
STATIC SENSITIVITY OF PRIMARY MUSCLE SPINDLE ENDINGS

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Static discharges were studied in 75 primary endings of passive muscle spindles during stepwise stretching of the cat triceps surae muscle. Afferents conducting excitation with velocities of between 72 and 115 m/sec, with high dynamic sensitivity, and with static thresholds below 8 mm were chosen. The muscle was stretched by 10 mm relative to the completely relaxed state with a step of 0.8 mm. Spike discharges were recorded 40 sec after each stretching for 30 sec and the mean frequency was calculated. Comparison of static and differential static responses for different units, of the "muscle length--mean discharge frequency" dependence, and of the static thresholds showed that a linear (under 4.5 spikes/sec/mm) or steady increase in the mean discharge frequency to 40 spikes/sec took place in only 20% of primary endings with a probability of more than 0.7 for each step of muscle stretching. In most primary endings a narrow range of sensitivity to a change in the static length of the muscle was found. It is suggested that the "poor" static sensitivity was due either to high static thresholds or to the absence of increases in mean discharge frequency despite continued stretching.

INTRODUCTION

During the study of static sensitivity of muscle receptors mainly the influence of stimulation of fusimotor axons on this parameter has been examined [11, 15, 18], and static responses of primary and secondary muscle spindle endings have been compared [10, 11, 15-19]. It has been shown that the mean frequency of static discharges in primary endings increases proportionally to muscle stretching [10, 15, 17, 18], but this conclusion is contradicted by another to the effect that primary endings are insensitive to changes in the stationary length of the muscle [19].

A solution to the problem of ability of primary endings of passive muscle spindles to respond to changes in the degree of static stretching of the muscle requires additional investigations based on assessment of responses of different units with respect to several criteria. If a receptor is "good" at detecting equal changes in the stationary length of the muscle, it must be expected that the probability of increases in the mean discharge frequency to each step of stretching is close to unity and that the values of the increases in frequency are equal, which would be reflected in a linear relationship between muscle length (ML) and mean discharge frequency (MDF), and also that there is a wide range of static sensitivity which is possible if the static thresholds of the receptors are low and stabilization of the attained discharge frequency at the same level during further stretching of the muscle does not take place. The aim of the present investigation was to use the criteria listed above to analyze long spike trains from receptors after stabilization of their discharge frequency at a definite muscle length. It was envisaged that answers to the following questions would be obtained: is the view that primary endings are comparatively insensitive to changes in the stationary length of the muscle correct [19]; what is the form of the "ML-MDF" relationship;
Fig. 1. Responses of group Ia muscle afferents to stepwise (step 0.8 mm) stretching of triceps surae muscle at a speed of 0.6 mm/sec. I) Traces of discharges of typical primary ending of dynamic type (conduction velocity 90 m/sec) during last three steps of muscle stretching. Arrows indicate segments of recording action potentials on magnetic tape, asterisks indicate maximal dynamic peak and static response used to calculate standardized dynamic index. II) Traces of discharges of three muscle afferents not included in the sample. Responses during last step of muscle stretching (different experiments). a) Absence of static discharge, b) low dynamic sensitivity, c) low (under 50%) standardized dynamic index. Velocity of conduction of excitation: 88 (in a), 82 (in b), and 95 (in c) m/sec. 1) "Zero" line of muscle tension, 2) marker of stretching, 3) passive tension, 4) momentary discharge frequency (scale on right), 5) "zero" frequency line. Time marker 2 sec.

for most receptors; can it be taken to be approximately linear; and what are the particular features of the measuring properties of receptors with different static thresholds?

EXPERIMENTAL METHOD

Adult cats were anesthetized with sodium pentobarbital. After laminectomy the ventral roots L5-S2 were divided; the undivided dorsal roots L7-S1 were teased into thin filaments and placed on platinum wire electrodes to record discharges of single units. All cutaneous and muscular nerves of the rigidly fixed left hind limb were divided except two small branches to the triceps surae muscle. The animal's body and the wound surface were constantly heated. The Achilles' tendon was divided and the muscle connected to a mechanical stimulator, stretching it relative to the completely relaxed state by 10 mm with a step of 0.8 mm and with intervals of 70 sec between consecutive stretchings. All units were tested by stepwise stretching of the muscle at a speed of 0.6 mm/sec. To assess the reproducibility of the static characteristics of the receptors discharges of 17 units also were studied during stretching at speeds of 0.3, 1.5, and 3.5 mm/sec.

Action potentials were led to a standard pulse shaper and, after transformation into instantaneous frequency, were recorded together with the length and degree of passive stretch-