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FULL PAPER

Meditative music listening to reduce state anxiety in patients during the uptake phase before positron emission tomography (PET) scans

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Objective: This study examines the effects of listening to meditative music on state anxiety and heart rate variability (HRV) of patients during the uptake phase before positron emission tomography (PET) scans.
Methods: A two-group randomized experimental design was used. Eligible patients were randomly assigned to either the experimental or control group. All patients received baseline assessments of state anxiety using Spielberger State-Trait Anxiety Inventory (STAI-S) and HRV before receiving an intravenous injection of radiopharmaceutical fluorine-18 fludeoxyglucose in the uptake room. The experimental group ($n = 35$) listened individually to 30 min of meditative music, integrating Chinese "Chi" and western frequency resonation in the uptake room. The control group ($n = 37$) lay on bed quietly for 40 min in the uptake room without music. All patients were assessed for their anxiety level and HRV again, before receiving PET scanning as post-test.
Results: The results indicated that patients in the experimental group showed a significant reduction in state anxiety and heart rate, and increase on high frequency norm of HRV ($p < 0.001$). There was a statistically significant reduction on anxiety level ($p < 0.001$), heart rate ($p < 0.001$) and high frequency norm ($p = 0.001$) in the experimental group compared with those of the control group.
Conclusion: Listening to meditative music as a non-invasive and cost-effective strategy can help maximize efforts to promote comfort and relaxation for patients awaiting stressful procedures, such as PET scans. Meditative music can be effective in alleviating state anxiety of patients during the uptake phase before PET scans.
Advances in knowledge: The study provides scientific evidence of the effects of listening to meditative music for reducing state anxiety in patients during the uptake phase before PET scans. It may have the potential to lower the risk of unwanted false-positive fluorine-18 fludeoxyglucose uptake in normal organs and to further improve image quality and image interpretation. Listening to meditative music is a safe and inexpensive intervention which can be incorporated into routine procedures to reduce anxiety of patients undergoing PET scans.

INTRODUCTION

Positron emission tomography (PET) is a diagnostic imaging technique which demonstrates high sensitivity and excellent diagnostic accuracy.[1] However, anxiety has been reported in patients undergoing radiological procedures, such as PET scan.[2] Anxiety associated with PET scan may be related to: (1) unfamiliarity, (2) lack of understanding regarding the procedures,[3] (3) concerns about their diagnosis or prognosis, (4) anticipation of pain or discomfort, (5) loss of control and (6) perceived or actual physical risk.[4] Patients who undergo PET scans usually need to receive an intravenous injection of radiopharmaceutical fluorine-18 fludeoxyglucose (^{18}F-FDG) and wait 30–40 min in the uptake room for preparation prior to PET scans. Waiting time, which often provides patients the opportunity for thinking, worrying and fearing the procedures, may induce stress and exacerbate anxiety.[5,6] Studies also found that patients reported moderate levels[3] and high levels[7] of anxiety while they awaited PET scanning.

Anxiety may manifest as physiological arousal, such as increased heart rate, blood pressure and respiratory rate. Anxiety can also result in negative alterations in psychological function.[4] These manifestations of anxiety can lead to negative impact on patient's recovery and recuperation.[8,9] Vogel et al[7] found that approximately 60% of patients experienced high anxiety while entering the PET uptake room and many demonstrated unwanted false-positive ^{18}F-FDG uptake in normal tissues which further complicated diagnosis.[10] Literature indicate that uptake of ^{18}F-FDG in the neck and upper chest region in some patients with cancer may be muscular[11] and brown adipose tissue[12] uptake, secondary to anxiety or tension. Non-specific uptake of ^{18}F-FDG in the neck and upper chest region can interfere with image quality and image interpretation.[13] Therefore, researchers have suggested that reduction of anxiety in patients undergoing PET may lower uptake of ^{18}F-FDG in brown adipose tissue and reduce noise for better image quality.[14] Anxiolytics can be used to reduce pre-procedure anxiety in patients awaiting invasive procedures, but it may cause unwanted effect and delay discharge from hospital.[15] Patients undergoing PET who are taking diazepam may experience undesirable interactions with other medications as well as be unable to drive home.[7] At present, there remains no common agreement on the use of pharmacological interventions to reduce anxiety level in patients undergoing PET during the uptake phase.[7]

