

Implementation and result of the takizawa method to the outpatient rehabilitation facility and evaluation of the brain activity by fNIRS

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We examined changes to the level of care needed by the patients who have been rehabilitated by the Takizawa method over an extended period of time. Although it was reported that approximately 29% of elderly needing some level of care in Japan got worse within two years, aggravation was seen less with this method. Then, in order to investigate a mechanism, we performed cerebral function evaluation by the functional Near-Infrared Spectroscopy. The Shimadzu Company offered the Near-Infrared Spectroscopy and

analysis software; we analysed not only the motivative exercise for the ankle joint dorsiflexion and plantar flexion exercise, but also resistive self-exercise facilitated by using the device and passive exercise supervised by the physiotherapist. It was found that the motivative exercise on an ankle activated the cerebral function more than the passive exercise [$P < 0.05$] and the motivative exercise and resistive self-exercise had no significant difference.

Key Words: Disabled elderly, Restructuring, Rehabilitation medicine, Cerebral function, Motivative exercise, Takizawa method, fNIRS

We planned 10 studies due to our estimate that the motivative exercise was useful and effective training in re-acquiring patient's functions from the viewpoint of cerebral function activation by the Kaken grant. This study is one of those. And also we planned this in order to verify the introductory effect of the Takizawa Method (1-3) to the daycare rehabilitation facility, which focuses on the prevention of care needed by the rehabilitation medicine to elderly people and disabled elderly under the Long-Term Care insurance [LTCI] (4). LTCI is introduced in Japan by the Japanese government. It is known that the change of level of care needed [LCN] shown in Table 1 for 29% of the patients is worsening within two years (5). The patients of this facility maintained the function and

improved the width of activity by performing individual programs such as neuromuscular re-education and basic motion training with using abundant subprograms since 2003. The outpatients in this facility have less functional decline, and there are many who are maintaining the function for a long time (6,7). The motivative exercise is an easy functional training as a self-exercise. It is performed by exercising using devices which make bilateral movement for both legs simultaneously in order to make the affected side leg active by the movement of the unaffected side. It is the core rehabilitation technique of the Takizawa Method. If this effective medical method (8-10) can be used widely, it will become good news for many people. For that purpose, it is necessary to clarify the mechanism of the rehabilitation medical effect in this facility. In order to solve the above-mentioned subjects, we set the study purposes as following: 1. Survey of the discriminative contents of rehabilitation training of this facility and the changes of LCN: 2. Clarify the stimulation and influences of the brain function of performing motivative exercise on the lower extremities, resistive exercise on the lower extremity and passive exercise on the lower extremity with using the functional near-infrared spectroscopy [fNIRS] in order to compare the effect of those.

MATERIALS AND METHODS

The study of fNIRS was registered as a clinical trial (11) No.UMIN000006563 after the examination by the Ethical Review Board of the Biophilia Rehabilitation Academy and done in 2009. The subjects' eligibilities were set by the outpatients of the facility who consented to join the study, over 65 years old with an upper limit of 100 years old and both sexes. LTCI is introduced in Japan by the Japanese government so that LCN is decided by it. The LCN is graded requiring support 1-2, requiring long-term care 1-5 as shown in the Table 1. The discriminative contents of rehabilitation training, then the other facilities were shown in Figures 1A and 1B and matters of fact were shown in Table 2. The point differentiated to other facilities is the introduction of the Takizawa Method. Towel sanding is training for both arms simultaneously; in other words, it is a motivative exercise for arms by holding a towel with both hands and a board to polish.

We selected the official report about the changes of LCN from the data published (12), which should be compared to the data of this facility.

fNIRS test

Subjects were 10 outpatients who had obtained consent in the daycare

TABLE 1
Level of care needed (LCN)

LCN classification (shown as)	The content of Classification
Requiring support 1-2 (S)	Need assistance, such as the ability to regain lost.
Requiring long-term care 1 (I)	Rise, "to stand on two feet, one foot" and "keeping a sitting position" is unstable. Need assistance indirect "clean up after urination" and "clean up after defecation".
Requiring long-term care 2 (II)	People cannot do their own, "rising", "stand on two feet, one foot" on and "keep a sitting position".
Requiring long-term care 3 (III)	Add following to III, Assistance overall increase "clean up after urination" and "clean up after defecation".
Requiring long-term care 4 (IV)	Capacity to act has been considerably reduced, must be totally dependent "walking", "bathing", "excretion", "cleanliness, grooming" and "putting on and taking off clothes".
Requiring long-term care 5 (V)	Capacity is significantly reduced, must be totally dependent for life in general.

