

## CLINICAL STUDY

# Coronary Calcification in Body Builders Using Anabolic Steroids

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*The authors measured coronary artery calcification as a means of examining the impact of anabolic steroids on the development of atherosclerotic disease in body builders using anabolic steroids over an extended period of time. Fourteen male professional body builders with no history of cardiovascular disease were evaluated for coronary artery calcium, serum lipids, left ventricular function, and exercise-induced myocardial ischemia. Seven subjects had coronary artery calcium, with a much higher than expected mean score of 98. Six of the 7 calcium scores were >90th percentile. Mean total cholesterol was 192 mg/dL, while mean high-density lipoprotein was 23 mg/dL and the mean ratio of total cholesterol to high-density lipoprotein was 8.3. Left ventricular ejection fraction ranged between 49% and 68%, with a mean of 59%. No subject had evidence of myocardial ischemia. This small group of professional body builders with a long history of steroid abuse had high levels of coronary artery calcium for age. The authors conclude that in this small pilot study there is an association between early coronary artery calcium and long-term steroid abuse. Large-scale studies are warranted to further explore this association. (Prev Cardiol. 2006;9:198–201) ©2006 Le Jacq*

The inordinate use of anabolic steroids has long been associated with many adverse side effects, including cardiovascular disease. There have been sporadic, anecdotal reports of heart attack and stroke in young weight lifters who have used anabolic steroids to promote muscle mass and strength, but published reports thus far have not established a direct link between steroid abuse and the development of

atherosclerotic disease.<sup>1–3</sup> The purported increased risk for heart attacks and stroke has rather been attributed to the effect of anabolic steroids on risk factors for cardiovascular disease. It is well known that supraphysiologic doses of anabolic steroids can dramatically lower serum concentrations of high-density lipoprotein cholesterol (HDL-C) and adversely increase the total cholesterol/HDL-C ratio—both risk factors for cardiovascular disease.<sup>4,5</sup>

This study was conducted as a pilot project to determine whether any unusual pattern of coronary artery calcification was detectable in this group of relatively young men, where little or no coronary artery calcium is usually found. We measured coronary artery calcification as a means of examining the impact of anabolic steroids on the development of atherosclerotic disease in body builders using anabolic steroids over an extended period of time. Coronary artery calcium has been shown in numerous studies to correlate with the total plaque burden in the coronary arteries and is thus a more direct measure of endothelial damage than secondary risk factors such as HDL-C.<sup>6,7</sup>

## METHODS

Fourteen professional body builders volunteered for evaluation of left ventricular function, exercise-induced ischemia, coronary artery calcium, and serum lipids. The mean and median age of the participants was 39 years, and the age range was from 28 to 55 years. None of the participants had a history of cardiovascular disease. Although the amount and type of anabolic steroids use cannot be quantified, it was anecdotally described as substantial, as would be expected, since many of the subjects had been top-tier body builders. The mean number of years of anabolic steroid use among the group was 12.6 years.

## Stress Echocardiography

All patients underwent a complete resting echocardiogram and Doppler study using a commercial ultrasound system (Sonos 5500, Philips Ultrasound, Andover, MA) equipped with an S3 harmonic imaging transducer. Patients were imaged in the left lateral position. Standard measurements were made directly from the 2-dimensional images (left

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ventricular internal diameter, interventricular septum, left ventricular posterior wall, right ventricle, aorta, left atrium). Left ventricular ejection fraction was measured from the apical 4-chamber view using Simpson's formula.<sup>8</sup> After resting images were obtained, the patient was placed on a motorized treadmill on an accelerated Bruce (2-minute stages) protocol until at least 90% of the maximum predicted heart rate was obtained. Upon termination of exercise, standard images were obtained within the first minute of the postexercise period. The resting and postexercise images were then compared and interpreted by an experienced echocardiographer.