Many studies have investigated the effects of various non-pharmacological interventions to reduce anxiety in patients awaiting surgical or other medical procedures. These have included: patient education,[3] the use of massage, aromatherapy and hypnosis.[16] One of the frequent researched interventions for managing pre-procedural anxiety is listening to music. Listening to music has been suggested to be effective in managing psychological and emotional problems. It is believed that the auditory stimulation *via* music can occupy neurotransmitters to divert feelings of anxiety and fear.[17] Listening to music can facilitate relaxation through distraction of the patient's attention from negative sensation.[18] When listening to music, awareness of the passing time may be diverted as they focus on the music, thereby enhancing relaxation.[19] Furthermore, listening to soothing music was found to decrease cortisol, which increases in the presence of stress, and may in turn reduce anxiety and promote relaxation.[20] Systematic reviews concluded that listening to relaxing music had positive effects on reducing patients' pre-procedural anxiety[8] and pain in pre-operative settings.[21] However, none of these studies investigated the use of music for patients awaiting PET scans. Little is known about the effects of listening to meditative music on anxiety in patients during the uptake phase prior to PET scans.

METHODS AND MATERIALS

Design

This study used a two-group randomized experimental design to evaluate the effects of listening to meditative music on state anxiety level and heart rate variability (HRV) of patients during the uptake phase before PET scans.

Participants

Patients scheduled for PET scans in a local medical centre in Taiwan were recruited for the study. The inclusion criteria consisted of (1) inpatient or outpatient aged 18 years or above; (2) cognitively intact; (3) the physical and mental ability to complete the questionnaires without assistance; (4) no severe hearing problems, acute pain and acute period of any cardiac or psychiatric problems; and (5) willing to participate in the study and signed an informed consent. 80 eligible patients participated in the study. Patients were randomly assigned to two groups using their PET scan scheduled dates. Patients with PET scan scheduled date on the odd-number weeks were assigned to the experimental group and those with PET scan scheduled dates on the even-number weeks were the control group during a 16-week period. There were 39 patients in the experimental group and 41 in the control group.

Intervention

The intervention was listening to meditative music. A music auditory compact disk (CD) consisting of recordings of 30-min relaxing meditative music produced by music composers and a well-known Taiwanese physician specialized in immunology, Chinese and western medicine was used. The relaxing meditative music was composed by integrating Chinese "Chi" regimen and western frequency resonation to enhance listener balance and relaxation. The music consists of the following characteristics: slow and flowing relaxing music, a tempo of 60–80 beats per minute, instrumental with no lyrics and volume level of 50–60 db. These characteristics of the meditative music were consistent with the recommendations for genre and types of therapeutic music for anxiety, based on a systematic review.[17] The patients individually listened to 30 min of meditative music *via* a CD player while they lay on the bed during the uptake phase before PET scanning in the private uptake room with dim lighting and consistent comfortable temperature.

Measurement

The level of state anxiety was assessed by the Spielberger State-Trait Anxiety Inventory-State scale (STAI-S).[22] The STAI-S scale is a self-reported psychometric test which consists of 20 items describing different mood states rated on a four-point Likert scale. It yields a total score ranging from 20 to 80. The higher the score, the greater the level of anxiety perceived. A score of 40 and above is usually considered as indicative of high level anxiety. The STAI-S scale is a commonly used, valid and reliable tool. The Chinese version of STAI-S has a Cronbach's α of 0.92.[23]

HRV was measured using the NeXus-10 device with Biotrace+ Software (Mind Media B.V., Herten, Netherlands). The NeXus-10 device records heart rate using a standard three-lead electrocardiogram at 1024 Hz. The Nexus-10 software allowed for analysis of heart rate data and provided HRV parameters. Two 5-min epochs were selected: heart rate at the beginning of the uptake period (before listening to music) and heart rate at the end of the uptake period (after listening to music). Frequency-domain analysis was used to analyze the HRV data. High values of the low-to-high [low frequency (LF)/high frequency(HF)] ratio indicate a dominance of sympathetic activity, whereas low values indicate a dominance of parasympathetic activity. When experiencing anxiety, the sympathetic nerves will be activated and can cause the heart rate to increase, high frequency to decrease, and low frequency and the LF/HF ratio to increase. The LF/HF ratio is a widely used HRV index of sympathovagal balance between the sympathetic and parasympathetic branches, and their interactions of the autonomic nervous system.[24]

