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ORIGINAL PAPER

Using Mindfulness to Reduce Anxiety During PET/CT Studies

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Abstract

The aims of the present work were to identify the levels of subjective and objective anxiety and heart rate in patients attending a nuclear medicine service to undergo a 18F-FDG PET-CT scan, and to evaluate the effectiveness of an intervention based on a mindfulness meditation recording in order to verify the possible immediate effect of reducing anxiety and heart rate. This is a randomized, prospective study with pre- and post-intervention measures. The sample comprises 108 cancer patients attending the nuclear medicine service to undergo a 18F-FDG PET/CT study. Mean age was 58.81 years; 54 were assigned to the experimental group and 54 to the control group. The most frequent location of the primary tumor was in the lymphatic system (22.2%), and the most common treatment was chemotherapy (21.3%). There was no presence of artifacts (97.2%). With regard to the intervention, the group that listened to the mindfulness recording exhibited lower subjective anxiety (F, 526.95; $p = 0.000$; η^2 partial = 0.83); lower total anxiety as measured on the State-Trait Anxiety Inventory scale (F, 271.80; $p = 0.000$; η^2 partial = 0.72), and lower heart rate (F, 27.15; $p = 0.000$; η^2 partial = 0.84). A single-session mindfulness practice using a meditation recording reduces both subjective and objective anxiety and heart rate in patients undergoing a PET/CT study.

Keywords Cancer · Anxiety · Heart rate · Mindfulness · PET-CT

The diagnostic procedures to which patients with cancer are submitted generate fear, uncertainty, distress, pain, anxiety, irritability, and discomfort. The more complex the diagnostic test is, the higher are the levels of distress and anxiety (Domènech et al. 2010; Flory and Lang 2011). Positron emission tomography (PET) in combination with computed tomography (CT), PET/CT, is increasingly used in the study of individuals with cancer since it allows to characterize lesions, stage the disease, evaluate response to treatment, and detect tumor recurrence (Comprehensive Cancer Information n.d.).

Attending a nuclear medicine service to undergo ^{18}F-FDG-PET/CT may generate high levels of anxiety, distress, and unrest in patients with cancer (Lee et al. 2017; Abreu et al. 2016); House 2002; Rehse and Pukrop 2003). Not only should this situation be avoided but it also may result in wasted resources. Elevated anxiety impacts on implementation of the diagnostic test, leading to lack of patient cooperation and inability to complete the process or movements during imaging. This results in impaired quality in the procedure (Munn and Jordan 2011; Munn and Jordan 2014) and even the appearance of false positive uptakes, such as uptake in muscles and

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brown fat, causing decreased image quality and lower diagnostic performance.

Thus, it is clear that the anxiety felt by patients with cancer when attending an image diagnostic service must be diagnosed and treated prior to the intervention (Zabihi et al. 2016; Vøllestad et al. 2011). To this end, different interventions have been undertaken to reduce anxiety and distress in patients with cancer attending a medical imaging service, including providing the patient with more information on the procedure itself, giving out leaflets and educational comics for patients to read (Anderson et al. 2016), exposure to relaxing images and music or sounds from nature (Vogel et al. 2012), relaxation training (Sheldon et al. 2008), sedation with anxiolytic drugs such as diazepam (Helmus et al. 2005; Miyasaka et al. 2003), and improving resting conditions (Aukema et al. 2010; Zukotynski et al. 2010), etc.

The aim of the present work is first to identify the levels of subjective and objective anxiety exhibited by patients attending the nuclear medicine service to undergo a PET/CT scan, and, second, to evaluate the effectiveness of an intervention based on successful traditional mindfulness-based stress reduction interventions.

Method

Participants

The present study is an analytical epidemiological study with pre/post-intervention measures with one intervention group and a control group, recruiting a total of 108 patients undergoing a PET/CT study. The sample was distributed in two groups (one experimental group and one control group), with 54 subjects in each group.

Patients are eligible if they meet the following criteria: (1) over 18 years of age, (2) oncological patients (i.e., those who had diagnosis of previous cancer of at least 2 months), and (3) able to hear audio recordings. Patients are excluded if they are (1) considered by the clinician to be too unwell to participate or (2) unable to understand and complete the self-administered questionnaires.

The study simply comprised 108 participants, distributed in two groups (experimental and control) of 54 patients each. Mean age was 58.81 years (SD, 14.65). In general, participants presented no history of depression (97.2%), anxiety (96.2%), or family history of psychopathology (91.7%). Only 7.4% had knowledge of relaxation techniques. Regarding the current illness, the most frequent location of the primary tumor was the lymphatic system (22.2%), breast (18.5%), gynecological system (12%), and lung (11.1%). Most of the patients had received treatment prior to the PET/CT study; only 25.9% had not commenced treatment.

