the following: Total testosterone, $F(2,12.71) = 27.54, p = .000, \eta^2 = .81$; Estradiol, $F(2,12.07) = 6.88, p = .01$; SHBG, $F(2,11.86) = p = .000$.

(66.1, 67.2, and 69.0). Due to concerns with reliability, these measurements were not used in any of the statistical analyses.

Table 8. Hormone and protein measurements of the study population

Variable	AAS users (<i>n</i> = 8)		Bodybuilders (<i>n</i> = 8)		Aerobic controls (<i>n</i> = 8)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Testosterone (nmol/L)	52.60 _a	12.63	17.06 _b	3.93	21.21 _b	4.86
Estradiol (pmol/L)	352.88 _a	184.76	109.38 _b	16.78	105.13 _b	12.12
SHBG (nmol/L)	8.13 _a	5.28	27.88 _b	13.90	34.50 _b	11.23
Albumin (g/L)	44.63	2.77	46.63	1.69	46.13	1.96

Note. Groups with different letter subscripts are significantly different ($p < .05$) for Games-Howell post hoc comparisons. SHBG = Sex-hormone binding globulin.

Preliminary cognitive and psychological analyses

In the interest of limiting the number of exploratory analyses due to a small sample size, the principal investigator initially computed Pearson correlations between variables from the same cognitive measure (i.e., RAVLT, BVMT-R). Redundant variables were identified as those with a bivariate correlations greater than .70. There were large correlations between the total and delayed recall scores of the RAVLT ($r = .72, p < .001$), and the total and delayed recall scores of the BVMT-R ($r = .79, p < .001$). As the RAVLT and BVMT-R total scores were felt to be the best indices of overall memory performance, only these measures were included in the data analyses. All subsequent analyses were performed on the reduced set of measures. Appendix F displays the

intercorrelations among the remaining cognitive measures for the whole sample. In the current study, all correlations below $p < .05$ are highlighted.

Pearson correlation coefficients between variables of each psychological domain (i.e., personality, body image/disordered eating) were also examined. There was a large correlation between the Drive for Muscularity Scale and the Drive for Bulk scale ($r = .80$, $p < .001$). Since the Drive for Muscularity Scale has demonstrated adequate reliability and validity, only this measure was included in subsequent analyses. Although there were still a large number of measures, the principal investigator did not create composite scores because variables within each domain investigated separate psychological functions. Within-group correlations among the remaining psychological variables are presented in Appendix G.

Primary Cognitive Analyses

Planned orthogonal comparisons are presented first in each section (AAS group compared to the combined control group³, and bodybuilding controls versus aerobic controls), followed by post hoc comparisons between AAS users and each separate control group. Table 9 presents the descriptive statistics for the three groups of men on the cognitive outcome measures.

Mental rotation. As hypothesized, the AAS group ($M = 10.75$, $SD = 3.41$) obtained lower scores on the mental rotation task than the control group ($M = 14.25$, $SD = 2.65$), $F(1,7) = 7.75$, $p = .03$, $\eta^2 = .53$. This group difference was particularly notable as two controls performed below one standard deviation ($z = -1.11$, -1.65) and one AAS user performed above one standard deviation ($z = 1.33$). As expected, the bodybuilding and

³ The term 'control group' will be used in further discussions to refer to both bodybuilders and aerobic exercisers. Separate groups will be identified by 'bodybuilding controls' and 'aerobic exercisers/controls.'

aerobic controls did not differ on the mental rotation task, $F(1,7) = 0.00$, ns , $n^2 = .00$.

Post hoc comparisons revealed that the AAS group performed worse than the aerobic control group, $F(1,7) = 8.37$, $p = .023$, $n^2 = .54$. Although there was a trend in the predicted direction, with the bodybuilding controls obtaining an overall higher score on the mental rotation task than the AAS users, the results failed to attain significance [$F(1,7) = 4.18$, $p = .08$, $n^2 = .37$]. Outliers might have had an impact on the results. One bodybuilding control scored much lower than his fellow participants (raw score = 7, range of other scores = 13 to 20), whereas one AAS user scored much higher than the participants in his group (raw score = 18, range of other scores = 7 to 12).

Verbal fluency. The AAS group was expected to obtain higher scores on the phonemic fluency task than the control group. However, the AAS group ($M = 47.75$, $SD = 5.15$) did not differ significantly from the control group ($M = 47.88$, $SD = 8.75$) on this task, $F(1,7) = 0.002$, ns , $n^2 = .00$. As expected, there was no difference in phonemic fluency for the bodybuilding and aerobic controls, $F(1,7) = 1.27$, ns , $n^2 = .15$. Post hoc comparisons revealed that the AAS group did not differ significantly from the bodybuilding controls [$F(1,7) = 0.11$, ns , $n^2 = .02$] or the aerobic controls [$F(1,7) = 0.12$, ns , $n^2 = .02$].

Verbal memory. The hypothesis that the AAS group would demonstrate higher scores on the RAVLT than the control group was not supported. There was no difference in total recall scores for the AAS users ($M = 56.63$, $SD = 7.11$) and controls ($M = 58.63$, $SD = 4.52$, $F(1,7) = 0.39$, ns , $n^2 = .05$). Both of the control groups also did not differ significantly on this task, $F(1,7) = 0.21$, ns , $n^2 = .003$. Based on post hoc comparisons,

there were no differences between the AAS users and the bodybuilding controls [$F(1,7) = 0.50$, *ns*, $n^2 = .07$] or the aerobic controls [$F(1,7) = 0.27$, *ns*, $n^2 = .04$].

Perceptual speed. The AAS group was expected to display higher scores on the WAIS-III Digit-Symbol Coding subtest than the control group. Contrary to this expectation, the control group ($M = 86.88$, $SD = 8.21$) obtained higher scores than the AAS group ($M = 76.13$, $SD = 9.08$) on this measure [$F(1,7) = 32.52$, $p = .001$, $n^2 = .82$]. The bodybuilding controls did not differ significantly from aerobic controls, $F(1,7) = .19$, *ns*, $n^2 = .03$. Post hoc comparisons indicated that only the aerobic group performed significantly better than the AAS group, $F(1,7) = 16.69$, $p = .005$, $n^2 = .70$. Although the bodybuilding group obtained a higher overall score on this measure than the AAS group, this difference did not reach significance [$F(1,7) = 3.17$, $p = .12$, $n^2 = .31$]. An outlier ($z = -1.54$) in the bodybuilding group likely had an impact on this score. When this outlier was removed from the analysis, the groups differed in the expected direction [$F(1,7) = 11.30$, $p = .015$, $n^2 = .65$].

Motor speed. The hypothesis that the AAS users would complete the fine-motor dexterity task faster with their dominant hand relative to the controls was not supported. The AAS group ($M = 61.63$, $SD = 5.61$) and control group ($M = 60.81$, $SD = 5.27$) did not differ significantly on the Grooved Pegboard task, $F(1,7) = 0.06$, *ns*, $n^2 = .01$. Both control groups also demonstrated similar performance on this variable, $F(1,7) = 0.40$, *ns*, $n^2 = .05$. Post hoc comparisons also revealed that the AAS users did not differ significantly from the bodybuilding controls [$F(1,7) = 0.01$, *ns*, $n^2 = .001$] or the aerobic controls [$F(1,7) = 0.20$, *ns*, $n^2 = .03$].

Visuospatial working memory. The AAS users were expected to make fewer errors on the SOPT as compared to the control group. Although the AAS users ($M = 10.00$, $SD = 6.85$) made slightly fewer errors than the controls ($M = 12.44$, $SD = 2.68$); there was no significant difference between groups [$F(1,7) = 1.40$, ns , $n^2 = .17$]. On the other hand, the bodybuilding control group made significantly more errors on this task than the aerobic control group, $F(1,7) = 8.06$, $p = .03$, $n^2 = .54$. Post hoc comparisons showed no differences between the AAS users and the bodybuilding controls [$F(1,7) = 2.72$, ns , $n^2 = .28$] or the aerobic controls [$F(1,7) = 0.34$, ns , $n^2 = .05$].

Table 9. Descriptive statistics for cognitive measures

Test measure	AAS users ($n = 8$)		Bodybuilders ($n = 8$)		Aerobic controls ($n = 8$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Mental Rotation	10.75	3.41	14.25	3.77	14.25	3.11
Phonemic Fluency	47.75	5.15	48.88	10.15	46.88	7.92
RAVLT Total Recall	56.63	7.11	58.75	4.89	58.50	5.35
BVMT-R Total Recall	28.38	6.09	28.00	4.00	28.75	3.37
WAIS-III Coding ^a	76.13	9.08	85.25	15.10	88.50	11.55
Grooved Pegboard	61.63	5.61	61.88	7.59	59.75	6.54
SOPT Total errors ^a	10.00	6.85	13.75	3.01	11.13	2.95
WAIS-III LNS	13.25	2.49	13.25	2.87	13.63	2.13

Note. RAVLT = Rey Auditory Verbal Learning Test; BVMT-R = Brief Visuospatial Memory Test-Revised; WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; Coding = Digit-Symbol Coding subtest; SOPT = Self-Ordered Pointing Test; LNS = Letter-Number Sequencing subtest.

^a Lower values indicate better performance.

Verbal working memory. The hypothesis that AAS users would obtain significantly higher scores on the WAIS-III Letter-Number Sequencing task than the control group was not supported, $F(1,7) = 0.05$, *ns*, $n^2 = .01$. The AAS group ($M = 13.25$, $SD = 2.49$) and the control group ($M = 13.44$, $SD = 1.64$) obtained similar scores. The bodybuilding and aerobic controls also did not differ on this task, $F(1,7) = 0.08$, *ns*, $n^2 = .01$. Based on results of the post hoc comparisons, there were no differences in Letter-Word Sequencing scores for the AAS users and bodybuilding controls [$F(1,7) = 0.00$, *ns*, $n^2 = .00$] or the aerobic controls [$F(1,7) = 0.18$, *ns*, $n^2 = .03$].

Exploratory Cognitive Analyses

Visuospatial memory. Given the evidence that testosterone supplementation improves spatial memory in healthy older men, it was hypothesized that the AAS users would obtain higher scores on the BVMT-R relative to the control group. However, there was no significant difference in the total recall scores between the AAS group ($M = 28.38$, $SD = 6.09$) and the control group ($M = 28.38$, $SD = 2.03$), $F(1,7) = 0.00$, *ns*, $n^2 = .00$. Both of the control groups also did not differ significantly on this task, $F(1,7) = 0.12$, *ns*, $n^2 = .02$. Lastly, post hoc comparisons did not demonstrate any significant differences between AAS users and bodybuilding controls [$F(1,7) = 0.02$, *ns*, $n^2 = .003$] or aerobic controls [$F(1,7) = 0.02$, *ns*, $n^2 = .003$].

Measures of testosterone and cognitive variables. The bivariate associations between serum total testosterone and cognitive outcome measures are shown in Table 10. Only total testosterone was examined in this study due to unreliable measurements of free and bioavailable testosterone for three AAS users, and a set value of <100 nmol/L for all estradiol levels between 0 nmol/L to 100 nmol/L. To increase statistical power and the

range of testosterone levels, all three participant groups ($n = 24$) and additional control participants ($n = 24$), who were not matched but met study criteria aside from testosterone levels, were included in the analysis. Five of the unmatched controls had total testosterone levels falling just outside the physiological range, three on the low end (range = 8.8 to 9.7) and two on the high end (range = 31.1 to 31.6). Hormone levels ranged from slightly below the physiological range to supraphysiological levels.

Table 10. Intercorrelations between serum total testosterone and cognitive measures

Test measure	Pearson's Product Moment Correlations (r)
Mental Rotation	-.18
Phonemic Fluency	.03
RAVLT total recall	-.14
BVMT-R total recall	.03
WAIS-III Digit-Symbol Coding	-.18
Grooved Pegboard	.03
SOPT total errors	-.07
WAIS-III Letter-Number Sequencing	.01

Note. RAVLT = Rey Auditory Verbal Learning Test; BVMT-R = Brief Visuospatial Memory Test-Revised; WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; SOPT = Self-Ordered Pointing Test.

As per Table 10, there were no significant associations between total testosterone and performance on the cognitive tasks. In all cases, the effect sizes were small to nonexistent. However, as research has suggested a potential curvilinear relationship

between testosterone and cognitive abilities, this was also investigated. Graphical inspection revealed no significant curvilinear relationships between testosterone and cognitive abilities. The largest relationship identified, albeit a statistically nonsignificant effect ($r^2 = .10$), was between testosterone and mental rotation (see Figure 3).

