Role of Nitric Oxide in Modulation of Afferent Impulses in Cutaneous Branches of Somatic Nerves by Polarized Light

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Subcutaneous injection of L-NAME inhibited afferent impulse activity in *n. ischiadicus* and *n. saphenus* and abolished the increase in this activity induced by stimulation of mechanoreceptors after skin irradiation with polarized light with various spectral characteristics. Subsequent subcutaneous injection of sodium nitroprusside restored the pattern of afferent impulse activity in these nerves during repeated skin irradiation with polarized light.

Key Words: *synthase inhibitor; nitric oxide; polarized light; afferent nerve fibers; impulse activity*

Light-sensitive endogenous nitrocompounds promote the realization of various biological effects associated with photolytic generation of nitric oxide (NO) [1,2,7]. Photorelaxation was demonstrated in the trachea, aorta [5,6], urethra [13], blood vessels [8,9], and smooth and skeletal muscles [12]. The experimental data, which are of considerable theoretical interest, do not elucidate the mechanisms of these processes under natural conditions (*i.e.*, during light action on the skin). Here we studied changes in impulse activity in cutaneous branches of the femoral and sciatic nerves induced by irradiation of the skin of rat hind limbs with polarized light [4,10,11] of various wavelengths (450-480, 480-550, 620-760, and 400-2000 nm). NO donors and NO synthase inhibitors were used to evaluate the role of photoactivation of NO-containing tissue components.

MATERIALS AND METHODS

Experiments were performed on 17 male rats weighing 240-290 g and kept in a vivarium (Institute of Physiology, Belarussian Academy of Sciences) under standard conditions. The rats were intraperitoneally injected with 30 mg/kg nembutal and 400 mg/kg urethane and then placed into a shielded room. Impulse activity in afferent fibers of the sciatic and saphenous nerves was continuously monitored using bipolar AgCl electrodes (under mineral oil) [3]. The results were analyzed using software elaborated at the Belarussian Academy of Sciences.

Polarized light (Bioptron AG) with wavelengths of 450-480 (blue), 480-550 (green), 620-760 (red), and 400-2000 nm (white) and 40 mW/cm^2 power was applied to a 1.8-cm^2 area of depilated skin on rat hind limb from a distance of 5 cm. The skin was irradiated for 5 min after initial recording of baseline impulse activity in nerves. Light exposure began if the impulse activity remained unchanged for at least 15 min. After irradiation, the impulse activity was recorded for at least 20 min. Each exposure to light was preceded by estimation of mechanoreceptor sensitivity to mechanical stimulation (0.5 g/cm^2) produced by 1-min compression of the irradiated skin area with a small clamp, which caused no nociceptive response in narcotized animals. The order of exposure to polarized light with different spectral characteristics varied in each experiment. Sodium nitroprusside (5 μg/kg, RBI)

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or L-NAME (20 μg/kg, RBI) was injected subcutaneously (0.05 ml) into the tibial area of rat hind limb.

The results were analyzed using Student's *t* test and ANOVA.

RESULTS

Linearly polarized light with wavelengths of 620-760 and 450-480 nm activated slowly adapting receptors, which followed an initial increase in impulse activity of rapidly adapting receptors (Fig. 1). Polarized light with wavelengths of 620-760 and 450-480 nm increased the mean impulse activity to 158.7±9.9 ($p<0.001$) and 123.4±8.5 impulse/sec ($p<0.01$), respectively, compared to the control (92.6±6.3 impulse/sec). Polarized light with wavelengths of 620-760 nm was most effective in stimulating slowly adapting receptors.

Activation of slowly adapting receptors after irradiation at 480-550 and, especially, 400-2000 nm was less pronounced that that induced by 620-760-nm polarized light (Fig. 1).

Subcutaneous injection of L-NAME attenuated or even abolished (25-30 min postinjection) the response of slowly adapting receptors to skin irradiation (Fig. 2).

