International Congress Series 1232 (2002) 549-554

Measurement of Cerebral Circulation Using Near-Infrared Spectroscopic Topography during Music-Exercise (trampoline) Therapy as a Method of Brain Rehabilitation for the Stroke Patient

Yukio Goto[a]*, Ryo Noda[b] , Noriyoshi Ichikawa[c], Michiyuki Fujiwara[c]

[a] *Department of Anesthesiology, Aichi Medical University, Nagakute, Aichi, 480-1195, Japan*
[b] *Arts planning Department of Osaka University of Arts, Minami-kawachi-gun, Osaka, 585-0001, Japan*
[c] *Hitachi Medical Co., Kakiwa, Chiba, 277-0804, Japan*

Abstract

For the purpose of brain stimulation and regeneration in the stroke patient, the clinical effect of music-exercise (trampoline) therapy (which used music performance jointly with trampoline moving), was scientifically verified. The mapping of the cerebral cortex circulation was examined by use of light topography and was derived from the time-dependent measurement of blood hemoglobin (oxy-hemoglobin and deoxy-hemoglobin) in 24 areas of the right and left cerebral cortex by use of near-infrared radiation spectroscopy, the value of which was extrapolated out. This was accomplished by comparing four different types of music and during the trampoline-movement. In the case of a normal person being the control patient, the right cerebral cortex had a reaction, with a greater reaction to the familiar selection of music. The significance of brain rehabilitation by music-exercise (trampoline) therapy has proven, especially in the case of the stroke patient, that the trampoline's upward and downward motion had a stimulus to the disordered side of the brain, with a reaction that was remarkable. The repetition of the music-exercise (trampoline) therapy was seen as effective for the stroke patient with lesions of the brain, and it is certain that the continued rehabilitation by music-exercise (trampoline) therapy will assist in the promotion of the regeneration of brain function and/or autonomic nervous function.

Keywords: Prolonged consciousness disorder, Stroke; Brain rehabilitation; Music; Trampoline; NIRS

* Corresponding author. Tel.: +81-561-62-3311; fax: +81-561-63-6621.
E-mail address: yogot@aichi-med-u.ac.jp (Y.Goto)

0531-5131/02 © 2002 Elsevier Science B.V. All rights reserved.
PII: S0531-5131 (01) 00689-6

1. Introduction

For the stroke patient, music-exercise (trampoline) therapy has gained attention as a method of brain rehabilitation, due to it's stimulation of a natural force over the whole body. No previous reports have been shown about the relationship between music and/or trampoline movements on brain activities of patients having prolonged consciousness disorders, such as brain strokes or brain-related injuries.

By dividing this type therapy into the effect of trampoline moving only and the effect of listening to four different types of music, the effects were investigated on the cerebral circulation using the method of near-infrared light topography [1].

2. Materials and method

2.1 *Patient*

(1) The subject used for the measurement of the effect of music-exercise (trampoline) therapy was a bedridden, 63-year old male suffering from prolonged stroke with a 14^{th} month postoperative subarachnoidal hemorrhage on the left anterior cerebral segment, right hemiplegia. A normal 20-year old female nonmusical specialist was used as a control subject.

2.2 *Measurement equipment*

Using near-infrared light topography equipment (HITACHI-MEDICO), the continuous and noninvasive measurement of cerebral cortex circulation from the bedside was possible. Its distinctive feature was the availability of the optical absorption property of the hemoglobin in the blood. The measurements taken were oxy-hemoglobin, deoxy-hemoglobin and total hemoglobin; showing the blood volume at its local field. From the basis of these measurements, the two-dimensional light imaging picture (light topography) as computerized. As a result, the local field functions of the cerebral cortex in the right and in the left of the 24 areas could be estimated.

3. Results

3.1 Effects of listening to music

3.1.1 On a healthy 20-year-old female

(2) There was more reaction on the right cerebral cortex in comparison with the reaction on the left side. This was evidence that the brain accepted the music for the purpose of receiving images. The vertical oscillation of the hemoglobin curves showed great up and down movements in the right and left temporal lobes (left region of 11, right region of 24), indicating acceptance of the music for image reception. These are also involved with auditory memory and have a deep relation with language skills.

(3) Especially in the left cortex, the blood volume, oxy-hemoglobin, and brain activity gradually declined with time during which four kinds of music were sequentially presented.