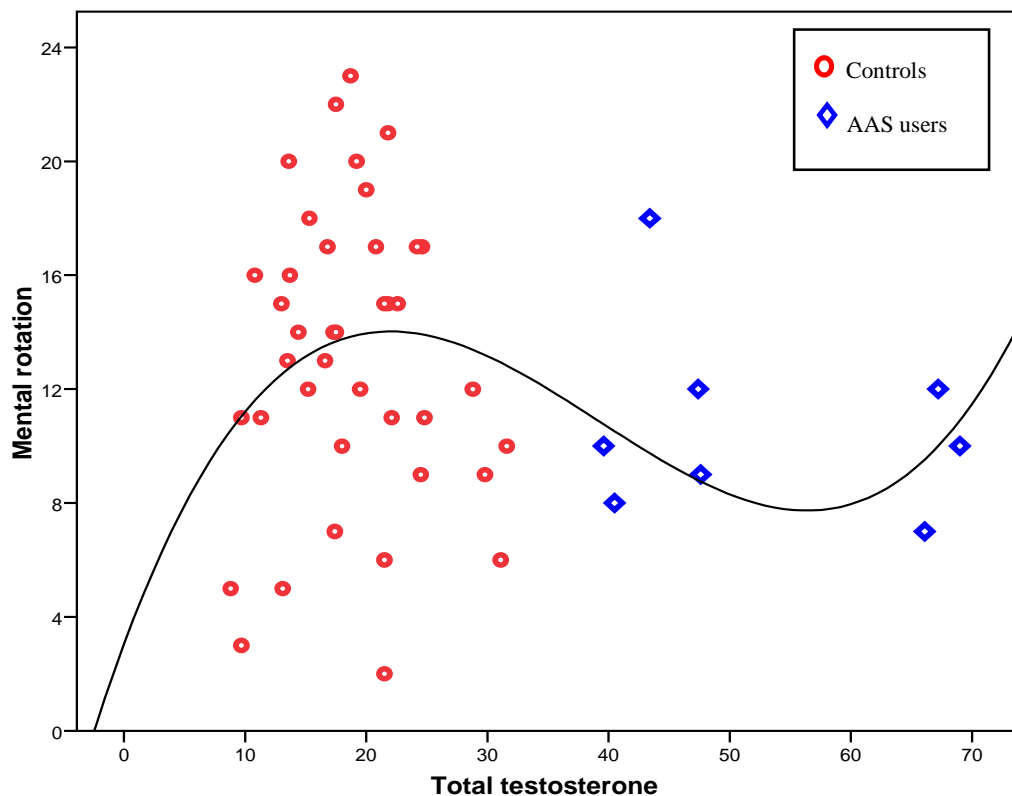


Figure 3. Scatterplot of total testosterone levels and mental rotation scores with the best-fitting function ($N = 48$).

As there were only a few AAS users in the current study, there was little power to reliably demonstrate whether a curvilinear relationship exists between total testosterone and cognitive abilities. Thus, this was examined using only matched and unmatched control participants who met study criteria aside from testosterone levels ($N = 40$).

Overall, there were no significant linear or nonlinear relationships between testosterone and cognitive abilities. However, a significant quadratic effect was noted between total testosterone and mental rotation performance ($r^2 = .20$, $p = .02$). This result is portrayed in Figure 4.

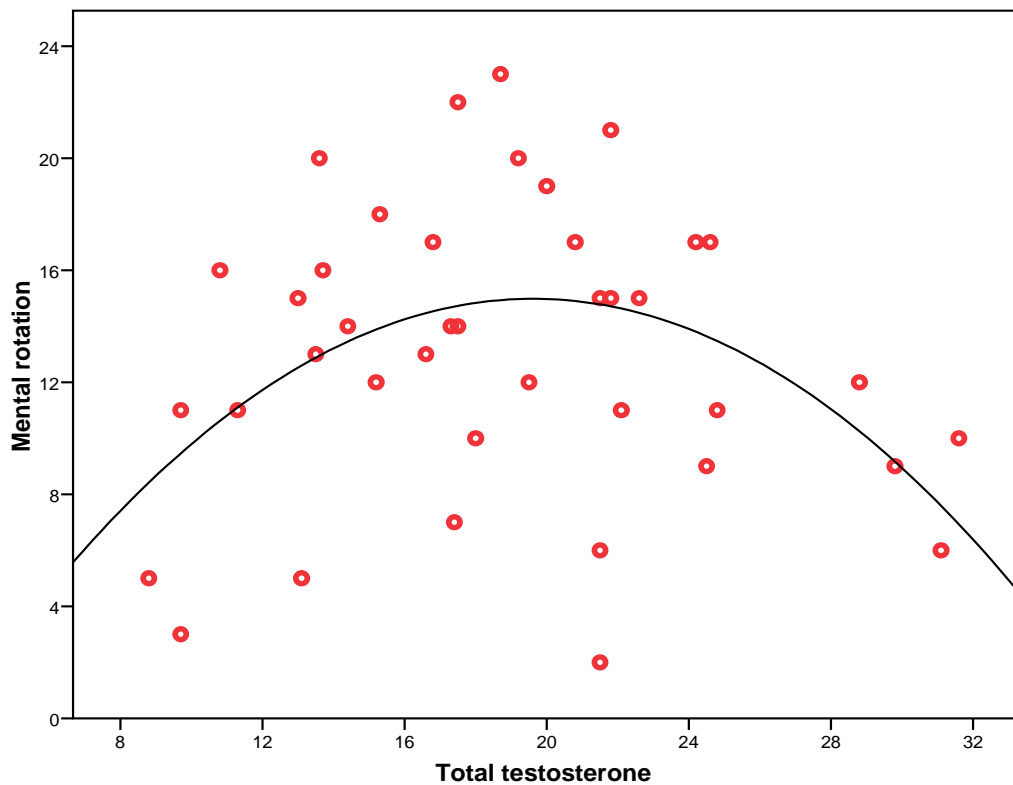


Figure 4. Scatterplot showing relationship between total testosterone and mental rotation scores ($N = 40$).

Although the present study controlled for group differences in age, education, and estimated verbal intelligence by matching two controls to each AAS user, the research literature suggest that these factors might have an influence on spatial ability. Age often shows a negative relationship with spatial ability scores in adulthood, and education and

intelligence are positively associated with spatial ability. Trends were examined in the current data set through correlational analyses across matched groups. A pattern of relationships is evident; age was significantly correlated with mental rotation, with scores declining with advancing age ($r = -.47, p = .02$). Estimated intelligence had a moderate effect on mental rotation performance ($r = .42, p = .04$). There was a trend for individuals with more formal education to obtain higher raw scores on mental rotation ($r = .17, ns$). Overall, there were no significant age, education, or estimated intelligence effects for any of the other cognitive outcome measures. However, age showed a positive, significant relationship with SOPT errors ($r = .52, p < .01$); older participants made more errors on this task.

Profile analysis of cognitive abilities. As a female-typical pattern of performance was expected in the AAS users (i.e., lower mental rotation with higher verbal fluency, working memory, memory abilities, and perceptual/motor speed), performance on all cognitive outcome measures was examined in two AAS-using bodybuilders with the highest total testosterone levels. Their cognitive profile was compared to the mean score for the matched controls ($n = 16$), which is presented in Figure 5. Raw scores were converted to standardized scores for ease of presentation.

As seen in Figure 5, overall results do not suggest a consistent pattern of performance in the AAS users. Nonetheless, consistent with other findings in the current study, both of the AAS users performed lower on the mental rotation task than the control group. Of note, mental rotation scores of these two AAS users were not impaired, as evidenced by z-scores falling in the low average to average range.

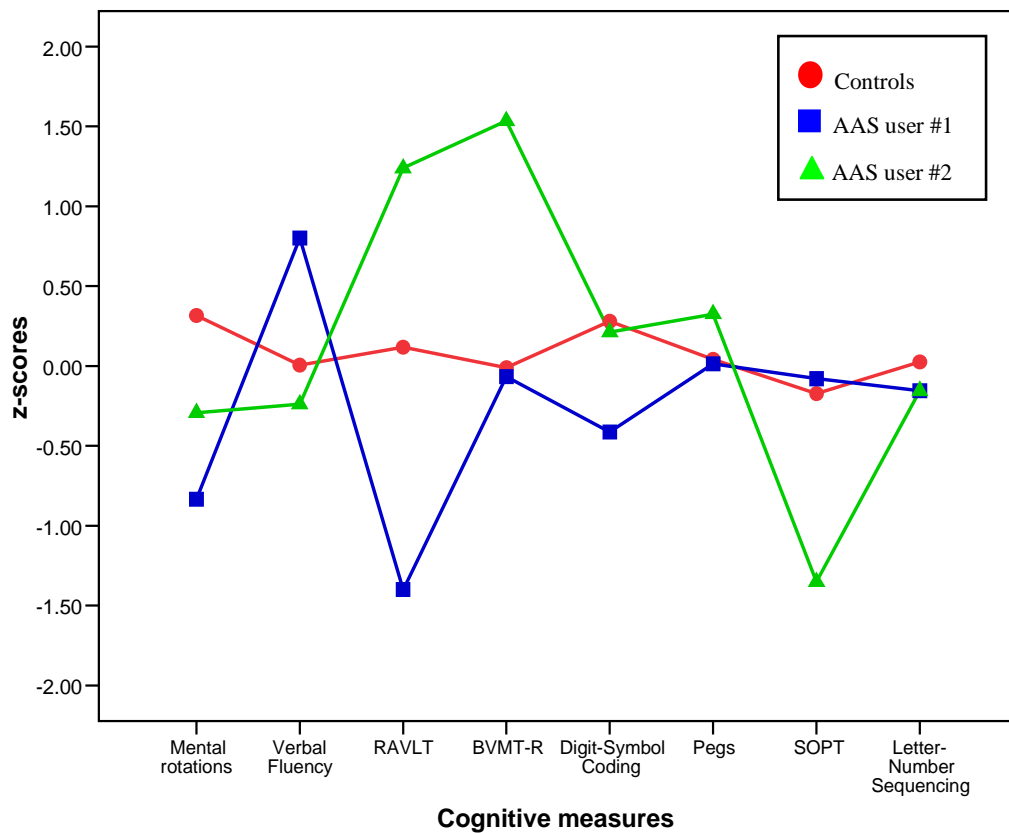


Figure 5. Cognitive profile of matched control group and two AAS users with the highest testosterone values as assessed by z-score performance.

Primary Psychological Analyses

As there were multiple variables testing the psychological hypotheses, they were broken into three domains: (1) aggression (one dependent variable), (2) personality (four dependent variables), and (3) body image and eating attitudes/behaviours (eight dependent variables). Planned comparisons are presented first in each section. Post hoc contrasts were run when a significant difference was identified for the initial analyses.

Aggression. The AAS group was expected to show elevated levels of aggression as compared to the averaged control group. However, there was no significant difference in the AQ total scores between the AAS group ($M = 70.25$, $SD = 15.35$) and the combined

control group ($M = 65.69$, $SD = 18.68$), $F(1,22) = 0.36$, ns , $n^2 = .02$. As expected, the bodybuilding controls ($M = 72.63$, $SD = 22.77$) and aerobic exercisers ($M = 58.75$, $SD = 10.95$) did not differ in self-rated aggressive behaviour, $F(1,14) = 2.41$, ns , $n^2 = .15$.

Some researchers argue that weight training might be a potential confounding factor when investigating the psychological effects of AASs (Bahrke & Yesalis, 1994). Thus, an exploratory analysis was conducted to determine whether bodybuilders as a group endorsed higher levels of aggression than aerobic exercisers. An alpha level of .025 was selected to control for a Type I error. Although the bodybuilders obtained a higher mean score on the AQ than the aerobic controls, a one-way ANOVA failed to reach significance, $F(1,22) = 3.08$, $p = .09$, $n^2 = .12$.

Personality. It was predicted that the AAS group would show elevated levels of personality traits, specifically antisocial, obsessive-compulsive, narcissism, and neuroticism, as compared to the control group. As can be seen in Table 11, the AAS users obtained higher mean scores than both of the control groups on all the personality scales. However, these groups did not differ significantly for obsessive-compulsive traits: $F(1,22) = .42$, ns , $n^2 = .02$; narcissism: $F(1,22) = 1.25$, ns , $n^2 = .05$; or neuroticism: $F(1,22) = 1.22$, ns , $n^2 = .05$. There was a statistically significant group effect on the antisocial personality disorder scale [$F(1,22) = 4.78$, $p < .04$, $n^2 = .18$], with the AAS users reporting more antisocial traits than those in the control group. As the statistical power was low, post hoc tests failed to show any significant differences between AAS users and bodybuilding controls [$F(1,14) = 2.76$, $p = .12$, $n^2 = .17$], or AAS users and aerobic controls [$F(1,14) = 3.09$, $p = .10$, $n^2 = .18$]. Lastly, there were no significant differences between the bodybuilding and aerobic control groups on the antisocial,

$F(1,14) = 0.08$, ns , $n^2 = .01$; obsessive-compulsive, $F(1,14) = 0.15$, ns , $n^2 = .01$; narcissism, $F(1,14) = 0.09$, ns , $n^2 = .01$; or neuroticism, $F(1,14) = 0.02$, ns , $n^2 = .00$, subscales of the OMNI Personality Inventory.

