



Gym nephropathy; an emerging disease among athletics

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Abstract

Athletes and bodybuilders, both professional and amateurs, use supplements such as an androgenic-anabolic steroid (AAS) worldwide. They are mainly used by males and to increase muscle mass and strength, speed recovery of the muscles, decrease fatigue, reduce muscle damage, decrease abdominal fat, and reform the body to a lean shape. However, these substances usually have some side effects such as renal damage and impairment. Gym nephropathy includes injury to the glomeruli, tubules, or interstitium of the kidneys. Herein, we discuss some of these renal diseases. Prompt diagnosis and treatment of these renal complications are critical to prevent chronic kidney disease.

Keywords: Gym nephropathy, Androgenic-anabolic steroid, Substance abuse, Athletes

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Introduction

Regular physical activity reduces the risk factors for heart diseases and may decrease mortality. In addition, recent investigations have shown a positive relationship between regular physical activity levels and more gradual development of chronic renal failure (1,2). However, in the few last decades, the pattern of sports has changed. Despite the various known side effects of androgenic-anabolic steroid (AAS) supplements, both elite and amateur athletes use AASs as they are interested in increasing the bulk of their muscles faster for various reasons, including aesthetic purposes (3,4).

Some of the supplements that are used include growth hormone, erythropoietin, insulin-like growth factor-1, insulin, anabolic androgenic steroids thyroid hormone, beta-2 agonists, anti-estrogens, human chorionic gonadotropin, creatine, vitamins, proteins, amino acids, glutamine, arginine, energy drinks, and carnitine (4,5).

The side effects of AAS are serious and include hypertension, accelerated atherosclerosis, reduced fertility, liver toxicity, and suppression of the immune system. In addition, mood changes are common and vary from aggression and violence to different patterns of impulsive behaviors (3,6). The abuse of these substances is common and ongoing worldwide due to the social interest of increased muscle mass and strength, mainly in males (3). The other main reasons that athletes use these substances are their beneficial effects in speed recovery of muscles, decreasing fatigue, reducing muscle damage, helping in the lipolysis process, decreasing the abdominal fat, and reforming the body to a lean shape (3,4,6,7).

However, these agents usually have some side effects such as renal damage and impairment (6). Gym nephropathy can be categorized as injury to the glomeruli, tubules, or interstitium of the kidneys. We aim to review several renal impairments associated with exercise or gym activity in athletes.

Glomerular involvement in athletes

Focal segmental glomerulosclerosis in athletics

Various case reports have shown focal segmental glomerulosclerosis (FSGS) following the use of some types of anabolic agents; however, the exact underlying mechanism of FSGS is unclear. FSGS is a type of glomerular disease characterized by podocytopathy, mostly in primary FSGS. The glomerular damage in secondary FSGS is caused by adaptive situations that lead to increased glomerular capillary pressures. Therefore, circumstances that cause either increased demand or decreased glomerular quantity on a previously normal nephron will lead to increased single-nephron glomerular filtration rates (GFRs). The suggested underlying mechanisms of FSGS are diverse and may be due to enlarging muscle mass or deleterious toxic effects of a high protein diet on the glomeruli. In addition, AAAs may have direct nephrotoxic effects (8). The absence of massive proteinuria and lack of IgM deposition is against the primary origin for FSGS. A study reported that individuals with this type of FSGS have normal-sized kidneys, no history of obesity, infections, diabetes, or intravenous drug abuse. However, their history was positive for high-protein intake and excessive use of AAS and growth hormone. In addition, there was

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■ Implication for health policy/practice/research/medical education

Athletes and bodybuilders use supplements such as an androgenic-anabolic steroid (AAS) globally. These substances usually have some side effects such as renal impairment. Gym nephropathy includes injury to the glomeruli, tubules, or interstitium of the kidneys.

no positive familial history of a similar glomerulopathy in these patients (9).

Although some conditions, such as the decreased proportion of nephrons in low-birth-weight, unilateral renal agenesis, or surgical ablation are the usual causes of FSGS, individuals with a normal proportion of nephrons may also develop secondary FSGS due to morbid obesity which causes morphologic variables of FSGS (8). The linkage between obesity and FSGS is well detected. The term obesity-related glomerulopathy is used for a type of chronic glomerular disease in highly obese individuals who develop proteinuria (10). However, sclerotic lesions like FSGS have been reported in several highly muscular, non-obese individuals with a higher body mass index (11).

Additionally, excessive intake of salt and protein may cause glomerular hypertension and secondary FSGS (12,13). Another factor that may aggravate FSGS is anabolic-steroid-induced hypertension (8,9). Furthermore, hypertensive alterations are detected in some bodybuilders. Repetitive episodes of severe rises in blood pressure due to weight lifting have a direct toxic effect from a high-protein diet and the pharmacological doses of drugs may be the major insult (9, 14). Finally, the aforementioned conditions lead to glomerular hypertrophy which is a maladaptive condition leading to glomerulosclerosis.

Renal tubular and interstitial involvement in athletes

Bile cast nephropathy

Acute renal failure (ARF) may arise from renal hypoperfusion due to bile cast nephropathy which causes tubule obstruction with bile substances and direct toxicity of bile acids (15).

Exercise-induced acute kidney injury

Recent studies show that exercise-induced AKI has two types; AKI with myoglobinuria and without myoglobinuria.

