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Effects of Different Musical Stimuli in Vital Signs and Facial Expressions in Patients With Cerebral Damage: A Pilot Study

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ABSTRACT

Background: Along history, music has been used in a variety of ways for therapeutic purposes and has long been recognized for its physiological and psychological effects. Music listening can be an effective nursing intervention, to enhance relaxation, provide distraction, and reduce pain. **Objectives:** The aims of this study were to identify changes produced by different musical stimuli in blood pressure (BP), heart rate (HR), respiratory rate (RR), and oxygen saturations (SpO_2) and to verify the influence of music listening on patients' facial expressions with severe cerebral damage. **Method:** A quasiexperimental study was performed in 26 patients with severe cerebral damage, divided into control and case groups. Patients belonging to the case group were exposed to musical stimuli, radio, classical relaxing music (CRM), and relaxing music with nature sounds (RMNS). Patients were evaluated by measuring vital signs before and after exposure to each musical stimulus, as were the patients within the control group. Patients in the control group were exempt from any musical stimulus. Facial expressions were observed in each patient within the case group during the intervention. **Results:** The results show that radio produced a slight increase in systolic BP, HR, RR, and SpO_2. The CRM induced a decrease of RR and an increase of SpO_2 and also produced alterations of the facial expression. When RMNS was played, a decrease was displayed in BP, HR, and RR and an increase was displayed in SpO_2. Alterations in facial expression were displayed in each patient. **Conclusions:** The results of the study suggest that the application of musical stimuli such as CRM and RMNS can be used to provide a state of relaxation in patients with severe cerebral damage.

Keywords: facial expression, music listening, music therapy, severe cerebral damage, vital signs alterations

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At present, there exists an increasing interest to find nursing interventions and other nonpharmacological methods, which can favor the well-being of the patient within the hospital environment. The use of music therapy as a nonpharmacological aid has been used throughout time with curative purposes and in rituals (Covington, 2001). Music is a very powerful multimodal stimulus that transmits visual and auditory information to the brain, which in turn is processed in specific networks composed by the frontal and temporal–parietal regions (Soria-Uros, Duque, & García-Moreno, 2011). Music processed via these networks evokes patterns of unconscious movement; the interpretation by the brain of the musical stimulus responds according to the intensity and harmony of the sounds, which promote and alter behavioral and sensory processes. The basic components of music—rhythm, melody, and harmony—are the same that compose our organism, such as cardiac rhythm, the rhythmic synchronization of walking, and the melody and volume of our spoken voice. Every musical note contains specific physical qualities, which are interpreted in a mathematical way and, when played in different ways, in different intervals, and with different rhythms, dynamics, and volumes, can powerfully influence the human being in a psychological way (Rebolledo, 2006). Florence Nightingale recognized the beneficial effect of music and used it as an aid of care delivery for soldiers in the Crimean war. She describes how nurses used their voices alongside the melody of flutes to produce beneficial effects in soldiers with pain (McCaffrey & Locsin, 2002).

Since the middle of the 20th century, music therapy appears in nursing literature not only as a potentially effective intervention, which can diminish patient anxiety, but also having favorable effects on variables such as the mental state or pain (Marwick, 1996). Neural impulses produced by music may mediate changes in blood pressure (BP), heart rate (HR), anxiety, and mood by affecting the release of corticotrophin-releasing hormone secreted from the hypothalamus or the release of norepinephrine from the sympathetic nervous system (SNS; Watkins, 1997). Music therapy is the systematic use of music to produce relaxation and reduce psychophysiological stress (Khalfa, Dalla Bella, Roy, Peretz, & Blondin, 2003). However, it is necessary to point out that not any type of music can induce these responses in the SNS, as this can be influenced by both personal preference and the number of cycles per second (Hertz) of the chosen music (Wong, López-Nahas, & Molassiotis, 2001). This implies the possibility of using music by means of the rhythmical stimulation for patients who experience altered cognitive processes such as memory, attention, and conduct in neurological rehabilitation and in some neurological illnesses such as cerebral damage (Magee & Davidson, 2002; Thaut, Kenyon, Schauer, & McIntosh, 1999). Some research studies on the use of music in patients with acquired brain injury have reported positive results in rehabilitation settings to stimulate brain functions involved in movement, cognition, speech, emotions, and sensory perceptions (Bernardi, Porta, & Sleight, 2006; Puggina, Silva, & Santos, 2011; Thaut et al., 1999; Turner-Stokes & Wade, 2004).