Table 11. Descriptive statistics for OMNI Personality Inventory scales

Test measure	AAS users ($n = 8$)		Bodybuilders ($n = 8$)		Aerobic controls ($n = 8$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Antisocial	21.00	7.11	16.25	3.85	15.63	4.93
Obsessive-Compulsive	26.00	5.66	23.88	5.38	25.00	6.05
Narcissism	305.88	44.17	288.88	51.85	282.63	27.61
Neuroticism	288.88	69.31	260.13	64.89	255.38	65.58

Body image and disordered eating. Table 12 presents the means and standard deviations for each group on the body image and eating disorder inventories. It was hypothesized that the bodybuilding group (AAS users and bodybuilding controls) would exhibit greater body image dissatisfaction, and disordered eating attitudes and behaviours than the aerobic exercisers. As expected, significant differences were found for the drive for muscularity [$F(1,22) = 10.13$, $p = .004$, $n^2 = .32$] and the drive for tone [$F(1,22) = 10.46$, $p = .004$, $n^2 = .32$]. The bodybuilders reported a greater desire for muscularity and a toned body as compared to the aerobic exercisers. Post hoc comparisons indicated that both the AAS users and bodybuilding controls scored higher on the drive for muscularity scale than the aerobic exercisers, $F(1,14) = 9.78$, $p = .007$, $n^2 = .41$; $F(1,14) = 7.10$, $p = .02$, $n^2 = .34$, respectively. However, only the bodybuilding control scores on the drive

for tone scale were significantly higher than those in the aerobic group [$F(1,14) = 9.96, p = .007, n^2 = .42$], with the increase in AAS users' scores approaching the more stringent alpha level correction [$F(1,14) = 5.95, p = .03, n^2 = .30$].

Table 12. Descriptive statistics for body image and eating disorder scales

Test measure	AAS users ($n = 8$)		Bodybuilders ($n = 8$)		Aerobic controls ($n = 8$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Drive for Muscularity	61.13	17.71	53.50	12.12	38.00	11.12
Drive for Tone	14.25	6.56	14.88	4.61	6.88	5.49
MBRSQ AE	3.43	0.63	3.79	0.36	3.86	0.43
MBRSQ AO	3.55	0.26	3.21	0.59	2.95	0.69
MBRSQ BAS	3.49	0.56	3.39	0.75	3.67	0.32
EDI Drive for Thinness	7.38	6.29	4.75	3.92	3.38	3.82
EDI Bulimia	2.75	2.87	0.88	1.46	1.38	1.30
EDI Perfectionism	9.63	2.45	9.25	2.55	8.00	3.74

Note. MBSRQ = Multidimensional Body Self-Relations Questionnaire; AE = Appearance Evaluation subscale; AO = Appearance Orientation subscale; BAS = Body Area Satisfaction subscale; EDI = Eating Disorder Inventory-Third Edition.

In contrast, the bodybuilders and aerobic exercisers did not differ significantly for overall appearance satisfaction: $F(1,22) = 1.34, ns, n^2 = .06$; investment in appearance: $F(1,22) = 2.17, ns, n^2 = .09$; satisfaction with specific body areas: $F(1,22) = 0.89, ns, n^2 = .04$; drive for thinness: $F(1,22) = 1.65, ns, n^2 = .07$; bulimic tendencies: $F(1,22) = 0.23, ns, n^2 = .01$; or perfectionism: $F(1,22) = 1.30, ns, n^2 = .06$. Planned comparisons between

AAS users and bodybuilding controls also indicated no significant differences on any of the body image and eating disorder variables.

Psychological profile. Although it is interesting to investigate group differences, it is also important to determine whether the groups demonstrated clinically significant levels of aggression, personality traits, body image dissatisfaction, and disordered eating attitudes/behaviours. Mean scores of the AAS group and both control groups were compared to normative data published for these scales (Buss & Warren, 2000; Cash, 2000; Garner, 2004; Loranger, 2001). Overall, mean scores for aggression, personality, and MBSRQ scales fell within the average range for all the groups. Mean raw scores of study participants on the EDI-3 drive for thinness, bulimia and perfectionism subscales were lower than the male clinical sample, and similar to those of the male nonclinical sample. On the other hand, mean scores for all of the groups in the current study were in the high average range for the narcissism factor subscale. Since the groups exhibited high levels of narcissism, the principal investigator examined whether the OMNI narcissistic personality disorder scale (which is a subset of the narcissism factor subscale) was also elevated. Mean scores for all of the groups fell below a T score of 70, suggesting no clinically significant personality dysfunction.

As the EDI-3 scaling was used for the Drive for Tone scale in the current study, we were unable to compare scores to a previous study (Goldfield et al., 2006). The Drive for Muscularity Scale has not been normed, thus information from previous studies was used for comparison purposes. Although the mean for drive for muscularity of the aerobic group was almost identical to male averages reported in other research studies, the AAS users and bodybuilding controls demonstrated higher mean scores on this scale (e.g.,

Davis, Karvinen, & McCreary, 2005; McCreary, Saucier, & Courtenay, 2005). These studies investigated drive for muscularity in general university samples. Wojtowicz & von Ranson (2006) found higher levels of drive for muscularity in male weightlifters ($M = 50.7$, $SD = 9.5$) than non-weightlifters ($M = 41.0$, $SD = 9.4$) in a university sample. For the current study, mean scores for the bodybuilding controls were more consistent with the male weightlifters; however, the AAS group obtained higher scores (Wojtowicz & von Ranson, 2006).

The psychological profile of participants with multiple clinical scores was also explored. Most participants exhibited fewer than two elevations on the scales, specifically personality, drive for muscularity, appearance evaluation, and body area satisfaction. Although perfectionism raw scores of 13 participants (6 AAS users, 5 bodybuilding controls, 2 aerobic exercisers) fell in the 'typical clinical range', a score in this range was common among male adults from the nonclinical sample (Garner, 2004). These scores were not considered clinically significant, and thus will not be discussed further in this section. Three AAS users and one bodybuilding control exhibited three or more elevated scores; each psychological profile will be discussed briefly.

One AAS user obtained high scores on subscales for bulimia, body area dissatisfaction, as well as antisocial, narcissistic, and neurotic personality traits. He reported frequent binge eating episodes with fasting. Elevated scores suggest the possibility of clinically significant antisocial and narcissistic personality traits (T scores > 70). Although depression was not investigated in the current study, he reported depressive symptoms associated with body image disturbances both during periods of AAS use and non-use. This individual also reported that AASs amplify his negative body

image concerns, which was described as “body dysmorphia.” He described prior symptoms of depression related to teenage obesity, and thus uses AASs to help combat obesity.

The second AAS user endorsed some weight preoccupation and overeating tendencies, with higher levels of drive for muscularity, obsessive-compulsive and narcissistic personality traits. This participant recently increased his aerobic activity and changed his diet (high protein, low carbohydrates) to lose weight for the summer, as he would like to be “ripped.” The third AAS user was tested on and off steroids. He endorsed higher levels of general aggression, antisocial and narcissistic personality traits during his second cycle. An elevated score suggests the possibility of clinically significant antisocial personality traits (T scores > 70). In discussions with the investigator, he also reported increased irritability while on steroids. When tested “off steroids”, his scores for general aggression, antisocial and narcissistic personality traits were lower, although still within the high to above average range.

Lastly, one bodybuilding control also demonstrated high levels of aggression, drive for muscularity, body area dissatisfaction, and narcissistic personality traits. This participant indicated that they would like a “more sculpted physique.” Of note, he reported a history of adult ADD, as well as symptoms of depression and anxiety in the past. Although he has never taken AASs, he is considering taking them to increase muscularity and reduce the effects of aging on testosterone levels.

Discussion

This exploratory study investigated the effects of exogenous steroids on sex-related cognitive abilities in male bodybuilders who use AASs. To date most research has focused on the anabolic properties and short-term health risks of AAS use. In contrast, there is very little known about the cognitive functioning of men who use high doses of exogenous testosterone and/or synthetic steroids. Male bodybuilders were selected as the most appropriate athletic population to study cognitive effects, as bodybuilders frequently use combinations of AASs in large doses, well above the therapeutic range, to enhance lean muscle mass and strength. Based on review of the literature, this appears to be the first study to examine the effects of non-medical AAS use on cognitive abilities in male bodybuilders. The second part of the study investigated the psychological functioning of male bodybuilders who use AASs. Research elucidating the psychological effects of exogenous steroids has been less extensively studied than those reporting short-term health risks, showing inconsistent findings about aggression, personality traits, body image disturbances, and disordered eating.

To assess group differences on the primary cognitive hypotheses, the bodybuilding and aerobic controls were combined as there were no significant differences in testosterone levels. Based on the primary psychological hypotheses, control groups were combined for the aggression and personality variables. As bodybuilding rather than AAS use was expected to influence body image and eating disorder variables, the bodybuilding groups were combined for these analyses.

Cognitive Findings

Based on available evidence of intra- and inter-individual variations in circulating testosterone levels, and that controlled exogenous testosterone supplementation might

modify cognitive patterns in clinical populations and healthy men, it was hypothesized that the male bodybuilders who used AASs would demonstrate a shift towards a female-typical pattern of cognitive performance. Specifically, it was expected that the AAS users would obtain higher scores than the control participants on verbal fluency, verbal and spatial working memory, memory for verbal and visuospatial information, as well as speeded perceptual and motor tasks. On the other hand, the AAS users were expected to obtain a lower score on mental rotation relative to the controls.

Overall, the findings of the present study did not support the predicted female-typical cognitive profile. For the majority of tasks, mean performance did not differ significantly between the AAS users and the controls. The groups obtained similar scores for verbal fluency, working memory, memory abilities, and fine-motor dexterity. However, as hypothesized, the AAS group obtained lower scores on the mental rotation task than the combined control group. Contrary to what was expected, the AAS group also scored lower on the WAIS-III Digit-Symbol Coding task as compared to the controls. Cognitive profile analysis of the two AAS users with the highest testosterone levels also supported most of these findings. The results did not suggest a reliable female-typical pattern of performance. Nonetheless, both of the AAS users scored lower on the mental rotation task than the matched controls.

Post hoc comparisons shed further light on the significant group differences. When analyzed separately, only the aerobic controls obtained statistically higher mean scores on mental rotation and Digit-Symbol Coding than the AAS users. Although the mean scores did not differ significantly, there was a similar trend for the AAS users to score lower on both tasks than the bodybuilding controls. One explanation is that outliers had an impact

on these results. For example, one bodybuilder scored much lower than his fellow participants on mental rotations, whereas one AAS user scored much higher than the other participants in his group. An outlier in the bodybuilding group also scored lower on the perceptual speed task. Using the mean score across the two control groups had the advantage of providing more statistical power as compared to each separate analysis.

Additional planned analyses on cognitive outcome measures suggested that the bodybuilding and aerobic control groups performed similarly on the tasks. An unexpected finding was that the bodybuilding controls made more mean errors on the visuospatial working memory task than the aerobic exercisers. From a statistical perspective, the two control groups have a much smaller variance on this task than did the AAS group. Although the AAS group has the smallest mean raw score of all the groups, it also has a large confidence interval that includes the means of the two control groups. When all control participants who met inclusion criteria were considered, scores indicated a great deal of interindividual variability on this task (range = 2 to 19).

In addition to determining whether there are group differences on cognitive measures, another method to assess whether a hormone has an influence on cognition is to relate serum hormone levels to cognitive performance. When all three participant groups and unmatched control participants who met study criteria aside from testosterone levels were included in the analysis, it was found that total testosterone was not significantly correlated with performance on any of the cognitive tasks. Due to a small sample of AAS users in the current study, this might have limited the power to observe a relationship between testosterone levels and cognitive abilities. Therefore, further analyses were conducted using only matched and unmatched control participants who

met study criteria aside from testosterone levels. Overall, there were no significant linear or nonlinear associations between testosterone and cognitive abilities. However, a significant quadratic (inverted U-shaped) relationship was noted between circulating total testosterone levels and mental rotation. It appears that intermediate concentrations of testosterone within the physiological range were related to better performance on the mental rotation task, with lower performance related to both decreases and increases in serum testosterone levels.

