Proprioceptive Neuromuscular Facilitation With Electrical Stimulation

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Abstract: The aim of Proprioceptive Neuromuscular Facilitation (PNF) method is to promote functional movement of paralyzed limb through facilitation, inhibition, strengthening, and relaxation of muscle groups. The handicapped person produce the movement, which is combined with a properly graded resistance, fitted to the patient’s needs by a physiotherapist. New addition introduced here, is the assistance of surface functional electrical stimulation during some movement patterns of the leg (e.g. flexion-adduction-external rotation). Customized electrical stimulator was mounted inside a leg pedal housing, enabling precise control of stimulation amplitude.

INTRODUCTION

PNF is a well-conceived physical therapy modality developed in the 1940s and 1950s to rehabilitate patients with paralysis as a result of neurological dysfunction. In the 1980s, sport therapists began using the stretching components of PNF with healthy athletes to increase their range of motion, to improve performance and to reduce the risk of injury. The PNF is observed more than a technique, it is a philosophy of treatment. Each treatment is directed at a total human being, not at a specific problem or body segment. The basic facilitation procedure provides the tools for the therapist to help the patient gaining efficient motor function. The effectiveness does not depend on conscious cooperation of patient. The desired motor response in general, smooth, coordinated and optimal muscle pattern is consisting of both isometric and isotonic contractions. In PNF there are used resistance, irradiation and reinforcement, manual contact, stretch, guidance and control, traction, verbal commands, vision and timing. Resistance is used to aid muscle contraction, supervise motor control and increase strength. Irradiation and reinforcement rely on spread of response to stimulation. Manual contact is used to increase strength and guide motion with grip and pressure. Stretch action assists muscle elongation and provokes stretch reflex in order to facilitate contraction and decrease muscle fatigue. Guidance and control of the provoked movement trajectory by the fine alignment of therapist’s body arms and hands are here to assist to achieve desired pattern and timing of motion. Verbal instructions and visual information stimulate the patient for maximal active cooperation. The common denominator in PNF is always the patient’s voluntary mediated, complex activity in several joints resulting (most frequently) in limb movement.

In the cases with severe neuromuscular dysfunction, the range of motion or the achieved performance in general is not adequate if compared to the patient intention, desire or psychical effort during the exercise. In these cases the assistant with Functional Electrical Stimulation seems to be a valuable addition to achieve: (i) instant improvement of motor response, (ii) steady and marked progress of the health condition, (iii) last, however very important the help to the physiotherapist. This introductory study used modified one channel electrical stimulator. Prior to the session is required that the physiotherapist adjusts the maximal desired amplitude. Latter, during the PNF training, while is the physiotherapist still being involved with the patient by classical PNF means, in addition also controls the stimulator amplitude with the leg pedal from null amplitude up to the previously adjusted 100 % level. In such a way the physiotherapist supervises the timing and the “degree of help” needed in particular moment.

METHODS AND RESULTS

FES stimulator

For PNF task was developed simple microprocessor based stimulator with surface electrodes. Minimum required maintenance, easiness of use and the compliance with EC requirements were among design goals. To enhance versatility and accommodate the device to individual needs, the stimulator enable adjustment of stimulation parameters including: pulse width, stimulation frequency and amplitude, which can be set by the clinician via PC computer or a simple external module in advance or during stimulation if necessary. External module enables communication with the user via two pushbuttons and LED bar display. The frequency may be preset at [15 20 25 30 40 50 70 100] Hz, stimulation pulse width at [150 200 250 300 350 400 500 600 700] μs and stimulation pulse amplitude from 0 up to 135 V. Stimulation level is adjusted with two potentiometers. The potentiometer, mounted aside of the housing, is used to set the overall maximum stimulation amplitude. This is preset when the pedal is fully pressed down. The second potentiometer mounted on the pedal plate is adjusting stimulation amplitude from 0 up to the maximal level adjusted before. Amplitude is low when the pedal is in upward position. In this upward position is the DC/DC converter switched off automatically via hidden contact-less reed relay. Such ON/OFF operation regime is significantly extending battery life.

The device use is for the physiotherapist very simple; additional controls, not mentioned before, include only ON/OFF switch and connector for electrodes. External parameter adjustment module, if needed, can be connected via DB9 connector on the side of pedal. The unit is meant to stay on the floor and is operated (stimulation amplitude modulated) during a session with a foot only. The low battery situation is indicated with a beep signal.
PNF Application

When treating neuromuscular dysfunction, complex motor patterns are reduced to their basic movement and developmental components. The emphasis is placed upon selective reeducation of individual motor elements, through development of the fundamental skills of the limb control, stability and coordinated mobility. Possible example includes electrode pair placement on the calf's or equivalently on the peroneal nerve under the knee, both places being appropriate to elicit the flexion of knee joint. Such electrode placement is suitable for the leg flexion-adduction-external rotation task, when the therapist in addition to normal PNF practice, as described in introduction section, also varies stimulation level via the leg pedal (stimulator). These basic motor skills are later built upon by more functional activities. Each movement is reinforced through repetition and at the beginning high degree of FES assistance, which through time gradually decreases.

CONCLUSIONS

This presentation outlines the PNF stimulator with simple operation, robust design, adjustable parameters and good energy efficiency. To make it as simple as possible, the number of controls was reduced to a minimal possible number. Secondly, depicted is application of therapeutic electrical stimulation for leg (knee) flexion-adduction-external rotation task pattern in PNF practice. This example of electrical stimulation in PNF training is giving only one possible pattern for both, previously separated techniques, however several other movement patterns with this merged approach are possible.

REFERENCES