Gait analysis in patients treated with spinal cord stimulation

L. P. Ardigò¹, A. Giordano³, C. Bonezzi², D. Miotti², G. Bazzini¹ and F. Saibene¹, ⁴
¹C. S. A. M. - Ergonomia, Istituto scientifico di Pavia of the Fondazione S. Maugeri, Clinica del Lavoro e della Riabilitazione, IRCCS, Italy
²Unità di Terapia del Dolore, Istituto scientifico di Pavia of the Fondazione S. Maugeri, Clinica del Lavoro e della Riabilitazione, IRCCS, Italy
³Servizio di Bioingegneria, Istituto scientifico di Veruno of the Fondazione S. Maugeri, Clinica del Lavoro e della Riabilitazione, IRCCS, Italy
⁴Laboratory of Physiology I. T. B. A., CNR, Milano/Italy

Introduction
Spinal cord stimulation has been used for about 30 years to manage different chronic pain syndromes (Bennett et al., 1999, Bonezzi et al., 2000). The procedure offers several potential benefits: relatively simple implantation technique, control of stimulation parameters by patients, and reversibility. Besides an objective pain evaluation it is important to follow the potential benefits of a spinal cord stimulator (SCS; Pisces-Quad Model electrodes, Medtronic, Inc. Minneapolis, MN) with simple functional tests related to common everyday activities, like walking (North et al., 1991).

Methods
Five patients (4 males and 1 female, mean±standard deviation 65±14.1 y, 72±10.5 kg, 165±7.9 cm) with failed back surgery syndrome (FBSS) performed a standard test walking 8 times at their spontaneous speed (SW) and 8 times at their fastest velocity (FW) along a 9 m walkway. The test was performed at the beginning of their first admission (A), after SCS implant (I) and about 3 months later (L). The 3D position of their feet was digitised (100 Hz) by an automatic motion analyser (ELITE, B.T.S., Milan, Italy) and then processed by a gait analysis software (Giordano et al., 1999), to measure: speed (s), step length (sl, average between left step and right one), step frequency (sf), monopodal stance (ms) and single foot support (ss).

Results & Discussion
All the measured and derived parameters were expressed as the ratios I/A and L/A. At SW (5 subjects), s, sl, sf, ms and ss, were respectively 1.33±0.21, 1.18±0.14, 1.12±0.06, 1.12±0.11 and 0.94±0.06 for I/A; and 1.64±0.83, 1.46±0.73, 1.12±0.06, 1.13±0.10 and 0.93±0.04 for L/A. At FW (2 subjects), s, sl, sf, ms and ss were respectively 1.15, 1.17, 0.99, 1.09 and 0.95 for L/A, 1.66, 1.82, 0.93, 1.13 and 0.93 for I/A. At SW the large speed increase, observed already at I, was due to an increase of both sl and sf, while at L the further speed increase was mostly due to sl (fig. 1, left). The monopodal stance which is considered a positive outcome indicator, increased at I, remaining thereafter constant (fig. 2, left), besides the ss decreases already at I and then remains constant (fig. 3, left). At FW only sl contributes to the s increase (fig. 1, right), ms increases (fig. 2, right) and ss decreases (fig. 3, right). The speed increment measured at A and L on the 9 m walkway test was similar to that measured in 6 min walking test (Enright et al., 1998), that was terminated without symptoms of fatigue. However at the same speed, the cost of walking, measured on a treadmill as energy expended per unit distance and unit body mass, remained at rather high values also after SCS implant. It must be acknowledged that the reduced walking ability depends not only on the pain, but also on impairment of the functionality due to long history of muscles disuse, and it takes time to recover to full normality. This simple test allows to quantify the functional effect of SCS implant during the follow-up. More experiments are needed to provide better insight of the argument.
**Figure 1:** sl, sf and s, as I/A and L/A, at SW (left) and FW (right)

**Figure 2:** ms, as I/A and L/A, at SW (left) and FW (right)
Figure 3: ss, as I/A and L/A, at SW (left) and FW (right)

References


Acknowledgements

The authors aknowledge the assistance of Edda Capodaglio in sampling data and Raffaella Bettaglio in helping with patients.