Mental rotation performance in the current study is strongly supported by a combination of previous research. The literature suggests that gonadal hormones, particularly androgens and estrogens, might modify cognitive patterns in adulthood. Sex differences have been reported in specific cognitive abilities, such as three-dimensional mental rotations. On average, men outperform women on mental rotation, a task that consistently shows one of the largest effect sizes (Linn & Peterson, 1985; Voyer et al., 1995). Diurnal and seasonal intraindividual variations in serum testosterone concentrations in adult males have been associated with changes in spatial performance (Kimura & Hampson, 1994; Moffat & Hampson, 1996). Specifically, men performed better on spatial tasks later in the day or in spring, when testosterone levels were lower. Clinical studies have also shown modifications in spatial performance with testosterone supplementation. Female-to-male transsexuals when given androgen treatment exhibited improvements on a mental rotation task (Van Goozen et al., 1994, 1995). These findings are also consistent with the effects of short-term testosterone supplementation in older men, which raised endogenous testosterone levels and showed improvements in spatial abilities (Cherrier et al., 2001; Janowsky et al., 1994). Lastly, a randomized placebo-

controlled study examining the effects of administration of a moderately supraphysiological dose of testosterone on cognitive functions in healthy eugonadal men found an associated decrease in spatial ability (O'Connor et al., 2001).

Functional neuroimaging studies have demonstrated activation in various regions of the brain. Most studies have shown bilateral activations in the superior parietal lobe, suggesting that this area plays an essential role in mental rotation performance (e.g., Cohen et al., 1996; Richter et al., 2000; Tagaris et al., 1996; Tagaris et al., 1997). Although the parietal cortex is the most robust and consistently activated area, studies have shown that other cortical areas are also activated during mental rotation performance. For example, various regions of the frontal cortex have been shown to be activated during mental rotation performance (Cohen et al., 1996; Richter et al., 2000).

The present study also provided support for the existence of a curvilinear relationship between spatial ability and total testosterone in right-handed healthy men who did not use AAS. As there were only a few AAS users in the current study, there was little power to demonstrate a curvilinear relationship. The research literature is contradictory about the relationship between circulating testosterone levels and spatial abilities in men. Taken together, findings from hormone studies investigating clinical populations and normal healthy men suggest that a curvilinear relationship might exist, such that optimal expression of spatial ability is associated with intermediate levels of circulating testosterone. It is important to note that the curvilinear relationship in the current study was identified for right-handed men. Thus, this relationship might not generalize to left-handers.

Even though the current study found that the AAS users obtained lower scores on the Digit-Symbol Coding subtest than controls, correlational analyses did not find any significant linear or nonlinear relationships with total testosterone. It is possible that the effects are mediated through other gonadal hormones, such as estradiol. As Digit-Symbol Coding requires adequate spatial skills and there was a strong positive correlation between this task and mental rotation, spatial ability might be mediating the effect. Another possibility is that there is an underlying inefficiency to process visual information quickly, resulting in decreased performance on the speeded perceptual task and mental rotations. In a placebo-controlled study by Daly and colleagues (2003), men who received moderately supraphysiological doses of methyltestosterone reported increased distractibility and forgetfulness (Daly et al., 2003).

As this study only considered the cognitive effects of total testosterone, the data do not preclude a relationship between other gonadal hormones and cognitive abilities. For example, estradiol levels in healthy young men were found to be positively associated with two measures of immediate visual memory (Kampen & Sherwin, 1996). In addition, the mechanisms of action for the effects in the current study cannot be adequately addressed. Testosterone could exert its effects directly through androgen receptors in the brain, and/or indirectly through aromatization to estradiol with a subsequent effect via estrogen receptors in the brain. A recent animal study also found evidence that the 5α -reduced androgen, DHT, might enhance cognitive performance (Frye, Edinger, Seliga, & Wawrzycki, 2004). Shute and colleagues (1983) argued that only free testosterone, not the bound form, can pass the blood-brain barrier and hence potentially exert its influence on androgen receptors in the brain that are associated with cognitive

function. Although the current study included multiple hormone measurements (i.e., free testosterone, bioavailable testosterone, total estradiol), these were not included in the data analyses due to reliability concerns. Thus, future studies should include different measures of testosterone (total, free, bioavailable) and its metabolites (estradiol, DHT).

Several potential confounding variables known to influence hormone levels were addressed in the current study (i.e., alcohol/drugs, physical and sexual activity). In addition, the present study controlled for group differences in age, education, and estimated verbal intelligence by matching two control participants to each AAS user. Although data analyses did not show any group differences on these variables, mental rotation scores were negatively associated to age and positively correlated to estimated intelligence. Other factors might also have influenced the results, such as nutrition, use of dietary supplements, and sexuality.

Based on the results of this study, there are multiple lines of evidence to suggest that high doses of exogenous testosterone and/or synthetic steroids might modify spatial ability in males. The mechanisms of action for this effect were not addressed in this study. In addition, it is uncertain whether chronic administration of supraphysiological doses of AAS results in transient or permanent changes in neural organization and cognitive behaviour.

Psychological Findings

Based on available evidence, it was hypothesized that male bodybuilders who use AAS would demonstrate elevated levels of general aggression and certain personality traits (antisocial, narcissistic, neurotic, obsessive-compulsive) relative to non-AAS using men. As the goal of bodybuilding is to shape the body into the mesomorphic sociocultural ideal, this drive might foster increased preoccupation and criticism of one's

physical appearance possibly leading to body image dissatisfaction and abnormal eating patterns. Thus, it was expected that bodybuilders, as a group, would exhibit elevated levels of body image disturbances and disordered eating as compared to the aerobic exercisers. All psychological measures administered in the current study were self-report inventories.

In discussing the psychological results obtained in the current study, findings regarding the main hypotheses and how they relate to the literature will be addressed first. Following this, a discussion of the results generated from exploratory analysis of the psychological profiles of AAS users will be presented in order to provide a more comprehensive understanding of the nature of their psychological and behavioural characteristics.

Aggression. In contrast to predictions, there were no significant differences in general aggression between the AAS users and control groups. To control for the potential confounding factor of weightlifting, the bodybuilding groups (AAS users and bodybuilding controls) were combined to determine whether bodybuilders as a group would endorse higher levels of aggression than aerobic exercisers. This difference failed to reach significance, although there was a trend for the bodybuilders to exhibit elevated levels of aggression as compared to the aerobic exercisers. As compared with the normative sample (Buss & Warren, 2000), two bodybuilders, one in each group, reported higher scores for general aggression.

Aggression or 'roid rage' is one of the most widely publicized behavioural effects of AAS use. Animal studies provide strong evidence of a positive relationship between exogenous testosterone administration and aggressive behaviour in rodents (e.g., Farrell

& McGinnis, 2003; Lumia et al., 1994; Melloni et al., 1997). Nonetheless, caution must be exercised when drawing conclusions from animal studies about psychological effects in humans. Anecdotal and case reports suggest that high doses of AASs might result in highly aggressive and violent behaviour (e.g., Pope & Katz, 1990). Research studies using standardized rating scales with athletes also indicate, on average, significantly higher levels of self-rated aggression during periods of AAS use (e.g., Choi et al., 1990; Choi & Pope, 1994; Parrott et al., 1994; Yates et al., 1992).

Based on the available evidence in the literature, it appears that non-medical use of high doses of AAS is associated with marked aggression in some individuals. It is possible that supraphysiological doses of AASs lower the threshold for aggressive behaviour in individuals with an underlying genetic predisposition. Premorbid personality traits or psychiatric disorders, environmental conditions, and psychosocial stress likely interact in the expression of dysfunctional hostility and aggression. Animal researchers have found that the behavioural effects of AASs were mediated by an animal's social status (e.g., Rejeski, Gregg, Kaplan, & Manuck, 1990). Specifically, injections of exogenous testosterone increased aggressive behaviours in dominant monkeys, but increased submission in the subordinate monkeys. Thus, a genetic vulnerability when combined with a sufficiently stressful environment might increase the probability that an AAS user becomes aggressive or violent.

The present study does not support previous findings that exogenous steroid administration is associated with increased aggression. Although most of the bodybuilders in the current study used multiple steroids in high doses, overall scores fell in the average range for aggression as compared to the normative sample. An aggressive

attitude is often valued in many strength sports, and when directed appropriately could result in greater gains in athletic performance. Thus, mild levels of aggression might facilitate more frequent and intensive weight training sessions.

Personality. As predicted, AAS users reported more antisocial traits than the combined control group. However, as the statistical power was low, post hoc tests failed to identify significant differences in antisocial traits between the AAS users and each separate control group. Mean score for the AAS group on the antisocial personality disorder scale suggests no clinically significant personality dysfunction. However, three AAS users scored above a T score of 70, suggesting the possibility of clinically significant antisocial personality traits. None of the controls showed significantly elevated scores on this scale.

There were also trends for the AAS group to show elevated levels of obsessive-compulsive, narcissistic and neurotic personality traits as compared to the non-AAS using active males; however, differences in mean scores did not reach statistical significance. When compared to the normative sample (Loranger, 2001), all of the current study groups reported high levels of the narcissism personality trait. Nonetheless, mean scores do not suggest a clinically significant personality disturbance. Only one participant, an AAS user, reported an elevated score on the narcissistic personality disorder scale.

Although the majority of AAS users did not exhibit abnormal personality traits, a few AAS users showed elevated scores on the antisocial (38%) and narcissistic (13%) personality disorder scales. It is possible that some of the other personality disorder scales were also elevated; however, they were not analysed in the current study. Other studies have shown a higher prevalence of personality traits in male strength athletes using

AASs. Cooper et al. (1996) found higher levels of abnormal personality traits, such as antisocial and narcissistic, in bodybuilders during periods of AAS use as compared to non-AAS using controls. In another study by Yates and colleagues (1990), AAS-using weightlifters displayed significantly more cluster B personality traits (75%) than non-weightlifting community controls. Similar to the current study, there was a higher prevalence of antisocial traits in the AAS users (45%) than the community controls (0%). However, the finding appears to be due in part to a weightlifter group membership, as the non-AAS using weightlifter controls also had higher rates of Cluster B traits than community controls.

As this study did not control for premorbid personality traits, it is uncertain whether these characteristics are longstanding concerns, consequent to exogenous steroid administration and/or exacerbated by AAS use. In a cross-sectional study, 1 in 3 AAS users satisfied diagnostic criteria for at least one personality disorder prior to AAS exposure (Cooper et al., 1996).

Use of multi-methods, including a self-report inventory to screen for personality disorders and a semi-structured clinical interview to confirm diagnoses, is recommended to increase validity of an assessment. Although collateral information would also be helpful in confirming premorbid and current psychiatric history, this would likely prove to be a difficult task as some of the AAS users in the current study had not informed their significant other of their AAS use. Longitudinal studies using each participant as his own control, comparing symptoms during steroid use with symptoms during non-steroid use, might also help in distinguishing chronic traits that are attributed to a personality disorder and transient states that may improve with non-steroid use.

Body image and eating disorders. As predicted, bodybuilders as a group demonstrated a greater desire for muscularity and a toned body as compared to the aerobic exercisers. When analyzed separately, both the AAS users and bodybuilding controls desired greater muscularity than the aerobic controls. However, only the bodybuilding controls obtained a statistically higher score on the drive for tone scale than the aerobic exercisers. There was a similar trend for the AAS users to report higher drive for tone, though this did not reach the stringent alpha level correction. Using the mean score across the bodybuilding groups provided enhanced power to detect statistical differences. When compared to results of previous studies, the AAS users and bodybuilding controls demonstrated a greater desire for muscularity as compared to male university students (e.g., Davis et al., 2005; McCreary et al., 2005). On the other hand, when compared to a male weightlifting group (Wojtowicz & von Ranson, 2006), only the AAS users obtained a higher mean score.

In contrast to predictions, the bodybuilders as a group did not differ significantly from the aerobic exercisers on any of the other body image or eating disorder measures. Planned comparisons of the AAS-using bodybuilders and non-AAS using bodybuilders provided a validity check of the appropriateness of combining the bodybuilding groups. Results showed no significant group differences on any of the body image and eating disorder measures. When compared to normative data published on these scales, mean scores for the MBSRQ subscales fell within the average range for all the study groups (Cash, 2000). Study participants in all groups also scored in the normal range for the male nonclinical sample (Garner, 2004).

