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Original article

Listening to music tuned to 440 hz versus 432 hz to reduce anxiety and stress in emergency nurses during the Covid-19 pandemic: a double-blind, randomized controlled pilot study

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Abstract. *Background and aim of the work:* Healthcare providers in the emergency first response units have been exposed to a considerable stress during the SARS-CoV-2 pandemic. This study was designed to identify the effects of listening to music during the work break compared to the routine break (in the absence of listening to music) on the level of state anxiety and the vital parameters of the nurses on duty at the operations center. *Methods:* Randomized, controlled, three-arm, double-blind, single-center clinical study. Healthcare providers were divided into three groups according to study intervention (Group 1: listening to 440Hz music; Group 2: listening to 432Hz music; Group 3: liberal activity). The study was conducted during the working hours of dayshifts in an emergency first response unit station located in Tuscany, Italy. Outcomes were measured using measures of stress (State-Trait Anxiety Inventory – STAIX1), heart rate (HR), respiratory rate (RR), systolic/diastolic blood pressure (SBP/DBP), pain and productivity (Likert Scale) measured at baseline (T0) and at the end of exposure (T1). *Results:* Overall, 54 healthcare providers were enrolled; 32 females (59.3%); mean age of 39.64 years (SD±9.94); the total measurements performed were 83. The median values of STAI X1 decreased in all the 3 groups from T0 to T1 (Group 1: 34.5 vs. 32, p=0.000; Group 2: 34 vs. 29, p=0.001; Group 3: 33 vs. 31, p=0.028). In Group 2 a reduction of mean values of respiratory rate and systolic blood pressure was recorded at T1 (-2.714 b/min, p=0.000 and -3.821 mmHg, p=0.031, respectively). *Conclusions:* Listening to music at 432 Hz is a low cost and short intervention that can be a useful resource to manage anxiety and stress. Further studies are needed to assess medium and long-term effects of listening to music.

Key words: nurses, 440 Hz music, 432 Hz music, vital signs, pain, anxiety

Introduction

The current SARS-CoV-2 disease pandemic and its disease (COVID-19) which originated from Wuhan (China) at the end of December 2019 (1) exposed communities to completely new living and working conditions. For healthcare providers, and especially nurses, the psychological burden of COVID-19 has been unprecedented and mostly relatable to implement direct nursing assistance with maximum personal protective equipment (PPE), organizational flexibility required for the sudden reallocation in departments other than the usual ones, the increase in workloads and the psychological impact due to the high mortality of the disease (2, 3).

Cross-sectional data has shown how anxiety among health providers has increased together with fear (4), potentially due to not only working conditions, but

also isolation from family and next of kin (5). Nursing staff was perhaps the most affected, especially for those working in infectious disease units (4, 6).

Attention to the emotional state of nurses may be of particular in specific work contexts, such as that of the Emergency Department (ED) or of the out-of-hospital emergency services, where there is a need for rapid cognitive processes to make challenging clinical decisions while delivering optimal patient care (7-9). Stress, anxiety, and even post-traumatic stress disorder have been reported among out-of-hospital staff (8-11). For this reason, it is necessary to find effective strategies that can allow nurses and healthcare staff to reduce the effects of anxiety.

These interventions should promote psychological well-being and put nurses in the best possible condition to cope with work-related stress.

Listening to music during work breaks has been assessed as a potential short-term intervention. Nurses listening to pre-selected music tracks for 30 minutes were shown to have lower levels of self-perceived stress, heart rate, blood pressure and cortisol (12). Similarly, combined strategies such as aromatherapy massage with music or meditation significantly reduced emergency nurses' anxiety (13), but also improved well-being in students at University of Queensland, and members of the general community, who experience "a busy and sometimes stressful work life" (14).

In the above-mentioned studies, music was always tuned at 440 Hz. However, the results of a pilot study suggest that music tuned to 432 Hz vs 440 Hz may have better benefits for humans, in terms of heart rate reduction and greater satisfaction after listening (15). In a recent pilot crossover study involving patients with spinal lesions a significant improvement in sleep quality was recorded for those who listened to music tuned at 432 Hz vs those who listened to tracks tuned at 440 Hz (16). Moreover, the use of music at 432 Hz was effective in decreasing stress and salivary cortisol levels before tooth extraction (17).

For this reason, the aim of this study was to compare the effects of music tuned at 440 Hz vs 432 Hz during work breaks in nurses belonging to first emergency response units by analyzing vital parameters (VP) and stress.