Survey of the LCN and the discriminative contents of rehabilitation training

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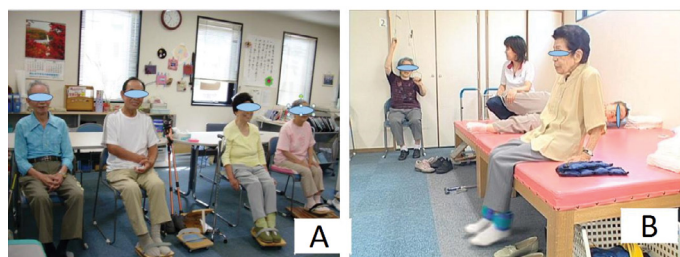


Figure 1) Training scenery. The motive exercise by Pata and Koro

TABLE 2
Program card in this facility

Individual programs	Range of motion exercise
	Muscular power reinforcement training (Kg pile weight training)
	Physical therapy for hemiplegia
	Basic motion training
	Keeping posture by elbow
Takizawa Method	Pulley
	PataKoro
	Konnichiwa (forward bending of trunk)
	Parallel bars (walking to front and rear, right and left)
	Standing position balance
Machine training	Leg press, Time
	Abduction, Kg
	Rowing, Kg
Sub programs	Gait training and stairs rise and fall
	Standing training with wall bar
	Stretch board
	Ergo meter
	Towel sanding
	Group gymnastics, Chair
	Hot pack, numbers and part

rehabilitation facility. They have after-effect of cerebrovascular disorder [7 cerebral infarction, 2 intracerebral bleeding and 1 brain cancer]. 5 women and 5 men are 67 to 81 years old [the average age is 75.4 years old] as shown in Table 3. 5 of them have right hemiplegia and 1 has left hemiplegia.

Comparison of changes to the oxyhemoglobin in the brain with the time of rest and task of the passive exercise and the motive exercise were examined in this test by Near-Infrared Spectroscopy [fNIRS] test with the FOIRE-3000 by Shimazu Corporation. The 14 sets of Light Sources and Detectors measuring 45 channels were used shown in Figures 2A and 2B. The Light Sources No. 7 [middle of a channel 10-23] was set at the center crown of the head [Cz] for the measurement. The task cycle for each patient was set 20 seconds rest from a start -30 seconds task -20 seconds rest and performed for three cycles. Evaluation is performed by the load average of 3 cycles of exercise. The test was conducted December 8-11, 2009 with motive exercises for legs, ankles dorsiflexion and plantar flexion exercise simultaneously and resistive exercise for the affected leg, ankle dorsiflexion and plantar flexion exercise by using the device and the passive exercise to the affected leg, ankle dorsiflexion and plantar flexion exercise at the test. The test scenes were shown in Figures 2C and 2E.

RESULTS

LCN survey

The detail of the subjects of the LCN Survey and fNIRS was shown in the Table 3. Survey for 2900 subjects who did the care needs assessment based on LTCI were conducted for the field study to examine the changes of LCN by the Prefectural government at the Shimane Prefecture from 2000 to 2002 (12). The result of this facility was compiled as shown in Table 4. The

TABLE 3
Subjects

Subject	Clinical history	Age	Sex
A1	Cerebral infarction	70	women
A2	Cerebral infarction, R-hemiplegia	73	women
A3	brain cancer, R-hemiplegia, R-knees osteoarthritis	67	women
A4	Cerebral infarction, R-hemiplegia	71	man
A5	After brain bleeding, L-hemiplegia, Cerebral infarction, R-hemiplegia,	79	man
A6	femoral neck fracture and knee arthropathy	81	women
A7	After brain bleeding, R-hemiplegia, both knees osteoarthritis	71	man
A8	Cerebral infarction	95	man
A9	Cerebral infarction	73	man
A10	Cerebral infarction	74	women