Results of the current study are partially supported by previous research. In the

current study, the high drive for increased muscularity combined with the desire for a well-toned body reflects the characteristic standards in bodybuilding: the pursuit of a lean and hypermesomorphic ideal. A bodybuilder's drive to develop a lean and muscular physique might foster increased preoccupation and criticism of one's physical appearance, possibly leading to body dissatisfaction and abnormal eating patterns. Hausenblas & Carron (1999) identified more bulimic and drive for thinness symptomatology in male athletes involved in aesthetic and weight-dependent sports. Based on elevated eating disorder scores in male bodybuilders and men with a previous history of obesity, Franco and colleagues (1988) suggested that males who are overinvested in their body and physical appearance are at greater risk for developing eating disorders. Bodybuilders often engage in strict weight training regimens, dieting and weight loss practices, and supplementation with various ergogenic aids to develop the mesomorphic ideal. An uncontrolled study demonstrated higher rates of food and weight preoccupation, and more extreme dietary practices amongst competitive bodybuilders (Andersen et al., 1995). Nonetheless, controlled studies investigating body image dissatisfaction and disordered eating in male bodybuilders have shown inconsistent findings.

Blouin & Goldfield (1995) found that male bodybuilders demonstrated greater body dissatisfaction with a higher drive for bulk and thinness, bulimic tendencies, and elevated feelings of perfectionism relative to other male athletes. When investigated further, it was found that the male bodybuilders who used AASs reported greater drive for muscle bulk and bulimic tendencies than the non-AAS using bodybuilders. In another study, male bodybuilders, who are current and ex-AAS users, scored higher for drive for thinness and

a modified version of the EDI body dissatisfaction scale than those in the non-AAS using aerobic and bodybuilding groups (Cole et al., 2003). Nonetheless, only the ex-AAS users scored higher for bulimic tendencies and perfectionism than non-using male bodybuilders and aerobic trainers. Marked pathological preoccupation with muscularity and physical appearance is termed “muscle dysmorphia” (Pope et al., 1997). Male weightlifters with muscle dysmorphia differed significantly from nonclinical comparison weightlifters in terms of body dissatisfaction, eating attitudes, prevalence of AAS use and lifetime prevalence of mood, anxiety and eating disorders, with the nonclinical weightlifters showing little pathology (Choi et al., 2002; Olivardia et al., 2000).

Although results of the present study also suggest some body weight concerns in the bodybuilding groups, in particular a drive for muscularity and a well-toned body, there were no significant differences between the AAS users and bodybuilding controls. Neither bodybuilding group in the current study obtained higher scores on the body image measures (e.g., MBSRQ subscales) than the aerobic exercisers. Although several studies have identified abnormal eating patterns in bodybuilders, the current study did not show any group differences in drive for thinness, bulimic tendencies, and feelings of perfectionism. Both of the bodybuilding groups and aerobic exercisers in the current study also scored in the normal range for the EDI-3 nonclinical male sample (Garner, 2004). Another study found similar results: mean scores on the EDI-2 did not suggest increased eating disorder tendencies in a group of male recreational and competitive bodybuilders as compared to male controls (Anderson, Zager, Hetzler, Nahikian-Nelms, & Syler, 1996).

The majority of AAS users and bodybuilders in the present study exhibited minimal

psychopathology as measured by self-report inventories. However, there was a subgroup of bodybuilders, comprised of 3 AAS users and 1 bodybuilding control, who exhibited significant psychological disturbances. A psychological disturbance was identified as three or more elevations on the psychological scales. Psychological profiles differed between these bodybuilders, with elevated scores for general aggression, personality, body image, and/or abnormal eating patterns. Although many researchers attribute the psychological effects to AAS use, it is important to consider potential premorbid factors. For example, one AAS user reported a history of teenage obesity and depression, with likely longstanding concerns with body image. He started using AASs to combat obesity, and the steroids have reportedly amplified his negative body image concerns. In addition, a semi-structured diagnostic interview might have identified additional pathology in the current sample.

Limitations of the Current Study

Interpretation of the results should be considered in conjunction with the associated methodological limitations. Limitations of the present study involve three main concerns: (1) nature of the sample, (2) reliability and validity of self-report, and (3) reliability and validity of outcome measures.

Nature of the sample. When discussing generalizability of the findings, the size and characteristics of the sample need to be considered. In the current study, the sample size was very small due to stringent study criteria and difficulties in participant recruitment. This small sample size might have limited the ability to detect small but important changes in cognitive and psychological variables. While inclusion and exclusion criteria might have potentially affected the external validity of the study findings, these criteria

were necessary to rule-out potential confounding effects of medical and psychological abnormalities on cognitive functions. Additional studies conducted with larger sample sizes are needed to clarify the effects of non-medical AAS use on cognitive abilities and psychological characteristics in male bodybuilders. Larger samples are also necessary as the effect sizes are likely to be small due to the significant overlap in cognitive performance between men with similar education and intellectual abilities.

Recruitment of AAS users for the study was an arduous task. Participation rate was likely limited in part to concerns regarding confidentiality and potential legal ramifications of admitting AAS use. For example, some AAS users questioned the legitimacy of the research project on an internet posting, commenting that it might be a front for a 'sting operation.' This reluctance to participate might have led to a selection bias in the AAS group, with study participants being more open about their AAS use. It is also possible that AAS users with less prominent psychopathology volunteered for the study. Other studies have reported similar difficulties with recruiting AAS users (e.g., Cole et al., 2003; Fudala et al., 2003). Obtaining control participants was more straightforward by comparison.

Other participant specific factors that could also have influenced the results were prior clinical concerns such as depression and/or anxiety, attention deficit disorder (ADD), and traumatic brain injury or concussions. Two bodybuilders (one in each group) described prior anxiety and/or depressive symptoms, and the bodybuilding control also reported a diagnosis of adult ADD. They also reported higher levels of psychological symptoms on some objective measures in the current study. For the AAS user, it is difficult to differentiate the effects of AAS from his prior psychological history.

However, while having experienced blows to the head was relatively common among study participants in each group, no one had a history of a head injury in the moderate to severe range.

Although the principal investigator attempted to recruit competitive bodybuilders for the current study, recreational and competitive bodybuilders were included in both bodybuilding groups due to difficulties with recruitment. Bodybuilders in the current study described weight lifting for primarily hypertrophy or strength purposes, and showed more dependence on the social aspects of bodybuilding training. However, a distinction among subgroups of bodybuilders might help to differentiate inconsistent findings in the literature concerning aggression, muscle dysmorphia, eating disorders, and personality traits.

The current AAS regimens varied widely between participants, such as types, combinations, dosages, and patterns of use. A randomized controlled design would allow for standardization of steroids across participants, minimizing ambiguity about the source of group differences. However, this is at a loss of ecological validity because it does not represent non-medical steroid use in the bodybuilding community. Most clinical studies examine the effects of a single AAS at therapeutic dosages, which is typically less than doses used by bodybuilders. Thus, clinical studies are unable to identify the extent of actual side effects. As previous research studies have found increased frequency of physical and psychological side effects with supraphysiological doses of testosterone and/or synthetic steroids (e.g., Pagonis et al., 2006), it is unlikely that steroid regimens commonly used by strength athletes could be used in long-term clinical trials. Thus, findings from naturalistic studies provide an important complement to randomized

clinical trials. The steroid regimens of bodybuilders in the current study closely approximate non-medical patterns described by other researchers (e.g., Fudala et al., 2003; Pagonis et al., 2006).

Reliability and validity of self-report. There are often inherent methodological limitations in using self-report measures to document drug use. These methods rely on valid self-reporting of sensitive behaviour, which may generate inaccurate reporting. Although assured confidentiality of the current study should minimize the incentive to exaggerate usage by bragging or failing to disclose AAS use by the control participants, dishonest positive and negative responses cannot be fully excluded.

Bodybuilding is a unique sport in that AAS are very much a part of the bodybuilding culture. Since steroids are an accepted aspect of this sport and are only banned from 'natural' bodybuilding competitions, it was initially felt that bodybuilders would be more willing to discuss their steroid use. However, due to difficulties with recruitment, the principal investigator recognized that being a part of the 'subculture' is likely an important aspect of gaining trust among AAS users. Although only a few AAS users participated in the study, it was felt that they were open about their drug use as suggested by their willingness to participate and their interest in learning about the study. In addition, the hormonal profile of the AAS users was consistent with the use of exogenous steroids, thus providing indirect validation of current AAS use.

Overall, self-report methods help to delineate attitudes and behaviours among AAS users. Some research studies have found no inconsistencies between self-reported AAS use and urinalysis, suggesting that self-report might be a reliable measure in this context (Bond et al., 1995; Pope and Katz, 1994). However, urinalysis would have greatly

enhanced confidence in the accuracy of self-report in both the AAS users and controls. The dosage or identity of the self-reported drugs can only be confirmed by objective measurement of these substances. As several bodybuilders obtained their AAS from the “black market”, the potency and type of drugs might not be what they think they are taking. In a recent study, high performance liquid chromatography using mass spectrometry detection was used to ensure the validity of steroids that were of unknown origin and/or were purchased from the black market (Pagonis et al., 2006). These researchers identified a large group of individuals who thought they were using AAS, but in fact were only using placebo drugs. Urinalysis might also identify other active steroids or performance-enhancing drugs besides those reported by the participant. Although urine testing would be the best confirmatory approach, this was not feasible in the current study as it is an expensive method of AAS detection. Nonetheless, researchers should consider including urinalysis as an objective measure of AAS use.

Reliability and validity of outcome measures. The significance of study results also depends on the reliability and validity of outcome measures. Overall, the psychometric properties of the cognitive and psychological measures were adequate. Although the principal investigator chose cognitive measures that have shown sex-related differences, some of these measures might not have been sensitive to detecting subtle cognitive changes. It is also possible that the effects of AAS are not limited to tasks where there are observed sex differences. For example, in a randomized controlled study, men receiving moderately supraphysiological doses of testosterone reported increased symptoms of distractibility and forgetfulness (Daly et al., 2003). It is possible that AAS might have a generalized effect on cognitive functioning, such as reducing attention.

Inclusion of a semi-structured diagnostic interview would have been helpful in clarifying the nature and severity of self-reported body image dissatisfaction, disordered eating, and personality traits. It is also possible that some of the AAS-using bodybuilders met criteria for current anabolic-androgenic substance dependence or abuse. Lastly, a structured clinical interview would have confirmed the severity of previous illicit drug use, anxiety, and depressive symptoms.

Although total estradiol as well as free and bioavailable testosterone were measured in the present study, they were not included in any statistical analyses due to concerns with the sensitivity and reliability of the measures. It is possible that this study missed identifying some important relationships between these steroid hormones and cognition.

Due to the cognitive hypotheses, blood specimen collection was conducted in the afternoon immediately following the testing sessions. This is not the typical approach for most hormone studies, with serum collection typically occurring early in the morning when testosterone levels are at higher. As research has shown enhanced performance on spatial tasks when testosterone levels are low, testing later in the day might ensure a male-typical pattern of performance among controls. Timing of blood specimen collection should be taken into consideration when comparing results of research studies.

Lastly, another concern was the potential effects of fatigue and effort on test performance. Fatigue and/or poor effort can lead to suboptimal performance on cognitive measures. As the testing sessions ranged in length from 2.5 to 3.5 hours, and most participants chose to complete sessions without any breaks, it is possible that some participants started to tire towards the end of the session. Nonetheless, it is not expected that fatigue had an effect on mental rotation scores in the AAS group, as there were no

significant group differences on any of the other measures (i.e., Letter-Number Sequencing, SOPT, verbal fluency) completed towards the end of the session. The investigator also attempted to reduce potential adverse effects of fatigue and decreased effort. All participants who demonstrated significant fatigue or decreased effort on test measures were excluded from the statistical analyses.

Implications and Future Directions

Notwithstanding the above limitations, the results of this preliminary study provide some useful insights into the potential activating effects of exogenous testosterone supplementation on sex-related cognitive abilities. This is the first study to examine the cognitive abilities of male bodybuilders who administer non-medical AAS regimens. There is some evidence that high doses of exogenous testosterone and/or synthetic steroids in males might influence some aspects of cognition, specifically reducing complex visuospatial skills and perceptual speed. Although the AAS users performed lower than the controls, mean scores on these tasks would not be considered impaired. However, it is uncertain whether chronic administration or higher dosages of multiple combinations of AASs would result in further detriments in performance, and exert transient or permanent changes in neural organization and cognitive abilities.