Objectives

The main objective of the study was:

- Identify the effects of listening to music during the work break compared to the routine break (in the absence of listening to music) of a duty shift, on the level of state anxiety and on the VP of the nurses on duty at the operations center of the territorial health emergency service.

The secondary objectives were:

- Identify the presence of differences related to listening to music tuned to different frequencies (440 Hz versus 432 Hz) on state anxiety and on VP.
- Explore the presence of differences in perceptions of work productivity and the ability to cope with the working day by those who have listened to music during the shift and those who have not.
- Explore the level of satisfaction and subjective perceptions of the participants regarding the experience of listening to music during the break.

Methods

Study design and settings

A randomized, controlled, three-arm, double-blind, single-center clinical study was designed. The study was conducted during the working hours of dayshifts in a medical emergency first response unit station located in Tuscany, Italy from August to September 2020 and was approved by the Nursing and Midwifery Department (AUSL Toscana Centro, Florence, Italy).

Participants were randomized to three study groups during 10-minute pre-specified work breaks, namely:

- Group 1 (experimental – double blind): operators randomized to listening to music tuned to 440 Hz

- Group 2 (experimental – double blind): operators randomized to listening to music tuned to 432 Hz
- Group 3 (Control intervention): operators randomized to routine break activities.

The random assignment was carried out with a generator available online (https://wwwservizi.regione.emilia-romagna.it/generatore/). The first author who did not participate in the data collection, generated the random allocation sequence, he enrolled participants, and he assigned participants to interventions. Double blind was guaranteed with the assignment of a colored sticker on mp3.

During their working shifts, study participants were invited to take a 10-minute break in a dedicated meeting room inside the station with controlled temperature (24°Celsius / 72.3°Farenheit). Windows were always kept with the curtains raised to allow those who wanted to look out. For those who were randomized to Group 3, participants were given the possibility to exit the room and perform their routine break activities outside their working area.

All activities performed by study participants were monitored by a trained study coordinator and recorded in a dedicated form (Tool D, see in the following sections). Finally, participants were given the possibility to participate to the study again via a further randomization after at least one day from the prior.

Nurses and health-care collaborators who provided informed consent were enrolled. Operators with chronic use of anti-psychotic medications, beta-blocking agents or anti-arrhythmic drugs were excluded.

No changes to methods after trial commencement were done.

Music at 440 and 432 Hz

Each participant in Group 1 and 2 was provided with an mp3 player (Tabmart®) with earphones (Numark HF125®) which contained three music tracks tuned at 432 Hz or 440 Hz, depending on randomization. The researcher collecting data was blinded to the randomization. All participants were invited to listen to all three tracks.

Participants would be allowed to listen to the track just once during the experimental window.

To avoid bias related to previously known tracks, an experienced composer provided several tunes and ultimately three were randomly chosen. All tracks were tuned originally to 432 Hz and later converted to 440 Hz specifically for this study, via Cubase Pro 10 (Steinberg Media Technologies GmbH, Hamburg Germany).

The tracks included in the mp3 players were:

- Track 1– Dile Love, from the album "Me, Dile and 432 Hz" (DileSound Recording). Evocative-rhythmic (inspiring) genre
- Track 2– Latin Lovers, from the album "Me, Dile and 432 Hz" (DileSound Recording). Latin-rock genre
- Track 3– Anahata Chakra Meditation, from various compilations (Rehegoo Music). Meditation genre.

Outcomes and Data Collection

The following tools were used for data collection:

- Tool A (pre-intervention): questionnaire for demographic characteristics exploring age, gender, years of service, drugs prescribed by the doctor and taken during the investigation period, start and end time of the shift, and time of administration of the intervention.
- Tool B (pre- and post-study intervention): form which would allow recording of VP (heart rate, blood pressure, respiratory rate) and pain through Visual Analog Scale (VAS). A GIMA® pulse oximeter (OXY-5) was used to measure the heart rate; an Aneroid Sphygmomanometer with GIMA® Stethoscope was used to measure blood pressure. In the case of assignment to Groups 1 and 2, the detection of the VP took place before and immediately after listening. In the case of assignment to Group 3, the detection of the VP took place immediately before the break and 5 minutes after the end of the break, because the subjects could have spent the break standing or walking.

- Tool C: STAI X1 (State-Trait Anxiety Inventory) (pre- and post-intervention) (18) for situational (state) anxiety. [The Italian validation of the STAI X1 has a Sensitivity of 52% and a specificity of 99% (19)].

