Facilitatory Interaction in Transmission to Motoneurones from Vestibulospinal Fibres and Contralateral Primary Afferents

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Summary. Interaction between volleys in the vestibulospinal tract and contralateral primary afferents in transmission to motoneurones has been investigated with intracellular recording from motoneurones in cats.

Stimulation of Deiters' nucleus facilitates crossed reflex action, excitatory to extensor and inhibitory to flexor motoneurones, evoked from the flexor reflex afferents (FRA; high threshold muscle afferents and cutaneous afferents tested). It is postulated that vestibulospinal fibres and contralateral (co) FRA converge on common interneurones.

Reversed conditioning-testing revealed that volleys in the coFRA facilitated disynaptic vestibulospinal PSPs. Control experiments showed that this facilitation was not due to an action by the FRA volleys at the level of Deiters' nucleus or other brain centres. It is postulated that vestibulospinal fibres have monosynaptic connexions with last order interneurones in certain crossed reflex pathways from the FRA, mainly excitatory to extensors and inhibitory to flexors. Some exceptions are described notably that in toe flexor motoneurones the dominating connexion is with last order excitatory interneurones. Mixed excitatory and inhibitory effects are evoked in motor nuclei to some muscles among them hip abductors.

In knee flexor motoneurones volleys in the coFRA gave a parallel facilitation of the disynaptic vestibulospinal IPSP and of the Ia IPSP, while in ankle flexor motoneurones there was no concomitant facilitation of the Ia IPSP. From this difference it is postulated that the disynaptic vestibulospinal IPSP in knee flexor motoneurones is evoked largely or entirely via Ia inhibitory interneurones (which are also excited from the coFRA) but in ankle flexors by monosynaptic excitation of last order interneurones in an inhibitory pathway from the coFRA not shared with Ia afferents.

The results are discussed in relation to vestibular regulation of extension and sideways limb movements, to interaction between the two limbs in standing and to feed-back control from the FRA of vestibulospinal actions.

Key words: Deiters' nucleus — Vestibulospinal tract — Motoneurones — Disynaptic PSPs — Crossed extensor reflex

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**Introduction**

Vestibulospinal fibres have monosynaptic connexions with motoneurones to certain knee and ankle muscles (for references see Grillner and Hongo, 1972) and in addition mediate di- and polysynaptic effects which consist mainly of excitation in extensor and inhibition in flexor motoneurones (Grillner, Hongo and Lund, 1970). Investigations on the segmental organization of these pathways revealed that vestibulospinal fibres have monosynaptic connexions with interneurones belonging to the reciprocal inhibitory pathway from extensor Ia afferents to flexor motoneurones (cf. Grillner, Hongo and Lund, 1966; Grillner and Hongo, 1972). There was, however, only occasionally evidence for interaction with transmission from other ipsilateral primary afferents.

The distribution of the disynaptic excitatory and inhibitory effects from the vestibulospinal tract resembles that of the classical crossed extensor reflex (Sherrington, 1910) and it will be shown that there is a mutual facilitatory interaction in transmission to motoneurones from vestibulospinal fibres and contralateral flexor reflex afferents (coFRA) suggesting convergence on common interneurones. Moreover, since conditioning stimulation of the coFRA facilitates disynaptic PSPs evoked from the vestibulospinal tract in motoneurones it is inferred that vestibulospinal fibres connect monosynaptically with last order interneurones in both excitatory and inhibitory pathways of the crossed extensor reflex.

The present investigation extends the results reported in a short communication (Bruggencate et al., 1969). Some of the findings were discussed in reviews (Lundberg, 1969; Grillner and Hongo, 1972; Hultborn, 1972). Similar findings have been reported by Hongo et al. (1972).

**Material and Methods**

**Anaesthesia and Dissection**

The experiments were performed on cats (2.5—3.5 kg) operated upon under ether anaesthesia which was subsequently replaced by chloralose (40—50 mg/kg). In the further course of the experiments small doses of Nembutal were given, adding to a total amount of 10—20 mg/kg. The animals were immobilized by Flaxedil and artificially respired. End expiratory CO₂-concentration, arterial blood pressure and rectal temperature as well as the temperature within the mineral oil pools were measured throughout.

The following hindlimb nerves were dissected, the abbreviations used being given in parenthesis: quadriceps (Q), sartorius (Sart), gracilis (Grac), adductor femoris (Add), posterior biceps and semitendinosus (PBSt), anterior biceps and semimembranosus (ABSm), gastrocnemius and soleus (G-S), flexor digitorum and hallucis longus plus plantaris (FDL), tibial (Tib), anterior tibial and extensor digitorum longus (DP), saphenous (Saph), sural (Sur), skin division of superficial peroneal (SP). On the contralateral, right side the hamstring nerve (coIt, consisting of PBSt and ABSm), gastrocnemius-soleus (coG-S), and sural (coSur) were dissected. In one experiment, the ipsilateral superior (nerve to tensor fascia lata removed) and inferior gluteal nerves were also dissected, in other experiments gluteal motoneurones were identified according to convergence of Ia EPSPs from hip muscles and G-S. In 4 experiments there was a more extensive dissection of the peroneal group into: anterior tibial (TA), extensor digitorum longus (EDL), peroneus longus, brevis and tertius (SPM). The nerves were dissected and mounted on bipolar silver wire electrodes in mineral oil pools; the ventral nerves Q, Sart, Saph were mounted in buried electrodes. Stimulation strength is given in times threshold (T) of the most excitable fibres in the nerve stimulated.