The study also provided support for the existence of a curvilinear relationship between spatial ability and total testosterone in right-handed healthy men who did not use AASs. It appears that intermediate concentrations of testosterone within the physiological range were related to better performance on the mental rotation task, with lower performance related to both decreases and increases in serum testosterone levels. The results complement previous hormone studies investigating endogenous testosterone

levels and exogenous testosterone supplementation in clinical populations and healthy men. Collectively, these studies suggest that optimal spatial performance might be related to intermediate testosterone levels. As this study only investigated right-handed healthy active men, this information might not generalize to left-handers. Due to the small sample of AAS users in the current study, this might have also limited the power to observe a relationship between testosterone levels and spatial ability. Replication studies with larger samples of AAS users are required to determine the relationship between supraphysiological testosterone levels and cognitive performance.

As this study only considered the cognitive effects of total testosterone, the data do not preclude a relationship between other gonadal hormones and cognitive abilities. In addition, the mechanisms of action for the cognitive effects could not be adequately addressed in the current study. Future studies investigating cognitive abilities in AAS users should include different measures of testosterone (total, free, bioavailable) and its metabolites (estradiol).

The study also contributes to the growing literature on psychological effects of bodybuilding and AAS use. Not all AAS users and non-using bodybuilders demonstrate clinically significant pathological attitudes and behaviours. Nonetheless, there appears to be a subgroup of AAS users (and bodybuilders) who exhibit significant disturbances in several psychological domains. Researchers will need to be vigilant in controlling for potential confounding factors, including premorbid medical and psychiatric history, weightlifting, and diet, in order to draw strong conclusions. It remains to be determined whether psychological and behavioural symptoms are either a cause or a direct effect of AAS use.

Current research suggests some body weight concerns in the bodybuilding groups, specifically a drive for muscularity combined with a drive for a well-toned body. Given the emphasis on development of muscularity, muscular definition, and symmetry in the sport of bodybuilding, bodybuilders walk a very fine line between safe and pathogenic attitudes and weight control behaviours. Some individuals may not recover from the temporary disordered attitudes and eating practices associated with bodybuilding, and thus might develop longstanding pathological body image disturbances and eating disorders. There is a need for more research to identify risk factors associated with the development of psychopathology and AAS use in male bodybuilders. Inclusion of competitive and recreational bodybuilders, in addition to current users and non-users, might help delineate inconsistent findings in the research literature. Psychological profiles of AAS-using athletes and non-athletes should also be investigated.

Future research should continue to assess the effects of non-medical AAS use on cognitive abilities and psychological functioning. Aside from capturing a single time point, longitudinal studies using AAS users as their own controls would be another viable option to test altered cognitive and psychological effects of steroid use. This would provide an opportunity to track effects of acute and chronic use, as well as single and multiple combinations of AASs. Testing could occur at various intervals, comparing effects during cycles of steroid use with non-steroid use, and after cessation of AASs. This would help us better understand whether specific steroid regimens (e.g., types, dosages, combinations) exert transient or permanent changes in cognitive abilities and psychological symptomatology. As recruitment proved to be a difficult task with this population, case studies using ABA designs and indepth interviews might be a useful

method to study the cognitive and psychological effects of non-medical AAS use.

Another interesting question would be to investigate the cognitive effects of AASs in women.

Ongoing investigations of the effects of non-medical AAS use on cognitive abilities and psychological functioning will be an important aspect to better understanding the risks and benefits of AAS use, and to the consideration of effective modes of treatment. Despite athletic associations banning these substances and warnings about the potentially adverse consequences, athletes and non-athletes will continue to use these substances for lean muscle development, muscular strength, athletic performance, and even purely for aesthetic reasons. As researchers, we can provide athletes and the general population with a balanced view of the risks and benefits of AAS use to help promote educated choices.

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Appendix A: Information Letter

INFORMATION LETTER FOR RESEARCH STUDY ON THE EFFECTS OF HORMONES ON COGNITION AND PSYCHOLOGICAL FUNCTIONING

Dear Participants,

You are invited to participate in a study entitled "Activational effects of exogenous steroid hormones on cognitive performance: A study of anabolic-androgenic steroids in men." This study is being conducted by myself, Sandra Mish, a graduate student in the Clinical Psychology program at the University of Victoria, as part of my doctoral dissertation.

FUNDING

This research is being funded in part by the Canadian Institute for Health Research, University of Victoria/Michael Smith Foundation, and Lions Gate Healthcare Research Foundation.

PURPOSE

This study investigates the effects of anabolic steroids on cognitive abilities (one's ability to think, reason, and remember) in men who use steroids. Another goal is to evaluate the emotional well-being and personality characteristics of these individuals. To get a better understanding of the cognitive and psychological effects of anabolic steroid use, I will be assessing men who use steroids (males serious about weight training) as well as men who do not use steroids (males serious about weight training, and males involved in regular aerobic activities).

WHY IS THIS RESEARCH IMPORTANT?

Steroid use has increased substantially over the past few decades. Many athletes take anabolic steroids for their 'muscle building' properties, as well as to enhance their athletic performance. There is very little information regarding the effects of anabolic steroids on cognitive abilities. Psychological effects and personality characteristics have also been less extensively studied than health risks and the muscle-building properties of steroids. It is important to study the short-term and long-term effects of anabolic steroid use to promote educated and healthy decisions

WHAT IS INVOLVED:

If you decide to participate in this study, you will be asked to volunteer approximately 4 to 4 ½ hours of your time. A package of forms (asking you about your medical history, pattern of substance use, athletic endeavours, etc...) will be mailed to you, which will take about 1 hour to complete. You will be asked to bring the completed forms to your session. The session will be set up at your convenience (either at the University of Victoria, in Duncan, Nanaimo, or Vancouver area), requiring about 2½ to 3 hours of your time. During this time, you will be asked to complete:

- a) a brief interview
- b) some tasks that require thinking skills, such as responding to questions, drawing, and solving problems.
- c) questionnaires that will ask you how you have been feeling and describe what you think about yourself.

After you have completed your session, you will be sent to an MDS Metro Lab close by for blood collection (this should take no more than ½ hour of your time). No more than 12 ml of blood will be taken. The following tests will be done on the blood collected – total, free and bioavailable testosterone, total estradiol, albumin, and sex-hormone binding globulin. We are not testing for drugs. Your blood samples will not be used for any other purpose than those outlined in the study.

When these tests are done, your blood samples will be destroyed within 7 days. With your agreement, I would like to contact you again in about a week to provide you with the blood test results.

You will receive \$40 and a t-shirt from *Reflex* to acknowledge your time and contribution to the study, as well as to compensate for expenses associated with your participation. You will receive compensation after your session at MDS.

POTENTIAL RISKS

Given that the tasks require brain power, you might feel slightly fatigued during testing. If you experience some fatigue, you will be offered a break(s). If you are too fatigued to complete all the tasks, the session will be discontinued and rescheduled at another convenient time for you.

Blood collection is generally considered to be a safe procedure. Because the amount of blood taken is small, individuals typically do not feel any ill effects. However, blood drawing does involve some risks, including discomfort from insertion of the needle (common), feeling light-headed or fainting (infrequent), bruising at puncture site (infrequent), and infection at the same site (rare). MDS Metro Laboratory Services follows strict safety guidelines for blood collection and will take every precaution to protect your safety. There is always a doctor on site in case of an emergency. If you feel any ill effects after leaving MDS, please see a doctor immediately.

Blood test results are reported with 'reference ranges' (referred to as the 'normal' range of test results). 95% of healthy people have values within this range. About 5% of healthy individuals fall outside the 'normal range.' A test result that falls outside this range (an 'abnormal' value) does not necessarily mean that there is something wrong. In the event of an abnormal blood test result, you will be contacted and sent a copy of the results. Although an 'abnormal' test result may or may not indicate a problem, you are strongly encouraged to consult with your physician.

POTENTIAL BENEFITS

This study may be of benefit to you. You will be provided with general information regarding blood test results – 'within normal limits' or 'abnormal result(s)'. On a broader level, information gained from this study might increase our knowledge about the benefits and risks of using anabolic steroids, and provide resources for steroid education in schools and in the community. Specifically, it might help us better understand the effects of anabolic steroids on cognitive abilities and emotional well-being.

CONSENT

Your participation in this study must be completely voluntary. If you decide to participate, you have the right to refuse to answer any questions you do not want to answer. You may withdraw from the study at any time without explanation or negative consequences. Doing so will not affect any current or future involvement you may have with the university. If you choose to withdraw before completion of the study, you will still be offered compensation for your participation (t-shirt from *Reflex* and payment for parking). In addition, all of the information that has been collected will be destroyed immediately. Regardless of your decision to continue with, or withdraw from, the study, we can discuss your concerns at the end of a test or of the session.

CONFIDENTIALITY

Individuals and organizations involved in recruitment will not be informed of whether or not you decide to participate in the study. Information that you provide in this study is confidential and will have no impact on your education, work, medical status, and/or athletic endeavours.

My research assistant, Kate Randall, is a graduate student in the Clinical Psychology program at the University of Victoria. She is well-informed in the confidentiality process (according to the Canadian & American Psychological Code of Ethics), and will complete an oath of confidentiality prior to assistance with this study.

Any information that is obtained during this study will be kept in strictest confidence. In the event that there is evidence of immediate and serious harm to self, I will contact, with your permission, a family member or friend to support you in this matter.

To protect your identity, **YOU MUST NOT IDENTIFY YOURSELF**. You will provide a false name to use at all times throughout the study, or simply do not use any name in your discussions. You will also be assigned a code number so that your name will not appear on any of the paper forms.

MDS Metro Laboratory Services will only be provided with your code number and a 'default' birth date. They require a birth date in order to match your results with reference ranges. However, we will **only** require your month and year of birth.

I will be keeping an information sheet (with your 'fake name', address, and telephone number) so that I can contact you about the blood test results. Only the principal investigator, Sandra Mish, will have access to this information. Your information sheet will be securely stored in a locked cabinet separate from any of the paper forms, and will be shredded immediately after you receive general information about your blood test results. The paper forms used in this study will also be kept in a locked cabinet and shredded 5 years after completion of the study. Access to test results (paper forms) will be restricted to the principal investigator, supervisor, and research assistant.

Information from this study will be included in a doctoral dissertation, and may later be submitted for publication in a scientific journal or book. Results might also be presented at scholarly meetings, workshops, and presentations at schools, worksites, or for athletic teams/organizations. This information might also be used for educational purposes (e.g., information sheet on benefits and risks of steroid use, story in newspaper or on an internet website). Presentations and published results will not connect you with any of the information you provide.

QUESTIONS:

You may contact me at (250) 472-4339 or at smish@uvic.ca if you have any further questions. Dr. Catherine Mateer, my supervisor at the University of Victoria, can be reached at (250) 721-8590.

In addition to being able to contact me and my supervisor at the above phone numbers, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President Research at (250) 472-4545 or ovprhe@uvic.ca.

Thank you,

Sandra Mish, M.Sc.
Graduate Student in Clinical Psychology
University of Victoria

By completing and returning the forms, you are providing consent to participate in this study.

Appendix B: Consent Form

Participant Consent Form

THE STUDY

You are invited to participate in a study entitled "Activational effects of exogenous steroid hormones on cognitive performance: A study of anabolic-androgenic steroids in men." This study is being conducted by myself, Sandra Mish, a graduate student in the Clinical Psychology program at the University of Victoria, as part of my doctoral dissertation. You may contact me at (250) 472-4339 or at smish@uvic.ca if you have any further questions. Dr. Catherine Mateer, my supervisor at the University of Victoria, can be reached at (250) 721-8590.

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MDS Metro Laboratory Services will only be provided with your code number and a 'default' birth date. They require a birth date in order to match your results with reference ranges. However, we will **only** require your month and year of birth.

I will be keeping an information sheet (with your 'fake name', address, and telephone number) so that I can contact you about the blood test results. Only the principal investigator, Sandra Mish, will have access to this information. Your information sheet will be securely stored in a locked cabinet separate from any of the paper forms, and will be shredded immediately after you receive general information about your blood test results. The paper forms used in this study will also be kept in a locked cabinet and shredded 5 years after completion of the study. Access to test results (paper forms) will be restricted to the principal investigator, supervisor, and research assistant.

Information from this study will be included in a doctoral dissertation, and may later be submitted for publication in a scientific journal or book. Results might also be presented at scholarly meetings, workshops, and presentations at schools, worksites, or for athletic teams/organizations. This information might also be used for educational purposes (e.g., information sheet on benefits and risks of steroid use, story in newspaper or on an internet website). Presentations and published results will not connect you with any of the information you provide.