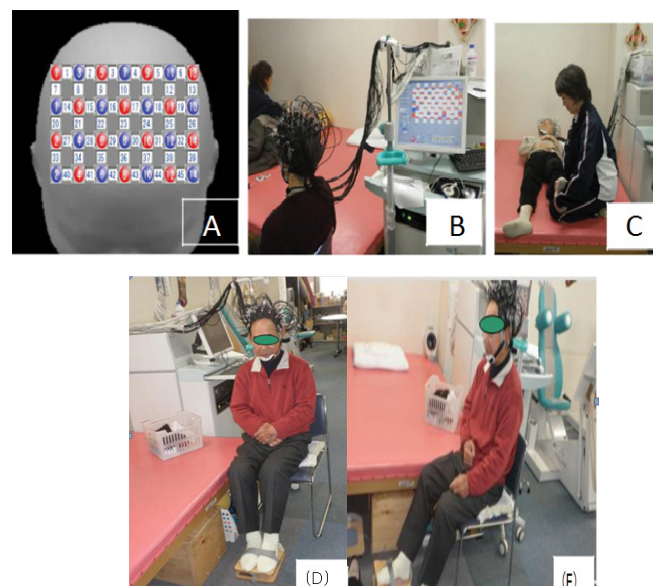


Figure 2) fNIRS test scenes. (A) Detectors measured 45 channels, 14 light sources shown in red and 14 detectors shown in blue. (B) Head set and 45 channels are shown in the display of FOIRE-3000. (C) Test scenes of the passive exercise by the physiotherapist. (D) Test scenes of the motive exercise with using Pata device. (E) Test scenes of the motive exercise with using Pata device

TABLE 4
Result of LCN survey

Code	First examination		Second examination		Changes
	Date	LCN record	Date	LCN record	
A1	2003.8.22	V	2009.8.25	II	UP
A2	2008.4.1	II	2009.10.27	II	Upkeep
A3	2008.8.21	II	2009.11.17	II	Upkeep
A4	2004.2.27	IV	2009.10.23	III	UP
A5	2006.4.10	III	2009.10.28	II	UP
A6	2004.4.20	I	2009.10.26	I	Upkeep
A7	2003.12.3	II	2009.8.31	III	Down
A8	2006.10.11	S	2009.10.23	S	Upkeep
A9	2003.7.1	III	2009.10.23	II	UP
A10	2004.8.16	II	2009.9.14	II	Upkeep

changes of LCN at the Shimane Prefecture were UP 7.8%, Upkeep 35.8%, Down 29.1% and No grade 27.3% including Dead 23.2% and the changes of LCN at this facility were UP 40%, Upkeep 50% and Down 10% as shown in Table 5, that were investigated.

The survey results of this institution and Shimane Prefecture is Up 32.2%, Upkeep 14.2% and down -19.1%.

All the tests were shown in Table 6. This analysis was performed using the FOIRE software (13) equipped with FOIRE-3000. The yellow frames [channels] in Figures 3A and 3C shows the oxyhemoglobin [OxyHb] changes according to the time changes and the significant differences of rest score to task score that were examined by Bonferroni's Method with the FOIRE software [$P < 0.001$] while the white frames show no significant difference, and the results of ankle joint's Dorsiflexion and Plantar Flexion exercise, Code 275 [passive exercise], 277 [motivative exercise] and 279 [resistive exercise] for women Age 81, Cerebral infarction, R-hemiplegia, Femoral neck fracture, both Knees osteoarthritis and Knee arthropathy.

Tables 7a-7c were created showing all the test results of all the channels replaced "1" with the significant difference and "0" without the significant difference. The average shown in the tables were assayed by SPSS 15.0J. The result showed that the motivative exercise with the Dorsiflexion and Plantar Flexion of the ankle joint activate and influence brain activity more than the passive exercise which a therapist performs [$p < 0.05$]. There was no statistically significant difference between the motivative exercise and resistance exercise. Changes of activity of oxyHb were shown in Figures 4A and 4B. The green is the same as the starting activity of oxyHb [at the time of a start]. The red is the increase in activation 16 seconds after and Black shows activation reduction. We can confirm that the motivative exercise using Pata influences brain activity within a larger range than the passive exercise with the Dorsiflexion and Plantar Flexion of the ankle joint on changes of oxyHb in Figures 4A and 4B analysis.