### Coronary Calcium Scan

Coronary artery calcium was measured with a General Electric Imatron (South San Francisco, CA) electron beam tomography system, the C-150XL. Scans were acquired using a modified Agatston protocol with 3-mm thick slices and a 2-mm table increment. This method has demonstrated a median reproducibility of 8% based on sequential scans.<sup>9</sup> Results from large population studies have established percentile tables that provide expected coronary calcium scores for nearly all age groups.<sup>10</sup> The resulting coronary calcium score was compared with a calcium score percentiles table based upon scanning 6683 male patients using the same modified Agatston protocol.<sup>11</sup>

### Lipids

Total cholesterol, HDL-C, low-density lipoprotein cholesterol (LDL-C), triglycerides, intermediate-density lipoprotein and very-low-density lipoprotein were measured from an antecubital venous blood sample after a 12-hour fast.

## RESULTS

### Stress Echocardiogram

The mean left ventricular ejection fraction was 59% as measured by ultrasound, with a range of 68%–49%. No patient demonstrated coronary ischemia by standard electrocardiographic criteria or by stress-induced wall motion abnormalities on postexercise echocardiographic images.

### Coronary Calcium Scan

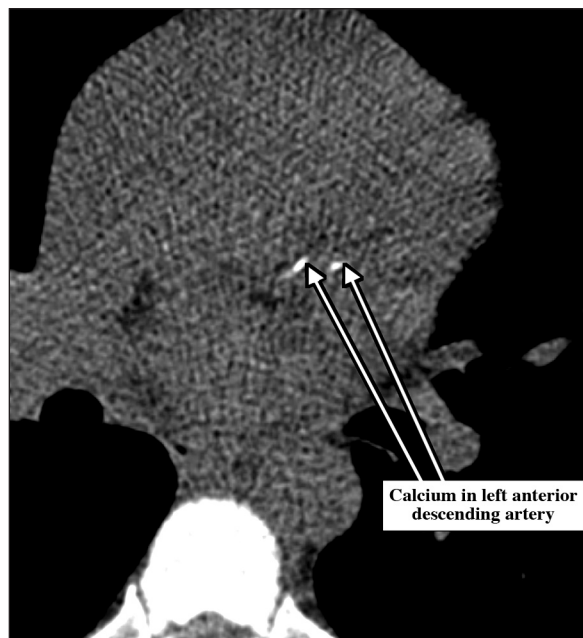
The mean coronary artery calcium score for the 14-person cohort was 98. This is near the coronary calcium score of 100 that is considered to place a patient at elevated risk for an event. In the recently reported St Francis Heart Study,<sup>12</sup> the 10-year event rate (soft and hard events) for patients with coronary artery calcium scores of 100 or more was 20%, a rate that would indicate that a patient is a candidate for secondary risk prevention strategies.

Seven of the 14 subjects (50%) had coronary artery calcium (Figure 1 and Figure 2). The number of men expected to have coronary artery calcium in this group is 3 (21%). Furthermore, the 2 oldest men, aged 49 and 55 respectively, had calcium

**Table.** Subject Mean CAC Score Percentile by 5-Year Age Interval

AGE, Y	SUBJECTS WITH CAC	MEAN CAC SCORE	PERCENTILE RANKING
<30	1 of 1	3	>95
30–34	0 of 3	0	<90
35–39	2 of 3	127	>95
40–44	3 of 4	88	>90
45–49	1 of 2	24	>50
>50	0 of 1	0	<50

CAC indicates coronary artery calcification.



**Figure 1.** Electron beam tomograph of coronary arteries of a 38-year-old male steroid user. Total calcium score, 350; 95th calcium percentile. Calcium scores: left main, 96; left anterior descending, 91; right coronary, 163.

scores of zero. If these 2 subjects are removed from the sample, 7 of the 12 participants aged 45 years and younger (58%) vs an expected 2 of 12 (17%) had coronary artery calcium. A table was constructed to compare the subjects with the typical population by 5-year age categories. The average coronary calcium score for each 5-year subgroup was ranked by percentile as determined by the calcium score percentiles table. Excluding the 1 subject older than 50 years with a zero score, 4 of 5 groups were above the 50th percentile. Three of 4 groups younger than 45 years were above the 90th percentile (Table).