Acquired brain damage embraces a range of conditions involving rapid onset of brain injury including trauma, vascular accident, cerebral anoxia, toxic or metabolic insult, infection, inflammation, and tumors. This cerebral damage can result in impairments in motor function, language, cognition, sensory processing, and emotional disturbances (Royal College of Physicians, 2004). Furthermore, some patients with severe brain injury proceed to have a good recovery, whereas others awaken from the acute comatose state but do not show any signs of awareness. If repeated examinations yield no evidence of a sustained, reproducible, purposeful, or voluntary behavioral response, a diagnosis of a vegetative state is made. A complication of severe brain damage, regardless of etiology, is a syndrome of marked agitation, hypertension, tachycardia, and tachypnea accompanied by hypertonia and extensor posturing (Monti et al., 2010).

The authors examine the effects of planned music therapy on multiple parameters, particularly those affected by corticotropin-releasing hormone and norepinephrine, in patients with neurologic disorders.

From a nursing perspective, the importance of developing and implementing a noninvasive intervention such as music listening is paramount for the promotion of relaxation and patient well-being. Nevertheless, the introduction of new interventions in nursing practice requires the basis of solid scientific evidence. On the basis of a review of limited existing literature generally consisting of reports of a single or few cases with brain injury, numerous studies indicate a beneficial response from these patients (Bernardi et al., 2006; Chlan, 1998a; Puggina et al., 2011). However, for patients with a diagnosis of a vegetative state, further studies need to be done to determine other available methods of measuring the responses to music listening. For this reason, this study has set the following objectives: to identify changes produced by different musical stimuli in BP, HR, respiratory rate (RR), and oxygen saturations (SpO_2) and, finally, to verify the influence of music listening on patient's facial expressions with severe cerebral damage.

Patients and Methods

A quasiexperimental study was performed using music listening as an intervention (independent variable). Alterations in vital signs and in facial expressions (dependent variables) were used as indicators for the results.

The sample group consisted on 26 patients hospitalized in the irreversible brain injury unit of a hospital in Madrid (Spain) and met the following inclusion criteria: (a) diagnosed as in a vegetative state for at least 12 months before the investigation; (b) lacking previous diagnosis of auditory damage, which would limit auditory capacity; (c) hemodynamically stable without receiving any inotropic support, continuous intravenous analgesia, centrally acting drugs, or sedation; and (d) have a written consent from the family or legal guardians for the patient's participation in the research study.

The heterogeneity of etiology was not an exclusion criterion, because the patients shared the same diagnosis (vegetative state because of severe brain injury). These patients are wakeful with preserved sleep–awake cycles; are incapable of interacting, understanding, or communicating with others; and do not carry out any purposeful or voluntary behavior (American Academy of Neurology, 1994). Data collection began after approval from the ethics committee.

The selected patients were randomly allocated in two groups, a control group (13 patients) and a case group (13 patients); only the case group received the intervention of music stimuli. The method used to select patients for this study was a simple random selection. Demographic data of all subjects were obtained from their medical chart.

Previous research has documented the importance of the listener's musical preference for the selection of music; however, in this sample group of patients, personal music preference has been omitted. Music intervention for relaxation must have a regular rhythm (less than 80 beats per minute); have no extreme pitch or dynamics; and provide a melodic sound that is smooth and flowing, with tonal qualities, which include strings, flute, piano, or specially synthesized music (Robb, Nichols, Rutan, Bishop, & Parker, 1995). A minimum of 20 minutes of music is necessary to induce relaxation (Guzzetta, 1995). The control of stimulus volume is essential to induce relaxation; several authors recommend a volume of 60–70 dBSL, as decibels higher than 90 dBSL cause discomfort (Robb et al., 1995). According to these guidelines, a new age (relaxing music with nature sounds [RMNS]) and a classical musical theme (classical relaxing music [CRM]) were selected. Both themes of musical stimuli used were instrumental without words. The third musical stimulus selected was radio (various musical genres and commercial messages), because as some authors believe, radio is a form of rhythmic auditory stimulation (Chlan, 1998b).