Procedure

This study was approved by the Clinical Research Ethics Committee (La Paz University Hospital, Madrid, Spain), and the authors report no conflict of interest. After patients accepted and signed the informed consent, they were immediately assigned to one of the two groups: 54 in the experimental group (intervention based on brief mindfulness) and 54 in the control group.

All patients initially completed a demographics ad hoc questionnaire and mood measures (STAI) followed by acquisition of a BP and HR baseline. Immediately following ^{18}F-FDG was injected in the waiting room and during this time, mindfulness meditation group listened to MP3 intervention (described below), and only rest in the control group.

Once the waiting time was over, the patients in both groups were taken for the PET/CT scan. Subsequently, following the diagnostic test, participants were administered the STAI questionnaire (post-test administration), as well as psychical parameters and the ad hoc questionnaire.

The patients in the experimental group were told that they were going to listen to a recording concerning mindfulness on an MP3 player with earphones in the 50–60-min waiting period during which they had to remain in a state of rest after being injected with the ^{18}F-FDG before undergoing the study.

This recording was applied and lasted 45 min. It is based on a transcript from Institute of Limited Time Psychotherapies, an established institution where the psychological clinic, research, and teaching coexist with the objective of getting patients to obtain the psychological benefits. It contained background music and sounds of nature over which an off-voice made descriptions in order to guide the patient and induce a state of deep relaxation with the fomentation of self-observation and the acceptance of thoughts and feelings, be they positive or negative, of which no judgment was made. We insisted that the patients should maintain their minds in the present. They had to focus on their breathing, concentrating on how inhaling and exhaling would allow them to enjoy the sensations that they were feeling and ignore thoughts that appeared. The objective was to prioritize self-consciousness, full attention, contact with breathing, being present in the here and now, not judging thoughts and reflections, self-observation without judgment or criticism, etc.

Measures

The study was conducted using an ad hoc questionnaire and the standardized State-Trait Anxiety Inventory (STAI) (Spielberger et al. 1973) . To assess the variables most directly related to patients' personal and medical data, an ad hoc questionnaire was designed including the most representative and characteristic variables relevant to the study. This ad hoc questionnaire contained questions on the following

categories: (1) *sociodemographic data* (age, gender, date of birth, educational background, job, marital status, number of children); (2) *family history of psychopathology* (personal history of depression or anxiety, family history of depression or anxiety, knowledge of relaxation techniques or similar); (3) *data on current diagnosis* (primary location of tumor, treatment received, reason for PET/CT); (4) *pre-intervention physical data* (blood pressure [BP], heart rate [HR], feeling of dyspnea, digestive problems [nausea, vomiting], muscle tension and stiffness, dizziness and instability; level of subjective anxiety [0–10] at current time); and (5) *post-intervention physical data* (blood pressure [BP], heart rate [HR], feeling of dyspnea, digestive problems [nausea, vomiting], muscle tension and stiffness, dizziness and instability; level of subjective anxiety [0–10] at current time).

Data Analyses

Once the data were collected, we conducted statistical analysis using SSPS 22. We performed a univariate analysis to compare frequency distribution. We also conducted descriptive analyses (mainly means and standard deviations) and covariance analyses, which were used to measure the effectiveness of the intervention in modifying anxiety and different biomedical parameters. For the analysis, we took the post-intervention measures of anxiety, HR and BP as dependent variables. The independent variable was the intervention group mindfulness status vs control. Finally, we took the pre-intervention measures as covariates. Thus, we assessed the effects of the intervention on the two groups, taking into account the prior levels of each group.

Results

As regards the type of treatment received prior to the PET/CT study, the most frequent treatment was chemotherapy (21.31%). A total of 25.9% had not yet started treatment, with the PET/CT being used as an initial staging test (Table 1). The motives for performing the PET/CT study were monitoring treatment response (50%), initial staging (27.8%), and detection of recurrence (22.2%). This was the first PET/CT study for the majority of the patients (53.7%), compared with 46.3% who had previously undergone one or more studies. The mean number of previous PET/CT studies per patient was 0.79 with a standard deviation of 1.05. No antihypertensive treatment was required by 86.1% of the sample before PET/CT; nobody needed anxiolytic treatment due to anxiety crisis during the procedure.

Prior to the PET/CT, participants exhibited no dyspnea (100%), digestive problems (99.1%), muscle stiffness (99.1%), or dizziness (91.7%). Similarly, after the test, they exhibited no problems of dyspnea, muscle stiffness, digestive problems (99.1%), or dizziness (97.2%). In Table 2, we can see the mean scores and the other STAI statistics before and after the PET/CT in all the sample.

