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Effects of NESS on Stroke Patients at a Long-Term Care Health Facility

Youko Maeda[1], Hiroaki Harashima[1], Tomoko Yasumoto[2], Atsuko Ikeda[2], Satoshi Furumizo[1] and Masahiro Abo[3*]

[1]*Department of Rehabilitation Medicine, Tokyo General Hospital, 3-15-2 Egota, Nakano-ku, Tokyo 165-8906, Japan*

[2]*Tokyo General Health Welfare Center Egotanomori, 3-14-19 Egota, Nakano-ku, Tokyo 165-0022, Japan*

[3]*Department of Rehabilitation Medicine, The Jikei University School of Medicine, 3-25-8, Nishi-Shimbashi, Minato-Ku, Tokyo 105-8461, Japan*

[*]**Corresponding author:** Masahiro Abo, Department of Rehabilitation Medicine, The Jikei University School of Medicine, 3-25-8, Nishi-Shimbashi, Minato-Ku, Tokyo 105-8461, Japan, Tel: +81-3-3433-1111; E-mail: abo@jikei.ac.jp

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Abstract

Many stroke patients suffer sequela, such as the loss of limb mobility. Recently, a range of rehabilitation approaches have been developed and reported against the functional impairment of the hemiplegic upper limb. One of these approaches is the NESS H200 Hand Rehabilitation System. NESS is a functional electrical stimulation device for patients with motor paralysis of the fingers. In this study, NESS was used by 47 patients with motor paralysis of the upper limbs in the maintenance phase at our facility (1 to 2 sessions daily; duration of each session: 20 minutes). All the study subjects underwent 11 sessions in total: the residents used NESS every day, while the outpatients used it once or twice a week. Before and after using NESS, the active flexion angle of the wrist dorsal, FMA, MAS, and ARAT were measured and compared. It is presumed that the use of NESS improved some of the upper limb motor functions and eliminated disuse syndrome in the paralyzed muscle.

Keywords: Hemiplegic upper limbs; Cerebral vascular disorder; Long-term care health facility; Functional electrical stimulation

Introduction

According to "Overview of the Patient Survey in 2014" by the Ministry of Health, Labor and Welfare, the number of stroke patients amounted to 1,179,000, and many patients suffer sequela, such as motor paralysis [1]. In recent years, research has indicated brain plasticity in the recovery process of a functional disorder of the hemiplegic upper limb after a stroke, and a range of rehabilitation approaches have been developed and reported [2-5]. One of these approaches is the NESS H200 Hand Rehabilitation System (Bioness, hereinafter "NESS"). NESS is a functional electrical stimulation device with surface electrodes that is used for motor paralysis of the fingers due to a central nervous disorder, such as a stroke or spinal cord injury. The device consists of two components: a brace with five surface electrodes (for the extensor digitorum muscle, the extensor policies brevis muscle and the extensor policies longus muscle, the thinner muscles, the flexor digitorum superficialis muscle, and the flexor policies longus muscle) and a control unit. Each electrode stimulates the target muscle, and the device is programmed to reconstruct the function of the fingers by combining multiple patterns of movement, such as extension/flexion training mode, cylindrical grip mode, and key grip mode [6,7]While several reports have been announced to show that motor function can be improved by the use of NESS in the acute phase and the recovery phase, there are few publications and articles [6,7] in which NESS was used for upper limb motor paralysis in the maintenance phase, when the symptoms and degree of dysfunction are stable. In this study, we examined the efficacy of NESS for upper limb motor paralysis in the maintenance phase.

Subjects and Method

Subjects

Of the residents and outpatients who used Ekoda-no-Mori, Tokyo General Health and Welfare Center during the period from January to March, 2017, we included 47 patients with upper limb motor paralysis after a stroke and wrist joint dorsiflexor contraction that can be visually confirmed. The patient characteristics are as follows: 12 residents and 35 outpatients; 31 males and 16 females; mean age of 72.0 years; 22 patients with the dominant hand affected and 25 patients with the non-dominant hand affected; 26 patients with cerebral infarction and 21 patients with intracerebral hemorrhage; and average time after the onset of 77.7 months (Table 1).

