

## Muscle Hypertrophy in Bodybuilders

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**Summary.** Muscle biopsy samples were obtained from m. vastus lateralis and m. deltoideus of three high caliber bodybuilders. Tissue specimens were analysed with respect to relative distribution of fast twitch (FT) and slow twitch (ST) fiber types and different indices of fiber area. In comparison to a reference group of competitive power/weight-lifters the following tendencies were observed: the percentage of FT fibers was less, mean fiber area was smaller and selective FT fiber hypertrophy was not evident. Values for fiber type composition and fiber size were more similar to values reported for physical education students and non-strength trained individuals. The results suggest that weight training induced muscle hypertrophy may be regulated by different mechanisms depending upon the volume and intensity of exercise.

**Key words:** Muscle fiber types – Muscle fiber size – Muscle hypertrophy – Muscle strength

### Introduction

It is well documented that skeletal muscle hypertrophy, manifested in increased weight or cross-sectional area of muscle, occurs as a result of overloading induced either by surgical manipulation or by training (cf. Goldberg et al. 1975). It is generally believed that such an increase in muscle volume is due to enlargement of individual muscle fibers (Morpurgo 1897; Goldberg et al. 1975; Gollnick et al. 1981) as a result of an enhanced protein synthesis, increased size and number of myofibrils and addition of sarcomeres within the individual muscle fiber (Goldspink 1964; Denny-Brown 1961). The hypertrophy seen in

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strength trained athletes has been attributed to a supranormal size of individual muscle fibers (Edström and Ekblom 1972; Gollnick et al. 1972; Prince et al. 1976; Häggmark et al. 1978). Recently, however, several reports have proposed hyperplasia, induced by longitudinal fiber splitting, as an alternative mechanism for skeletal muscle hypertrophy (Rowe and Goldspink 1968; Reitsma 1969; Gonyea 1981). To further study the influence of specific long-term exercise stress on over-all muscle hypertrophy, biopsy samples from the muscle of successful bodybuilders were examined with special regard to muscle fiber composition and size. These athletes are characterized by possessing an extraordinary body composition, indicated by gigantic limb circumferences and low percent body fat (Katch et al. 1980; Spitler et al. 1980).

## Subjects and Methods

Three bodybuilders volunteered to take part in this study<sup>1</sup>). They were examined the day following a Mr. Scandinavia contest, in which all finished among the top five participants. Age, height, weight and percent body fat as calculated from skinfold measurements (Hermansen and von Döbeln 1971), averaged 25 (20–32) years, 177 (173–183) cm, 84 (80–88) kg and 4 (2–6) %.

Muscle biopsies (Bergström 1962) were obtained from m. vastus lateralis and the lateral portion of m. deltoideus. Cross-sections of the samples were histochemically stained for myofibrillar ATPase and NADH tetrazolium reductase. Individual fibers were identified either as fast twitch (FT) or slow twitch (ST), and fiber type distribution (%FT and %FT area) and fiber area (FT, ST and mean fiber area) were calculated. FT fibers were further subdivided into FTa and FTb (cf. Tesch 1980). Strength measurements were performed during velocity controlled leg extensions at selected constant angular velocities (Hislop and Perrine 1967) using a commercial dynamometer (Cybex II, Lumex Inc., NY, USA). Two reference groups of physical education students, (1)  $n = 50$ , 23 (19–32) years, 180 (171–190) cm, 72 (62–89) kg, and (2)  $n = 12$ , 21 (19–26) years, 181 (174–185) cm, 72 (66–80) kg, and one group of national elite power- and weight-lifters,  $n = 8$ , 26 (19–31) years, 170 (164–178) cm, 85 (75–104) kg, were selected for comparison.

## Results

Fiber type distribution in m. vastus lateralis and m. deltoideus averaged 44 (37–49) and 36 (29–41) %FT, respectively. The corresponding values for a reference group, comprising non-strength trained physical education students ( $n = 12$ ), were 53 (29–79) and 50 (36–67) %FT. The percentage of FTa and FTb in m. vastus lateralis averaged 40 (37–49) and 4 (0–6) respectively. Values for m. deltoideus were 33 (27–41) and 3 (0–8) % respectively. Values for mean fiber area were 62 (47–74) and 47 (44–49)  $\mu\text{m}^2 \cdot 100$  in bodybuilders and 62 (36–92) and 56 (41–70)  $\mu\text{m}^2 \cdot 100$  in the reference group. Values for fiber type distribution and different indices of fiber area of m. vastus lateralis and m. deltoideus respectively are presented in Table 1. Information on muscle strength of bodybuilders, power- and weight-lifters and physical education students is summarized in Table 2.

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1 The study was approved by the Human Ethics Committee at Karolinska Institutet, Stockholm