Daily "endurance-demands" in cat's ankle muscles

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Introduction

It is well known that normal muscles are markedly heterogenous with respect to the fatigue resistance of their motor units. In most known kinds of motor behaviour, units with a high degree of endurance are more easily recruited than those that are more fatigue-sensitive. Hence, the high-endurance units will be more heavily used per day or, in other words, they face a greater daily "endurance-demand" in terms of cumulative daily activity time.

Altered endurance-demands lead to long-term changes in fatigue resistance. Chronic stimulation experiments on cat's pretibial ankle muscles have indicated that endurance becomes markedly improved after a few weeks of extra activity covering 5% of total daily time; 0.5% of such extra duty time was insufficient for increasing endurance (Kernell et al. 1987). This might be taken to suggest that the most heavily used units of a mixed cat muscle would normally be active during at least about 0.5-5% of total daily time.

A greater daily activity time might normally be expected in muscles containing a large percentage of high-endurance units than in those which are relatively more dominated by fatigue-sensitive units. The present experiments were designed for testing these predictions by obtaining activity measurements from muscles that are known from literature to:

1/ contain markedly different percentages of slow-twitch high-endurance units and the corresponding histochemical type of muscle fibre (S-units, type I fibres; percentages are much higher for soleus than for extensor digitorum longus or tibialis anterior; Ariano et al. 1973);

2/ be regionalized in such a way that different muscle portions contain different densities of S-units/type I fibres (in tibialis anterior, such densities are higher for posterior than for anterior portions; Iliya and Dum 1984).

Material & methods

The experimental data were obtained from 4 adult, female cats (weights 2.6-4.1 kg), chronically implanted with bipolar "patch-electrodes" on soleus (anterior side, SOL), extensor digitorum longus (posterior side, EDL), and tibialis anterior (anterior side, TAA; posterior side, TAP). During each recording session of 24 hours, one experimental animal and one cat for company were housed together in a large cage (1x3 m floorspace) within which they could move about freely.

The recordings consisted of telemetrically transmitted electromyographic (EMG) signals from different pairwise combinations of the 4 implanted muscle portions. Each session lasted 24 hr, and the EMG signals from each analyzed muscle pair were then recorded during 48 continuous 4 minute periods, as sampled at half hour intervals. All EMG recordings were saved on tape.

During the subsequent off-line analysis, the EMG signals were rectified and smoothed (time constant 20 ms), and this "integrated EMG" was used to trigger a voltage-level discriminator. For each recording separately, the threshold of the voltage-level discriminator was adjusted to be as low as possible above the baseline noise. The total duration of time that a muscle (portion) were found to be active was expressed in per cent of total recording time, i.e. in a value equivalent to the relative amount of activity per 24 hours for the most active units "seen" by the EMG electrode.

Results and conclusions

1. Cumulative activity times all exceeded 0.5% and were, for most recordings from mixed muscles (TAA, EDL, TAP), in the range 0.5-5% (Fig.1).

2. The cumulative activity times tended to be significantly higher for muscles (muscle portions) known to contain a high percentage of S-units/type-I fibres than for those with smaller fractions of such markedly fatigue-resistant units and fibres (SOL vs. others; TAP vs. TAA; Fig.1).

3. The extreme composition of the cat's soleus muscle (typically 100% slow units and type I fibres) was matched by extreme cumulative activity times of more than twice those seen in the other sampled muscles. The results from soleus resemble those earlier published by Alaimo et al. (1984).

TAA **1.54 ± 1.11 (11)**
[0.7-4.4]
ns

EDL **1.91 ± 0.94 (10)**
[0.7-3.4]
******

TAP **4.01 ± 1.71 (17)**
[2.0-7.8]
****

SOL **12.87 ± 5.30 (23)**
[5.2-23.6]

mean ± S.D. (N)
[range]

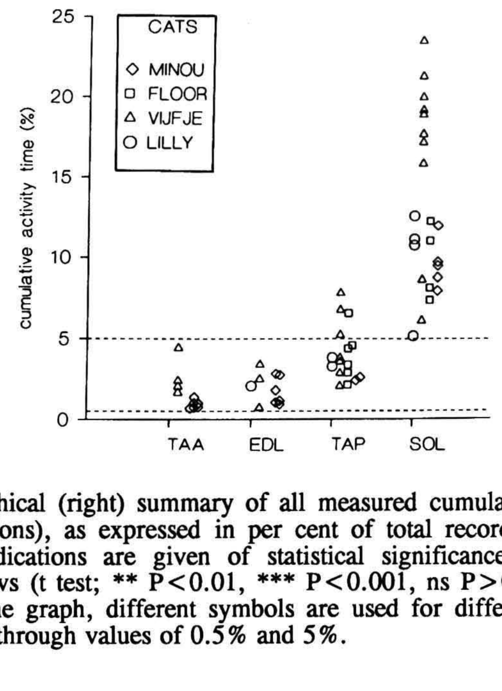

Figure 1. Numerical (left) and graphical (right) summary of all measured cumulative activity times for four muscle (portions), as expressed in per cent of total recording time. In the numerical section, indications are given of statistical significance of differences between neighbouring rows (t test; ** $P<0.01$, *** $P<0.001$, ns $P>0.4$; for TAA vs. TAP, $P<0.001$). In the graph, different symbols are used for different cats, and interrupted lines are drawn through values of 0.5% and 5%.

References

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