	Total	Mild	Moderate	Severe	Everyday	1-2 times a week
Age(years old)	72.0 ± 10.6	78 ± 8.7	72.2 ± 8.9	64.1 ± 8.35	71.8 ± 13.8	72.3 ± 8.5
Gender(number)	n=47	n=15	n=20	n=12	n=12	n=35
Male	31	11	10	10	6	25
Female	16	4	10	2	6	10
Dominant hand(number)						

Dominant	22	5	10	7	4	18
Non-dominant	25	10	10	5	8	17
Types of stroke(number)						
CI*	25	11	11	4	8	17
ICH**	22	4	9	8	4	18
Time after stroke(month)	77.7 ± 52	84.3 ± 56.1	64.8 ± 40.4	91 ± 58.6	66.7 ± 65.6	81.5 ± 45.9
*CI: Cerebral Infarction						
**ICH: Intracerebral Hemorrhage						

Table 1: Clinical characteristics of studied patients.

Treatment using NESS was offered after detailed explanations of the study and treatment were provided to all the patients and families, and their written consent was obtained.

Method

Treatment: We used the personal mode for the study program. One session lasted for 20 minutes and included the following exercise:

(1) Finger extension exercise: 6 minutes,

(2) Finger flexion exercise: 3 minutes,

(3) Break: 1 minute,

(4) Finger extension exercise: 4 minutes,

(5) Finger extension exercise and rapid flexion: 1 minute,

(6) Break: 1 minute, and

(7) Finger extension exercise: 4 minutes.

All the study subjects underwent 11 sessions in total: the residents used NESS every day, while the outpatients used it once or twice a week on the facility visit days. The stimulation intensity was adjusted within the range where wrist joint dorsiflexion could be visually confirmed and pain was controlled within manageable limits.

In addition to treatment with NESS, the subjects underwent regular rehabilitation (stretching and walking exercises), but did not conduct rehabilitation known as facilitation techniques, such as Proprioceptive Neuromuscular Facilitation or the Bobath method.

Evaluation items: Before and after the treatment, the range of active wrist joint dorsiflexion (hereinafter "ROM")the Modified Ashworth Scale (hereinafter "MAS"), the Fugl-Meyer Arm Score (hereinafter "FMA") and the Action Research Arm Test (hereinafter "ARAT") were evaluated.

(1) ROM

The subjects underwent measurements of the range of active dorsiflexion in the chair-sitting position with a wrist goniometer. The starting limb position was as follows: shoulder joint flexion and abduction 0 degree, elbow joint flexion 90 degrees, and forearm pronation position.

(2) MAS [8,9]

MAS is a 6-point scale devised by Bohannon et al., which is a modified version of the 5-point scale developed by Ashworth to quantitatively determine the degree of spasticity according to the resistance against passive exercise of limb joints. The subjects underwent the measurement of elbow joint extension, wrist dorsiflexion, and finger extension in a chair-sitting position.

(3) FMA [10]

FMA is a comprehensive evaluation scale consisting of 33 items on motor function, sensory function, passive range of motion of joints, and degree of joint pain. Each item is scored on a 3-point scale (0=cannot perform, 1=performs partially, 2=performs fully), and the maximum score is 66.

(4) ARAT [11]

ARAT is an index developed by Lyle to monitor upper limb function related to daily life. It consists of four subtests to evaluate the major functions of the upper limbs (grasp, grip, pinch, and gross movement) using tools and it includes a total of 19 items. Each item is rated on a 4-point scale (0 to 3), and the maximum score is 57 points.

Statistical analysis: The subjects were grouped by the following: the measurements of FMA at the beginning of the study according to the three group classifications proposed by Woodbury [12] (0 to 19: severe, 20 to 46: moderate, and 47 to 66: mild), handedness (whether the dominant hand or the non-dominant was treated using NESS), and the frequency (the residents using NESS daily and the outpatients using it once or twice a week).

Each evaluation item was compared before and after the treatment and statistically analysed by Wilcoxon signed rank test. Statistical processing was performed using 4 Steps Excel statistics, and the significance level was less than 5%.

Results

After using NESS, all the subjects showed significant improvements in ROM and the "grasp" of ARAT (Table 2).

