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Address: Mashhad Nursing and Midwifery School, Ebn-e-Sina St., Mashhad, Iran
P.O.Box: 9137913199
Tel.: (098 51) 38591511-294
Fax: (098 51) 38539775
Email: EBCJ@mums.ac.ir

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Effect of a Structured Sensory Stimulation Program on the Sensory Function of Patients with Stroke-induced Disorder of Consciousness

Khadijeh Sargolzaei[1], Maryam Shaghaee Fallah[2], Nahid Aghebati[3*], Habibollah Esmaily[4], Mohammad Taghi Farzadfard[5]

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Abstract

Background: About 50% of stroke patients suffer from the disorder of consciousness with such adverse effects as sensory deprivation. The provision of a care program consisting of simple and safe stimulations can prevent sensory deprivation and improve the patient's sensory function.

Aim: This study aimed to determine the effect of structured sensory stimulation program on the sensory function of the patients with stroke-induced disorder of consciousness.

Method: This randomized clinical trial was conducted on 80 patients with stroke-induced disorder of consciousness admitted to the Intensive Care Unit and Emergency Department of Ghaem Hospital, Mashhad, Iran, in 2016. The participants were randomly assigned into two groups of control and intervention. The patients in the intervention group were subjected to a sensory stimulation program consisting of auditory, visual, olfactory, gustatory, tactile, and motor stimulations for 14 consecutive days. The sensory function was measured every day before and after the intervention using the Sensory Modality Assessment and Rehabilitation Technique (SMART) instrument. On the other hand, the control group received the routine care. The data were analyzed in the SPSS version 11.5 using the Mann-Whitney test, Chi-square test, and independent t-test.

Results: According to the results, the patients in the intervention and control groups had the mean ages of 66.2±8.9 and 63.8±10.8, respectively. The pre-intervention SMART scores of the two groups were homogenous (P=0.23). However, the independent t-test showed that the final SMART score was significantly higher (P<0.001) in the intervention group (25.1±6.6) than that in the control group (15.5±3.9).

Implications for Practice: As the findings of the study indicated, sensory stimulation with simple and accessible stimuli in the course of therapeutic programs could improve the sensory function of the stroke patients with the disorder of consciousness and prevent sensory deprivation.

Keywords: Consciousness, Sense, Sensory stimulation, Stroke

1. MSc Student of Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
2. MSc in Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
3. Assistant Professor of Nursing, Department of Medical Surgical Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran
4. Associate Professor, Department of Biostatistics and Member of Health Sciences Research Center, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran
5. Assistant Professor, Department of Neurology, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

* Corresponding author, Email: aghebatin@mums.ac.ir

Introduction

Stroke is the most prevalent disabling neurological disorder among the adults. This disease is the world's third leading cause of mortality after cardiovascular diseases and cancer (1). According to the Iranian Ministry of Health, 372 per 100,000 Iranians annually experience stroke for the first time. This rate is significantly high, compared to that of the developed countries (2).

The stroke patients may develop a variety of sensory, motor, perceptual, and emotional disorders depending on the type, size, and position of the involved artery. This disease can lead to coma in its most severe form (3). In a study conducted by Lawrence et al. (2001), the reduced level of consciousness was reported as one of the most prevalent disorders among the stroke patients as 30% of these patients had Glasgow Coma Scale (GCS) of ≤ 8 (4).

One of the most important complications threatening the stroke patients in the Intensive Care Units (ICUs) is the sensory deprivation due to damage to the brain and consciousness structures, long-term immobility, social isolation, and special condition of these units (5). In these patients, the reduction of sensory stimuli leads to a raised Reticular Activating System (RAS) activation threshold and the loss of ability to induce a normal level of brain activity (6), which in turn leads to prolonged coma and hospital stay (7).

According to the studies carried out by Karter (1989) and Dyang (1987), the provision of proper and safe sensory stimuli can establish synaptic links, provide sufficient stimuli for RAS, and improve consciousness (8). Sensory stimulation is a treatment in which the auditory, visual, tactile, gustatory, and olfactory stimuli as well as modes of balance and position are used with the intensity and frequency tailored to the patient's personal thresholds to increase their arousal, awareness, and incidence of obvious behavioral responses (9).

