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EMG Responses in Lower Leg Muscles Elicited by Head -Taps

Masahiro IIDA*, Masahiro TAKAHASHI*, Makoto IGARASHI*, **, Kayoko HITOUJI* and Kimihisa NOMURA*

*Department of Otorhinolaryngology, Tokai University School of Medicine
**University Research Center, Nihon University

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Forehead-taps elicited short-latency motor responses in the lower leg muscle which, together with vestibulocollic reflexes, might contribute to multisensory control of posture. We tested this paradigm in human subjects standing upright in order to determine if the responses differed depending on whether the taps were to the forehead or temporal bone. Forehead-taps elicited short-latency inhibitory EMG responses in both gastrocnemius muscles with a mean latency of 48 to 99 ms. The right or left temporal bone-taps elicited short-latency inhibitory EMG responses in the ipsilateral gastrocnemius muscle of 47 to 77 ms, short-latency excitatory EMG responses in the contralateral gastrocnemius muscle of 46 to 78 ms, and short-latency excitatory EMG responses in the contralateral tibialis anterior muscle of 48 to 78 ms. The temporal bone-taps elicited short-latency inhibitory EMG responses in the ipsilateral gastrocnemius muscle and excitatory EMG responses in the contralateral gastrocnemius muscle, which were thought to be generated by vestibular afferents and convergent with vestibular input for the multisensory control of posture.

Keywords : Head-taps, Short-latency EMG potentials, Vestibulospinal reflex, Lower leg muscles

INTRODUCTION

The monitoring of otolithic vestibulospinal reflexes in unexpected falls in humans have shown that initial electromyography (EMG) potentials, with a latency of 60 to 80 ms, are evoked in the lower limb muscles [1-3]. Colebatch *et al.* [4] demonstrated that the evocation of short-latency EMG potentials in sternocleidomastoid muscles to click stimuli depended on the integrity of the vestibular apparatus, mainly the saccule. In a study of sound-induced myogenic reflexes of lower leg in a patient with otolithic Tullio phenomenon, Brandt *et al.* [5] detected a short-latency activation, ranging from 47 to 80 ms, for the ipsilateral tibialis anterior muscle. Halmagyi *et al.* [6] reported that gentle head-taps evoked short-latency EMG potentials in the sternocleidomastoid muscles, with characteristics similar to the EMG potencials elicited by clicks. The aim of the present study was to test this paradigm in erect human subjects, in order to determine if the response differed according to whether the taps were to the forehead or temporal bone.

SUBJECTS AND METHODS

The EMG activity elicited by head-taps in the lower leg muscles (gastrocnemius and tibialis anterior) was measured according to the method of Halmagyi *et al.* [6] as follows : the subjects stood on a slanted platform with eyes closed and toes tilted upward by 5°. Fifteen healthy volunteers (11 males and 4 females, 20 to 44 years old, mean age 30.3), in whom caloric responses were normal, participated in the study. Six healthy volunteers (5 males and 1 female, 22 to 42 years old, mean age 31.5), with normal caloric responses, participated in the study of EMG activity elicited by right or left temporal bone-taps. The head-taps were manually administered at a distance of 10cm from the forehead, at random times, with a reflex hammer. A quantitative analysis of the head-

Masahiro IIDA, Department of Otorhinolaryngology, Tokai University School of Medicine, Bohseidai, Isehara, Kanagawa 259-1193 Japan TEL: 81-463-93-1121 FAX: 81-463-94-1611

taps was not done. Rectified EMG responses of the lower leg muscles were recorded and averaged. An active surface electrode was placed over the middle of each muscle and a reference electrode over each tendon. To trigger the averager, we used an accelerometer mounted on the forehead. 100-200 sweeps were recorded and the responses to taps in different places (forehead or temporal bone) were analyzed. All subjects gave informed consent to participate in the study, after the experimental procedure had been explained in accordance with the Helsinki Declaration.

RESULTS

The type of response differed according to whether the taps were to the forehead or temporal bone

Forehead-taps;

The forehead-taps elicited short-latency, inhibitory EMG responses in both gastrocnemius muscles. The mean latency ranged from 47 ± 4.1 to 98 ± 5.8 ms on the right side, and from 48 ± 4.1 to 99 ± 6.8 ms on the left side (Fig. 1). In one subject, the forehead-taps elicited short-latency, inhibitory EMG responses of 49 to 91 ms in the right gastrocnemius muscle, 48 to 90 ms in the left gastrocnemius muscle, and a short-latency, excitatory EMG response of 27 to 78 ms in the right tibialis anterior muscle (Fig. 2).