(4) The music selection "number D" greatly stimulated brain activity, a selection which the subject indicated that she knew well. This stimulation was seen as a sudden increase of deoxy-hemoglobin and a reversely decreased oxy-hemoglobin (especially, regions 16, 18,19,20,21 and 23 of the right cortex) (Fig. 1).

3.1.2 On a 63-year old prolonged stroke patient 14-months after brain subarachnoid hemorrhage

(1) The cerebral cortex blood volume increased as a result of stimulation of olfaction and sole reflex zone sensory irritation, and gradually decreased as time passed, during which the four kinds of musical performance music were presented (as was the case of the normal person), and it was also similar that the reaction level of the right brain was greater than that of the left. In the case of this patient with the failure in the left side of the brain, key points noted were: (2) in the integrating region of the speech area and memory area of sound and consciousness, the local blood volume increased, in addition to a very good reaction in the auditory memory region of 24 of the right cortex in all progresses. (3) Furthermore, the blood volume was maintained in region 21, (the lip of the right region), during the four connected musical performances. This is noted as the motor area near the tongue or sensory area.

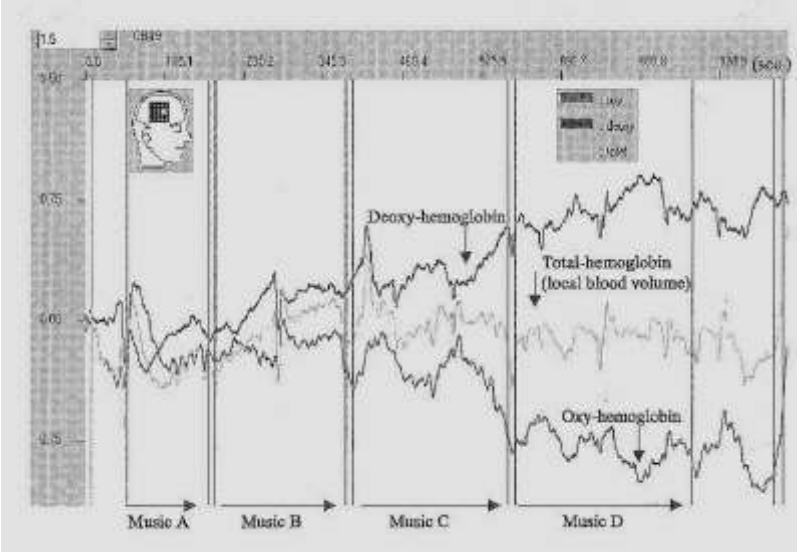

Fig. 1. Hemoglobin fluctuating waves at the right cerebral cortex region 19. Music A, Music B: not known musical piece. Music C: musical piece with asked memory. Music D: well known and liked musical piece.

3.2 Effects of trampoline moving

3.2.1 On a normal person

The numerical value of oxy-hemoglobin in all processes during the trampoline up and down motion kept constant, and the uptake of oxygen maintained large features. That is to say, the only difference was the uptake of the oxygen showing decline only in the hearing of the music while supine. The maintenance of the desired oxygen level seemed to be skillfully adjusted by an auto-regulation function of the cerebral circulation (during trampoline movement), even when the blood volume of the brain was decreased therefore, deoxy-hemoglobin on the plus-minus seem to show the decreased value.

3.2.2. On a consciousness disorder patient

All hemoglobin fluctuating waves maintained the parallel lines during trampoline moving. Large peculiar features were: (4) oxy-hemoglobin was fixed and kept in place in the left brain region of the illness, in spite of the increase of deoxy-hemoglobin. This was regarded as important data. Otherwise, the slight decrease of oxy-hemoglobin in the motor area of 1, 2, and 4 of the left region might have been because the assistant, who had contact by the hand, moved the patient's arm on the trampoline during the musical performance. In addition, at the end of the series of music-exercise brain rehabilitation therapy, the patient stood up with assistance and was measured. (5) Simultaneously, the features of the cerebral circulation seem in the bedridden patient almost commonly increased in the right and left brain during the time of standing up. These changes upon topographies are shown on the right side of Fig. 2. However, deoxy-hemoglobin demonstrated a slow tendency to increase with the time while the oxy-hemoglobin gradually decreased.