In case this stimulation is applied with right intensity and repeated properly and accurately, it can improve the rate of consciousness recovery, facilitate the achievement of a higher level of sensory function, and therefore reduce the duration of coma (10). Within a few weeks after the stroke, a damaged brain enters the plasticity period and experiences some changes that can contribute to its repair and recovery. During this period, some environmental stimuli can accelerate the recovery process (11); therefore, a proper and timely rehabilitation can significantly improve the brain function in these patients.

Although the medical science has achieved acceptable standards in relation to the rehabilitation of sensory, motor, behavioral, and cognitive disorders, there are still some controversies over the efficacy of sensory stimulation programs in the disorder of consciousness (8). Some studies have supported the efficacy of structured and systematic stimulation in this regard.

For example, in a study conducted by Mitchell et al. (1990), it was observed that the implementation of a sensory stimulation program on the patients in concussion-induced coma resulted in increased consciousness and decreased coma duration (12). In Iran, in a study performed by Hassanzadeh et al. (2012), it was shown that the early sensory stimulation with familiar stimuli increased the level of consciousness in the patients with traumatic brain injury (13).

On the contrary, the studies of Pierce (1990) and Johnson (1993) did not indicate any significant changes in the level of consciousness among the traumatic brain injury patients after the implementation of sensory stimulation program (14, 15). According to a systematic review carried out by Lombardi et al. (2002), the validity and reliability of sensory stimulation programs are yet to be clinically confirmed as different studies have tried different stimulation types and durations. In addition, none of the reviewed studies have reported conclusive and reliable results on the clinical outcome of the sensory stimulation program regarding the level of consciousness in comatose patients (16).

Furthermore, the authors of this study did not find any study on the effect of such stimulations on the recovery of coma in the stroke patients as an exclusive group. This is while stroke and brain trauma do not have the same nature and pathophysiology, and the mechanism of stroke-induced coma differs from that of a coma induced by brain trauma. Ischemic stroke interrupts blood delivery and circulation in the brain, which leads to the deficient delivery of oxygen and glucose, accumulation of lactate as well as acidosis, and ultimately cell damage and mortality (17, 18).

In comparison, brain traumas can directly damage the brain tissues, and typically cause coma via compression or direct injury of the structures responsible for consciousness (19). In addition, studies have shown that the majority of the brain trauma patients are young (20), while the stroke patients are mostly elderly (21). Consequently, given the differences between the mean age of the patients

suffering from these diseases and the nature of brain trauma and stroke, the patients inflicted with these two conditions will not have the same response to sensory stimulation.
Regarding this, the results of the studies investigating the effect of sensory stimulation on the recovery of brain trauma patients cannot be generalized to the stroke patients. From another perspective, the increasing frequency of stroke among the Iranian population highlights the need for the direction of further attention to stroke treatment issues (22). Furthermore, it underscores the necessity of establishing a care program consisting of safe and simple stimulation methods targeting toward the prevention of sensory deprivation and other complications caused by long-term stroke-induced coma and acceleration of patient recovery.
With this background in mind, the present study was conducted to investigate the effect of a structured sensory stimulation program on the sensory function of the patients with stroke-induced disorder of consciousness.