Table 1 Patient characteristics

Characteristic	Entire cohort
Age (median, SD)	58.81 (14.65)
Gender (*n*, %)	
Male	47 (43.5%)
Female	61 (56.5%)
Background (*n*, %)	
No depression	104 (97.2%)
No anxiety	100 (92.6%)
Primary cancer (*n*, %)	
Lymphoma	24 (22.2%)
Breast	20 (18.5%)
Gynecological	13 (12%)
Lung	12 (11.1%)
Treatment (*n*, %)	
Chemotherapy	23 (21.3%)
No treatment	28 (25.9%)
PET/CT indication (*n*, %)	
Initial staging	30 (27.8%)
Monitoring treatment	54 (50%)
Relapse	24 (22.2%)

The PET/CT results showed that 59.3% of the participants tested positive for metabolically active tumor tissue, compared with 31.5% who tested negative for tumor viability with ^{18}F-FDG affinity. An associated infectious-inflammatory process was clearly detected in 6.5% of participants, while 2.8% presented doubtful findings which might be related to an acute infectious-inflammatory process, but the existence of metabolically active tumor tissue could not be ruled out. As regards tumor staging, 38% exhibited no staging; the tumor was metastatic in 25.9%, localized in 24.1%, and locoregional in 12%. No artifacts were detected in the immense majority of patients (97.2%), meaning no problems were encountered for diagnostic interpretation. Artifacts were detected in 2.8% of studies as a result of movements and due to patient preparation only in the control group. Presence of artifacts was never a consequence of brown fat or muscle tension.

Regarding the effectiveness of the intervention, firstly, we found a significant effect on the level of post-intervention subjective anxiety, controlling for the effect of pre-intervention anxiety levels (F,526.95; $p = 0.000$; η^2partial = 0.83). Statistically significant differences were found between the control group (5.70) and the mindfulness group (1.07) in the corrected means of the level of post-intervention anxiety. With

Table 2 Descriptive statistics of the different pre- and post-intervention measures of anxiety between two groups

Statistic	Pre-intervention level of subjective anxiety	STAI pre-intervention state anxiety	STAI pre-intervention trait anxiety	STAI pre-intervention total anxiety	Post-intervention level of subjective anxiety	STAI post-intervention state anxiety	STAI post-intervention trait anxiety	STAI post-intervention total anxiety
Mean	6.03	28.38	16.09	11.84	3.39	19.78	15.88	3.81
Deviation	1.59	8.08	5.6	8.14	2.79	10.83	5.77	9.03
Minimum	1	9	5	−21	0	1	5	−14
Maximum	9	49	31	35	9	48	31	28

respect to the effectiveness of the mindfulness meditation on the post-intervention STAI state anxiety score, controlling for the effect of the pre-intervention STAI state anxiety, we found significant differences between the intervention group and controls (F, 487.07; $p = 0.000$; η^2partial = 0.82). The mindfulness group (10.47) presented lower corrected mean scores on the post-intervention STAI state anxiety scale, showing statistically significant differences with the control group (29.07).

The post-intervention STAI trait anxiety score yielded no significant differences between groups. This suggests that almost all the variabilities in the post-intervention STAI trait anxiety scores were explained by the level of the pre-intervention score. This confirms the stability of this variable, which coincides with our prior expectations based on trait anxiety being a personality characteristic.

Results for the post-intervention total STAI score reveal statistically significant effects for both the covariate (pre-intervention total STAI) and the intervention group, with effect sizes between moderate and high (Table 3). This model explains 72% of the variance of the post-intervention STAI total scores.

On assessing the means of the post-intervention total STAI scores corrected for the effect of the covariate, we found statistically significant differences between the control group (11.65) and the mindfulness group (− 4.04).

In relation to blood pressure, we did not find statistically significant differences. Finally, for the post-intervention heart rate variable, we found statistically significant effects of the covariate and the mindfulness group (F, 27.15; $p = 0.000$; η^2partial = 0.84). The corrected means of post-intervention heart rate show statistically significant differences between the control group (70.53) and the mindfulness group (67.57).

Discussion

This paper has measured the emotional change in patients who undergo PET/CT throughout brief mindfulness intervention with relevant results in well-being patients with cancer. Broadly speaking, the data collected for the present work indicate that the primary location of the tumor for which the patients were to undergo a PET/TC study was the lymphatic system, followed by the breast, gynecological system, and lung. These data are similar to those of other studies (NCCN guidelines). Chemotherapy is the most frequently administered treatment, according to international guides and protocols (Ledesma and Kumano 2009).