Temporal bone-taps;

The temporal bone-taps elicited short-latency, inhibitory EMG responses in the ipsilateral gastrocnemius muscle, excitatory EMG responses in the contralateral gastrocnemius muscle, and excitatory EMG responses in the contralateral tibialis anterior muscle. The right temporal-taps elicited short-latency, inhibitory EMG responses ranging from 47 ± 4.2 to 76 ± 7.6 ms in the right gastrocnemius muscle, excitatory EMG responses of 47 ± 5.1 to 78 ± 5.5 ms in the left gastrocnemius muscle, and excitatory EMG responses of 49 ± 4.5 to 76 ± 6.8 ms in the left tibialis anterior muscle (Fig. 3). The left temporal-taps elicited short-latency inhibitory EMG responses ranging from 47 ± 5.3 to 78 ± 5.6 ms in the left gastrocnemius muscle, excitatory EMG responses of 46 ± 5.9 to 78 ± 6.2 ms in the right gastrocnemius muscle, and excitatory EMG responses of 47 ± 5.3 to 77 ± 7.6 ms in the right tibialis anterior muscle (Fig. 4).

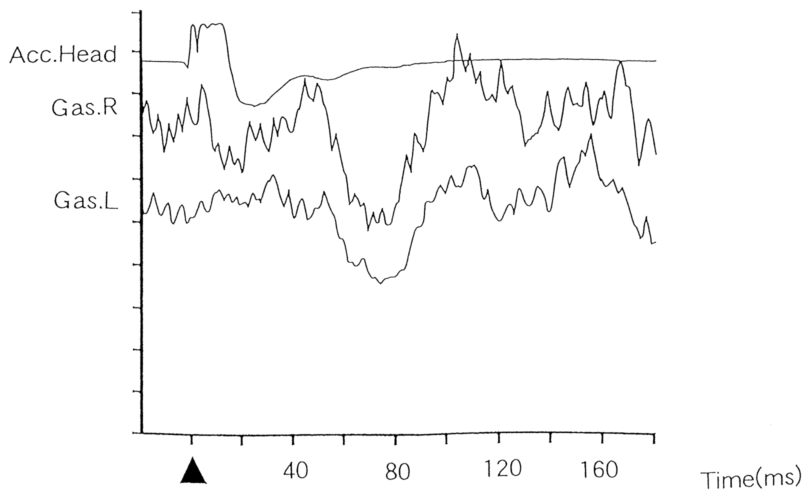

Fig. 1 EMG responses of the right and left gastrocnemius (Gas. R, Gas. L) muscles elicited by forehead-taps in a normal human subject. Trigger: an electric switch affixed to the hammer. Acceleration of head (Acc. head) was measured by an accelerometer mounted on the forehead. Top trace shows triggering by forehead-taps, and the middle and bottom traces show the EMG potentials in the right and left gastrocnemius muscles. Triangle shows the time of trigger. Each time scale division equals 20 ms. Note that activity of the right gastrocnemius muscle is inhibited with a latency of 52 (onset) ms to 92 ms (end), and activity of the left gastrocnemius muscle is inhibited with a latency of 52 (onset) ms to 90 ms (end).