Methods

This randomized controlled clinical trial was conducted on the patients with stroke-induced consciousness disorder, who were admitted to the ICU and Emergency Department of Ghaem Hospital, Mashhad, Iran within June 21 to October 22, 2016. The sample size was calculated based on a pilot study performed on 10 patients using the comparison of mean formula with 80% test power and 95% confidence interval.
In the pilot study, the mean sensory function scores were 17.8±3.3 and 14.4±3.2 in the intervention and control groups, respectively. Ultimately, the group size was estimated as 40 cases while considering the sample loss. The study population was selected through the simple random sampling technique. The participants were randomly assigned into the intervention and control groups, using the table of random numbers.
The inclusion criteria were: 1) age range of 35-75 years, 2) coma duration of 72 h to14 days, 3) GCS score of 6-12, 4) access to one of the patient's first-degree family members with the age of ≥ 18, 5) Iranian citizenship and fluency in Farsi, and 6) lack of visual (e.g., color blindness), hearing, psychiatric, and skin problems. On the other hand, the exclusion criteria included: 1) presence of metabolic disorders, 2) use of sedative and opiate medications during the study, 3) development of sudden abnormal hemodynamic disorder causing critical condition, 7) prohibition of limb movement, and 8) mortality before the 14^{th} day of the intervention.
The data were collected using the standard demographic form, hemodynamic monitoring checklist, and Sensory Modality Assessment and Rehabilitation Technique (SMART). The SMART, which was first introduced by Gill-Thwaites (1997), is a standard instrument for the structured and graded analysis of the behavioral responses of comatose patients. This tool covers eight modalities, including auditory, visual, olfactory, gustatory, tactile, motor function, functional communication, and arousal.
Each modality is evaluated based on a five-point hierarchical scale (level 1: no response, level 2: reflex response, level 3: withdrawal response, level 4: localizing response, and level 5: differentiating response). The minimum and maximum scores of this instrument are 5 and 40, respectively. Lower scores indicate low function, and higher scores represent the patient's better response to stimuli. The validity and reliability of this instrument has been confirmed by Gill-Thwaites in 2004 (23).
Since the authors could not find any study validating the SMART instrument or its Persian translation, first, we translated this tool into Persian, and then examined the validity of the translated version. According to Polit and Beck (2012), when the content and construct validities of an instrument is well established, and its capability to measure a concept is widely accepted, any researcher seeking to use the instrument in another language can use a standard procedure to validate a translation (24).
To acquire such translation, first, the English version of the SMART instrument was translated into Persian by a Persian translator, who was fluent in both languages. Subsequently, the translated version was reviewed by the authors to ensure the consistency between the concepts and terms of the translated and original versions. Next, another translator, who was blind to the original items, back translated the content. Then, the consistency of the retranslated version with the original instrument was evaluated.
In the end, the final instrument was shared with ten experts, including neurologists, nurses of neurology department, and nursing instructors, and the consistency of the translated terms with the original text as well as their clarity and simplicity were verified. It is worth noting that the original

instrument was not modified, but simply translated to be applicable for the Persian speakers. The reliability of the translated instrument was estimated as 0.92 using the inter-rater agreement method with 2 raters and 10 patients.

The eligible patients were identified by reviewing the medical records and interviewing the family members. Therefore, after receiving the written consent from the family and subsequent approval of assisting neurologist, the eligible participants were entered in the study. In addition to routine care, the patients in the intervention group received a sensory stimulation treatment consisting of auditory, visual, olfactory, gustatory, tactile, and motor stimulation in form of a regular individualized program. To design this program for each patient, the suitable stimulation modality was determined according to the patients' familiarity and interests based on the information provided by their family members. In addition, a list of stimuli that should be used in sensory stimulation program was arranged. Then, the patient was exposed to stimuli on a regular basis. Auditory stimulation was performed through direct verbal communication by the researcher (informing the patient about his identity, time, and place), the recorded voices of family members (i.e., narration of pleasant memories), and the patient's favorite music.

In this type of stimulation, first, the patient was called by his/her given and family names, informed about the time and place, and given brief information about sensory stimuli. Then, the recorded voices of the patients' family members and their favorite music (previously prepared in a MP3 Player) were played using headphones for 10 min. Visual stimulation was conducted using a flashlight, family photographs, familiar objects, and a mirror. For visual stimulation, the mentioned objects were held at the center of the patient's field of vision, and then moved in vertical and horizontal directions. During this stimulation, the researcher had to keep the patient's eyes open.

Olfactory stimulation was carried out using familiar aromatic scents, including perfume and scents of orange or lemon, coffee, vanilla, and rose water. For gustatory stimulation, the mouth was first washed with cold water, and the gums were massaged with a swab; subsequently, a swab dipped in lemon juice was placed on the sides of the tongue. For tactile stimulation, after washing the hands with cold or hot water and drying them with a towel, the limbs were massaged with olive oil.