Procedure

Ethical approval was obtained from the institution review broad of a local medical centre. Eligible patients were provided with detailed explanation of the study, and those who provided informed consent were included. All patients were reassured of confidentiality and anonymity. The routine procedures prior to PET scanning included: receiving an intravenous injection of ^{18}F-FDG from a radiological technician and lying on the bed and waiting for 40 min quietly in the uptake room. Prior to intravenous injection of ^{18}F-FDG, each patient received a baseline assessment for anxiety level using STAI-S. Patients in the experimental group then lay on the bed in the private uptake room, and NeXus-10 device was applied for 5 min and HRV measured before the music started. The patients individually listened to the 30 min of meditative music played *via* a CD player while lying on the bed during the uptake phase. At the end of the uptake phase, the music was stopped and 5 min of HRV was measured again. Patients in the control group went through the same procedures without the music-listening intervention. All patients received post-test assessment of anxiety level prior to entering the PET scanning room.

Data analysis

Data were managed and analysed using the statistical package SPSS® v. 18.0 (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL) for Windows. Descriptive statistics were used to summarize the characteristics of the sample. Independent *t*-test was used to compare the mean difference of the outcome measures between groups. The statistical significance was set at $p < 0.05$ level (two-tailed).

RESULTS

35 patients of the initial experimental group ($n = 39$) completed the study, as 4 patients refused to complete the post-test assessments. In the control group, 37 patients completed the study as 4 patients of the initial control group ($n = 41$) refused to complete the post-test assessments. The patients' average age in the experimental group was 59.03 years [standard deviation (SD) 14.58] and 60.27 years (SD 13.38) in the control group.

Table 1. Baseline characteristics of two groups ($N = 72$)

Variable	Experimental group ($n = 35$)	Control group ($n = 37$)	*p*-value
	n (%)	*n* (%)	
Gender			
Male	17 (48.6)	15 (40.5)	0.49
Female	18 (51.4)	22 (59.5)	
Patient type			
Inpatient	7 (20)	9 (24.3)	0.66
Outpatient	28 (80)	28 (75.7)	
Perceived health			
Very good	0 (0)	1 (2.7)	0.76
Good	6 (17.1)	4 (10.8)	
Fair	22 (62.9)	22 (59.5)	
Poor	5 (14.3)	7 (18.9)	
Very poor	2 (5.7)	3 (8.1)	
Visit to PET facility			
First visit	15 (42.9)	19 (51.4)	0.47
Return visit	20 (57.1)	18 (48.6)	
	Mean (SD)	Mean (SD)	
Age (years)	59.03 (14.58)	60.27 (13.38)	0.71
Number of diagnosis	1.23 (1.17)	1 (0.67)	0.31
Number of medications	0.71 (0.79)	0.51 (0.56)	0.22
Waiting time (min)	32 (2.77)	31.49 (2.32)	0.40

PET, positron emission tomography; SD, standard deviation.

The average waiting time for the uptake phase was 32 min (SD 2.77) for the experimental group and 31.49 min (SD 2.32) for the control group. The mean baseline anxiety score for the experimental group was 40.26 (SD 5.68) and 37.73 (SD 5.07) for the control group, indicating moderate level of anxiety for both groups at baseline. There were no statistically significant differences in the demographic characteristics and anxiety level at baseline between the groups (Table 1).

Effectiveness of listening to meditative music on state anxiety level

After listening to meditative music, the mean anxiety score in the experimental group was reduced significantly from 40.26 (SD 5.68) at pre-test to 34.97 (SD 6.73) at post-test. The mean anxiety score in the control group increased slightly from 37.73 (SD 5.07) at pre-test to 38.38 (SD 5.66) at post-test (Table 2). Independent *t*-test found a significant reduction in anxiety of the experimental group compared with that of the control group ($t = -4.40$, $p < 0.001$) (Table 3).

