New methods for the estimation of motor unit numbers in a muscle

SIR,—Dr Panayiotopoulos (1976) has stated that the most essential requirements of the motor unit counting techniques are that motor unit potentials be summated in a precisely additive manner and that this summation would be affected by even small latency differences resulting from differences in the diameters and lengths of motor nerve fibres. Dr Panayiotopoulos correctly points out that we have investigated this problem using our computer subtraction method (Ballantyne and Hansen, 1974b, 1975) for obtaining the configuration of the first 10 to 15 evoked motor unit potentials used in the calculation of motor unit numbers. However, he has neglected to point out that we were also at some pains to explain that our computer method for the estimation of motor unit numbers is designed to take account of the variation not only in the latency of the first 10 to 15 motor unit potentials recruited but also of their durations, areas, amplitudes, and, indeed, contours. The area of the potential containing up to 10 to 15 sequentially evoked motor unit potentials, regarded as a representative sample from which motor unit numbers are estimated, is determined by the relative variations of these motor unit potential parameters. It is therefore incorrect for Dr Panayiotopoulos to claim that precise additive summation of these potentials is a necessary requirement for all counting methods, although we would agree that it is a requirement of methods using only amplitude of motor unit potentials for the calculation. It was because we recognised this limitation of the original technique that we introduced our computerised method, which we believe has adequately overcome these criticisms (Ballantyne and Hansen, 1974a, 1975). The basic assumption that we make in our method is that variations in latency, amplitude, areas, and durations of the first 10 to 15 evoked motor unit potentials are representative of the variation in these parameters in the total motor unit content of the muscle. While we did point out that the temporal relationships of motor unit potentials in, for instance, control subjects and patients with Duchenne type muscular dystrophy were different, the importance of this observation lay

in drawing attention to the pitfalls involved in using amplitude increments as an index of the true amplitude of motor unit potentials when comparing these parameters between control subjects and pathologies.

A second point raised by Dr Panayiotopoulos is that the amplitude and areas of the sequentially evoked motor unit potentials appear to increase as the units are progressively recruited. Certainly, in the individual subjects there is a difference in the sizes—that is, areas—of the first 10 to 15 motor units as one would expect, some are larger than others and some are smaller, and in an occasional patient there does appear to be a progression towards larger units as the strength of the stimulus is increased. However, we have examined the first, second, third, fourth, and so on motor unit potentials in the whole population of controls and found that the mean value for the first unit is not significantly different from that of the second, third, fourth, fifth and so on. In our population of 50 control subjects, we have found no evidence that there is any significant trend towards recruitment of larger or smaller motor unit potentials as further motor units are recruited in response to incrementing stimulation. We also find ourselves in disagreement with Kadrie *et al.* (1976) who state that motor units are excited in order from small to large and from longer to shorter latencies. In our control subjects there is no correlation between the motor unit potential size and motor unit potential latency. Our results, however, have been obtained by single point stimulation over the anterior nerve and not from multiple point stimulation as used by Kadrie *et al.* (1976).

As there is no universally accepted electrophysiological or anatomical method of estimating motor unit numbers then the present arguments about the merits of the various techniques may perhaps be clarified by the demonstration that motor unit counts estimated by electrophysiological methods can be correlated with other electrophysiological parameters obtained by entirely unrelated techniques. For example, in our recent study of patients with diabetic neuropathy, we have found highly significant correlations between motor unit numbers in the EDB muscle and shortest distal motor latencies ($r = -0.590$; $P < 0.001$) and

fastest motor nerve conduction velocities ($r = 0.564$; $P < 0.001$) (Hansen and Ballantyne, in preparation). Motor nerve conduction velocities and shortest distal motor latencies are easily and, in controlled conditions, accurately measurable. The correlation with these parameters, which we have found in both diabetic and renal neuropathies, encourages us in our belief that our method of estimating motor unit numbers in the EDB muscle is reliable and that the values obtained in population studies are indeed accurate indicators of the actual number of motor units in the EDB muscle.

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