The most common reason for implementing the PET/CT studies was to monitor treatment, followed by initial staging and detection of recurrence. For most of the participants, however, this was their first experience of a PET/CT test, and for a large number, no antihypertensive treatment took previously. Indeed, in our study, nobody needed anxiolytic treatment during the procedure; this finding is important since many studies report the need to administer anxiolytics (Sheldon et al. 2008; Helmus et al. 2005; Miyasaka et al. 2003). We find that most

Table 3 Results of the ANCOVA on the post-intervention total STAI score

	Type III sum of squares	*df*	Root mean square	*F*	*p*	η^2 partial
Corrected model	6337.130	2	3168.565	138.637	.000	.725
Interception	17.806	1	17.806	.779	.379	.007
Pre-int. total STAI	974.898	1	974.898	42.656	.000	.289
Intervention group	6212.076	1	6212.076	271.802	.000	.721
Error	2399.787	105	22.855			
Total	10,301.000	108				
Corrected total	8736.917	107				

R^2 adjusted = .725

participants have no psychopathological history of anxiety or depression.

Focusing on the aim of the present work, total STAI score indicated the appearance of subjective and objective pre-intervention anxiety (Domènech et al. 2010; Lee et al. 2017; Abreu et al. 2016). However, post-interventions, both the level of subjective anxiety and the standardized indicators, decrease. This finding highlights the effectiveness of an intervention of the type administered in the current study in reducing both subjective and objective anxiety.

The participants exhibited no dyspnea, digestive problems, muscle stiffness, or dizziness either before or after undergoing the PET/CT. It is also worth noting the lack of artifacts generated during the test (Kabat-Zinn 1990; Cash et al. 2014; Zukotynski 2010) as a result of patient movement or muscle tension, with the subsequent accumulation of brown fat, in our experimental group.

As regards the effectiveness of the intervention conducted in the present study, as expected, statistically significant differences were found between the mindfulness group and the control group in all the post-intervention anxiety measures (level of subjective anxiety, STAI state anxiety score, and STAI total anxiety score). In contrast, the post-intervention STAI trait anxiety score showed no significant differences between groups. Furthermore, the mindfulness meditation was effective in reducing post-intervention HR.

These findings showed that a mindfulness intervention of the type used in this study significantly reduces both HR and levels of subjective and objective anxiety as measured by the standardized STAI questionnaire. As expected, since trait anxiety is a personality characteristic and thus a more stable measure, scores on this subscale remained unmodified. HR can be a good psychophysiological measure of anxiety, although in other studies (Vogel et al. 2012), it has been measured by means of more complex techniques such as saliva sampling, electrocardiography, or electromyography. However, few studies have measured BP, and we used this measure as an anxiety-related parameter because it is a direct, noninvasive, simply measured, economic, and easily available measure, which also provides extensive information on the patient's response to anxiety.

Considering the above, and recognizing the methodological differences between our intervention and others, our findings are similar to those of other authors who report that the use of different mindfulness techniques (Tang et al. 2015, including brief interventions or audio recording of 15 min based on mindfulness, has major effects on individuals with cancer, generating significant enhancements in many health indicators (Sanada et al. 2017; Domènech et al. 2010; Schellekens et al. 2014). In the future, to bridge the methodological differences between studies, it would first be useful to identify the active ingredient or common principles of mindfulness in the different therapeutic modalities based on this meditation technique (Crane 2002). It seems that mindfulness activates many other active components as well as full awareness. (Elliston 2002)

Thus, it would be interesting to investigate these components and the role actually played by awareness and the non-judgmental attitude towards thoughts in the therapeutic effect of mindfulness.

It should not be ruled that the effects of mindfulness might stem from "nonspecific" factors such as social support, cohesion, relaxation, greater perceived self-efficacy, and the intention and attitudes of those who practice the technique (Grecucci et al. 2015). In relation to this last aspect, some authors suggest that the attitudes and positive expectations of patients towards the intervention may have contributed to its success in improving and changing the state of patients, while patients in the control group may have felt disappointed and subsequently improved less, as suggested by Speca et al. (2000). It seems clear there lies ahead a fascinating quest to clarify the specific elements needed in every mindfulness-based intervention to ensure its effectiveness in both healthy and clinical populations.

Limitations and Future Research Directions

In relation to our study limitations, the first limitation involves the procedure for delivering the mindfulness intervention. Our mindfulness practice consisted of a brief recording with specific psychoeducational components based on mindfulness characteristics, adapted to the situation and target population of our study. The second refers to the sample size and the geographical location of the population, which might be considered unrepresentative when attempting to generalize the findings. The third limitation involves the ad hoc questionnaire and its possible lack of validity and reliability. Finally, the limited existence of research and evidence on the use of mindfulness in nuclear medicine opens the door to important new projects since there are currently no programs of this type in the national health systems. This type of intervention would be a valuable improvement of great use in the treatment of patients with cancer undergoing ^{18}F-FDG-PET/CT diagnostic tests.

Compliance with Ethical Standards

Ethical Approval IRB approval by La Paz University Hospital, Madrid, Spain (HULP: 4286).

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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