After massage, the limbs were passively moved up and down; in addition, they were bended and straightened in their motion range (provided that such motions were not prohibited). Each of the patients in the intervention group received these six stimulations once a day for 14 consecutive days. The stimulations were performed consecutively with 10-minute rest intervals. Each stimulation procedure could take 5-10 min; therefore, the total duration of sensory stimulation program, including the rest, was about 90 min a day per patient.

It should be noted that the content validity of the sensory stimulation program, which was devised based on the study of Gerber (2005) (9), was assessed and confirmed by 10 faculty members of the Mashhad School of Nursing and Midwifery, Mashhad, Iran. To minimize the difference between the environments of the ICU and Neurological Emergency Department, the interventions were implemented between 8 and 9:30 a.m., when there was minimum need for medical-nursing intervention.

Furthermore, to assimilate the room condition to that of the ICU as much as possible, the interventions in the Emergency Department were performed while the door of the patient's room was closed and it was quiet. To determine the stability of the patients' condition, the researchers measured their hemodynamic parameters before and after each intervention. The sensory function improvement was measured every day before and after the sensory stimulation (i.e., twice a day) for 14 consecutive days using the standard SMART instrument.

Nevertheless, given the large number of measurements, statistical tests were performed using the pre- and post-intervention sensitivity scores obtained on the first (pre-intervention), fifth, tenth, and fourteenth days of the intervention. Due to the lack of access to enough eligible research staff for completing the research forms twice a day (i.e., before and after intervention) for 14 consecutive days for 80 patients, the research could not be blinded.

The control group received no particular intervention apart from the routine nursing care. The sensory function scores of this group were measured and recorded at the same time as those of the intervention group. In line with the ethical standards of research, the study was conducted with the approval of the Ethics Committee of the university. Furthermore, all the terms related to the voluntariness of the study, confidentiality of personal information, and safety of the intervention were assured.

Data analysis was carried out using the descriptive (i.e., frequency, mean, and standard deviation) and inferential statistics, including the Chi-square test, Mann-Whitney U test, independent t-test, and repeated measures ANOVA through SPSS, version 11.5.

Results

According to the results, the mean ages of the patients in the intervention and control groups were 66.2±8.9 and 63.8±10.8, respectively. Furthermore, 22 (55%) and 25 (62.5%) subjects in the intervention and control groups were female, respectively. The most common type of stroke in both groups was ischemic, i.e., 23 (57.5%) and 27 (67.5%) patients in the intervention and control groups, respectively. In addition, the majority of the strokes occurred in the right mid cerebral arterial (15 (37.5%) and 17 (42.5%) patients in the intervention and control groups, respectively). The demographic data of the two groups and the results of homogeneity tests are presented in Table 1.

The results of the independent t-test indicated no statistically significant difference between the intervention and control groups in terms of the SMART scores on day 1 at the pre-intervention stage (P=0.23). As shown in Figure 1, a significant increase was observed in the mean SMART scores of the intervention group over the four stages of analysis (i.e., scores of the 1st, 5th, 10th, and 14th days of the intervention). Nevertheless, the mean scores of the control group had no significant change in this regard over these stages.

Table 1. Demographic characteristics of patients in the intervention and control groups

Variables	Intervention group (n=40)	Control group (n=40)	P-value
Age (years) Mean±SD	66.2±8.9	63.8±10.8	*0.48
Coma duration Mean±SD	8.9±3.3	8.8±3.5	*0.81
Glascow Coma Scale Mean±SD	7.7±1.7	7.1±1.2	*0.20
Gender n (%)			
Male	18 (45.0)	15 (37.5)	**0.49
Female	22 (55.0)	25 (62.5)	
Type of stroke n (%)			
Ischemic	23 (57.5)	27 (67.5)	**0.35
Hemorrhagic	17 (42.5)	13 (32.5)	
Position of stroke n (%)			
Right mid cerebral arterial	15 (37.5)	17 (42.5)	
Left mid cerebral arterial	11 (27.5)	10 (25.0)	**0.93
Intracranial hemorrhage	11 (27.5)	9 (22.5)	
Intraventricular hemorrhage	3 (7.5)	4 (10.0)	