The intervention of music listening was based on the approach by Robb et al. (1995) and Guzzeta (1995). The case group was exposed to three types of musical stimuli: CRM, RMNS, and radio. These patients were exposed to 18 sessions (six sessions for each musical stimulus), being performed once a day, twice weekly at the same hour, without any alterations in drug therapy during the time of exposure. The CRM and RMNS were applied individually using an MP3 player via headphones for a period of 20 minutes with the music volume at 60 dBSL (Puggina et al., 2011). Radio (various musical genre and commercial messages) was played as environmental music (volume of 70 dBSL) for 1 hour via a stereo system (Chlan, 1998a). The control group was exposed to silence (MP3 player via headphones). The music/silence interventions were performed during nonvisiting hours (to avoid family influence) and while nursing care routines were not being provided. A calm atmosphere was selected during each exposure to avoid interference by external stimuli. Any manipulation or touch was avoided (Puggina et al., 2011). All patients were bedridden.

Based on results from previous similar studies (Chlan, 1995; Henry, 1995; Puggina et al., 2011; White, 1992, 1999), physiological measures such as BP, HR, RR, and SpO_2 are important indicators of relaxation or stimulation response. These vital signs were evaluated twice during each session, the first before exposure and before placing headphones on the patients, providing a baseline. The second evaluation was performed after 60 seconds of exposure to music (case group) or silence (control group). Vital signs were monitored obtaining BP values with a calibrated BP monitor as well as HR and SpO_2 with a pulse oximetry monitor. RR was registered manually for 1 minute on all subjects by the same researcher.

Facial expressions were evaluated at baseline and during the intervention periods described above. The patient's facial expressions (case group), during the CRM and RMNS, were evaluated in the following way: patients were observed immediately before the intervention, and their basal facial expressions were documented so that these preexisting expressions could be disregarded from the data collection. Alterations to the patients' baseline expressions were registered (head, mouth movements (smiling/yawning), eyebrow movements, facial tension and relaxation, tears, unspecific ocular opening, etc.). However, given the great diversity of results, a simplified analysis was performed by the presence or absence of alteration in facial expressions during music listening when compared with basal expressions (Puggina et al., 2011). On exposure to radio sounds, we did not evaluate facial expressions for various reasons such as the inability to use video recorders and time constraints experienced by the research nurse to observe the whole intervention period, given the length of exposure (1 hour for each patient).

Data were analyzed using SPSS (version 19.0 for Windows). A descriptive analysis of demographics and clinical data was performed. Data results are presented as mean ± standard deviation. Variable comparison was performed using the Fisher's test and the t test. Statistical significance was set at $p < .05$.

Results

As shown in Table 1, the sample of the study consists of 13 patients in the control group, composed of eight women and five men, whereas the case group contains 13 patients, five women and eight men. The mean age of the case group was 52.3 (± 16.01) years

TABLE 1. Patient's Demographic and Clinical Data (n = 26)

Item	Case Group (n = 13)	Control Group (n = 13)	p
Gender			
Male	8	5	.21
Female	5	8	
Age (years)	52.3 ± 16.01	55.8 ± 12.94	.50
Diagnosis			
Vegetative state	13	13	.80
Etiology			
Traumatic brain injury	5	5	
Hypoxic-ischemic encephalopathy	2	7	
Acute cerebrovascular accident	4	1	.16
CNS infections	1	0	
CNS tumors	1	0	
Vegetative state duration (months)	42.1 ± 23.6	49.7 ± 16.9	.29

Note. Scores: mean ± *SD*. Fisher's exact test, homogeneous group for $p > .05$. CNS = central nervous system.

and that of the control group was 55.8 (± 12.94) years. The patients of both groups have been admitted within the irreversible cerebral damage unit for >1 year and have a medical diagnosis of vegetative state for more than 3 years (the average of vegetative state duration is 45.9 ± 20.5 months). The etiology of these patients within both groups is displayed as 38.5% traumatic brain injury, 61.5% nontraumatic origin, 34.7% hypoxic–ischemic encephalopathy, 19.2% acute cerebrovascular accident, 3.8% central nervous system infections, and 3.8% central nervous system tumors (Table 1).

Comparing the two groups, the case and control groups, according to the Fisher's exact test, the groups were not significantly different in terms of gender, age, diagnosis, etiology, and vegetative state duration and therefore can be considered as homogenous (Table 1).

Changes in Vital Signs Produced by Radio Stimulus

The obtained results show statistically significant differences between the patients who were exposed to the stimulus and those who were exempt from any sonorous stimulus. A significant increase was observed for systolic BP (p = .02); this was not so, however, for the diastolic BP (p = .12). A significant increase was displayed in HR (p = .04), RR (p = .04), and also, SpO_2 (p = .02; Table 2).