QUESTIONS:

In addition to being able to contact me and my supervisor at the above phone numbers, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Associate Vice-President Research at (250) 472-4545 or ovprhe@uvic.ca.

You are invited to ask any questions you may have about this study or your participation in it. Your verbal consent indicates that you have read this form and understand the conditions of participation in this study, and that the researcher has answered all questions to your satisfaction.

You will be given a copy of this consent form.

Appendix C: Screening Questions

Screening Questions (Initial telephone contact)

The following questions will be asked to determine whether participants meet inclusion criteria for this study.

- 1) How old are you? _____
- 2) What hand do you write with? _____
- 3) Primary language spoken at home? _____
- 4) How many years of education? _____
- 5) Do you smoke cigarettes? **Y / N**
 If yes, how many cigarettes do you smoke/wk? _____
- 5) Do you have a history of (have you been diagnosed with):

learning disabilities/attention problems in school (e.g., LD, ADHD)	Y / N
neurological, endocrine, or metabolic abnormalities	Y / N
other medical problems (e.g., head injury, asthma)	Y / N
mental health problems (e.g., depression, anxiety)	Y / N
current alcohol or drug abuse problems (as per DHQ)	Y / N
- 6) How many days per week are you physically active? _____
 Are you a bodybuilder? **Y / N**
 If yes, how often do you work out? _____
 How long are your work-out sessions? _____
 How long have you been strength training? _____
 Do you do cardio regularly? How often? _____
 If no, are you active? **Y / N**
 How do you keep active? _____
 What types of aerobic activity are you involved in? _____
 How often do you do aerobic activities? And how long for each session? _____

 How long have you been active? _____
 Do you weight train? **Y / N**
- 7) Are you currently using anabolic-androgenic steroids? **Y / N**
 If not, have you ever used them in the past? **Y / N**
 If yes, when was the last time you used steroids? _____

Appendix D: Health History Form

ID: _____

HEALTH HISTORY FORM

Please complete the following information to the best of your knowledge. Answer all questions as honestly and accurately as possible – make sure you answer questions on **BOTH** sides of the pages. **All information contained in this form is strictly confidential.** A number will be assigned to ensure that there is no identifying name attached to the form. By completing and returning this form, you are providing consent to participate in this research. Thank-you!

PERSONAL HISTORY

Today's Date: _____ Age: _____

Primary language spoken at home: _____ Hand used for writing: _____

Ethnic Origin (check one)

- | | | |
|---|---|--|
| <input type="checkbox"/> Caucasian | <input type="checkbox"/> Black / African American | <input type="checkbox"/> First Nations |
| <input type="checkbox"/> Hispanic | <input type="checkbox"/> Native American | <input type="checkbox"/> Asian |
| <input type="checkbox"/> Native Hawaiian / Pacific Islander | | |
| <input type="checkbox"/> Biracial (Please describe: _____) | | |
| <input type="checkbox"/> Other (Please describe: _____) | | |

What is the highest level of education you have attained? (highest grade, year of school, and/or degree completed?) _____

Are you currently a student? (check one) Yes NoAre you currently employed? (check one) Yes No

If yes, please specify if part-time or full-time work _____

If no, have you been employed in the past? Yes No

Current Annual Income (check one)

- | | | |
|--|---|--|
| <input type="checkbox"/> <\$20,000 | <input type="checkbox"/> \$20,000-\$39,999 | <input type="checkbox"/> \$40,000-\$59,999 |
| <input type="checkbox"/> \$60,000-\$79,999 | <input type="checkbox"/> \$80,000-\$100,000 | <input type="checkbox"/> over \$100,000 |

Marital Status (check one)

- | | | |
|---|------------------------------------|-------------------------------------|
| <input type="checkbox"/> Single / never married | <input type="checkbox"/> Married | <input type="checkbox"/> Common-law |
| <input type="checkbox"/> Divorced / separated | <input type="checkbox"/> Remarried | <input type="checkbox"/> Widowed |

MEDICAL HEALTH

How would you rate your current overall health (check one)

- | | | |
|------------------------------------|------------------------------------|-------------------------------|
| <input type="checkbox"/> Excellent | <input type="checkbox"/> Very good | <input type="checkbox"/> Good |
| <input type="checkbox"/> Fair | <input type="checkbox"/> Poor | |

Childhood Illnesses (check all that apply)

- | | | |
|----------------------------------|--|-------------------------------------|
| <input type="checkbox"/> Measles | <input type="checkbox"/> Mumps | <input type="checkbox"/> Chickenpox |
| <input type="checkbox"/> Rubella | <input type="checkbox"/> Rheumatic Fever | <input type="checkbox"/> Polio |

Have you experienced any of the following? Please check one, and if yes, describe in space provided.

Note: Medical problems PRIOR to anabolic/androgenic steroid use (for those who use steroids).

- | | | | |
|--|------------------------------|-----------------------------|-------|
| Problems at birth or with early development | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Developmental delay | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Serious illnesses | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Hospitalizations / Major surgeries | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Major falls/sports accidents/industrial injuries | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Motor vehicle accidents | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Head injuries | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Loss of consciousness | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Back or neck injury | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Seizures | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Stroke | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Diabetes, heart disease or cancer | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Tics | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Allergies or asthma | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Eye problems | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Hearing problems/Ear infections | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Other (please describe) | | | _____ |
| | | | _____ |
| | | | _____ |

MENTAL HEALTH

Have you been diagnosed with any of the following? Please check one, and if yes, describe in space provided. Note: Mental health problems PRIOR to anabolic/androgenic steroid use (for those who use steroids).

- | | | | |
|------------------------------------|------------------------------|-----------------------------|-------|
| Learning Disabilities | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Language Problems | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| ADHD | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Oppositional Defiant Disorder | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Conduct Disorder | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Depression | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Mania / hypomania | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Anxiety | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |
| Psychotic episodes / schizophrenia | <input type="checkbox"/> Yes | <input type="checkbox"/> No | _____ |

Eating disorders Yes No _____

Other (please describe) _____

Please check one box: (**PRIOR** to anabolic/androgenic steroid use – for those who use steroids).

Have you ever had thoughts about harming yourself or committing suicide? Yes No

Have you ever been in counselling or under psychiatric care? Yes No

Have you ever been prescribed medications (for previous conditions)? Yes No

Have you ever been hospitalized (for previous conditions)? Yes No

SUBSTANCE USE

Tobacco

Have you ever smoked a cigarette? Yes No

If yes, at what age did you start? _____

When was the last time? _____

Do you currently smoke cigarettes? Yes No

How many cigarettes do you smoke per week (on average)? _____

Do you currently use other tobacco products?

Snuff Yes No

Cigars Yes No

Chewing tobacco Yes No

Other (specify: _____) Yes No

If yes, how much do you use per week for each (on average)? _____

Alcohol

Have you ever tried beer, wine, or other liquor? Yes No

If yes, at what age did you start? _____

When was the last time? _____

Have you ever been drunk? Yes No

Do you currently drink alcohol? Yes No

How many drinks per occasion (on average)? _____

How many drinks per week (on average)? _____

What do you typically like to drink? (e.g., beer, wine, coolers, hard liquor) _____

Street Drugs

Have you ever tried any street drugs such as marijuana/hashish, ecstasy, crystal meth, cocaine, crack, heroin, LSD, mushrooms, peyote, mescaline, and other? Yes No

If yes, which ones? _____

At what age did you start? _____

When was the last time? _____

Do you currently use any of the street drugs? Yes No

How often per week (on average) for each drug? _____

Anabolic/Androgenic Steroids

Have you ever used steroids or any other muscle-enhancing drugs (e.g., GH, clenbuterol)?

Yes No

If you answered no, continue answering from the stars (***) , **until end of page 7.**

Do you currently use steroids or any other muscle-enhancing drugs (e.g., GH, clenbuterol)?

Yes No

If no, when was the last time? _____

If you answered no, continue answering from the stars (***) , **until end of page 7.**

If you answered yes, **please skip to page 8**

*** Have you ever heard of steroids? Yes No

Have you ever considered taking steroids? Yes No

If yes, why would you try steroids? _____

How serious are you in trying steroids? _____

LIFESTYLE

Sports / Exercise

Have you always been active? Yes No

Do you play any sports (besides bodybuilding)? Yes No

At what age did you become involved in sports? _____

What do you currently play? _____

How long have you been involved in the current sport(s)? _____

How often do you play sports?

Days per week (on average)? _____

Minutes / hours each day (on average)? _____

Why do you play sports? _____

How do you feel after playing sports? _____

Do you do any aerobic exercise (cardio)? Yes No

At what age did you start exercising (aerobic exercise)? _____

What types of aerobic exercise do you do (e.g., jogging, biking, etc...) _____

How long have you been involved in current aerobic activities? _____

How often do you do aerobic exercise?

Days per week (on average)? _____

Minutes / hours each day (on average)? _____

Why are you involved in aerobic exercise? _____

How do you feel after aerobic exercise? _____

Do you lift weights? Yes No

At what age did you start lifting weights? _____

How long have you been weight lifting? _____

How often do you lift weights?

Days per week (on average)? _____

Minutes / hours each day (on average)? _____

Why do you weight train? _____

How do you feel after a workout? _____

What is your maximum bench press? _____

Have you ever been involved in bodybuilding competitions? Yes No

At what age did you start bodybuilding? _____

How long have you been a bodybuilder? _____

How many competitions have you been in? _____

What type of competitions? (e.g., amateur, pro) _____

Are you entering a competition(s) this year? Yes No

Do you have any plans to do a bodybuilding competition(s) in the future? Yes No

Nutrition / Diet

Do you eat healthy? Yes No

How often do you eat? (# meals/day) _____

Give an estimate of your current daily caloric intake _____

Have you ever dieted? Yes No

If yes, please describe: _____

Do you currently follow a special diet? Yes No

If yes, please describe (**competitive bodybuilders/strength athletes, fill section below**): _____

For competitive bodybuilders/strength athletes:

Describe your off-season diet _____

Describe your pre-contest diet _____

Are you happy with your current weight? Yes No

If no, do you wish you were more muscular? Yes No

If no, do you wish you were thinner? Yes No

Have you ever done any of the following to lose weight? (check all that apply)

Skipped Meals Taken pills or other medications (e.g., diet pills, diuretics)

Caused vomiting Used laxatives Exercised excessively

Caffeine

Do you drink any caffeinated drinks? Yes No

If yes, what is your current intake:

Coffee ____ cups/day

Tea ____ cups/day

Soda ____ cans/day

Other (specify: _____)

Do you consume any other food or products with caffeine? Yes No

If yes, what is your current intake:

Chocolate ____ oz./day

Caffeine pills ____ tabs/day

Guarana ____ tabs/day

Other (specify: _____)

Vitamins, herbs, supplements, & other substances

Do you currently take any vitamins, herbals, and supplements? Yes No

What do you take on a regular basis? For each item, describe what you take, daily intake (mg/day & # times/day or mg/week & # times/week), and why you take the substance?

Vitamins (e.g., multi, Vitamin C, E, etc...) _____

Minerals (e.g., selenium, chromium, etc...) _____

Amino acids (BCAA, glutamine, etc...) _____

L-carnitine _____

Creatine _____

Protein powder (whey, soy, etc...) _____

Sodium bicarbonate _____

DHEA _____

HMB _____

ECA stacks (ephedrine/caffeine/aspirin) _____

Herbals (e.g., ginseng, bee pollen, tribulus terrestris, yohimbine, kava kava, guarana, ginko biloba, etc...) _____

Other stimulants (amphetamines, ephedrine, Ma Huang, Ephedra, etc...) _____

Non-narcotic / narcotic analgesics (e.g., aspirin, ASA, Ibuprofen, codeine, Nubain, Vioxx, etc...) _____

Other (please describe) _____

Sleep

Overall, do you sleep well? Yes No

If no, describe your sleep difficulties (e.g., difficulty falling asleep, waking up several times in the night, problems falling back to sleep, nightmares, etc...) _____

Medications

List of current prescribed medication(s) (specify why you require the medication): _____

Additional Remarks

Please add any additional remarks here: _____

You are finished! Thank-you for taking the time to fill in this questionnaire!