  STAI X1 is a questionnaire which comprises 20 items. For each item, participant choose between four possible answers on a 4-point scale (1 - "not at all", 4 - "very much") the one that best describes the item. A lower score corresponds to lower anxiety levels.
- Tool D (Intra-intervention) questionnaire was used to investigate the observable behaviors of operators while listening. This tool was created by the Authors, after a literature review and through a structured meeting with the support of a psychologist. As validated tools useful for the study were not found in the Literature, a list of observable behaviors was structured. The list included the following elements: Beat the time; Talk to your cell phone; Use your cell phone; Raise and lower the volume of the mp3; Facial mimic (assent with the head, smile, furrowed forehead, wide eyes, alert eyes, lowered eyebrow, other [with specification]); Gaze (look up, look into space, look around, look out the window, look down, fleeting gaze; Position; Body movements (arms folded, hands on hips, hands in pockets, shoulders contracted, hands joined, arms behind, shakes head, shrugs.) In addition, this tool contained a blank space in which the detector could add elements deemed significant and also describe the activities performed by the nurses assigned to the control group during their break (Group 3).
- Tool E (post-intervention, at the end of the work shift), satisfaction questionnaire for the listening experience with the question "Did you like listening to music during the break, with mp3 and headphones?". The answer involved assigning a score on a numerical scale of 11 points, from 0 = Not at all to 10 = Very much (Likert Scale from 0 = Not at all to 10 = Very much).
- Tool F (post-intervention, at the end of the listening and after the detection of the vital parameters and of the STAI X1), contained a blank space in which the nurses were free to express themselves by describing their perceptions about the listening experience or related to the activities carried out during the break. The space available was 10 lines.

  The listening volume was reported in this instrument by the observer, when the mp3 was returned.
- Tool G (post-intervention, at the end of the work shift) questionnaire aimed at investigating the productivity perceived by the subject after the pause with or without listening (the answer provided for the assignment of a score on a scale of 0 = Not at all a 10 = A lot).

The surveys were all made blindly by a single researcher (one of the authors), who managed one participant at a time.

The survey time was chosen taking into account that the nurse had been able to work for a sufficient time, about 3-4 hours (before the survey), but also that he was sufficiently distant from the end of shift time (at least 2 hours), to allow the possibility of collecting data relating to service activity after the break with or without listening.

Table 1 describes the administration times of the instruments used.

Figure 1 summarizes the steps taken to carry out the study.

No changes to outcomes after trial commencement were done.

Table 1. Timing of tools administration to the study participants

Timing	*Group 1*	*Group 2*	*Group 3 (control)*
Before intervention	A	A	A
	B	B	B
	C	C	C
During intervention	D	D	D
After intervention	B	B	B
	C	C	C
	E	E	
	F	F	F
	G	G	G

