Central Nerve System Adaptation in People with Peripheral Neuropathy

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INTRODUCTION

Reduced mobility and postural stability in people with Peripheral Neuropathy (PN) are predicted by the impairments foot sole sensation. Other sensory information could compensate for the impairments. For example, visual feedback would be important for PN with loss of Plantar Pressure Sensitivity to maintain balance. In additional, the Central Nerve System (CNS) may compensate to the loss of peripheral sensory input. H - reflex and H-index could provide us a widow looking into potential CNS adaptation. The purpose of this study was to study the correlation between CNS modulation, assessed by H-index and H-reflex, and mobility and postural stability, assessed by functional walking and balance tests.

METHODS

21 participants with all caused PN and 12 health age-matched participants were recruited for this study. They all were 60 year old or above. Participants signed informed consent forms before test. The project was approved by local Institutional Review Board.

Procedures:
Height, weight, age, sex, the cause and the duration of PN, were recorded before test. Participation took test as follow: Plantar pressure sensitivity (PPS) test, H-reflex test, balance test and functional walking tests. Between each tests, participation had a break for at least 3 minutes.

Plantar pressure sensitivity test:
Foot sole sensitivity test was detected with 5.07 gauge Semmes-Weinstein monofilament (North Coast Medical. Inc, Morgan Hill, CA, USA). Five regions were tested with 3 trails each in random order – Big Toe, 1st & 5th metatarsal, Mid-Foot and Heel. The numbers of sensitive sites were recorded [1].

H-reflex test:
Participants maintained prone position with feet hanging slightly off the edge of the examination table during test. Two recording electrodes (EL503, Vinyl 1-13/8", BIOPAC Systems, Inc. Goleta, CA, USA) were placed in parallel with the direction of muscle fibers at the belly of lateral gastrocnemius on the right leg. The electrodes were 20 mm in diameter and the inter-electrodes distance was 20 mm from center to center. The reference electrode was placed above the calcaneus on the Achilles tendon. Abrasion of the skin was performed at the fixation sites with alcohol gauze to reduce impedance.

H- and M-wave were elicited at surface skin of posterior tibial nerve at back of knee joint by bipolar stimulator with 1 ms square-wave constant voltage stimulus. The signals were processed and measured by the BIOPAC Systems (BIOPAC Systems, Inc., Goleta, CA, USA). Maximal H-reflex was conducted 3 trials with a 30s break between each stimulation. The latency between h- and M-waves was measured 9 times, which was defined as a period between the onsets of H- and M-wave [2, 3]. H-Index was calculated as $[\frac{Height(cm)}{\Delta t_H - \Delta t_M}]^2 * 2$ [4].

Balance test:
Participation completed one 30-s trials with normal stance and eyes open. Standing balance was assessed with a force platform (AccuSway, AMTI, Watertown, MA, USA). Center-of-pressure was sampled (500 Hz). Area of a confidence ellipse enclosing 95% of the center-of-pressure trajectory (AREA) were calculated.

Functional walking test:
The 6-min walk (distance in meters) was used to represent functional gait and were administered using standard procedures [1].

Data Analysis:
One-way AVONA used to examine group effect for all measures. The interaction effects between predictors (H-index and H-reflex) and dependent variables (AREA, VEL, TUG and 6MW) in two groups were further analyzed by One-way ACVONA. Each pairs of predictor and dependent variable of two groups were pooled into the reduced model with a regression base (two slopes and one intercept). Data was processed by SAS statistic software (Version 9.2 SAS Institute Inc., Cary, NC, USA). The significant level was set at .05.

RESULTS AND DISCUSSION

There were 5 out of 21 failed to induce H-reflex in PN group. It has been shown that H-reflex cannot be elicited in everyone even with healthy older adult population [3]. The records of these 5 participants were excluded for data analysis. The results of AVONA in PN (N=16) and Control (N=12) groups are displayed in table. 1.

Table 1. Results of One-way ANOVA on all measures.