Changes in Vital Signs and Facial Expressions Produced by Exposure to CRM

By comparing both groups, significant statistical differences were observed in RR by a decrease (p = .01); at the same time, SpO_2 displayed a significant increase (p = .01; Table 2). Systolic (p = .16) and diastolic BPs (p = .70) and HR (p = .06), however, displayed no changes. Alterations in facial expression were observed in 53.8% of patients within the case group during exposure to CRM. When played, 53.8% of patients showed muscular facial relaxation, 25.2% manifested eye opening, 19% manifested mouth movements, 12% manifested head movements, 12% manifested yawning, 7.2% manifested smiling, and 6% manifested eyebrow movements and sound emission.

Changes in Vital Signs and Facial Expressions Produced by Exposure to RMNS

The results show a significant statistical difference between the control and case groups in both the vital signs and facial expressions for most of the patients. A decrease was observed in systolic (p = .03) and diastolic (p = .04) BPs (Figure 1). Likewise, a decrease was displayed in HR (p = .01; Figure 2) as well as in RR (p = .00; Figure 3), and an increase was displayed in SpO_2 (p = .04; Figure 4). An alteration of facial expression was observed in 38.5% of the patients from the case group, revealed by muscular facial relaxation; 36.3% manifested eye opening, 12.1% of the patients displayed smiling, 7.7% displayed mouth movements, 4.4% displayed head movements, 2.2% yawned, 2.2% displayed eyebrow movements, and 1.1% displayed an emission of sound and presence of tears.

Discussion

This study was designed to evaluate if musical stimuli—radio, CRM, and RMNS—produce statistically significant changes in vital signs and facial expressions

TABLE 2. Comparison of Vital Signs Averages Before and After the Intervention (Music/Silence)

Intervention	Physiological Measures		Case Group (*n* = 13)	Control Group (*n* = 13)	*p*
Radio	Systolic blood pressure	T_0	98 ± 13.01	90 ± 8.31	.02*
		T_1	112 ± 11.07	91 ± 4.72	
	Diastolic blood pressure	T_0	76 ± 10.24	61 ± 8.39	.12
		T_1	73 ± 8.13	60 ± 6.33	
	Heart rate	T_0	73 ± 11.96	79 ± 17.09	.04*
		T_1	79 ± 10.75	79 ± 14.78	
	Respiratory rate	T_0	17 ± 2.02	18 ± 2.22	.04*
		T_1	18 ± 1.24	18 ± 1.99	
	Oxygen saturations	T_0	96 ± 1.33	96 ± 2.53	.02*
		T_1	97 ± 0.92	96 ± 2.174	
Classic relaxing music	Systolic blood pressure	T_0	108 ± 9.78	105 ± 9.27	.16
		T_1	102 ± 7.03	102 ± 6.86	
	Diastolic blood pressure	T_0	71 ± 5.94	70 ± 8.59	.72
		T_1	67 ± 5.26	66 ± 6.08	
	Heart rate	T_0	79 ± 12.07	75 ± 14.17	.06
		T_1	76 ± 11.74	75 ± 12.62	
	Respiratory rate	T_0	18 ± 2.10	15 ± 2.56	.01*
		T_1	16 ± 1.59	15 ± 2.49	
	Oxygen saturations	T_0	95 ± 1.03	96 ± 1.85	.01*
		T_1	96 ± 0.83	96 ± 1.78	

Note. Scores: mean ± *SD*. *t* Test = *p*s represent the differences between T_0 (baseline) and T_1 (postintervention) for the case group.
*Statistically significant for $p < .05$.

in patients who experience severe cerebral damage (vegetative state). The results show that radio emissions produced alterations in vital signs and, more specifically, an increase in systolic BP, HR, RR, and SpO_2. The CRM induced a decrease in RR and an increase in SpO_2; a significant change was not observed in BP or HR, but alterations in facial expressions were displayed nonetheless. Exposure to RMNS showed a decrease in BP, HR, and RR rate as well as an increase in SpO_2 and alterations in facial expressions.