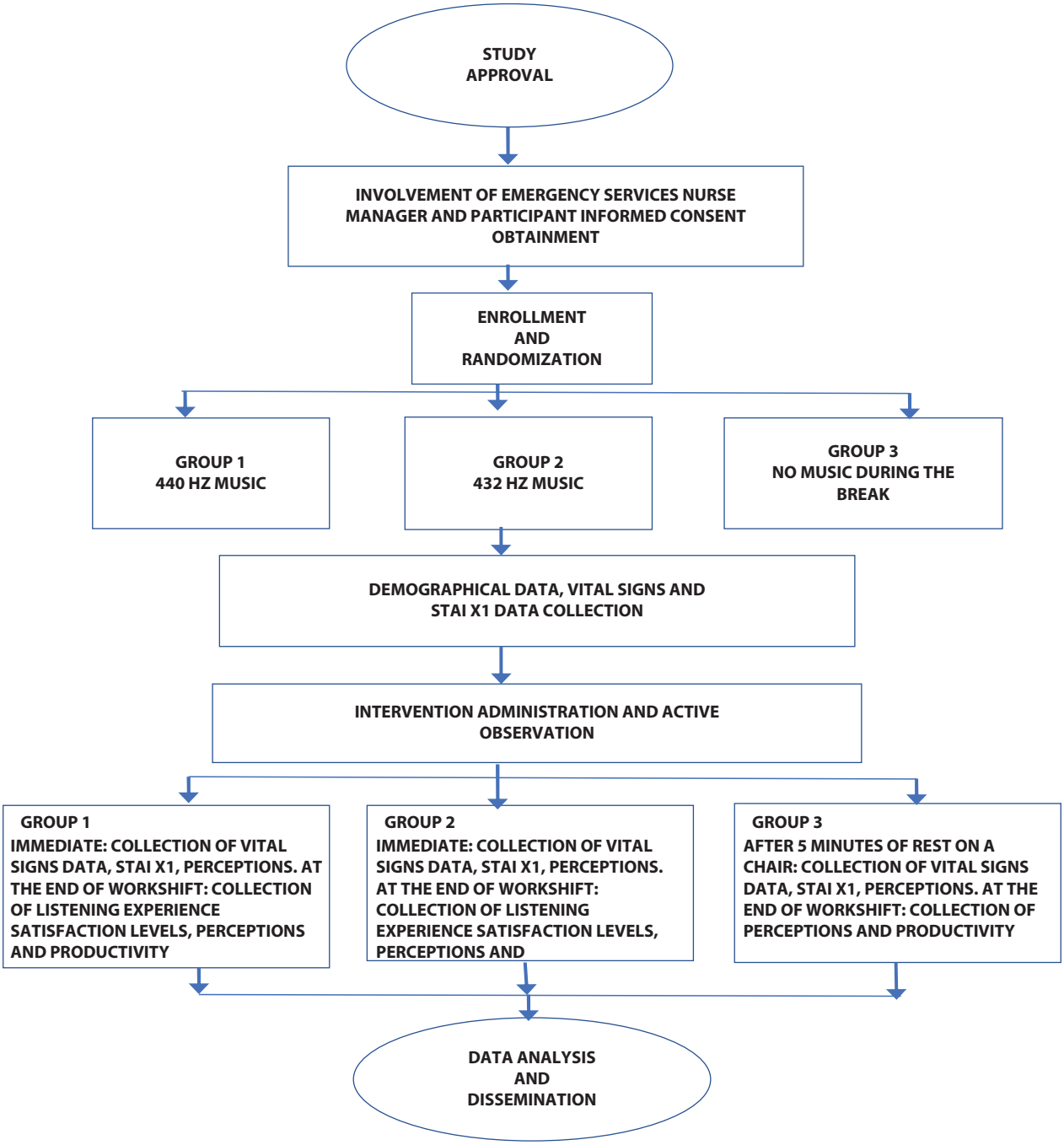

Figure 1. Steps taken to carry out the study.

Statistical analysis

The data were processed with SPSS Statistical Software version 17® and GraphPad Prism 9®.

The D'Agostino-Pearson normality test was performed. For the inferential statistics, for the comparison of the effects obtained on the variables in the T0 and T1 subjects belonging to the 3 groups (intra-groups), parametric and non-parametric statistical tests were used depending on the distribution of the data. The Wilcoxon Signed Rank Test (dependent samples) and the T test (paired samples) were then used for intra-group comparisons.

For the comparisons of intergroup variables, the Levene test (T test independent samples) was used. A p value of ≤0.05 was considered significant.

As for the perceptions written directly by the participants, an analysis of the text was not performed, but what was written by the participants themselves was read and summarized independently by three authors with subsequent comparison.

Ethical issues

According to the local Nursing and Midwifery Department procedure, and since no patient was involved in the study, the study was approved by the Nursing management service, without needing any ethical committee consultation. The participation to this experimental study was on voluntary basis. A written informed consent was obtained, and the participant could leave the study at any time. The study respected the standards for information privacy based on art.13 of the Italian Legislative Decree n. 196 of 30 June 2003, and subsequent changes. The study was conducted according to the Good Clinical Practice as set out in the last version recognized in Italian regulations, in the Helsinki Declaration, and in respect of other current and relevant regulations.

All the data collected were stored in a database that was accessible only to the researchers and protected by a password, thus protecting the confidentiality and the anonymity of the participants. The Full trial protocol is accessible from the first author.

Results

Demographic characteristics of the study sample

Overall, 54 individuals participated to the study for a total of 83 randomizations (Nurses, N=49 [91%]; health-care collaborators, N=5 [9%]), with an average age of 39.64 years (SD ± 9.94, range 25-63) and with a length of service of 4.84 years (SD ± 6.7, range 0-28). Notably, 32 were women (59.3%). A total of 28 randomizations were performed for Groups 1 and 2, while 27 for Group 3. No losses and exclusions of participants after randomization occurred.

Clinical and social characteristics are summarized in Table 2.

Of note, no significant differences were noted in these domains across study Groups (Table 3).