Effectiveness of listening to meditative music on heart rate variability parameters

The mean heart rate in the experimental group was reduced significantly from 59.49 (SD 10.08) at pre-test to 54.77 (SD 9.41) at post-test. The mean heart rate in the control group decreased slightly from 59.68 (SD 10.69) at pre-test to 58.84 (SD 11.06) at post-test (Table 2). There was a significant difference of mean change of heart rate between the groups, indicating listening to meditative music significantly lowered the heart rate ($t = -6.28$, $p < 0.001$) (Table 3).

The LF/HF ratio was decreased from 1.61 (SD 1.74) at pre-test to 1.33 (SD 1.32) at post-test, and the HF norm was significantly increased from 34.82 (19.92) at pre-test to 43.45 (SD 17.55) at post-test in the experimental group. The experimental group showed a significantly higher HF norm than the control group ($t = -2.74$, $p = 0.001$), but the decrease of LF/HF ratio was not significantly different between groups ($t = -1.71$, $p = 0.09$).

DISCUSSION

The study results indicate that patients who listened to 30-min relaxing meditative music during the uptake phase before PET scans experienced a significant reduction in state anxiety and heart rate and a significant increase on HF norm of HRV compared with the control group. In addition, the experimental group had an increase of HF norm and LF/HF ratio after listening to meditative music, which suggested a sympathovagal balance towards parasympathetic activity and reflected a state of relaxation. When a person is in a state of relaxation, the activity of the sympathetic nervous system is decreased and that of the parasympathetic nerve system increases, resulting in decreased LF norm and LF/HF ratio and increased HF norm. The control group showed a slight decrease of LF/HF ratio and heart rate, which may be due to resting quietly in the uptake room. However, the HRV results were not significant to indicate relaxation state among the patients in the control group. Although the differences between changes in the LF/HF ratio were not significant between the two groups, the differences between the change scores for the heart rate and HF norm were. Thus, the change in state anxiety level, as measured by both the subjective and objective indicators from baseline to post-test, was

Table 2. Pre-test and post-test mean state anxiety scores [Spielberger State-Trait Anxiety Inventory (STAI-S)] and heart rate variability data of two groups ($N = 72$)

Variable	Experimental group ($n = 35$)	Control group ($n = 37$)	t	p-value
	Mean (SD)	Mean (SD)		
State anxiety score (STAI-S)				
Pre-test	40.26 (5.68)	37.73 (5.07)	1.99	0.50
Post-test	34.97 (6.73)	38.38 (5.66)	−2.33	0.02
Heart rate (beats min^{-1})				
Pre-test	59.49 (10.08)	59.68 (10.69)	−0.08	0.94
Post-test	54.77 (9.41)	58.84 (11.06)	−1.68	0.10
LF norm (n.u.)				
Pre-test	31.80 (12.24)	36.52 (13.00)	−1.59	0.12
Post-test	33.85 (10.61)	33.48 (14.07)	−0.55	0.58
HF norm (n.u.)				
Pre-test	34.82 (19.92)	39.18 (20.68)	−0.91	0.37
Post-test	43.45 (17.55)	36.44 (18.27)	1.66	0.10
LF/HF ratio				
Pre-test	1.61 (1.74)	1.51 (1.29)	0.29	0.78
Post-test	1.33 (1.32)	1.18 (0.94)	0.54	0.59

HF, high frequency; LF, low frequency; SD, standard deviation; n.u., normalised unit.

Table 3. Mean change from pre-test to post-test in state anxiety scores [Spielberger State-Trait Anxiety Inventory (STAI-S)] and heart rate variability data for two groups ($N = 72$)

Measure	Experimental group ($n = 35$)	Control group ($n = 37$)	t	p-value
	Mean change (SD)	Mean change (SD)		
State anxiety score (STAI-S)	−5.29 (6.74)	0.65 (4.40)	−4.40	<0.001
Heart rate (beats min^{-1})	−4.71 (2.26)	−0.84 (2.92)	−6.28	<0.001
LF norm (n.u.)	2.06 (15.88)	−1.04 (14.19)	0.87	0.39
HF norm (n.u.)	8.63 (14.45)	−2.74 (13.15)	3.50	0.001
LF/HF ratio	−0.55 (1.50)	−0.02 (1.10)	−1.71	0.09

HF, high frequency; LF, low frequency; SD, standard deviation; n.u., normalised unit.

significantly greater in the experimental group than in the control group.