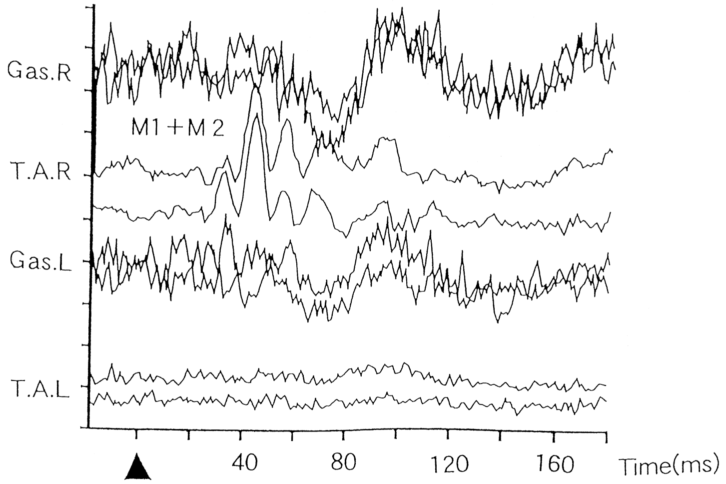

Fig. 2 EMG responses of the right and left gastrocnemius (Gas. R, Gas. L) muscles and tibialis anterior muscles (T.A. R, T.A. L) elicited by forehead-taps in a normal human subject. Trigger: an electric switch affixed to the hammer. Acceleration of head (Acc. head) was measured by an accelerometer mounted on the forehead. Top trace shows triggering by forehead-taps. Traces of two recordings are shown. Triangle shows the time of the trigger. Each time scale division equals 20 ms. Activity of the right gastrocnemius muscle is inhibited with a latency of 49 (onset) ms to 91 ms (end), and activity of the left gastrocnemius muscle is inhibited with a latency of 48 (onset) ms to 90 ms (end). Note the excitatory EMG responses (M1 and M2) with a latency of 27-78 ms in the right tibialis anterior muscle.

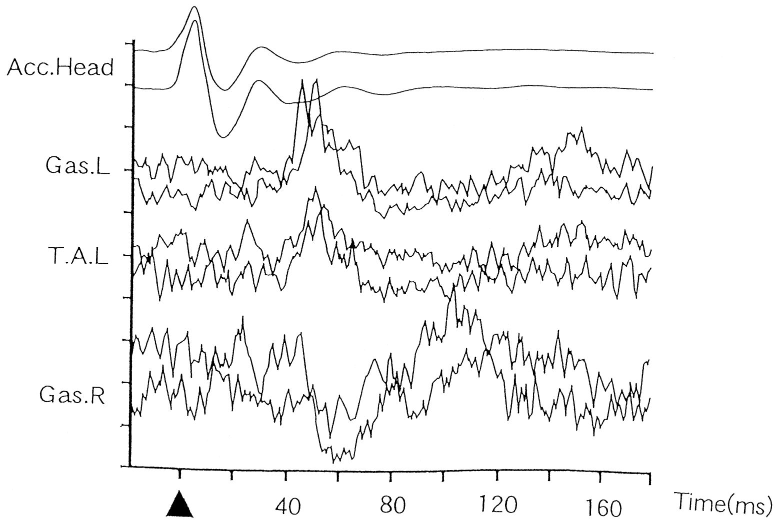

Fig. 3 EMG responses of the right and left gastrocnemius (Gas. R, Gas. L) muscles and the left tibialis anterior muscles (T.A. L) elicited by right temporal bone-taps in a normal human subject. Trigger: an electric switch affixed to the hammer. Acceleration of head (Acc. head) was measured by an accelerometer mounted on the forehead. Top trace shows triggering by forehead-taps. Traces of two recordings are shown. Triangle shows the time of the trigger. Each time scale division equals 20 ms. Note inhibitory EMG responses with a mean latency of 49-76 ms in the right gastrocnemius muscle, excitatory EMG responses with a mean latency of 43-71 ms in the left gastrocnemius muscle, and excitatory EMG responses with a mean latency of 42-72 ms in the left tibialis anterior muscle.

DISCUSSION

Myogenic potentials can be generated by click-evoked vestibulocollic reflexes [3, 4]. Halmagyi *et al.* [6] and Iida *et al.* [7] have reported that head-taps also elicited EMG potentials, since the vestibulocollic reflexes in the sternocleidomastoid muscles responded. The authors have found that head-taps elicited short-latency EMG reflexes from the vestibular afferent to the lower leg muscles, the conduction delay of the short-latency EMG potentials from the head movement elicited by the head-taps to the gastrocnemius muscles amount to about 50 ms, which were delayed on all patients with vestibular lesions on the affected sides, which was thought to be generated by vestibular afferent and converges with vestibular input for multisensory control of posture [8]. It could explain the latency of vestibulospinal reflexes in patient with the Tullio phenomenon [5, 9]. Therefore, the EMG potentials elicited by the head-taps in the lower leg muscles seemed to be vestibular evoked myogenic potentials(VEMP). The head movements elicited by the head-taps paralleled the direction of the head-taps [8]. Therefore, a linear accelerstion was given to the vestibular apparatus, which should stimulate the otolithic organs. In the present study (Fig. 2), the forehead-taps elicited short-latency inhibitory EMG responses of 27 to 78 ms in the right tibialis anterior muscle, which might be spinal stretch reflexes (M1 and M2) in the tibialis anterior muscle [10, 11]. Accordingly, the short-latency inhibitory EMG potentials elicited by the forehead-taps might be a vestibulospinal reflex. Furethermore, if these responses had been caused by spinal stretch reflexes, the gastrocnemius muscles would have been excited. However, our recordings indicate the opposite (Fig. 1).