TABLE 5
Changes of LCN

Division	UP	Upkeep	Down	No grade	Dead
This Facility	40.00%	50.00%	10.00%	0.00%	0.00%
Shimane Prefecture	7.80%	35.80%	29.10%	27.30%	23.20%
Difference	32.20%	14.20%	-19.10%	-27.30%	-23.20%

DISCUSSION

Although the numbers of the subjects were small because the facility is small, this article shows importance and abilities of the motivative exercise and Takizawa method (1-4) and (17) to determine the problems on the rehabilitation medicine as follows:

1. Rehabilitation medical specialists were doubled from 810 to 1,787 specialists and physical therapists increased 470% to 100,560 therapists over ten years, ending in 2012 in Japan. While some might think that the people who need care decreased, the patient load doubled from 2,180,000 people in 2000 to 5,540,000 people in 2012. This means that rehabilitation medical treatment needs to be restructured.
2. The joint guideline committee, which consists of 5 scientific societies, such as the Japanese Association of Rehabilitation Medicine, and 3 research groups of the MHLW published the Stroke Treatment Guidelines of 2004 (14) related to the method of treatment for the stroke rehabilitation medicine and medical treatment, training technique, etc., which put weight in either the handedness change

TABLE 6
Date and the code examined by fNIRS for Tachibana rehab. Day care service

Subject	Date	Passive Exercise	Motivative Exercise		Resistive Exercise	
		Ankle	Ankles	Knees	Ankle	Knee
A1	2009.12.8	258	259	260	261	262
A2		250	252	253	254	255
A3		242	243	244	245	247
A4		237	238	239	0	0
A5		282	283	284	0	0
A6	2009.12.9	275	277	278	279	280
A7		266	268	269	270	271
A8	2009.12.11	301	302	303	304	305
A9		294	295	296	297	299
A10	2009.12.10	287	288	289	291	292

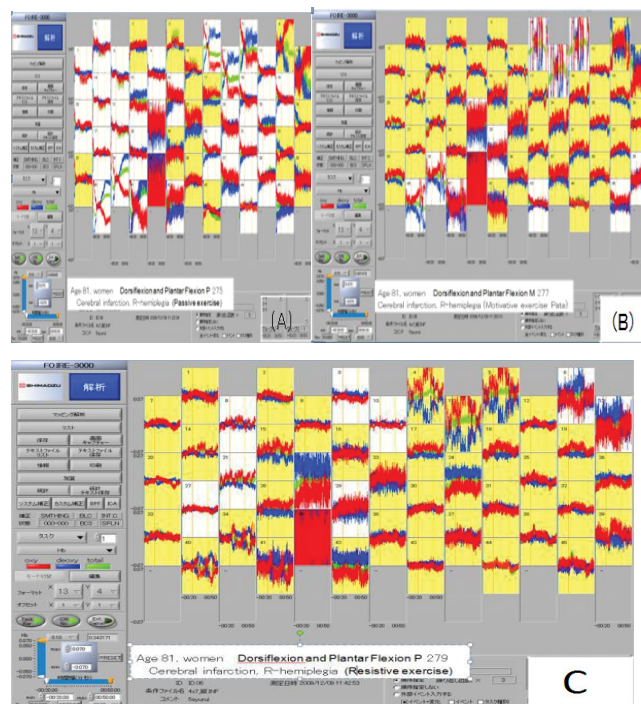


Figure 3) The result of exercise, women Age 81, cerebral infarction, R-hemiplegia, femoral neck fracture, both knee osteoarthritis and knee arthropathy. (A) The result of passive exercise, dorsiflexion and plantar flexion, Code 275. (B) The result of motivative exercise [Pata], dorsiflexion and plantar flexion, Code 277. (C) The result of resistive exercise [Pata], dorsiflexion and plantar flexion, Code 279