### Lipids

Lipids were not obtained in 2 of the 14 subjects. In the 12 participants in whom lipids were measured, the HDL-C was low, with a measured mean of 23 mg/dL. Five of those measured had an HDL-C of  $\leq 20$  mg/dL. The mean total cholesterol of the



Figure 2. Electron beam tomograph of coronary arteries of a 40-year-old male steroid user. Total calcium score, 196; 90th calcium percentile. Calcium confined to left anterior descending artery.

12 subjects from whom lipids were obtained was 192 mg/dL. The mean ratio of total cholesterol to HDL-C was 8.3. The mean triglyceride measurement in the group was 106 mg/dL.

## DISCUSSION

This pilot study analyzed professional body builders with a known history of steroid use. We found that they had significantly lower HDL-C levels than the typical population. The LDL-C and triglyceride levels were within the expected range for healthy active young men. The mean ratio of total cholesterol/HDL-C was unusually high, measuring 8.3. Ejection fraction was also within the expected range for healthy young men. Also, as expected, no evidence of ischemia was demonstrated. The number of professional body builders younger than 45 years with coronary artery calcium (6 of 11 subjects) was unusually high. The study appears to indicate that steroid abuse not only significantly lowers HDL-C, but contributes directly to the early development of coronary atherosclerosis as determined by the noninvasive measures of coronary artery calcium. For the entire group studied, only 3 of the 14 subjects (21%) would have been expected to have coronary calcium on electron beam computed tomographic scanning, based on the calcium score percentiles table. However, 7 of 14 subjects (50%) had significant coronary calcium. What is even more disturbing is that 3 of the subjects, each younger than 40 years of age, had significant calcium scores. It has been argued in publications that cater to body builders and weight lifters that these risks may be offset by exercise, diet, and the lowering of serum triglyceride levels associated with the

use of anabolic steroids.<sup>13</sup> In our small sampling of subjects, exercise, diet, and lower triglycerides do not seem to offset the possible deleterious effects of anabolic steroids.

This pilot study is limited in several respects. First, it is impossible to report the exact doses, types, and duration of steroid use. The steroid users varied the intake over the years based on availability and what stage of training they were involved in. The steroid use is also all self-reported by the users, since none of the drugs were prescribed by a physician or bought at the usual retail outlets. Suffice it to say, the use is typical of the steroid users in the past and in the present, since all study patients were still using steroids. Second, none of the study subjects saw physicians on a regular basis, if at all. Long-term documentation of their cholesterol levels before taking steroids is not available. Third, HDL-C levels for the study population are extremely low and are most likely due to steroid abuse; however, we cannot determine what other metabolic or dietary effects may have contributed to the low HDL-C levels. In addition, it is speculative whether the arteriosclerosis is due to an indirect effect of the steroids by lowering HDL-C or a direct toxic or inflammatory effect of the steroids on the endothelial lining. Finally, the number of study subjects is small. Ideally, a larger study is needed comparing body builders who are matched for age, with adjustment for body mass index and coronary risk factors.

## CONCLUSIONS

This is the first study that has documented an association of steroid abuse and coronary artery calcification in steroid abusers. Several large studies have indicated that coronary artery calcium is a major risk factor for coronary events, and a recent, large prospective study reported that coronary calcium predicts coronary disease events independently of, and more accurately than, standard risk factors.<sup>12,14,15</sup> The fact that these relatively young study patients developed early coronary arteriosclerosis may have significant health and social implications. We would expect that premature coronary events will occur in similar steroid abusers. Due to the rampant abuse of steroids from high school sports to the now well publicized abuse by professional sports figures, we may expect an increase in cardiac events in otherwise healthy athletes when they reach their late 30s to mid-40s.

In summary, long-term steroid abuse is associated with an increased risk of coronary arteriosclerosis as measured by increased coronary calcium seen with electron beam computed tomographic imaging. We hope that this study will now bring to light the clear cardiovascular risk of steroid abuse and perhaps discourage future athletes from using steroids. However, due to the small number of subjects in this pilot project, further large-scale studies are warranted.

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