	Total	**Mild**	**Moderate**	**Severe**
	(Pre/post) n=47	(pre/post) n=12	(pre/post) n=20	(pre/post) n=15
ROM				
Wrist dorsal flexion	15.1 ± 26.1/23.9 ± 26.9*	33.3 ± 18.6/44.6 ± 17.5*	16 ± 26.1/21.5 ± 25.0	-9.1 ± 9.7/2.08 ± 19.8
FMA				
Category A	19.6 ± 9.9/19.5 ± 10.4	53.8 ± 6.0/55.8 ± 5.1	34.2 ± 8.3/34.0 ± 9.9	10.5 ± 5.7/10.7 ± 7.1
Category B	4.6 ± 2.9/4.8 ± 3.3	7.8 ± 1.4/8.2 ± 1.2	4.4 ± 1.6/4.6 ± 2.5	0.9 ± 0.9/1.0 ± 1.2
Category C	8.0 ± 4.2/7.9 ± 4.8	11.5 ± 2.6/12.1 ±2.2	9.1 ± 1.8/8.6 ± 3.2	1.8 ± 2.2/1.6 ± 2.3
Category D	2.1 ± 2.0/2.3 ± 2.0	3.8 ± 1.6/4.2 ± 1.2	2.1 ± 1.5/2.3 ± 1.5	0 ± 0/0 ± 0
MAS				
Elbow	1.3 ± 0.5/1.3 ± 0.6	2.2 ± 0.6/2.2 ± 0.6	3.1 ± 0.9/3.0 ± 0.8	3.0 ± 0.8/3.2 ± 1.0
Wrist	1.1 ± 0.8/1.1 ±0.7	1.8 ± 0.4/2.0 ± 0.4	2.7 ± 1.1/2.5 ± 1.0	3.4 ± 1.0/3.1 ± 1.1
Finger	1.0 ± 0.8/0.9 ± 0.7	2.0 ± 0.8/1.9 ± 0.5	2.7 ± 1.1/2.6 ± 1.1	3.0 ± 1.0/2.9 ± 1.1
ARAT				
Grasp	8.1 ± 8.0/8.9 ± 8.3*	17.3 ± 4.7/17.7 ± 5.3	6.1 ± 5.1/7.7 ± 5.9*	0 ± 0/0 ± 0
Grip	5.8 ± 5.3/5.7 ± 5.2	10.8 ± 2.4/10.4 ± 2.7	5.6 ± 4.8/5.7 ± 4.7	0 ± 0/0 ± 0
Pinch	5.1 ± 6.5/5.4 ± 6.4	12.4 ± 5.8/11.3 ± 6.0	2.7 ± 3.7/4.2 ± 4.9*	0 ± 0/0 ± 0
Gross movement	5.4 ± 4.0/5.3 ± 3.6	9.2 ± 2.4/8.5 ± 1.4	5.2 ± 3.1/5.5 ± 3.2	1 ± 1.4/1.0 ± 1.5
*P<0.05				
Abbreviations: ROM: Range of Motion; FMA: Fugl-Meyer Assessment; ARAT: Action Research Arm Test				

Table 2: Effects of various indicates and FMA severity.

By severity according to FMA, 12 subjects were classified as severe (4 residents and 8 outpatients), 20 subjects were classified as moderate (6 residents and 14 outpatients), and 15 subjects were classified as mild (2 residents and 13 outpatients). The mild group showed a significant improvement in ROM, while the moderate group demonstrated a significant improvement in "grasp" and "pinch" of ARAT. In the severe group, no significant improvement was observed in any item (Table 2).

By handedness, the non-dominant hand group showed significant improvements in ROM, category A of FMA, and "grasp" of ARAT, while no significant improvement was observed in the dominant hand group (Table 3).

	Dominant	**Non-dominant**	**Every day**	**1-2 times a week**
	(Pre/post) n=22	(pre/post) n=25	(pre/post) n=12	(pre/post) n=35
ROM				
Wrist dorsal flexion	10.9 ± 26.5/14.5 ± 27.7	18.8 ± 25.1/32.2 ± 23.2*	16.3 ± 28.8/34.2 ± 23.1*	14.7 ± 25.1/20.4 ± 27.3*
FMA				
Category A	17.1 ± 10.6/15.9 ± 10.8	21.9 ± 8.6/22.8 ± 8.7	15.0 ± 10.1/17.2 ± 10.8*	21.3 ± 9.3/20.4 ± 10.2
Category B	3.5 ± 3.1/3.3 ± 3.0	5.5 ± 2.5/6.2 ± 2.9*	3.8 ± 3.1/4.8 ± 3.8*	4.9 ± 2.9/4.9 ± 3.1
Category C	7.0 ± 4.9/6.9 ± 5.1	8.8 ± 3.6/8.8 ± 4.3	7.5 ± 4.9/8.3 ± 5.8	8.2 ± 4.2/7.8 ± 7.8
Category D	1.6 ± 1.8/1.8 ± 1.9	2.5 ± 2.0/2.8 ± 1.9	1.2 ± 1.3/1.6 ± 1.5	2.5 ± 2.1/2.6 ± 2.2