Runner's Kidney is another condition that may be detected in athletics. In marathon runners, myoglobinuria may result in acute tubular injury (runners' AKI), probably provoked by ischemia due to the toxic effect of myoglobin on renal tubular cells as well as vasospasm and tubular obstruction (16). Various factors may lead to ARF such as dehydration and running in high-temperature situations, particularly, in individuals who take non-steroidal anti-inflammatory drugs (NSAIDs) before or after running

(17,18).

Some athletes, mostly young males, experience AKI without myoglobinuria which is caused by renal vasoconstriction. It is characterized by abrupt renal failure in addition to severe loin pain and patchy renal ischemia after prolonged anaerobic exercises. In addition, there is no myoglobinuria, and creatine kinase levels are within the normal or marginal normal ranges. Furthermore, AKI is a common disorder and has an increased risk of morbidity and mortality; however, it is associated with a good prognosis in athletics (19).

Creatine supplementation

Creatine is also widely used by bodybuilders throughout the world. This substance is synthesized endogenously but can also be obtained from meat and fish. Creatine supplementation is mainly used due to its performance-enhancing effects. In normal conditions, the enzyme of creatine kinase produces phosphocreatine which accumulates in the skeletal muscles. Phosphocreatine is an energy source derived from ATP (adenosine triphosphate) (20). The safety of consuming creatine supplements is controversial. While some studies suggest that creatine supplementation is safe even for a long period, others report that it has some side effects on various organs including the kidneys, liver, and gastrointestinal organs (21). For example, a study showed that long-term use of creatine (twenty-one grams daily for five days and a maintenance dose of three grams per day for nearly two months) in healthy men had no significant effect on the renal function, level of creatinine, hepatic function, and muscle function (22). However, various studies have shown that creatine supplements may induce acute renal dysfunction such as acute focal interstitial nephritis and acute tubular injury (21).

Hypercalcemia and nephrocalcinosis in athletes

Vitamin D receptor has been reported to have a significant role in muscle function. Therefore, it has been suggested that treatment of vitamin D insufficiency may affect muscle performance (23). However, there have been reports of vitamin D intoxication in bodybuilding individuals resulting in renal dysfunction by causing hypercalcemia and nephrocalcinosis (24). On the other hand, excessive milk intake with anabolic agents could provoke milk-induced hypercalcemia, nephrocalcinosis, and interstitial injury in bodybuilders, especially in those who drink milk instead of water to receive more protein (9).

Hyperuricemia in athletes

There is a risk of hyperuricemia due to excessive intake of anti-oxidant supplements or a high-purine diet. Hyperuricemia has deleterious effects on kidney morphology including tubular damage and interstitial nephritis. In addition, these substances can induce renal damage is by various pathways such as the provocation

of RAAS (renin-angiotensin-aldosterone system), impairment of the endothelium, and production of ROS (reactive oxygen species) (25,26).

Exercise-associated hyponatremia in athletes

Endurance athletes, such as marathons runners, may experience exercise-associated hyponatremia (EAH) which is characterized by a plasma sodium level less than 135 mmol/liter. The pathogenesis of EAH is complex and multifactorial. However, it has been reported that stimulation of arginine vasopressin has a major role, especially in circumstances with unbalanced water intake. Other influential factors include renal impairment and sweat sodium loss. During heavy exercise, athletes experience dehydration with a decrease in body mass. Therefore, to avoid dehydration, they take large amounts of water which may result in EAH and lead to severe hyponatremia. Most athletes with EAH that have a serum sodium level between 128-134 mmol/L, usually have mild symptoms such as dizziness, nausea, and vomiting, or no symptoms at all. However, those that have a serum sodium level less than 126 mmol/L usually have severe symptoms including neurological features (such as confusion, cerebral edema, or seizures), pulmonary edema, or even death (27-29).

Exertional heat-related illnesses

Prolonged exercise may lead to exertional heat-related illnesses (EHRIs), especially in hot and humid environments. For example, heatstroke is the most life-threatening condition of EHRIs and is associated with extensive inflammatory reactions that may result in multiple organ failures including renal failure. In addition, some supplements are associated with EHRIs including stimulant drugs, such as amphetamines and methylphenidate, alcohol, or some illicit drugs such as cocaine, heroin, and phencyclidine (18,30).

Non-steroidal anti-inflammatory drug-associated nephrotoxicity

Acute overuse sport-related muscle injuries, such as strains and lacerations, injuries in adolescents and young adults are common. Treatment with NSAIDs is common; however, it may lead to renal impairment. NSAIDs inhibit renal prostaglandins which are important in renal circulation. Consequently, the imbalance between renal vasoconstriction and vasodilation may lead to renal failures such as interstitial nephritis and NSAID-associated nephrotoxicity (31). Furthermore, it has been reported that NSAIDs for musculoskeletal pains in addition to decreased water intake or consumption of diuretics and laxatives (usually for muscle building and forming) may lead to interstitial injury in bodybuilders (9).

Conclusion

Athletes and bodybuilders, both professional and amateurs,

use supplements such as AASs. They are mainly used by males and to increase muscle mass and strength, speed recovery of the muscles, decrease fatigue, reduce muscle damage, decrease abdominal fat, and reform the body to a lean shape. However, these substances usually have some side effects such as renal impairment. Gym nephropathy includes injury to the glomeruli, tubules, or interstitium of the kidneys. Prompt diagnosis and treatment of these renal complications are critical to prevent chronic kidney disease.

Authors' contribution

The primary draft was conducted by EA and HN. Scientific editing was conducted by SH. All authors have read, signed, and approved the final paper.

Conflicts of interest

The authors declare that they have no competing interests.

Ethical considerations

Ethical issues (including plagiarism, data fabrication, double publication) have been completely observed by the authors.

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