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### Effects of vibration stimulus on lower-jaw-position sensation in patients with cerebral palsy during inhalation of laughing gas

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**Abstract** To clarify the effects of a vibration stimulus applied during sedation with nitrous oxide (hereafter referred to as laughing gas) on the ability of muscles attached to the lower jaw to sense lower-jaw position and on the sensation of muscle spindles attached to the lower jaw in patients with cerebral palsy (CP) using healthy adult subjects without functional abnormalities of the jaws and oral cavities as control subjects (hereafter referred to as healthy subjects). Experiments were performed under the following conditions: for each subject, before the application of the vibration stimulus (referred to as  $S_{pre}$ ) and after the application of the vibration stimulus ( $S_{post}$ ); before the inhalation of laughing gas (LG) and oxygen (air-inhalation condition: referred to as without LG inhalation) and during the inhalation of LG and oxygen (inhalation condition of LG and oxygen under LG-induced sedation: referred to as during LG inhalation). Subjects in the experiments were eight CP patients and eight healthy people as controls. The ability to discriminate lower-jaw position was estimated by asking the subjects to determine whether the diameter of a test stick was larger or smaller than that of a reference stick after performing the following tasks: a) holding a reference stick between the central teeth of their upper and lower jaws for 5 s, and b) replacing the reference stick with a test stick and holding it at the same position for 5 s, and the test stick was then removed. The following findings were obtained.

1) In comparing the ability of healthy subjects to discriminate between  $S_{pre}$  and  $S_{post}$  during LG inhalation using different test sticks, when the test stick diameter was 9.5 mm (smaller

than the reference stick diameter), the rate of mis-estimation (RME) for  $S_{\text{post}}$  was significantly larger than that for  $S_{\text{pre}}$  ( $P < 0.05$ ). No significant differences were observed for any other test sticks.

2) In comparing the ability of CP patients to discriminate between  $S_{\text{pre}}$  and  $S_{\text{post}}$  during LG inhalation using different test sticks, when the test stick diameter was 9.5 mm (smaller than the reference stick diameter), the RME for  $S_{\text{post}}$  was significantly smaller than that for  $S_{\text{pre}}$  ( $P < 0.05$ ). No significant differences were observed for any other test sticks.

These results suggest the following: the combination of LG for sedation with vibration stimulus further inhibits neuronal functions at the upper level of the central nervous system in CP patients, compared with cases in which each variable is applied separately, and the combination also inhibits the sustained increase in muscle tonus, which is characteristic of CP patients. LG reduces the activity of  $\gamma$ -motor neurons via the upper level of the central nervous system. In addition, tonic vibration reflex (TVR) develops due to the vibration stimulus, which increases the threshold value of sensitive muscle sensation and decreases the activity of  $\gamma$ -motor neurons, and furthermore decreases the activity of muscle spindles attached to the lower jaw. Consequently, a tendency toward increased ability to discriminate lower-jaw position is observed.

**Key words** Cerebral palsy, Laughing-gas, Lower-jaw-position sensation, Sedation, Vibration stimulus

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