MAS				
Elbow	3.0 ± 0.7/3.0 ± 0.9	2.6 ± 0.8/2.6 ± 0.8	3.3 ± 0.9/2.4 ± 0.9	2.6 ± 0.7/2.7 ± 0.9
Wrist	3.0 ± 1.0/2.9 ± 1.0	2.2 ± 1.0/2.2 ± 0.8	2.4 ± 1.5/2.3 ± 1.2	2.7 ± 0.9/2.7 ± 0.9
Finger	3.0 ± 1.0/2.7 ± 1.0	2.2 ± 1.0/2.2 ± 1.0	2.3 ± 1.4/2.4 ± 1.3	2.7 ± 1.0/2.5 ± 1.0
ARAT				
Grasp	5.3 ± 7.1/6.1 ± 7.7*	10.6 ± 7.8/11.4 ± 8.0*	7.2 ± 7.1/8.7 ± 7.2	8.5 ± 8.3/9.0 ± 8.7*
Grip	4.1 ± 5.2/3.9 ± 5.1	7.3 ± 4.9/7.3 ± 4.8	5.2 ± 5.0/5.4 ± 4.6	6.1 ± 5.4/5.9 ± 5.4
Pinch	4.2 ± 7.0/4.6 ± 6.6	5.8 ± 6.0/6.0 ± 6.1	3.6 ± 5.4/4.4 ± 6.3*	5.7 ± 6.9/5.8 ± 6.5
Gross movement	4.2 ± 4.6/3.9 ± 3.6	6.4 ± 2.9/6.6 ± 3.2	4.4 ± 3.8/5.4 ± 3.9	5.8 ± 4.0/5.3 ± 3.6
*P <0.05				
Abbreviations: ROM: Range of Motion; FMA: Fugl-Meyer Assessment; MAS: Modified Ashworth Scale; ARAT: Action Research Arm Test				

Table 3: Effects of Handedness and treatment frequency at pre and post NESS.

Discussion

The use of NESS resulted in improvements in some upper limb functions in stroke patients in the maintenance phase. Based on the analysis by severity according to FMA, significant improvements were observed in the mild and moderate groups. We attributed these achievements to the fact that the use of NESS helped alleviate disuse syndrome (hereinafter "disuse") in the extensor digitorum muscle, the extensor policies brevis muscle and the extensor policies longus muscle and increase the range of motion of finger extension, and allowed the subjects to grip bigger wooden blocks and pinch items more steadily than at the initial evaluation. The reason why there was no significant improvement in the severe group was probably because the upper limb centre was also severely paralyzed, and treatment with NESS, which focuses on finger function training, did not lead to the improvement of central functions. This suggested that in the future, it will be necessary to devise a training method that can improve central functions, such as bimanual action.

Based on the analysis by handedness, no significant improvement was observed in the dominant hand group, while the non-dominant hand group showed significant improvements in many items. Patients in the non-dominant hand group are more likely to have disuse or learned non-use than those in the dominant hand group, according to the study by Rinehart et al., [13]. showing that patients with right hemisphere injury tend to use the paralyzed upper limb less frequently in ADL than those with left hemisphere injury. The study suggested that NESS was effective for eliminating disuse and learned non-use, since the non-dominant hand group showed significant improvements in many items.

Based on the analysis by frequency, the daily group showed improvements in more items than the outpatient group. This is probably because the daily group was able to benefit from NESS more easily thanks to the carryover effect. The results suggested that we should devise voluntary training or an ADL instructional method that can help outpatients to maintain the effects obtained from NESS other than hospital visit days.

Rehabilitation at long-term care health facilities tends to have shorter hours of daily training than that at hospitals, and it is often difficult to spend sufficient time undergoing rehabilitation for upper limb paralysis, which tends to promote disuse or learned non-use of the paralyzed upper limb. Facilities can easily introduce NESS, which can be put on and taken off without difficulty. If the stimulation intensity is set in advance, even non-rehabilitation staff can lead voluntary training. It is suggested that NESS is effective in preventing disuse and learned non-use of the paralyzed upper limb in the maintenance phase.

Our future task is to conduct an additional study by establishing a control group.

Conclusion

The use of NESS in patients with upper limb paralysis in the maintenance phase led to the improvement of some upper limb functions.

Conflict of Interest

The author has no conflicts of interest to disclose concerning the article. The author borrowed NESS devices from France Bed Co., Ltd. for four months free of charge.

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