*Mann Whitney, **Chi-square

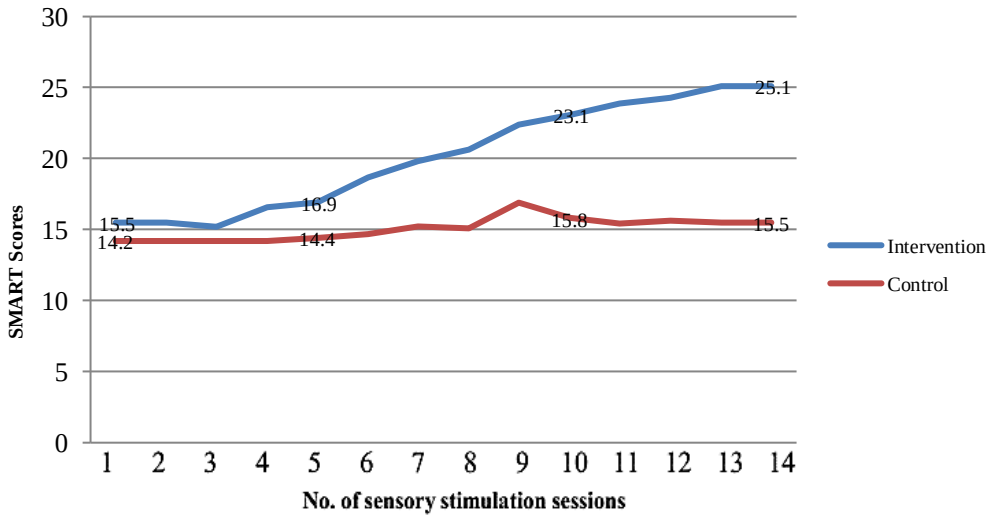

Figure 1. Comparison of mean sensory modality assessment and rehabilitation technique scores of the intervention and control groups

Table 2. Evaluation of sensory function based on total sensory modality assessment and rehabilitation technique scores in the intervention and control groups

Variable	Intervention group Mean±SD	Control group Mean±SD	Independent t-test
Session 1 (pre-intervention)	15.2±4.2	14.2±3.4	P=0.23, t=1.189
Session 5 (post-intervention)	16.9±3.8	14.4±3.6	P=0.004, t=2.955
Session 10 (post-intervention)	23.1±6.2	15.8±5.8	P<0.001, t=5.420
Session 14 (post-intervention)	25.1±6.5	15.5±3.9	P<0.001, t=8.066
Result of intergroup analysis of variance	F=32.327	df=1	P<0.001
Result of intragroup analysis of variance	F=93.203	df=2.051	P<0.001

Table 3. Changes in the scores of individual sensory modalities in the intervention and control groups based on the difference between the scores of days one and fourteen

Variables	Intervention group	Control group	Independent t-test	
Auditory	-2.02±0.8	-0.1±0.6	P<0.001	t=-11.175
Visual	-1.5±0.05	-0.3±0.8	P<0.001	t=-5.928
Olfactory	-1.3±1.04	-0.07±0.4	P<0.001	t=-6.876
Gustatory	-1.1±1.0	-0.07±0.6	P<0.001	t=-5.678
Tactile	-0.9±0.7	-0.05±0.3	P<0.001	t=-7.048
Motor function	-1.4±0.7	-0.2±0.6	P<0.001	t=-7.551
Communication	-0.7±0.9	-0.02±0.3	P<0.001	t=-4.430
Arousal	-1.1±0.9	-0.3±0.8	P<0.001	t=-4.055

More specifically, the mean SMART score of the intervention group increased from 15.2±4.2 on the 1st day to 25.1±6.5 on the 14th day of the intervention. Nonetheless, the mean SMART score of the control group showed only a slight increase from 14.2±3.4 on the 1st day to 15.5±3.9 on the 14th day of the intervention. The results of the repeated measures ANOVA on the changes of sensory function revealed statistically significant developments (P<0.001) over the course of intervention (principal measurements on the 1st, 5th, 10th, and 14th days).