Measures	PN		Control		P-value
	Mean	S.D.	Mean	S.D.	
Age (years)	72	9	70	10	0.67
Height (cm)	163	10	167	9	0.25
Weight(kg)	77	19	72	14	0.49
PPS	2.6	2.1	4.3	1.2	0.03
H-index	63.6	14.3	76.4	16	0.04
H-reflex(Mv)	0.62	0.8	0.78	0.55	0.55
AREA(in sq)	0.75	0.42	0.37	0.21	< 0.001
VEL(in/sec)	0.67	0.24	0.47	0.09	0.01
TUG(sec)	9.1	1.6	6.5	1.3	< 0.001
6MW(m)	442	87	525	68	0.01

There is no significant difference observed between groups among height, age, weight. However, significant group differences were observed for PPS, H-index, AERA, VEL, TUG, and 6MW ($p<.05$). No significant difference was observed at H-reflex.

The interaction effects are observed at predictors (H index and H-reflex) and dependent variables of AREA and TUG (*p<.05*). It indicates the linear relationships between each pair of predictors and dependent variables in two groups are significant different. It means the predicators influence the dependent variable differently in two groups. This study is only interested at the interaction, so the regression equations are not listed. Figure.1 displays the significant different regression lines in two groups, which e predictor pooled against dependent variable. No significant interaction effect is observed on other dependent variables.

The interaction effects suggest central neuron system would adapt to the feedback impairments at peripheral. Reduced performances of functional walking, balance control are due to impaired proprioception in PN, which would be represented by plantar pressure sensitivity. However, dis-functional proprioception would not explain the all facts (eg. the PN has different levels of balance maintain ability). It suggests central adaptive process occurred and involved with the motor control in PN, especially the behavior is dominated by feedback control, like balance control in standing rather than walking.

CONCLUSIONS

In this study, the predictions of central nerve system on AREA and TUG in PN are different with the ones in control, which suggests there are functional changes within central nerve system compensated to long term loss of propriocetion in PN. Moreover, the adaptation of CNS doesn't influence 6MW performance. One explanation is that walking as a rhythmic motion is dominant by feed forward control (eg. Central pattern generator). Also, compared to TUG, 6 minutes walking is more like to test the endurance of the participation rather than the dynamic and static balance control.

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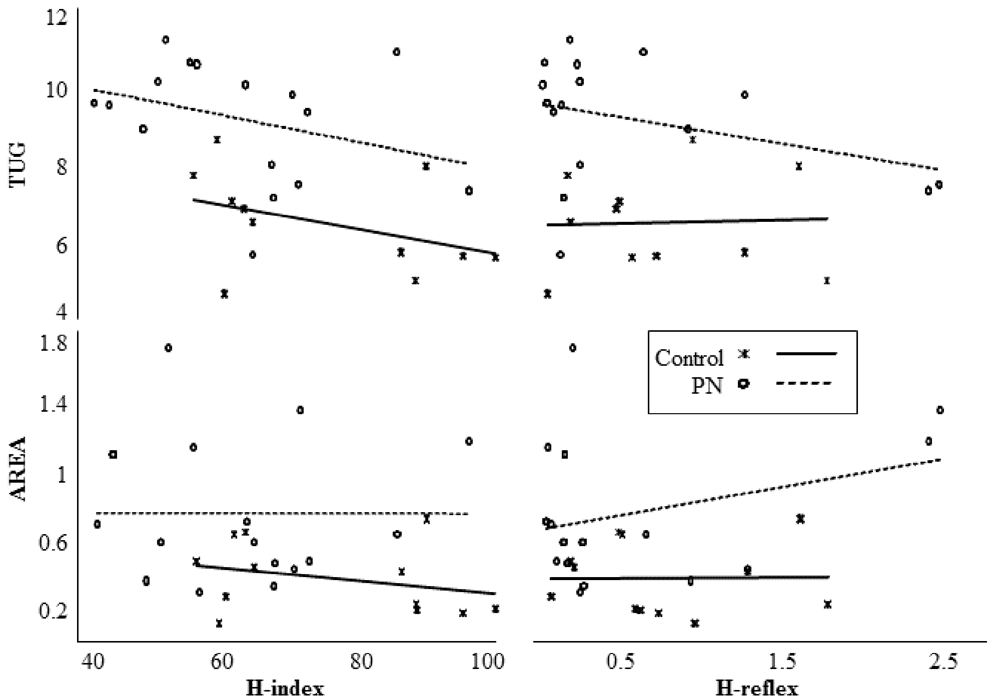

Figure.1: Relationships between parameters that reflex of CNS modulation (H-reflex and -index) and function (TUG, AREA) are significantly different between the two groups