Development of an Electrode Array for Transcutaneous Stimulation of Lumbar Posterior Roots

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LUMBAR posterior roots in humans can be activated by epidural [1] and transcutaneous [2] electrical spinal cord stimulation. Epidural spinal cord stimulation can control spasticity [3] and generate rhythmical activity [4] in spinal cord injured people. For both neuromodulatory effects the stimulation site had to be above the upper lumbar posterior roots [1,3,4]. Here, we studied the selectivity of transcutaneous spinal cord stimulation by eliciting posterior root-muscle (PRM) reflexes and recording the compound muscle action potentials. For special interest was the recruitment of PRM reflexes of the L2-L4 innervated quadriceps (Q) as opposed to the L5-S2 innervated triceps surae (TS) and their relation to rostrocaudal stimulation site.

In a pilot study the selectivity of transcutaneous stimulation of lumbar posterior roots at different spinal levels were measured in ten subjects (5 f.) with intact nervous system. The PRM reflexes of the quadriceps muscle group had the lowest thresholds and highest peak-to-peak amplitudes at stimulation site of 2 cm rostral to the interspinous space T11-T12, whereas all other muscle groups had the highest responses at the caudal electrode levels. PRM reflexes in quadriceps were markedly reduced and the probability of eliciting M waves increased at the caudal stimulation sites. The recruitment curve of Q and TS were significantly different (p-value < 0.01) at all stimulation sites. This study resulted in the electrode configuration (Fig. 1) where each electrode pad can be independently switched on or off. The material of the flexible printed circuit is polyimid and the contact pads (10x10 mm) are gold coated. The electrode is fixed to the skin with self-adhesive hydrogel pads.

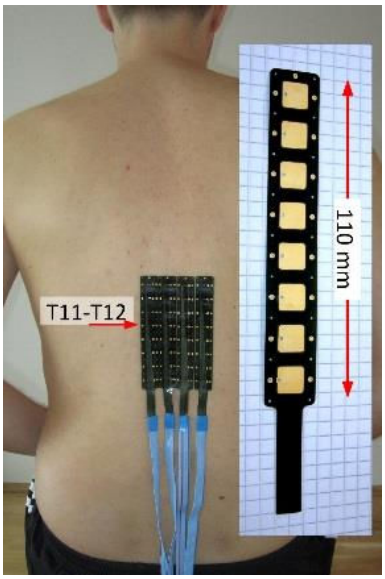

Figure 1: Electrode array. Each electrode pad has a size of 1 x 1 cm and is coated with gold.

Even though the distribution of the generated electrical field with transcutaneous electrodes is unfocused in relation to the target structures [5] selective stimulation is possible to some degree. The anatomical structure and electrical properties of the spine, e.g. relatively high conductivities of the intervertebral discs, might cause a segmental shift of the field, by changing the stimulation level. Differences between sensory and motor roots activation depending on spinal levels of transcutaneous spinal cord stimulation has been demonstrated [6]. Here we showed that predominate stimulation of lumbar posterior roots can be controlled by the transcutaneous technique which is of special interest in neuromodulation of lower limb functions.

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