# DEVELOPMENT OF MOTORIZED FACILITATED ANKLE STRETCHING

Fan Gao

UT Southwestern Medical Center at Dallas, TX, USA
email: fan.gao@utsouthwestern.edu, web: http://www.utsouthwestern.edu/findfac/

## INTRODUCTION

Proprioceptive neuromuscular facilitation (PNF) was first proposed by Herman Kabat for the purpose of rehabilitation of polio patients with paralysis [1]. The technique was mainly based on the principles of Sherrington's laws of irradiation, successive induction and reciprocal innervation. Under tendon loading the Golgi tendon organs which is located in the musculotendinous junction will be fired and result in neurological inhibition and muscle relaxation. In facilitated stretching, a strong isometric contraction of the target muscle will trigger the Golgi tendon organs and relax the target muscle to facilitate lengthening and increasing range of motion. Due to its effect and ease to implement, PNF has become popular for physical therapist and athletic trainers to facilitate joint flexibility. Klein et al. found that PNF treatment in elderly will significantly improve flexibility, ROM, strength and ADL function [2]. The PNF is even found effective to increase muscle volume and alter muscle fiber types [3] and compared to static stretching PNF technique is more effective [4].

Stroke induced contractures and/or spasticity around ankle joint can severely limit the mobility of stroke survivors. Currently, few effective treatments for contracture and/or spasticity are available. One treatment option is passive movement of the joint. Clinically, a physical therapist (PT), [5-7] passively stretches the joint by manually moving the joint through the range of motion (ROM) to reduce spasticity and/or contracture. Continuous passive motion (CPM) devices are widely used in clinics and in patients' homes to prevent postoperative adhesion and reduce joint stiffness. More recently, a motorized device with intelligent control has been developed [8]. Though intelligent stretching provides promising treatment intervention there are still some limitations. For example, the treatment is purely passive with muscles totally relaxed. Due to the lack of voluntary participation the effects induced by intelligent stretching are limited to improvement in passive joint properties instead of muscle strength and coordination which are more related to functional performance. PNF technique combines both passive and active stretching and significant improvement on muscle strength and coordination has been reported [2-4]. Therefore PNF technique will be an excellent candidate as a more effective intervention strategy. The goal of this study is to develop a single degree of freedom motorized device which could successively implement PNF hold-relax technique on the ankle joint.

## METHODS

Development of motorized device

The motorized device consists of a servo motor (Danaher motion Inc., USA) and an inline gear box with a 25:1 gear ratio which increases the loading capacity of the motor up to 50 Nm. One uniaxial torque sensor was mounted on the motor shaft to register the torque signal. The motor was controlled by a drive and speed mode was chosen to control the speed and direction of the motor rotation. A built-in rotation encoder was used to provide the current position of the motor shaft (figure 1).

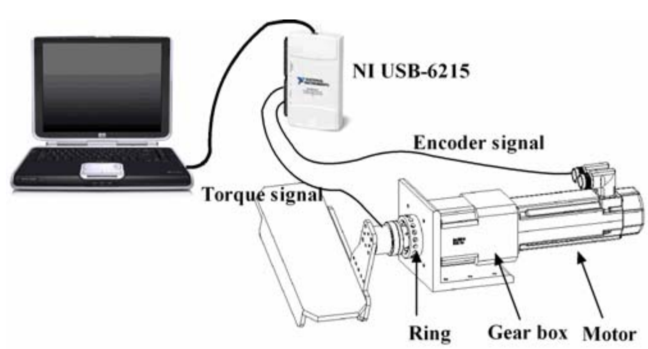


**Figure 1**: Illustration of motorized device

Implementation of intervention strategies

The motor drive and torque sensor are interfaced with custom LABVIEW program (National instrument Inc., USA). The control and encoder signals from the motor drive were connected with a National Instrument USB data acquisition card (NI USB-6215). Surface EMGs of the muscles were fed into the LABVIEW program. An illustration of foot-ankle was shown and updated on the front panel based on the current ankle position. With PNF technique, direct and indirect hold-relax (HR) were implemented. The ankle joint is first held at dorsiflexion which is adjusted for individual and the subject isometrically resists the movement of the motor by matching the prescribed muscle activation level (normalized EMG) for ~10 seconds. The motor slowly moved further toward dorsiflexion if the subjects could not match the prescribed muscle activation. The motor will then relax and move the ankle into a new dorsiflexion. The muscle groups activated depended on the selected technique. With direct HR (DHR) the calf muscle will be activated while the tibia anterior muscle will be activated with indirect HR (IDHR) (figure 2). Each short session will last ~5 min with one min break thereafter. The dorsiflexion position was updated after each short session and in total there were twelve short sessions.