The temporal bone-taps elicited short-latency inhibitory EMG responses in the ipsilateral gastrocnemius muscle, and excitatory EMG responses in the contralateral gastrocnemius muscle (Fig. 3, 4). These responses were similar to those in Markham's study [11]. However, the excitatory EMG responses in the contralateral tibialis anterior muscle were not clarified. The conduction delay in the short-latency EMG responses elicited by the temporal bone-taps in the lower leg muscles differed from the EMG responses elicited by the forehead-taps (Fig. 1, 3 and 4).

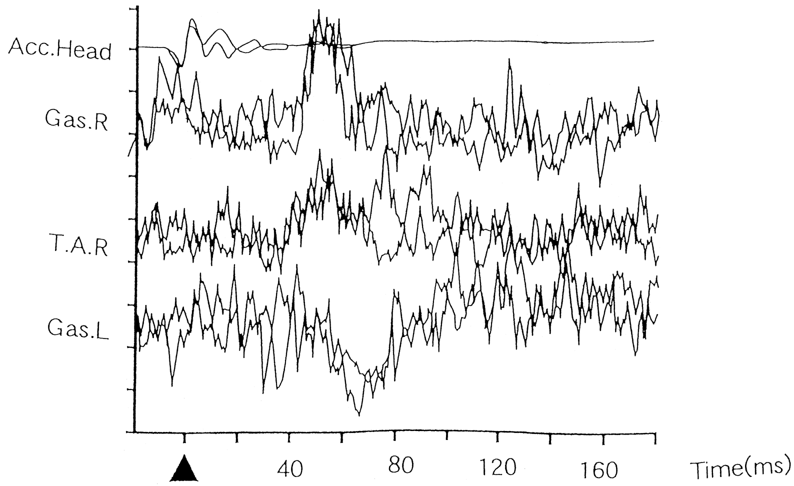

Fig. 4 EMG responses of the right and left gastrocnemius (Gas. R, Gas. L) muscles and the right tibialis anterior muscles (T.A. R) elicited by left temporal bone-taps in a normal human subject. Trigger: an electric switch affixed to the hammer. Acceleration of head (Acc. head) was measured by an accelerometer mounted on the forehead. Top trace shows triggering by forehead-taps. Traces of two recordings are shown. Triangle shows the time of the trigger. Each time scale division equals 20 ms. Note inhibitory EMG responses with a mean latency of 45-79 ms in the left gastrocnemius muscle, excitatory EMG responses with a mean latency of 45-70 ms in the right gastrocnemius muscle, and excitatory EMG responses with a mean latency of 42-72 ms in the right tibialis anterior muscle.

The end-latency of about 80 ms of EMG responses elicited by the temporal bone-taps in the lower leg muscles was shorter than those elicited by the forehead-taps. Accordingly, the latencies of the EMG responses in the lower leg musles were shortened when elicited by temporal bone-taps rather than forehead-taps, which is in agreement with the short-latency of vestibulospinal reflexes in patient exhibiting the Tullio phenomenon [5, 9].

It is still a controversial issue as to what extent vestibular mechanisms are involved in the control of posture and gait. It is noteworthy that the onset of short-latency EMG potentials (about 50 ms) in the lower leg muscles are elicited earlier by head-taps than that of the otolithic myogenic long-loop reflexes with a latency of 130 to 140 ms. It is assumed that the short-latency EMG potentials elicited by head-taps in the lower leg muscles may initially play a role in the postural control mechanism.

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