TABLE 7a

The passive exercise, ankle dorsiflexion and plantar flexion exercise

Subject	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	
Code	258	250	242	237	282	275	266	301	294	287	Ave.
Channel											
1	0	0	1	0	1	0	0	0	0	1	0.3
2	1	1	0	1	1	1	1	0	0	1	0.7
3	1	1	0	0	0	1	1	1	0	1	0.6
4	0	1	0	1	1	0	1	0	1	1	0.6
5	0	1	0	0	1	1	1	0	0	1	0.5
6	0	0	0	0	1	1	0	0	0	0	0.2
7	0	0	1	0	0	0	0	0	0	1	0.2
8	0	0	0	1	1	0	1	0	0	0	0.3
9	1	1	0	1	1	0	1	0	0	1	0.6
10	0	1	0	1	1	1	1	1	1	1	0.8
11	0	1	0	1	1	0	1	0	0	0	0.4
12	0	0	0	0	1	0	0	0	0	0	0.1
13	0	0	0	0	1	1	0	0	0	1	0.3
14	0	0	0	1	1	0	1	0	0	0	0.3
15	0	0	0	1	1	0	1	0	0	0	0.3
16	0	1	0	1	1	0	1	1	1	1	0.7
17	1	0	0	1	1	1	1	0	0	1	0.6
18	0	0	0	1	1	0	0	0	0	0	0.2
19	0	0	0	0	1	0	0	0	0	0	0.1
20	1	0	0	1	0	0	0	0	0	1	0.3
21	0	0	0	1	1	0	1	0	0	0	0.3
22	0	1	0	0	1	0	0	0	1	1	0.4
23	1	0	0	1	1	1	0	1	0	1	0.6
24	1	0	0	1	1	0	0	0	0	1	0.4
25	1	0	0	1	1	0	0	0	0	0	0.3
26	1	0	0	1	1	1	0	0	0	1	0.5
27	1	0	1	1	0	0	0	0	0	0	0.3
28	0	1	0	0	0	0	0	0	1	1	0.3
29	1	1	0	1	0	1	0	0	0	1	0.5
30	1	0	0	1	0	0	0	0	0	1	0.3
31	1	1	0	1	0	0	0	0	0	1	0.4
32	1	0	1	1	0	1	0	0	0	1	0.5
33	0	0	1	1	0	1	0	0	0	1	0.4
34	0	0	0	1	0	0	0	0	0	0	0.1
35	0	1	0	0	0	0	0	0	1	1	0.3
36	1	0	0	1	1	0	1	1	0	1	0.6
37	0	1	0	1	0	1	0	0	0	1	0.4
38	0	1	0	1	0	1	0	0	0	1	0.4
39	0	0	1	1	0	1	0	0	1	1	0.5
40	0	0	0	1	0	0	0	0	0	0	0.1
41	0	0	0	0	0	0	0	0	1	0	0.1
42	1	0	0	0	0	0	1	1	0	0	0.3
43	1	0	0	1	1	0	1	1	0	0	0.5
44	0	1	0	1	0	1	0	0	0	1	0.4
45	0	0	0	1	0	1	0	0	0	1	0.3

TABLE 7b

The motivative exercise, ankle dorsiflexion and plantar flexion exercise

Subject	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	
Code	259	252	243	238	283	277	268	302	295	288	Ave.
Channel											
1	1	1	0	1	1	1	1	1	0	1	0.8
2	1	1	1	1	1	1	1	1	0	1	0.9
3	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	0	1	0	1	1	1	0.8
5	1	1	1	1	0	1	0	1	0	1	0.7
6	0	1	1	1	0	1	1	1	0	0	0.6
7	1	1	1	1	1	1	1	1	1	0	0.9
8	1	1	1	1	1	1	1	1	0	1	0.9
9	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	0	1	0	1	0	1	0.7
12	1	1	1	1	1	0	1	1	0	1	0.8
13	0	1	1	1	0	1	1	1	0	0	0.6
14	1	1	1	1	1	1	1	1	0	1	0.9
15	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	0	1	1	0	1	0.8
19	1	1	1	1	1	1	1	1	0	1	0.9
20	0	1	1	1	1	1	1	1	1	1	0.9
21	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	0	0	1	0	1	0.7
26	1	1	1	1	1	0	1	1	0	1	0.8
27	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	0	1	1	1	1	1	0	0.8
29	1	1	1	1	1	1	1	1	1	0	0.9
30	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	0	1	1	1	1	0.9
32	1	1	1	1	1	0	1	1	1	0	0.8
33	0	1	1	1	1	1	1	1	1	1	0.9
34	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	0	1	1	1	0	0.8
36	1	1	1	1	1	1	1	1	1	1	1
37	0	1	1	1	1	1	1	1	1	1	0.9
38	0	1	1	1	1	1	0	1	1	0	0.7
39	0	1	1	1	1	0	1	1	1	0	0.7
40	1	1	1	1	1	1	1	1	1	1	1
41	1	1	1	1	1	0	1	1	1	1	0.9
42	1	1	1	1	1	1	0	1	1	1	0.9
43	1	1	1	1	1	0	0	1	1	0	0.7
44	0	1	1	1	1	1	0	1	1	0	0.7
45	0	1	1	1	1	1	0	1	1	0	0.7

TABLE 7c

The resistive exercise, ankle dorsiflexion and plantar flexion exercise by using devise

