

Effect of Testosterone and Anabolic Steroids on the Size of Sebaceous Glands in Power Athletes

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The effect of testosterone and anabolic steroids on the size of sebaceous glands was studied by means of interactive morphometry in skin biopsies of power athletes. The subjects used self-administered high doses of testosterone and anabolic steroids during a 4-week strength training period. After 4 weeks' use of hormones, the area of sectioned sebaceous glands enlarged significantly by a factor of 89.2% ($p < 0.005$). The number of cells in the so-called differentiating cell pool (DCP) and in the undifferentiated cell pool (UCP) also increased significantly ($p < 0.025$, $p < 0.05$, respectively). The size of the area occupied by UCP cells increased significantly ($p < 0.05$). The study suggests that high doses of testosterone and anabolic steroids lead to an enlargement of sebaceous glands in male power athletes.

Key Words: Androgenic hormones—Sebaceous glands—Morphometry—Sports medicine.

The function of human sebaceous glands reaches its peak in the late teens (1). Since the sebaceous glands are holocrine structures, the entire mature cell will rupture and the contents be discharged into the excretory stream as sebum (2). During cell differentiation the cells undergo massive enlargement, which may result in a 100–150-fold increase in cell volume (2). Strauss et al. (3) have demonstrated stimulated sebaceous gland activity and thus a marked enlargement caused by exogenous methyltestosterone in prepubertal males. In postpubertal males no clinical or histological changes were found (3). The maximal stimulation of the sebaceous glands is thought to be caused by endogenous androgens, and it has been suggested that exogenous testosterone does not increase sebum secretion or affect gland size (3–7). However, exogenous androgen has been found to increase the sebum excretion rate (sebum output) and cause acne vulgaris or seborrhea (8–10). In this study we decided to check whether self-administered high doses of testosterone and anabolic steroids affect the size of the sebaceous glands in power athletes.

MATERIALS AND METHOD

Seven male power athletes (mean age 28.7 years, range 24–34), who had previous experience in the use of androgenic steroids in their strength training, volunteered for this study as an experimental group (EG). Three of these athletes had a history of atopic dermatitis, but none had a history of acne. None of the athletes used any hormones for a 12-week period prior to the study.

Eight power athletes (mean age 31 years, range 24–34) served as the control group (CG). They had no experience in the use of androgenic hormones but were participating in a continuous training program. Four had a history of acne vulgaris. The ex-

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perimental subjects were included in the study from the moment they began the self-administration of non-medically prescribed testosterone and anabolic steroids. The steroids were obtained on the black market and were thus used outside of medical control.

The self-administration of hormones was followed by means of medical diaries. Methandienone (5–20 mg) was taken orally by most of the subjects daily. Nandrolone (50 mg) and stanozolol (50 mg) were usually injected once a week. Testosterone (250 mg, consisting of 30 mg testosterone propionate, 60 mg testosterone phenylpropionate, 60 mg testosterone isocaproate, and 100 mg testosterone decanoate) was self-administered 1–2 times per month. Because of the simultaneous use of several hormones, the results represent the combined effect of the treatment. The drugs and doses used are shown in Table 1. The body weight, the amount of body fat of the subjects (11), and the testicular volume (12) were examined before and after the study (Table 2).

Skin biopsies were taken at the left upper medial margin of the scapula before and after a 4-week use of androgens. Biopsies from the control subjects were taken once, at the beginning of the study. All of the biopsy specimens were fixed in 10% formalin and embedded in paraffin. Sections were cut at 5 μ m and stained with van Gieson-iron hematoxylin stain. Morphometry included estimation of gland size from cross sections and counting the number of cells in the glands. Gland size was estimated from serial sections cut perpendicular to the surface of the skin. Only the true sebaceous acini, but

TABLE 1. Individual and mean daily doses \pm SE of self-administered testosterone and anabolic steroids (mg/day) during a 4-week period in seven power athletes

| | Subjects | | | | | | | $\bar{x} \pm SE$ |
|------------------------|----------|----|----|----|----|----|----|------------------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Testosterone (0–4 wk) | 23 | 7 | 19 | 19 | 26 | 23 | 15 | 19 ± 2.4 |
| Nandrolone (0–4 wk) | 19 | 7 | 7 | 7 | 5 | 5 | 6 | 8 ± 1.8 |
| Methandienone (0–4 wk) | 21 | — | 13 | 13 | 15 | 10 | 10 | 14 ± 1.5 |
| Stanozolol (0–4 wk) | — | 19 | 2 | 2 | — | — | — | 8 ± 3.9 |

All athletes used testosterone and nandrolone. In addition, six athletes used methandienone, and three athletes stanozolol.