After the rejection of hypothesis related to the correlation between repeated measurements by the Mauchly's test (P<0.001), the Greenhouse-Geisser test was run to search for intra-group differences between the total SMART scores of the four principal measurements. The results of this test demonstrated a significant difference between these four measurements (P<0.001). In other words, the results showed a significant increase in the total SMART score at every stage of measurement; an increase that was significantly higher in the intervention group than that in the control group (Table 2).

Table 3 illustrates the changes in sensory function in the intervention and control groups, which was represented by the SMART scores in different sensory modalities. The independent t-test showed that the difference between the SMART scores in auditory, visual, olfactory, gustatory, tactile, motor, communication, and arousal modalities before and after the intervention (i.e., days 1 and 14) was significantly higher in the intervention group than that in the control group (P<0.001). In the intervention group, the greatest change in sensory function was observed in the auditory modality (-2.02±0.8), whereas the lowest change was observed in the communication (-0.7±0.9) and tactile modalities (-0.9±0.7).

Discussion

As the findings of the present study indicated, a regular and structured sensory stimulation program could improve the sensory function of the stroke patients with disorder of consciousness. Given the homogeneity of the sensory function scores of the intervention and control groups at the pre-intervention stage, the significant difference observed in the total scores at the end of the intervention signified the efficacy of the sensory stimulation program. In this respect, our findings are consistent with those of the previous studies.

In line with our results, Hassanzadeh et al. (2012) demonstrated that six days of sensory stimulation significantly increased the level of consciousness in the brain trauma patients (13). In the mentioned study, the duration of intervention was relatively short (i.e., six days), and the patients had a lower GCS (5-10). Nevertheless, the results showed a significant increase in the GCS scores of the patients. The positive effect of short-term intervention can be attributed to the younger age of the patients and

the fact that sensory stimulations were conducted by a family member. In the mentioned study, the mean age of the patients was 22.5 years; however, this value was 65 years in our study.

In another study, Davis and Gimenez (2003) observed a slight increase in the Sensory Stimulation Evaluation Measure scores of the patients in the intervention group after seven days of auditory stimulation (P=0.015). Nevertheless, the improvement in sensory function scores was considerably more significant in our study (P<0.001). The greater effect of sensory stimulation intervention in the present study as compared to that of Davis and Gimenez could be probably attributed to the use of not only auditory, but also other modalities of sensory stimulation, longer intervention, larger sample size, and use of a different sensory function measurement instrument.

On the contrary, in a study carried out by Ehsaei et al. (2004), no significant change was reported in the level of consciousness of the brain trauma patients in the intervention and control groups after sensory stimulation (25). This inconsistency could be due to the fact that in the mentioned study, the sensory stimulation was performed 10 min an hour for all 24 hours of the day; therefore, the sensory stimulations were continued throughout the night. This is while many related studies have suggested that sensory stimulation should not interfere with the natural day-night rhythm, and the cycles of sleep and wakefulness should be never disturbed by sensory stimuli or nursing care (26).

In the present study, we investigated the effect of structured sensory stimulation program on sensory modalities, including auditory, visual, olfactory, gustatory, tactile, motor function, functional communication, and arousal. Our findings revealed a significant increase in the mean scores of each modality in the intervention group as compared to those in the control group. In this investigation, the greatest change was observed in the auditory modality, while the lowest change was seen in the communication and tactile modalities.

Similarly, in a study performed by Urbenjaphol et al. (2009), sensory stimulation was demonstrated to improve the sensory function in every sensory modality, especially auditory (27). However, in the mentioned study, the second greatest change was observed in the tactile modality, whereas in the present study, this modality was found to be the least affected. The cause of this difference is perhaps the fact that our study population consisted of the stroke patients mostly with ischemic stroke in the right and left MCA, the majority of whom had obvious sensory and motor impairments on one side of their body, which undermined the efficacy of tactile stimulation.

