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Crossed proprioceptive reflexes in the human leg

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It is to be expected that crossed reflex actions are important in the co-ordination of the two legs during normal stepping and standing. However, despite a number of recent animal studies (Harrison & Zytnicki, 1984; Harrison *et al.* 1986; Bajwa *et al.* 1992) there is a remarkable lack of information regarding crossed reflexes in man. In the present investigation, following approval by the local ethical committee, crossed reflex actions were observed in healthy human subjects by observing the modulation of the ipsilaterally evoked H reflex from the gastrocnemius or from the soleus muscle, in response to stimulation of the tibial nerve contralaterally.

Stimulating and recording electrodes were sited so as to record H reflexes both ipsilaterally and contralaterally. The ipsilateral reflex was then observed while varying the stimulus strength to the contralateral electrodes and while varying the interval with which the contralateral (conditioning) stimulus preceded the ipsilateral (test) stimulus. The stimulation sequences were varied to allow responses evoked by the test stimulus preceded by a conditioning stimulus to be interleaved with responses evoked by the test stimulus alone. The two sets of data were then averaged separately for analysis. Successful recordings were obtained from six voluntary subjects.

Conditioning stimulation at two times nerve threshold produced an inhibition of the gastrocnemius H reflex. This inhibition was significant with a conditioning-test interval as short as 5 ms ($P=0.02$, *t* test) and was maximal with an interval of 10 ms ($P=0.001$). Conditioning stimulation at three times threshold produced, in addition to the inhibition, a significant facilitation of the H reflex, albeit at longer conditioning-test intervals (40 ms and greater) (cf. Kocejka & Ramen, 1992).

From these results it is evident that crossed reflexes are operative in normal awake individuals. At present it is uncertain whether the short latency inhibition is due to group I or to group II afferent fibres. The later facilitatory response is presumably due to the recruitment of smaller diameter fibres, possibly of group II or group III afferent origin.

Supported by the MRC.

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Cutaneous sensation and evoked potentials following foot stimulation are gated during human gait

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During movement, there often is a need to control the movement generated sensory input and its perception. A movement related increase in detection threshold of cutaneous stimuli has been demonstrated by several authors (Coquery, 1978; Dyhre-Poulson, 1978). Most studies have concentrated on cutaneous sensation of the hand. In contrast, little is known about movement related modulation of transmission from cutaneous afferents from the foot in humans.

To investigate how gait influences the perceived intensity of cutaneous input from the skin of the foot, the tibial or sural nerve was stimulated at the ankle during walking or running on a treadmill in a series of volunteers (with approval of the ethical committee). The task of the subjects was either to verbally report the detection of a stimulus or to press a hand-held force transducer with a force which was equivalent to the intensity of the sensation. As compared to standing, the detection threshold for these stimuli was raised by more than 30 % during locomotion. This relative insensitivity during gait was correlated with a reduction in evoked activity. Following sural nerve stimulation, the amplitude of somatosensory evoked potentials (SEP, P40-N80 complex), recorded at scalp level, was on average 62 % of the level during standing.

Moreover, during walking there was a phase-dependent modulation in perceived intensity for all stimulus levels used (in the range between 1.5 and 2.5 times the perception threshold measured while standing). Shocks given just prior to footfall, were perceived as more intense than shocks of equal intensity given in other parts of the step cycle. In contrast there was a decrease in sensitivity for stimuli delivered immediately after ipsi- and contralateral footfall. In agreement with this, during gait the amplitude of the SEP was larger than average at the end of the swing phase and smaller just after foot fall of the stimulated leg.

The reduced sensation and the decrease in amplitude of the evoked potentials after touchdown are thought to be due to occlusion or masking by concomitant afferent input from the foot. The phasic increase in sensitivity at end swing may result from a centrally generated facilitation of sensory transmission of signals related to anticipated touchdown.

Supported by NATO grant (CRG 910574).

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Does posture alter cutaneomuscular reflexes in the human lower limb?

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Cutaneomuscular reflexes (CMRs) with polyphasic excitatory and inhibitory components can be elicited in adults following innocuous electrical stimulation of the toes (Gibbs *et al.* 1993; Bagheri & Baxendale, 1993). We have extended our work by examining CMRs during standing with forward and backward leans to investigate if CMRs are modified by posture.