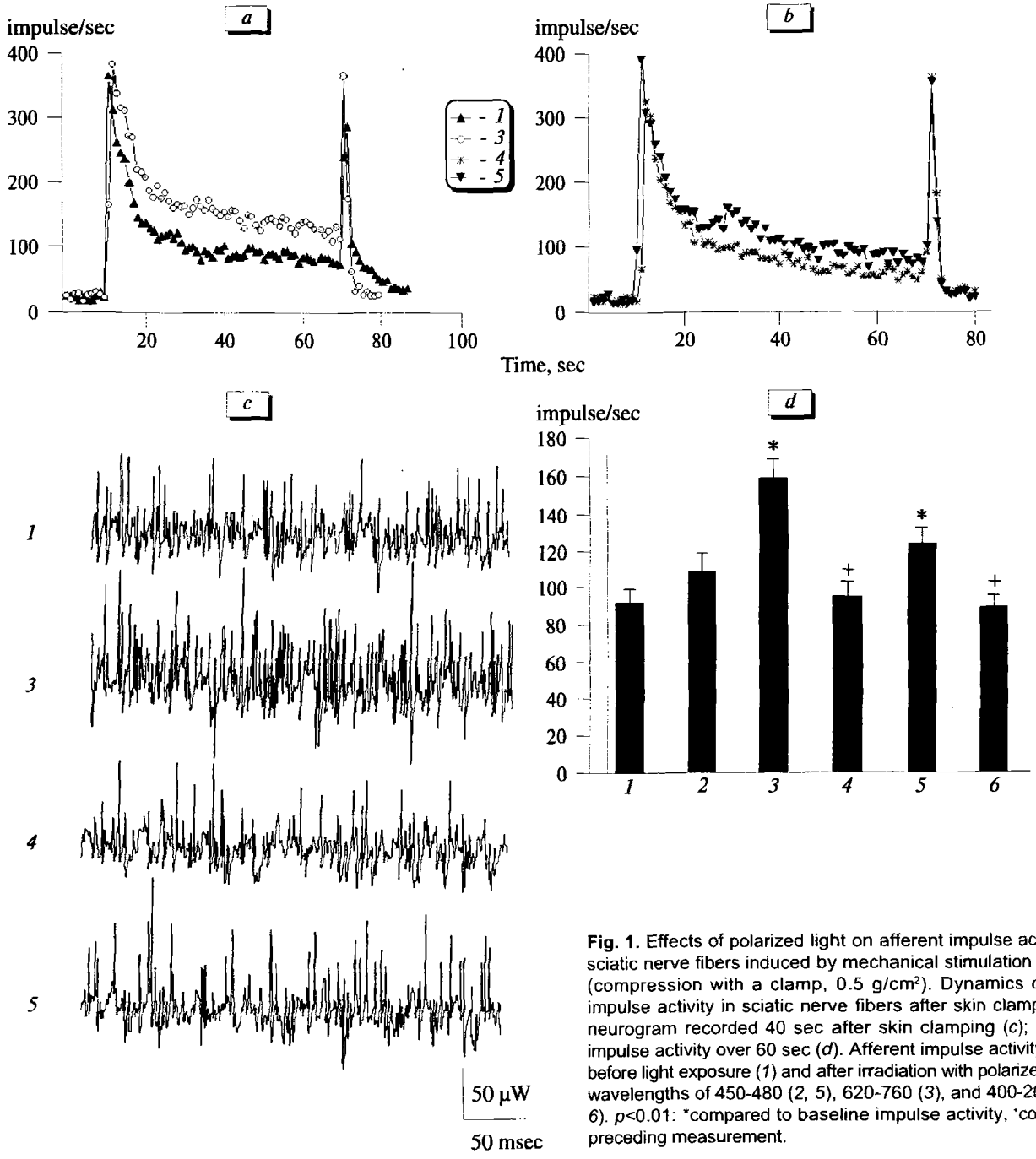

Fig. 1. Effects of polarized light on afferent impulse activity in rat sciatic nerve fibers induced by mechanical stimulation of the skin (compression with a clamp, 0.5 g/cm^2). Dynamics of afferent impulse activity in sciatic nerve fibers after skin clamping (*a*, *b*); neurogram recorded 40 sec after skin clamping (*c*); and mean impulse activity over 60 sec (*d*). Afferent impulse activity recorded before light exposure (*1*) and after irradiation with polarized light with wavelengths of 450-480 (*2*, *5*), 620-760 (*3*), and 400-2000 nm (*4*, *6*). $p<0.01$: *compared to baseline impulse activity, +compared to preceding measurement.