Subject	A1	A2	A3	A6	A7	A8	A9	A10	PASPLF
Code	262/R	255/L	247/R	280/R	271/R	305	299	292	Ave.
Channel									
1	0	1	1	1	1	0	0	1	0.63
2	0	1	1	0	1	1	0	1	0.63
3	1	1	1	0	1	1	0	1	0.75
4	1	1	1	0	0	0	0	1	0.5
5	1	1	1	1	0	0	0	1	0.63
6	1	1	1	0	1	0	0	1	0.63
7	1	0	1	0	1	0	0	0	0.38
8	1	1	1	0	1	0	1	0	0.63
9	1	1	1	0	1	1	0	1	0.75
10	1	1	1	1	1	1	1	1	1
11	1	1	1	1	0	0	0	1	0.63
12	1	1	1	1	1	0	0	1	0.75
13	1	1	1	1	1	1	0	1	0.88
14	0	1	1	0	1	1	1	0	0.63
15	0	1	1	0	1	1	1	1	0.75
16	1	1	1	1	1	1	1	1	1
17	1	1	1	0	1	1	1	1	0.88
18	1	1	1	1	1	1	0	0	0.75
19	1	0	0	1	1	0	0	0	0.38
20	0	1	1	1	1	1	0	1	0.75
21	1	1	1	0	1	1	1	0	0.75
22	1	1	1	0	1	1	1	1	0.88
23	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	0	0	0	0.63
26	1	1	1	1	1	1	1	0	0.88
27	1	1	1	0	1	1	0	1	0.75
28	1	1	1	0	1	1	1	0	0.75
29	1	1	1	0	1	1	1	1	0.88
30	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	0	1	0.88
32	1	1	1	1	1	1	0	0	0.75
33	1	1	1	1	1	1	0	1	0.88
34	1	1	1	1	1	1	1	1	1
35	1	1	1	0	1	1	1	0	0.75
36	1	1	1	1	1	1	1	1	1
37	0	1	1	1	1	1	1	1	0.88
38	1	0	1	1	0	1	1	0	0.63
39	0	1	0	1	1	1	1	0	0.63
40	1	1	1	1	1	1	1	1	1
41	1	1	1	1	1	1	1	1	1
42	1	1	1	1	1	1	1	1	1
43	1	1	1	1	1	1	1	1	1
44	1	0	0	1	0	1	1	0	0.5
45	1	1	0	1	0	1	1	0	0.63

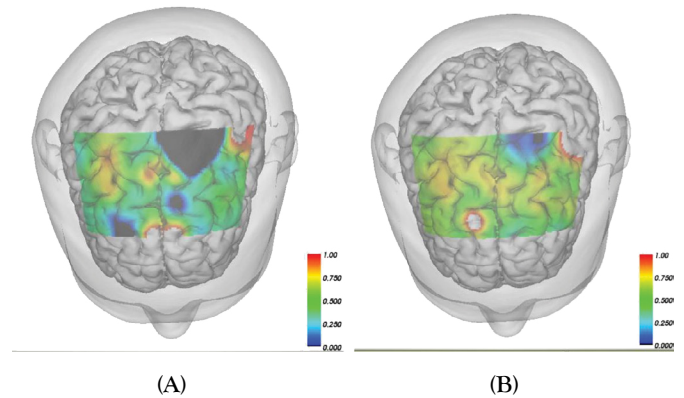


Figure 4) Changes of activity of oxyHb. (A) Passive exercise 16 min past after task started, test cord 275. (B) Motivative exercise 16 min past after task started, test cord 277. The standard brain is used as the base figure.

of the unaffected side or priority to function improvement of the paralysis side for the hemiplegia. It cannot be said that validity was enough; it was shown that more research was needed for these in the future. We showed the excellent enforcement result of the Takizawa method and the motivative exercise at this facility than the survey of Shimane Prefecture as shown in Tables 4 and 5. Therefore, we could show the possibility of restructuring it.

CONCLUSION

The result of the fNIRS tests showed that the motivative exercise in the dorsiflexion and plantar flexion exercise of the ankle joint activated and influenced a brain activity more than passive exercise which a physiotherapist performed [$p < 0.05$].

The motivative exercise is a rehabilitation training through self-exercise. It is achieved using devices which make bilateral movement for both legs in order to make the affected side leg active by the movement of the unaffected side.

In order to realize the restructuring of the rehabilitation medicine for assisting patients in reacquiring bodily functions in order to overcome their disabilities and dysfunctions, future research such as verification of the reconstruction of the neural transmission pathway by an increase of neural stem cells enabled by the motivative exercise, based on this study and the previous studies (15-17), And the randomized controlled trial of the motivative exercise (1) versus Passive exercise is expected, therefore we announced one of our Brain studies here.

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