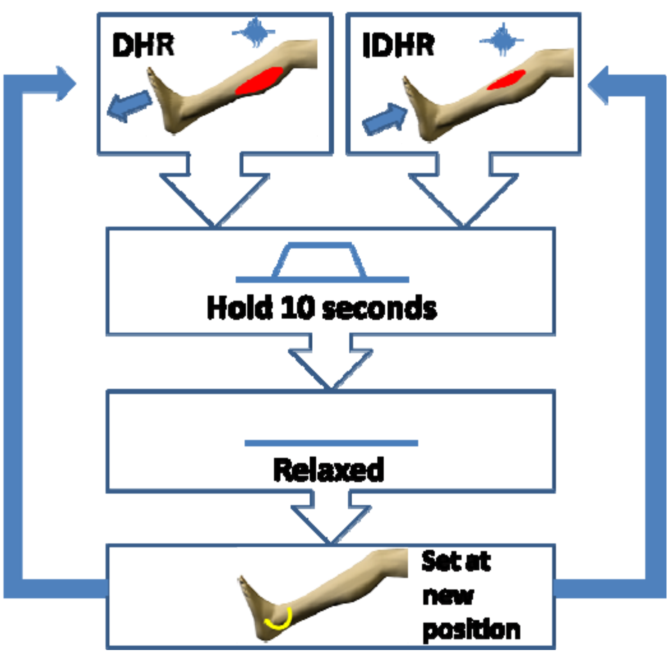


**Figure 2:** Flow chart of HR intervention

## RESULTS AND DISCUSSION

Pilot study showed successful implementation of facilitated ankle stretching using a motorized device. Outcome measurements including ankle range of motion, muscle power, locomotion are underway to evaluate the effects of the intervention. It is expected that the motorized facilitated ankle intervention will be more effective in increasing ankle joint range of motion and neuromuscular function. It will be a promising intervention for treating spastic joint in stroke survivors. However, stroke survivors might have difficulties in voluntary muscle contraction and maximal effort might be challenging. With PNF hold-relax intervention, the target level of muscle activation could be set submaximal instead of maximal and previous study comparing the effects using submaximal and maximal effort in a PNF intervention observed equally improvements in range of motion [9].

## REFERENCES

1.H. Kabat, M. Knott, *Phys Ther Rev* **33**, 53 (1953).
2.D. A. Klein, W. J. Stone, W. T. Phillips, J. Gangi, S. Hartman, *JOURNAL OF AGING AND PHYSICAL ACTIVITY* **10**, 476 (2002).
3.N. Kofotolis, I. S. Vrabas, E. Vamvakoudis, A. Papanikolaou, K. Mandroukas, *Br J Sports Med* **39**, e11 (Mar, 2005).
4.D. C. Funk, A. M. Swank, B. M. Mikla, T. A. Fagan, B. K. Farr, *The Journal of Strength and Conditioning Research* **17**, 489 (2003).
5.R. W. Bohannon, P. A. Larkin, *Phys Ther* **65**, 1676 (Nov, 1985).
6.M. L. Dombovy, B. A. Sandok, J. R. Basford, *Stroke* **17**, 363 (May-Jun, 1986).
7.A. M. Moseley, *Phys Ther* **77**, 240 (Mar, 1997).
8.L. Q. Zhang *et al.*, *IEEE Trans Neural Syst Rehabil Eng* **10**, 149 (Sep, 2002).
9.J. B. Feland, H. N. Marin, *Br J Sports Med* **38**, e18 (August 1, 2004, 2004).

## ACKNOWLEDGEMENTS

American Heart Association National Scientist Development Award