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Letters to the editors

Does maximal neural activation of muscle increase after resistance training?

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Sirs:

In a recent issue of this Journal Häkkinen et al. (1992) have argued that the human neuromuscular system undergoes marked adaptation in the early stages of resistance training. According to this view, initial increases in maximal force producing capacity are not a consequence of significant hypertrophy, but instead are secondary to "... increased voluntary neural activation of trained muscles" which is evident in an increased maximal integrated electromyogram (iEMG) (p 110). These conclusions seem questionable to us for several reasons.

Firstly, the data in Fig. 1 are meant to illustrate the change in maximal force after 2 weeks of intense training and after a 2nd week of reduced training volume. The difference between the day 0 measurement and the measurements at day 15 and again at day 21 are said to be significant at $P \leq 0.05$ and 0.01, respectively. This is questionable, however, given the rule of thumb that mean values with overlapping SEM are usually not significantly different. We wished to settle this issue by reanalysing the data with an analysis of variance rather than the multiple Student's *t* tests used by Häkkinen et al., since it is well-known that the latter approach drastically increases the probability of type 1 errors (Keppel 1991). We therefore requested the data from the authors, but they informed us that the data had been destroyed after the article had been accepted for publication. This is a surprising turn of events since we understand that it is normal practice to keep experimental data for at least 5 years in order to settle just such a question as we have posed.

Secondly, the investigators did not verify maximality of either the control or posttraining contractions with superimposed shocks (Fig. 1), a practice that has become standard in experiments of this kind over the past several years (Merton 1954; Belanger and McComas 1981; Bigland-Ritchie et al. 1979). Without verification one has no basis for judging whether all motor units have been optimally activated and maximal force has been achieved. Thus, the data points at day 0 and day 15 may actually reflect submaximal contractions.

The problem is further exacerbated by the absence of a control group with which to compare the experimental data. There are similar problems in trying to interpret the data in Fig. 2. The difference in maximal values from day 0 to day 15 are small relative to the variability and it is difficult to understand how the means can be different from each other. Moreover, the statement that there was "an unexpected change in the averaged maximal iEMG during ..." the period of reduced training (day 15 to day 21) is misleading because it has not been determined that the data points at day 17 and day 19 were, in fact, lower than they were at day 15 (p 110).

Thirdly, Häkkinen et al. (1992) have been selective in citing only literature that supports the notion of an increase in maximal voluntary activation (EMG) after resistance training. Reports from investigators who have not found an increase in maximal EMG after resistance training (Thorstensson et al. 1976; Komi and Buskirk 1972; Cannon and Cafarelli 1987) have not been cited. Perhaps an even more important issue is the difficulty in reconciling the conclusion of Häkkinen et al. (1992) with the finding of Merton (1954) that maximal force can be matched, but not exceeded, by maximal stimulation of the motor nerve *and* that during maximal voluntary contraction injecting a shock into a nerve does not momentarily increase force. Subsequent experiments have shown that maximal shocks delivered at supramaximal frequencies can produce forces that match, but not exceed, the largest force that subjects can produce voluntarily (Bigland-Ritchie et al. 1979). If these perturbations that mimic increased neural drive to muscle do not increase its mechanical output, why would one expect the complete opposite to occur after training?

That the human neuromuscular system expresses adaptations to resistance training in addition to hypertrophy is a possibility that certainly must be entertained. But given what we know about neuromuscular function under these conditions, it seems unlikely that one of those adaptations is an increase in voluntary activation.

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Because of statistical and methodological questions, the data of Häkkinen et al. (1992) have not convinced us to think otherwise.

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