During the study, when patients were exposed to radio music (various musical genres), a slight increase was observed in the systolic BP, HR, RR, and SpO_2. The radio may have had a stimulant effect for the activation of the SNS, as confirmed by Juslin and Sloboda (2001). In a study about the action of musical tones produced by drums, string, and wind instruments in healthy men and animals, it was observed that, depending on the rhythm and intensity of the tones used, a stimulant effect was produced when the

FIGURE 1 Comparison of Blood Pressure Averages (mm Hg) Before and After the Intervention (RMNS/Silence; Statistically Significant for *$p < .05$)

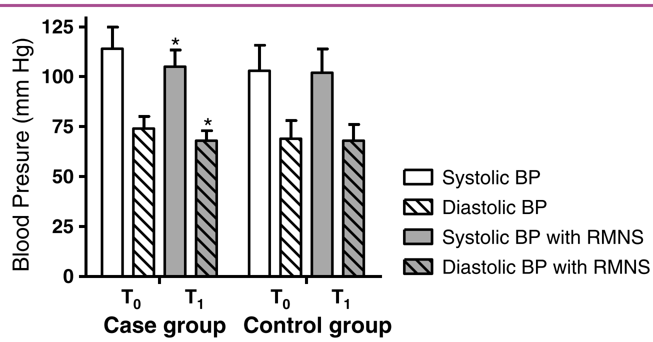
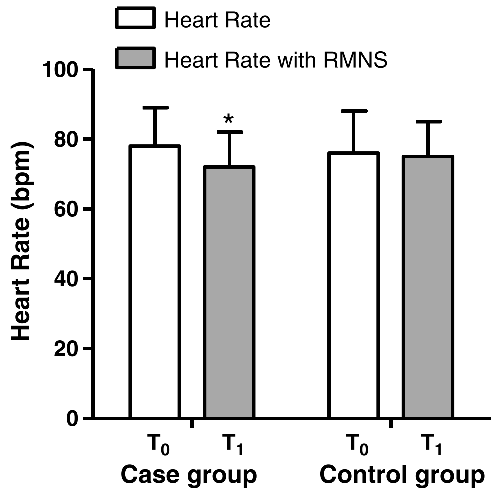


FIGURE 2 Comparison of Heart Rate Averages (Beats per Minute) Before and After the Intervention (RMNS/Silence; Statistically Significant for *$p < .05$)



tone was higher, obtaining an acceleration of cardiac activity and an increase in BP. Worthy of note is a study performed by Bernardi et al. (2006) on patients with reversible cerebral damage. The study investigated the effects in vital signs using different types of music. The patients were exposed to various music genres such as rock, rap, or techno, and slight increases in BP, HR, and RR were observed.

Bonny (1986) states that classical music is thought to evoke greater enjoyment and interest with repeated listening and patients in a weakened state respond less to popular music and more to the stimulus of classical music that is not constrained by the action of time. The exposure to relaxing music for the patients in this study lead to a decrease in RR and an increase in SpO_2 when exposed to CRM, and a decrease in BP, HR, and RR and an increase in SpO_2 were displayed after exposure to RMNS. Both types of music produced a slower and deeper respiratory pattern. A decrease of vital sign values from musical stimulus of CRM or RMNS indicated a relaxant response. A study by Aldridge, Gustorff, and Hannich (1990) was performed on patients who had experienced traumatic brain injury (coma state) and who were exposed to music therapy. The authors observed a change in the respiratory and heart frequency. After the exposure, a variety of reactions were noted: changes in breathing (which became slower and deeper) and occurrence of a succession of movements that were not present before the intervention, like fine motor movements, opening or closing the hands, head turning, and opening of the eyes. Puggina et al. (2005) also observed that patients who were in a coma because of traumatic etiology and were exposed to relaxing music

FIGURE 3 Comparison of Respiratory Rate Averages (Breaths/Minute) Before and After the Intervention (RMNS/Silence; Statistically Significant for *$p < .05$)

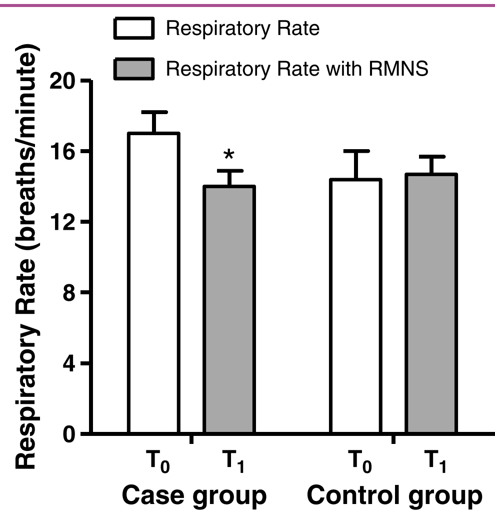
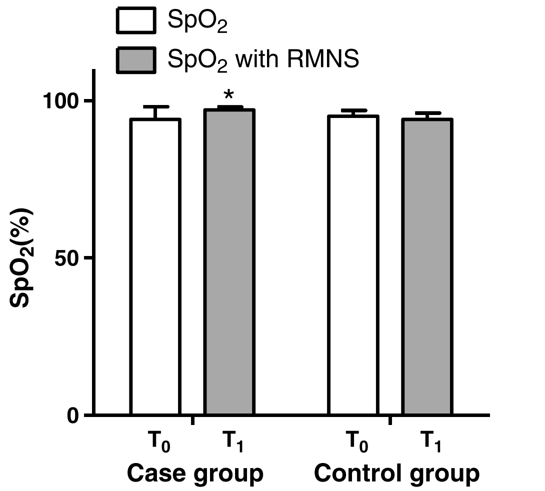


