SOCIÉTÉ BELGE DE RHYSIOLOGIE
Réunion de Liège, 2 avril 1960

J. M. GILLIS et G. MARÉCHAL — **Les déplacements ioniques au cours de la fatigue musculaire** *(Laboratoire de Physiologie, Université de Louvain).*

Translated from French.

Ionic displacements during muscular fatigue

The isolated muscle excited tetanically at regular intervals loses gradually its ability to develop tension (force per unit muscle cross-section). A part of the fatigue probably resides in the contractile mechanism, since the heat flow does not always evolve parallel to the tension (MARÉCHAL and AUBERT, 1958). But the deterioration of the processes generating the action potential plays an important role as well: this is what the fall of these potentials during the tetanus (BERGMANS and MARÉCHAL, 1960) demonstrates and the recovery of the muscle fatigue under the effect of a transverse alternating current (MARÉCHAL, 1960). This double aspect of fatigue could be easily explained if the modifications of the membrane caused by tetanic excitation led to the muscular fibers of the ionic changes which could alter the contractile mechanism.

To test this hypothesis, we have analyzed the total quantities of Na^+, K^+ and Ca^{++} ions of a series muscles fatigued in Ringer's solution flushed with nitrogen and excited by tetanically for a total duration of 80 s. (Rana temporaria sartorius; 100 alternating capacitive discharges per second, 18°C, following four modalities: 10 tetani of 8 s. or 100 tetani of 0.8 s at intervals either of 0.5 min. or of 5 min). Every frog has two sartorius muscles: one muscle of the pair was tetanized as described, the other one was not stimulated and was used as control. The average tension maintained during the 80 s. of excitation is an excellent measure of mechanical performance. It is estimated from the sum of the integral tension-time of each tetanus measured directly by an electronic integrator.

While the four modalities resulted in approximately the same fall in muscle performance, no significant ionic variation was observed in three of them. This allows us to exclude ion displacements as a general cause of fatigue. In the fourth case, the Na^+ and Ca^{++} contents doubled, while the K^+ content decreased by half, compared with the controls. Despite these considerable ionic variations, the mechanical performances are not inferior to those of other types of fatigue tests. This test consists of 100 short tetani succeeding each other at 5 min intervals, and is therefore characterized by its long duration, 500 min. instead of 0.5 or 5 mm. in other cases. One can imagine that in all cases the excitation leads to a disorganization of the membrane which would result not only in an impaired action potential (BERGMANS and MARÉCHAL, 1960), but also by an increased permeability to all ions and by a depression of the active transport mechanisms which maintain the ionic equilibrium. The consequences of this imbalance can only become perceptible in the long run.

In conclusion, if the fatigue by direct excitation is accompanied by a deterioration of the membrane, it cannot be explained by a variation of the content of the muscle in mineral cations.

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