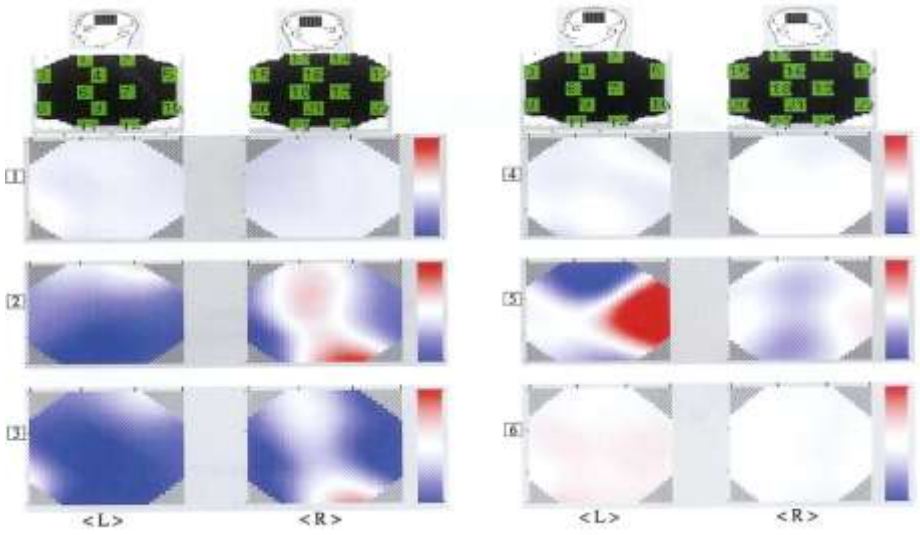

Fig. 2. Light topographies during progressive music-exercise therapy. The local blood volume computerized from total hemoglobin is shown in each figure [increase Red, decrease Blue]: (1) Before the start (supine); (2) Musical performance; at the end of music A. (3) Musical performance; at the end of music D. (4) Before starting the trampoline (sitting). (5) At the end of the trampoline-moving with musical performances. (6) At standing.

4. Discussion

Music exists as a means of communication among humans, via emotion or feeling, and has been utilized in medical treatment due to its stimulating and calming effects. The purpose of this type of brain rehabilitation for the stroke patient, utilized a method of music-exercise (trampoline) therapy that was developed for and has been increasingly used for positive outcomes in brain rehabilitation. [2]. Moreover, with this type of rehabilitation, there is no pain, it is rather enjoyable for the patient, and it is unique in its intention to heighten the patient's spirit. Though individual differences will exist, the data showed that trampoline-moving when performed even

in the sitting position provided the brain and spinal cord with a comfortable form of stimulation in the areas of balance that equaled the stimulation of walking/bipedal locomotion. Therefore, this music-exercise (trampoline) therapy is useful for the activation of regeneration of the cerebral nerve and autonomic nervous system, and for the rehabilitation of the patient's loss of function. The current study data showed that the auditory memory region of the brain was highly activated. Its function is to experience the sensation of music which apparently can be activated even in the prolonged stroke patient. It was surmised that the high-frequency acoustic wave component of the music, might be reintroduced onto the neural transmission pathway of the memory. Furthermore, the damaged left brain's reaction to the trampoline-moving showed an increased ability to maintain oxygen uptake, remarkably equal to that of the normal person [3]. The topographies were delicately emphasized at the turning point of the programs. It was also noted that there was a decrease of oxy-hemoglobin and the increase of deoxy-hemoglobin in the left frontal area lesions of the brain. The repetition of the music-exercise (trampoline) therapy was effective for this prolonged stroke patient with lesions of the brain, and it is certain that the continued rehabilitation by use of music-exercise (trampoline) therapy will enhance and promote the regeneration of brain function and /or autonomic nervous function.

Acknowledgements

This work was supported by the Research Grant for Cardiovascular Disease (11C-3) from the Ministry of Health and Welfare

References

[1] A. Maki, Y. Yamashita, Y.Ito, Spatial and temporal analysis of human motor activity using noninvasive NIR topography, Med. Phys. 22 (12) (1996) 1997-2000
[2] Y. Goto, Y. Handa, R. Noda, Effect of music therapy accompanied with up and down rhymes on the trampoline in impaired consciousness as evaluated by EEG action potentials and autonomic nervous function – with reference to 1/f fluctuation as an indicator of comfortableness in a healthy subject, Jpn.J. Reanimatol. 18 (1) (1999) 41-48.
[3] Y. Goto, R. Noda, M. Fujiwara, Cerebral circulation during music exercise therapy from brain mapping of cerebral local blood circulation by using NIR, Brain and Circulation 5 (4) (2000) 351-362.