It should be noted that the continuation of the sensory stimulation intervention for more than two weeks may yield better improvements in the tactile function of the stroke patients. This argument was supported by Ghanjal et al. (2016), who showed that 24 days of sensory stimulation in form of sensory retraining, including deep-strong and shallow-soft tactile stimulation, improved the upper limb sensory function of the ischemic stroke patients (28).

Gruner and Terhaag (2000) also investigated the effect of multimodal sensory stimulations on 16 patients with severe traumatic brain injury and GCS of < 8. They reported that the tactile and auditory modalities had the greatest response to sensory stimulations (29). Our findings are consistent with those obtained by Gruner and Terhaag on the effect of stimulation on auditory sense, but not on tactile sense.

In accordance with the present study, in a study carried out by Mandeep (2013), the lowest change was indicated to occur in the communication modality (30). However, inconsistent with our findings, this lowest change was not only reported in communication modality, but also observed in the auditory modality. This discrepancy might be ascribed to the fact that we applied familiar sounds, such as the voice of the patient's family members and favorite music 10 min a day; however, in the mentioned study, the researchers used the ring sound, which was a neutral audio for a short period of one minute.

In a study conducted by Alam (2016) on the brain trauma patients, the lowest and highest responses to sensory stimulation were observed in the auditory and tactile modalities, respectively (31), which is inconsistent with this study. This inconsistency could be caused by the fact that Alam used only one type of auditory stimuli (i.e., researcher's voice), whereas we used familiar auditory stimuli, such as the voice of the family members and patient's favorite music.

The difference in our tactile modality results (which had the lowest score among all modalities in our study) and those reported by Alam might be attributed to the difference in the research populations, as the studies of Urbenjaphol and Gruner also reported the tactile as the modality with second highest scores after auditory. In the present study, the increasing trend of daily mean scores of the patients in

the intervention group over the 14 days of sensory stimulation program and the insignificant changes in daily mean sensory performance scores of the control group revealed the positive effects of sensory stimulation on the sensory function of the stroke patients with disorder of consciousness.
In addition, the comparison of our findings with those of other studies indicated some inconsistencies, which could be attributed to the difference of our population. To be more specific, the majority of the previous studies on sensory stimulation were performed on patients with brain trauma-induced coma, whereas our study population consisted of stroke patients with disorder of consciousness, who mostly suffered from sensory impairments, such as hemiparesis. This difference can also explain why unlike many of the previous studies, in the present study, the tactile modality had the lowest score.
Furthermore, the mean age of our study population was higher than that of other studies, which is because the brain trauma patients are mostly young based on the statistics, while the stroke patients are typically elderly. The limitations of this study included the inability to consider the patients' diverse RAS activation thresholds and their individual characteristics and differences. In addition, it was not possible to blind the research and control the unwanted sensory stimuli in the environment (e.g., environmental noise and personnel movements).

Implications for Practice

As the findings of the present study indicted, sensory stimulation program in combination with typical therapies could play a significant role in the recovery of stroke patients with the disorder of consciousness. The nurses responsible for caring of the stroke patients can infuse the routine care programs by purposeful sensory stimulation due to their constant contact with these patients. As a result, they can improve the patient's sensory function and recovery by providing an environment filled with helpful sensory stimuli.
Further studies are recommended to investigate the sensory stimulation of this particular group of patients through single-blind or double-blind experiments. It is also suggested to evaluate the effect of more than two-week intervention on the outcomes, especially among the patients with ischemic stroke. It would be also helpful to apply long-term follow-ups and various tactile therapeutic techniques in the sensory stimulation program in the future study. Moreover, the impacts of such therapies on cognitive function, severity of illness, and other functional outcomes, and also the possible results of more active participation of family members in sensory stimulation are all worthy of further research.

Acknowledgments

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Conflicts of Interest

The authors declare no conflict of interest.

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