After local ethical committee approval was obtained, experiments were performed in ten neurologically normal subjects. CMRs were elicited by stimulation of the hallux with single pulses of 100 μ s duration, with an intensity three times perceptual threshold at about 2 Hz. The rectified surface EMG was recorded simultaneously from the anterior tibial muscles (TA), gastrocnemius (G), quadriceps (Q) and hamstrings (H) muscles of the right leg. Peristimulus time averages of 500 stimulus repetitions were prepared whilst the subjects stood leaning backwards or forwards. CMRs were identified by comparison of the averaged EMG in the 100 ms before and 200 ms after stimulation. CMRs were elicited whilst subjects leaned forwards or backwards by about 5 deg.

Table 1. Mean latency (\pm s.e.m.) of the first excitatory and inhibitory components of CMRs in two different positions

	Backwards Lean		Forwards Lean	
	Excitatory (E1)	Inhibitory (I1)	Excitatory (E1)	Inhibitory (I1)
TA	50.7 \pm 3.2 <i>n</i> = 9	52.4 \pm 3.2 <i>n</i> = 8	49.9 \pm 3.2 <i>n</i> = 8	54.6 \pm 4.5 <i>n</i> = 9
G	49.3 \pm 4.4 <i>n</i> = 6	57.8 \pm 5.3 <i>n</i> = 7	60.0 \pm 6.7 <i>n</i> = 5	65.3 \pm 5.1 <i>n</i> = 6
Q	57.3 \pm 6.1 <i>n</i> = 6	58.3 \pm 4.5 <i>n</i> = 7	55.7 \pm 8.8 <i>n</i> = 3	59.6 \pm 7.4 <i>n</i> = 5
H	56.8 \pm 7.1 <i>n</i> = 5	61.7 \pm 4.3 <i>n</i> = 7	67.0, <i>n</i> = 1	65.8 \pm 6.9 <i>n</i> = 5

No significant differences were found between the latencies of E1 and I1 during backward and forward leans ($P > 0.05$, Student's *t* test). Where the background EMG was small or absent it was not always possible to identify all components of each CMR.

In experiments where the intensity of contraction was changed with a fixed posture, the magnitude of the CMR increased with the intensity of the contraction. Thus in the experiments performed in two different body positions, when the magnitude of the components of CMR appeared to change it could be attributed to changing EMG background rather than to the posture.

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The ankle jerk in young men and women

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In earlier work we measured the mechanical events following a tap to the Achilles tendon in students. For both men and women we used throughout the observations steady dorsiflexing torque of 1.12 N m to induce some tension in the soleus muscle and thus allow the tap to be effective (Walsh *et al.* 1993). We found that the relaxation in the women was significantly slower than that of the men.

It is known, however, that the relaxation time of muscle varies with its length, becoming longer when the tissue is elongated (Hill, 1972; Sale *et al.* 1982). As women are on average less muscular than men our results might have been due to the dorsiflexing force inducing a greater degree of stretch of the muscle in the women.

In the present investigations we have used the same apparatus as was described previously but for each subject tested we adjusted the dorsiflexing force to bring the foot to rest at a right angle to the leg. We have thus controlled the length of the muscle. Our observations were on 85 male and 91 female first year students during their practical work in physiology. The half-relaxation times (mean \pm s.d.) were 35.7 \pm 7.9 ms in the men and 41.2 \pm 9.2 ms in the women. This difference is illustrated in Fig. 1 and is highly significant ($P = 0.001$). The mean age of both groups was 18.5 years.

Thus under these different conditions a similar difference between men and women has been found, as has previously been reported.

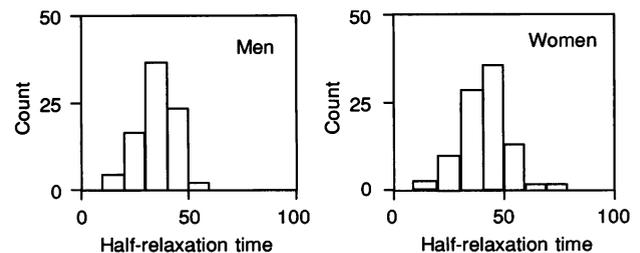


Fig. 1. Frequency distributions of the results. The abscissae refer to the times taken for the tension to fall from 75 to 25% of the peak value.

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