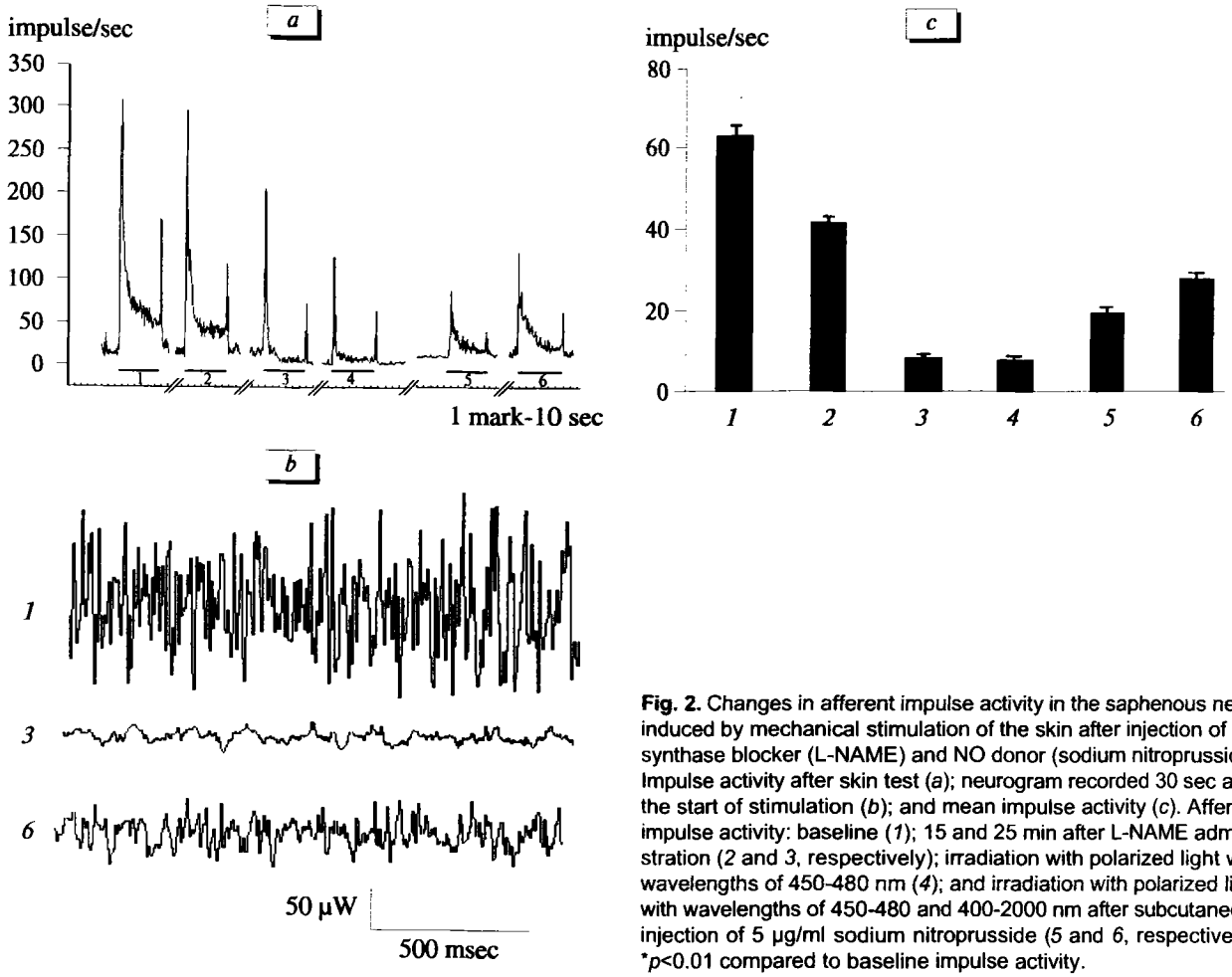

Fig. 2. Changes in afferent impulse activity in the saphenous nerve induced by mechanical stimulation of the skin after injection of NO synthase blocker (L-NAME) and NO donor (sodium nitroprusside). Impulse activity after skin test (*a*); neurogram recorded 30 sec after the start of stimulation (*b*); and mean impulse activity (*c*). Afferent impulse activity: baseline (*1*); 15 and 25 min after L-NAME administration (*2* and *3*, respectively); irradiation with polarized light with wavelengths of 450-480 nm (*4*); and irradiation with polarized light with wavelengths of 450-480 and 400-2000 nm after subcutaneous injection of 5 μg/ml sodium nitroprusside (*5* and *6*, respectively). *$p<0.01$ compared to baseline impulse activity.

L-NAME also inhibited the modulatory effect of polarized light on afferent impulse activity in cutaneous nerves (Fig. 2).

Repeated exposure to polarized light with wavelengths of 450-480 and 400-2000 nm after injection of L-NAME and sodium nitroprusside increased impulse activity in nerves to 20.1±1.4 and 28.4±1.3 impulse/sec, respectively (*vs.* 8.2±0.4 impulse/sec in the control). Taking into account published data on the activation of various receptors with NO [1,2,5,6,9,13] and light-induced stimulation of NO release from NO donors [5-9,12,13], our results suggest that NO synthase plays the major role in the activating effects of polarized light with various spectral characteristics on afferent impulse activity in cutaneous branches of somatic nerves.

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