Trivial and systemic names: testosterone, 17 β -hydroxy-4-androsten-3-one, nandrolone phenylpropionate, 17 β -hydroxy-4-estren-3-one phenylpropionate; methandienone, 17 α -methyl 17 β -hydroxy-1, 4-androstandien-3-one; stanozolol, 17 α -methyl-5 α -androstan-3-one-pyrazol-17 β -ol.

TABLE 2. Anthropometric characteristics of the groups studied; the experimental group used self-administered testosterone and anabolic steroids for 4 weeks

| | | Body weight (kg) | Body fat (%) | Testicular volume (ml) |
|---------------------------|----|------------------|-----------------|------------------------|
| At start of investigation | EG | 90.9 ± 3.4 | 11.1 ± 1.0 | 21.4 ± 1.4 |
| | CG | 75.3 ± 4.7 | 13.5 ± 0.01 | — |
| At end of investigation | EG | 95.5 ± 3.8 | 11.6 ± 1.3 | 16.0 ± 1.1 |
| | CG | — | — | — |

Values indicate means \pm SE.
EG, experimental group (n = 7); CG, control group (n = 8). NS, not significant.

^a p < 0.05.

^b p < 0.001 (two-tailed t test).

no areas with keratinizing cells of the pilosebaceous unit, were included. Areas consisting of the undifferentiated cell pool (UCP) were also measured. To avoid bias, planimetric measurements of the samples were made in random order, and only the two largest cross sections of each gland were measured (13). After planimetric evaluation, cell counts were performed for differentiating cell pool (DCP) producing fat droplets and for UCP areas (14). The latter do not produce lipid droplets as revealed by light microscopy (14). The number of

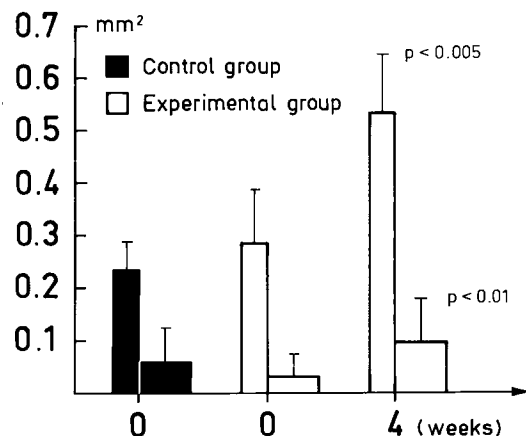


FIG. 1. Mean \pm SEM of cross-sectional areas in mm² for the sebaceous glands and for the undifferentiated cell pool areas of sebaceous glands of the back skin in the group studied. The experimental group (n = 7) used self-administered testosterone and anabolic steroids during weeks 0–4 (see Table 1). The narrow columns indicate the mean cross-sectional areas of sebaceous glands. The wide columns indicate the undifferentiated cell pool areas before and after the 4-week use of testosterone and anabolic steroids. The control group (n = 8) was examined once, at the beginning of the study.

cells in these cell pools were counted from color slides taken from the monitor of the semiautomatic image analyzer (Kontron IBAS 1 and 2) (15). The quantitative determination was restricted to true sebaceous cells; no keratin-forming cells of the sebaceous duct were included.

Means \pm SEM were calculated. Differences between mean values of the experimental and control groups were tested by unpaired *t* test and, differences between the values inside the experimental group were tested by paired *t* test for significance.

RESULTS

Table 2 shows that the control subjects were smaller than the athletes in the experimental group but had more body fat in relative terms. In the experimental group, there was weight gain during an-

drogen administration but no increase in body fat. Testicular volume decreased during androgen administration.

At the beginning of the study there were no differences in the cross-sectional areas of the sebaceous glands or in the UCP areas between the experimental and control groups (Figs. 1 and 2A). In the experimental group the mean cross-sectional areas of the sebaceous glands were 0.28 ± 0.08 mm² before the study. After 4 weeks' use of the steroids, the cross-sectional areas were significantly larger, 0.53 ± 0.1 mm² ($p < 0.005$) (Figs. 2A and 2B).