LIFESTYLE (To be answered by bodybuilders/strength athletes who use anabolic/androgenic steroids)

Sports / Exercise

- Have you always been active? Yes No
- Do you play any sports (besides bodybuilding)? Yes No
- At what age did you become involved in sports? _____
- What do you currently play? _____
- _____
- How long have you been involved in the current sport(s)? _____
- How often do you play sports?
- Days per week (on average)? _____
- Minutes / hours each day (on average)? _____
- Why do you play sports? _____
- How do you feel after playing sports? _____
- Do you do any aerobic exercise (cardio)? Yes No
- At what age did you start exercising (aerobic exercise)? _____
- What types of aerobic exercise do you do (e.g., jogging, biking, etc...) _____
- _____
- How long have you been involved in current aerobic activities? _____
- How often do you do aerobic exercise?
- Days per week (on average)? _____
- Minutes / hours each day (on average)? _____
- Why are you involved in aerobic exercise? _____
- How do you feel after aerobic exercise? _____
- Do you lift weights? Yes No
- At what age did you start lifting weights? _____
- How long have you been weight lifting? _____
- How often do you lift weights?
- Days per week (on average)? _____
- Minutes / hours each day (on average)? _____
- Why do you weight train? _____
- How do you feel after a workout? _____
- What is your maximum bench press? _____
- Have you ever been involved in bodybuilding competitions? Yes No
- At what age did you start bodybuilding? _____
- How long have you been a bodybuilder? _____

How many competitions have you been in? _____

What type of competitions? (e.g., amateur, pro) _____

Are you entering a competition(s) this year? Yes No

Do you have any plans to do a bodybuilding competition(s) in the future? Yes No

Nutrition / Diet

Do you eat healthy? Yes No

How often do you eat? (# meals/day) _____

Give an estimate of your current daily caloric intake _____

Have you ever dieted? Yes No

If yes, please describe: _____

Do you currently follow a special diet? Yes No

Describe your off-season diet _____

Describe your pre-contest diet _____

Are you happy with your current weight? Yes No

If no, do you wish you were more muscular? Yes No

If no, do you wish you were thinner? Yes No

Caffeine

Do you drink any caffeinated drinks? Yes No

If yes, what is your current intake:

Coffee ____ cups/day Tea ____ cups/day

Soda ____ cans/day Other (specify: _____)

Do you consume any other food or products with caffeine? Yes No

If yes, what is your current intake:

Chocolate ____ oz./day Caffeine pills ____ tabs/day

Guarana ____ tabs/day Other (specify: _____)

Anabolic / Androgenic Steroids

At what age did you start taking steroids? _____

How many years have you been taking steroids? _____

How many years since current cycle? _____

Why do you take steroids? _____

Where do you get your steroids (e.g., black market, pharmacy, doctor, etc. – **DO NOT provide any identifying information – names or company, etc.**) _____

What different methods do you typically use?

- Cycling Typical duration (# of weeks? Or continuous?) _____
- Pyramid
- Stacking
- Other (please describe) _____

Current cycle

What steroids are you taking during your current cycle? Please check all that apply. Note average dose/week, method of administration (IM, oral, etc...)

- Anavar _____ Anadrol-50 _____
- Deca-Durabolin _____ Dianabol _____
- Durabolin _____ Equipoise _____
- Halotestin _____ Masteron _____
- Nilevar _____ Primobolan _____
- Proviron _____ Sustanon 250 _____
- Teslac _____ Trenbolone _____
- Winstrol _____ testosterone _____
- testosterone cypionate _____
- testosterone enanthate _____
- testosterone propionate _____
- Others (please specify) _____

What other substances / products are you currently using? Please check all that apply. Note average dose/week, method of administration (IM, oral, etc...)

- androstendione _____ clenbuterol _____
- DHEA _____ ECA stack _____
- ephedrine _____ GH _____
- diuretics (e.g., Aldactone, Diazide, hydrochlorothiazide, Lasix, etc...) _____

- GH _____ HMB _____
- IGF-1 _____ insulin _____

Other stimulants (e.g., amphetamines – Ritalin, Ma Huang, Ephedra, etc...) _____

 Non-narcotic / narcotic analgesics (e.g., ASA, aspirin, codeine, Ibuprofen, morphine, Nubain, Stadol, Vioxx, etc...) _____

Antidepressants (e.g., Celexa, Elavil, Luvox, Paxil, Prozac, Wellbutrin, Zoloft, etc...) _____

 Antianxiety meds (e.g., Ativan, Centrax, Valium, Xanax, etc...) _____

 Antiestrogens (e.g., Arimidex, Femara, Nolvadex, etc...) _____

 Others (please describe) _____

 What nutritional supplements are you currently taking? For each item, describe what you take, daily intake (mg/day & # times/day or mg/week & # times/week), and why you take the substance?

Vitamins (e.g., multi, Vitamin C, E, etc...) _____

 Minerals (e.g., selenium, chromium, etc...) _____

Amino acids (BCAA, glutamine, etc...) _____

L-carnitine _____

Creatine _____

Protein powder (whey, soy, etc...) _____

Sodium bicarbonate _____

Herbals (e.g., ginseng, bee pollen, tribulus terrestris, yohimbine, kava kava, guarana, ginko biloba, etc...) _____

 Others (please describe) _____

 Please describe your current cycle in as much detail as possible. For example, give approximate length of cycle, describe pyramid / stacking techniques with each of the steroids & the changing dosages, etc...)

List other anabolic/androgenic steroids or muscle-enhancing drugs that you have used in the past (not during current cycle): _____

List other substances / products / nutritional supplements you have taken in the past (not during current cycle): _____

Do you feel that, if used carefully, anabolic/androgenic steroids will not harm an athlete?

- Yes No Varies Not sure

Have you experienced any side effects from steroids thus far? Please check all that apply, and describe in space provided.

- Acne Decreased body fat
- Edema Gynecomastia
- Hair loss Increased muscle mass
- Increased strength Heart problems (describe: _____)
- Impotence Liver problems (describe: _____)
- ↑ sexual drive ↓ sexual drive
- Tendon injuries Testicular atrophy
- Aggression (on or off steroids: _____)
- Irritability (on or off steroids: _____)
- Depression (on or off steroids: _____)
- Euphoria / Mania (on or off steroids: _____)

Personality changes (on or off steroids; _____)

Describe what they are: _____

Suicidal thoughts (on or off steroids: _____)

Others (please describe) _____

Describe how you feel when you are on steroids _____

Describe how you feel when you stop taking steroids _____

Do you consider regular anabolic/androgenic steroid use the same as having a drug problem?

- Yes No Varies Not sure

Sleep

Overall, do you sleep well? Yes No

If no, describe your sleep difficulties (e.g., difficulty falling asleep, waking up several times in the night, problems falling back to sleep, nightmares, etc...) _____

Medications

List current prescribed medication(s) (why do you need to take the medication): _____

Additional Remarks

Please add any additional remarks here: _____

You are finished! Thank-you for taking the time to fill in this questionnaire!

Appendix E: Information about AAS

ID _____

Bodybuilder's Survey1) How satisfied were you with your body and physical appearance **before** using steroids?

- a. Extremely satisfied
- b. Very satisfied
- c. Somewhat satisfied
- d. Not so satisfied

2) What benefits have you experienced from using anabolic-androgenic steroids? _____

3) Before using steroids:

- a. My weight was _____ pounds
- b. My maximum bench press was _____ pounds
- c. My maximum squat was _____ pounds

4) While using anabolic steroids:

- a. My maximum weight was _____ pounds
- b. My maximum bench press was _____ pounds
- c. My maximum squat was _____ pounds

5) Please estimate how many weeks in the **past year** you have used anabolic steroids?

6) What is the greatest number of steroids that you have used ("stacked") at one time?

- | | |
|----------------|----------------------|
| _____ Only one | _____ Four |
| _____ Two | _____ Five |
| _____ Three | _____ More than five |

7) Do you cycle on and off anabolic steroids? **Y / N****If yes**, how many cycles have you done altogether? _____

8) What is longest period of time that you have gone without steroids since starting their use?

(Please fill in the number of weeks, months, or years.) _____ weeks

_____ months

_____ years

9) Please circle your response for each question:

- a) Have you ever used steroids in small amounts with the intent to build up to larger amounts or more potent steroids? **Y / N**
- b) Have you ever needed larger doses of steroids to get the same effects as you used to with smaller doses? **Y / N**
- c) Have you often taken more steroids than you thought you would? **Y / N**
- d) Have you often used steroids over a much longer period of time than you thought you would? **Y / N**
- e) Have you ever really wanted to stop or cut down your use of steroids, but continued to use at the same level as before? **Y / N**
- f) Have you ever tried to stop or cut down on your use of steroids with the intention of never using more, but then used more? **Y / N**
- g) Have you ever felt sick when you cut down or stopped using steroids? **Y / N**

10) When you stopped or cut down your use of anabolic steroids, did you experience any of the following?

- a. Headaches **Y / N**
- b. Restlessness **Y / N**
- c. Difficulty concentrating or thinking clearly **Y / N**
- d. Decreased sex drive **Y / N**
- e. Unable to have an orgasm **Y / N**
- f. Unable to have an erection **Y / N**
- g. Depression **Y / N**
- h. Fatigue, feeling tired or without energy **Y / N**
- i. Difficulty sleeping **Y / N**
- j. Poor appetite for food **Y / N**
- k. Suicidal thoughts **Y / N**
- l. Disinterest in things **Y / N**
- m. Unable to enjoy yourself **Y / N**
- n. Dissatisfaction with your body image **Y / N**
- o. Desire to take more steroids **Y / N**
- p. Muscle aches or joint pains **Y / N**
- q. Feeling irritable **Y / N**
- r. Other: _____ **Y / N**

11) For how long did any of these effects (from a-r) last, after stopping the steroids? _____

12) Please circle your response for each question:

a. Have you often used steroids to keep yourself from having these effects (listed from a-r) or have you often used steroids when you were feeling these effects so that you would feel better? **Y / N**

b. While on steroids, have you spent less time working your job or studying, being with family and friends, or doing activities other than workouts? **Y / N**

c. Did you ever keep using steroids even though they caused problems with other people, such as with family members or people at work? **Y / N**

d. Did you ever keep using steroids even though they caused psychological problems, like making your feel nervous, irritable, or depressed? **Y / N**

e. Did you ever keep using steroids even though they caused medical or physical problems or made a physical problem worse? **Y / N**

I thank you for your time and willingness to complete this questionnaire.

Appendix F. Intercorrelations among the cognitive measures.

Within-group correlations for the cognitive measures ($n = 24$).

	Grooved Pegboard ^a	WAIS-III Coding	Mental Rotation	Verbal Fluency	RAVLT	BVMT-R	WAIS-III LWS
WAIS-III Coding	.19	--					
Mental Rotation	.12	.76***	--				
Verbal Fluency	-.04	.09	-.06	--			
RAVLT	-.34	.18	.14	-.04	--		
BVMT-R	-.21	.51*	.36	-.21	.41*	--	
WAIS-III LWS	-.34	.23	.13	.48*	.22	.18	--
SOPT ^a	-.14	.04	-.16	-.19	.17	.31	-.32

Note. WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; Coding = Digit-Symbol Coding subtest, RAVLT = Rey Auditory Verbal Learning Test total recall score, BVMT-R = Brief Visuospatial Memory Test-Revised total recall score, LWS = Letter-Word Sequencing subtest, SOPT = Self-Ordered Pointing Test total errors.

^aLower values indicate better performance.

* $p < .05$ (two-tailed), *** $p < .01$ (two-tailed).

Appendix G. Correlations among the psychological variables.

Within-group correlations for the personality measures ($n = 24$).

	Antisocial	Obsessive-Compulsive	Narcissism
Obsessive-Compulsive	.44*	--	
Narcissism	.68***	.59**	--
Neuroticism	.56**	.63**	.47*

* $p < .05$, ** $p < .01$ (two-tailed), *** $p < .001$ (two tailed).

Within-group correlations for the body image and eating disorder measures ($n = 24$).

	DMS Total	MBSRQ AE	MBSRQ AO	MBSRQ BAS	EDI DT	EDI Bulimia	EDI Perfection
MBSRQ AE ^a	-.39	--					
MBSRQ AO	-.26	-.09	--				
MBSRQ BAS ^a	-.36	.52*	-.22	--			
EDI DT	.35	-.35	.52*	-.50*	--		
EDI Bulimia	.19	-.41*	.21	-.36	.65**	--	
EDI Perfection	.05	-.09	.27	.07	.09	-.11	--
Drive for Tone	.62**	-.39	.57**	-.46*	.62**	.36	.11

Note. DMS = Drive for Muscularity total score; MBSRQ = Multidimensional Body Self-Relations Questionnaire; AE = Appearance Evaluation subscale; AO = Appearance Orientation subscale; BAS = Body Area Satisfaction subscale; EDI = Eating Disorder Inventory-Third Edition; DT = Drive for Thinness subscale; Perfection = Perfectionism subscale.

^aLower values indicate dissatisfaction with physical appearance.

* $p < .05$. ** $p < .01$ (two-tailed).