Many studies have evaluated the effect of soothing music on anxiety for patients undergoing day surgery or invasive procedures and found positive results which were similar to ours, but none of these studies were related to patients undergoing PET scans. This study was the first study to evaluate the effect of listening to meditative music on the level of state anxiety and HRV parameters for patients during the uptake phase before PET scans. Prior to PET scanning, patients usually lie on bed in the uptake room and may worry and fear procedures during this waiting time. Consequently, this may induce stress and exacerbate anxiety.[5] In this study, the state anxiety levels of both groups were moderate at baseline. The experimental group resulted in a significant reduction on their state anxiety scores and heart rate and a significant increase on HF norm after listening to 30-min meditative music. The results indicate that listening to meditative music can serve as an environmental modifier to distract patients' attention from uncomfortable feeling or anxiety during the uptake phase prior to PET scans.

The meditative music used in the study had the characteristics according to the current evidence-based recommendations of genre and types of therapeutic relaxing music. In addition, music preferences have been suggested as an important factor in many music studies, and several studies suggested that patients listen to music according to their personal preferences can have positive outcomes on alleviating anxiety. However, researchers also commented that using patient-preferred music may produce more heterogeneous results than using researcher-selected music.[25] One study used patient-selected music undergoing initial radiotherapy and found no significant reduction on anxiety level.[26] Whereas another study by Chen et al[27] used researcher-selected music with slow paced, soft, melodic harmonies and a consistent tempo and found a relaxing effect and reduction of anxiety level among oncology patients prior to radiotherapy. This study incorporated researcher-selected meditative music with a consistent slow tempo and integrated Chinese "Chi" regimen, producing uniform physiological and psychological responses, such as reduction of heart rate, LF/HF ratio and state anxiety level, and an increase of HF norm.

The mechanism regarding effects of listening to music for anxiety remains unclear. Passive listening to music can affect respiratory rate, blood pressure and HRV according to the music tempo and rhythm.[28] Research results suggest that slow or soothing music can induce a relaxing effect and facilitate reduction in anxiety levels. A systematic review[21] also concluded that listening to slow and soothing music reduced heart rate, respiratory rate and blood pressure. These physiological changes associated with slow and soothing music, such as meditative music used in this study, may induce a state of relaxation and further decrease anxiety levels.

Music-listening intervention is inexpensive as it requires only a CD player and a selection of music CDs. A private room is also essential as a quiet and private area or environment without interruptions or noises in order to facilitate listening to music. In this study, the patients in the experimental group listened to the same researcher-selected relaxing meditative music and did not have the opportunity to choose the music. However, each patient did listen to the music for 1–2 min prior to the beginning of the music intervention to make sure that they were comfortable with the music. It may be useful for future research to investigate the benefits of using or comparing patient-selected music with researcher-selected music for anxiety in patients awaiting PET scans.

In this study, less uptake of ^{18}F-FDG in brown adipose tissue was observed in patients who listened to the meditative music in the experimental group than in those of the control group. However, objective assessment and comprehensive data collection were not conducted and analysed. Therefore, further investigating the effects of meditative music on ^{18}F-FDG uptake and more detailed analyses focusing on false-positive ^{18}F-FDG uptake in relevant tissues are needed.

This study used a convenience sample of hospital outpatients and inpatients and was conducted as rigorous as possible. The use of a convenience sample may limit the ability to generalize the study results. Blinding of the patients and data collectors was not possible and may be a potential source of bias. The possibility of the Hawthorne effect occurring due to the fact that patients had awareness of participation in the study may also affect the data.

CONCLUSION

Relaxing meditative music can be used as audioanxiolytic or audiorelaxation as an integral part of the multimodal modality delivered to patients during the uptake phase prior to PET scans. Reduction of anxiety may have the potential to lower the risk of unwanted false-positive ^{18}F-FDG uptake in normal organs and further improve image quality and image interpretation. Listening to music is safe, inexpensive easy to implement and can alleviate state anxiety and help maximize efforts to promote comfort and relaxation for patients who undergo PET scans.

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