The UCP areas increased from 0.029 ± 0.0 to 0.090 ± 0.04 mm² (Fig. 1).

The number of UCP and DCP cells varied greatly, and did not differ significantly between the experimental and the control group (Table 3) at the

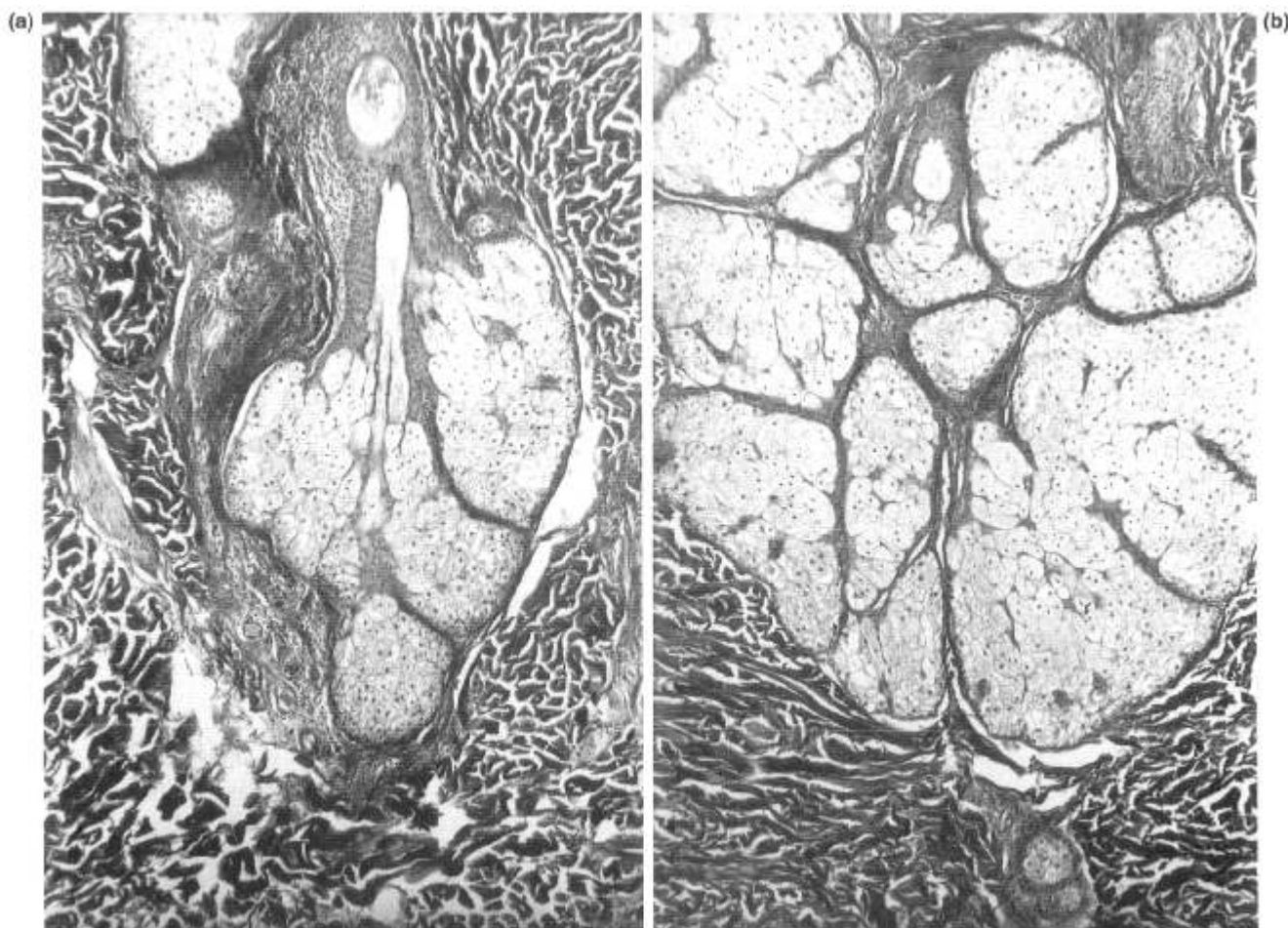


FIG. 2. A: Longitudinal section of a hair follicle-associated sebaceous gland on the back skin of a male athlete before starting the period of testosterone and anabolic steroid use. This is the largest section of the gland among the serial sections cut from the sample. **B:** The transected gland in this micrograph is from the back skin of an athlete after 4 weeks' use of testosterone and anabolic steroids. The gland is dramatically enlarged. Notice that the magnifications are identical in Fig. 2a and b. (van Gieson-iron hematoxylin stain, Magnification 135 \times .)