FIGURE 4 Comparison of SpO_2 Averages (%) Before and After the Intervention (RMNS/Silence; Statistically Significant for *$p < .05$)



displayed alterations in base parameters of the systolic BP, RR, and SpO_2 and in facial expressions. Our study shows that patients, once exposed to relaxing music, displayed changes in expressions indicative of muscular facial relaxation, largely accompanied by ocular opening; head, mouth, and eyebrow movements; the presence of smiling and yawning; and the emission of unintelligible sound. Another study (Jones, Hux, Morton-Anderson, & Knepper, 1994) performed a case study on a 16-year-old male victim of a traffic accident in comatose state, 42 days after trauma. The investigator utilized four types of auditory stimulus (voices of friends and relatives, classic music, popular music of which he favored, and nature sounds) using the parameters RR and HR. The results obtained after analysis displayed a change in parameters generated from all types of stimuli. The changes were evaluated in relation to the base measurements as well as an increase in corporal movements of the patient. The authors described how the patient opened his eyes, moved his head, and performed a few coordinated hand movements. Thaut et al. (2009) published a study after performing four sessions of 30 minutes of neurological musical therapy, in which they obtained immediate cognitive and emotional results in a group of patients with acquired cerebral damage.

We can state that there are multiple possibilities for the use of music listening, and although sufficient scientific evidence cannot be provided, relaxing music can be considered advantageous when used in rehabilitation and as a stimulant in diverse illnesses and clinical settings. It also becomes clear that it can be an excellent tool in developing diverse nursing skills, considering that it activates cognitive affective processes and motor sensory skills transferable to other cognitive functions (Thaut et al., 2009). For these kinds of patients, the exposure to relaxing music produced a calming response. These patients showed a reduced state of agitation accompanied by less hypertonia.

The evaluation of the patients' facial expressions included in this study is acknowledged as a limitation because a specific and validated scale does not exist. For this reason, the subjective observation is performed by the same investigator who knows the involuntary movements of the patients admitted in this study, to detect movements produced as response to the sonorous applied stimulus. The sample size of this study is small ($n = 26$); this study should only be regarded as a pilot study. The heterogeneity of pharmacological treatments could pose another limitation within this study. It was not possible to affirm if indeed these medications were similar and did not present some influence on the final results. The choice of musical selection may present another limitation, because the efficacy of music to act as a relaxing effect has been dependent on the type of music used, the preferences of the patient, and the patient's interest in music. Another limitation of the study was the difference in the time provided to each musical stimulus; the radio was played for 1 hour, and the CRM and RMNS were applied for a period of 20 minutes. To have a reliable comparison between the interventions, the time provided should be equivalent to each one.

Conclusion

The results of our study suggest that the application of musical stimuli such as CRM and RMNS can be used as a nonpharmacological therapy in patients with severe cerebral damage. Musical stimuli can therefore be considered as a contribution to patient relaxation and levels of consciousness when used in providing nursing care. In our study, the exposure to relaxing music produced a calming response. These patients showed a reduction in agitation accompanied by less hypertonia, making it easier to provide nursing care, such as grooming, dressing, postural changes, and so forth. Bearing in mind that this intervention is simple, of low cost, noninvasive, without harmful effects for the patient, and is not time consuming, it can be easily applied in practice to insure the well-being of admitted patients and can provide a welcoming and pleasant daily atmosphere for the patient.

On the other hand, regarding the response capabilities of patients diagnosed in a vegetative state, many questions remain unanswered. This occurrence is rarely studied, and more research in this area needs to be done. Healthcare professionals must always keep in mind that these patients are still able to perceive the environment around them, as indicated in the study, and therefore, it is important to always be ethical in all aspects of care.

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