TABLE 3. Cell counts for the differentiating cell pool (DCP) and the undifferentiated cell pool (UCP) of the cross-sectional areas of the back skin sebaceous glands

| Control group | | | | |
|--------------------|-------------------|-----------------------------|------------------|---------------------------|
| Subject | DCP | | UCP | |
| 1 | 285 | | 120 | |
| 2 | 356 | | 135 | |
| 3 | 419 | | 205 | |
| 4 | 1374 | | 187 | |
| 5 | 649 | | 121 | |
| 6 | 671 | | 263 | |
| 7 | 240 | | 166 | |
| 8 | 307 | | 111 | |
| Mean ± SE | 537.6 ± 133.8 | | 174.8 ± 18.5 | |
| Experimental group | | | | |
| Subject | DCP | | UCP | |
| | 0 weeks | 4 weeks | 0 weeks | 4 weeks |
| 9 | 544 | 461 | 217 | 218 |
| 10 | 333 | 1283 | 114 | 626 |
| 11 | 1042 | 3268 | 260 | 838 |
| 12 | 167 | 670 | 63 | 384 |
| 13 | 153 | 822 | 87 | 409 |
| 14 | 421 | 713 | 152 | 249 |
| 15 | 332 | 1185 | 137 | 121 |
| Mean ± SE | 427.4 ± 116.4; NS | 1200.2 ± 367.9 ^b | 147.1 ± 26.9; NS | 419.4 ± 90.4 ^a |

The experimental group (n = 7) used self-administered testosterone and anabolic steroids during weeks 0–4. The figures indicate individual cell count/gland cross-sectional area. Means \pm SE are also given. NS, not significant.

^a p < 0.05.

^b p < 0.01 (two-tailed t test).

start of the experiment. After 4 weeks' use of the steroid hormones, the number of UCP cells had increased significantly ($p < 0.025$) from 147.1 ± 26.9 to 419.4 ± 90.4 cells/gland cross-sectional area (Table 3). The number of DCP in sebaceous glands increased ($p < 0.05$) from 427.4 ± 116.7 to 1200.0 ± 376.6 cells/gland cross-sectional areas. The ratio of DCP cells to UCP cells did not change during the course of study.

DISCUSSION

After 4 weeks' use of testosterone and anabolic steroids, the cross-sectional areas of sebaceous glands had increased by $\sim 89.2\%$. This shows that high doses of exogenous androgens are capable of overstimulating the sebaceous glands in healthy young men. The observed increase in cross-sectional areas, which reflects the change in volume (13), is probably due to a direct effect of exogenous androgens. As in this study, assessment of the cross-sectional size has been used to estimate the effect of various stimulating or inhibiting factors on the sebaceous glands in former research efforts

(16). The experiment lasted 4 weeks because the synthesis and discharge of the lipids contained in sebaceous cells require ~ 3 –4 weeks to reach the skin surface (17). Because the sebaceous glands vary in size and shape from follicle to follicle, serial sections were used to find the largest cross sections involved, as has been done in earlier studies (3).

Strauss et al. (3) demonstrated a substantial enlargement of the glands in prepubertal boys. However, their paper did not demonstrate a corresponding change in postpubertal males during oral methyltestosterone treatment. The reason for the difference is obvious: our athletes used intramuscular testosterone, which is more effective than oral testosterone (18). In fact, most of the methyltestosterone is metabolized by the liver before reaching the systemic circulation (19).

As expected, the number of UCP cells increased significantly ($p < 0.025$), and so did the number of DCP cells ($p < 0.05$). However, the absolute values were below those reported by Plewig et al. (14).

The ratio of differentiating to undifferentiated cells was in line with published data (14), and these values did not change during the course of the study. This seems to indicate that there is no distur-

bance in the balance of cell differentiation (lipid production) during the use of androgens.

Contrary to what has been stated in numerous texts (3–7), our results show that under physiological conditions the sebaceous glands were not maximally stimulated in our subjects. It is probable that exogenous testosterone and anabolic steroids can further stimulate and enlarge the sebaceous glands in young healthy males. This size change parallels the functional activity of the glands under similar conditions (8). □

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