The list of activities during study period for Group 3 are presented in Table 4.

Change in vital parameters after study intervention

No change in heart rate (HR) was noted after study intervention in any study group (Table 5), although there was a trend towards lower heart rate in the 432 Hz group (Group 2).

Table 2. General Sociodemographic Characteristics of the study population

	440 Hz Group 1	432 Hz Group 2	Control Group 3
Characteristics by participants			
Participants	18	19	17
Nurses, N (%)	17 (94)	16 (84)	16 (94)
Healthcare collaborators, N (%)	1 (6)	3 (16)	1 (6)
Age, median (SD)	38.44 (9.22)	40.42 (11.41)	40.05 (9.38)
Gender (female), N (%)	12 (66)	11 (58)	9 (53)
Employment years, mean (SD)	5.16 (7.91)	5.26 (5.70)	4.35 (6.90)
Chronic prescription drugs (N)	0	1 (antidepressant)	1 (antihypertensive)
Characteristics by number of observations			
Observations	28	28	27
Nurses, N (%)	25 (89)	25 (89)	25 (93)
Healthcare collaborators, N (%)	3 (11)	3 (11)	2 (7)

	440 Hz Group 1	432 Hz Group 2	Control Group 3
Age, median (SD)	37.321 (8.965)	39.143 (10.940)	39.519 (9.283)
Gender (female), N (%)	17 (61)	16 (57)	15 (56)
Employment years, mean (SD)	3.500 (6.686)	5.286 (6.980)	3.704 (6.094)
Hours from workshift, mean (SD)	3.929 (1.514)	4.179 (1.467)	4.148 (0.936)
Chronic prescription drugs (N)	0	1 (antidepressant)	1 (antihypertensive)

Table 3. Comparative analysis of sociodemographic characteristics of participants

	Mean (SD±); median (IQR)*; N (%)**	Mean (SD±); median (IQR)*; N (%)**	Mean (SD±); median (IQR)*; N (%)**	ANOVA; Kruskall Wallis*; Chi square**	p
	440 Hz Group 1	432 Hz Group 2	Control Group 3		
Age	37.32 (8.965)	39.14 (10.94)	39.52 (9.283)	0.4009	0.671
Female	17 (60.7)**	16 (57.1)**	15 (55.6)**	0.2605**	0.8779
Men	11 (39.3)**	12 (42.9)**	12 (44.4)**	0.263**	0.609
Employment years	1 (0-3)*	1 (0-9.75)*	1 (0-3)*	1.131*	0.568
Chronic prescription drugs	0 (0) **	1 (3.6) **	1 (3.7) **	1.044**	0.5932

Legend: *=p value≤0.05; **=p value≤0.01; ***=p value≤0.001

Table 4. List of activities performed in the Control Group (Group 3, N of observations=27)

	Smoking outside (terrace)	Talking to colleagues	Smoking and talking to colleagues	Smoking, talking to colleagues and using mobile phones	Talking to colleagues and using mobile phones	Walking and using mobile phones	Using mobile phones
Nurses, N (%)	3 (11.11)	12 (44.44)	3 (11.11)	1 (3.70)	2 (14.81)	0	4 (14.81)
Healthcare collaborators, N (%)	0	1 (100)	0	0	0	1 (100)	0

The mean respiratory rate (RR) as well as systolic blood pressure (SBP) decreased in Group 2. SBP increase in the control group (Group 3). No significant change in diastolic blood pressure (DBP) was observed in the three groups.

Overall, 15 subjects (Group 1 - n = 4, Group 2 - n = 8, Group 3 - n = 3) presented with pain at the time of study intervention.

Of the 4 who were randomized in group 1, 1 suffered from menstrual pain, 1 reported headache, 1 pain in the hand and 1 back pain.

Of the 8 in Group 2, 5 reported back pain, 1 shoulder pain, 1 lower back pain, and 1 complained of headache.

Of the 3 in Group 3, 1 complained headache, 1 pain in the foot following a sprain and 1 in the hand from a spider bite. No significant change in pain was noted (Table 5).

Change in STAI X1

Median STAI X1 scores decreased significantly in the 3 post-intervention groups (Table 5, Before vs after intervention, Group 1: 34.5 vs 32 p = 0.0001; Group 2: 34 vs 29 p_0.001; Group 3: 33 vs 31 p = 0.028).

Gender-related differences

Gender-related differences were analyzed (Table 6). A statistically significant difference in the reduction of

RR after listening to music at 440 Hz was observed in males of Group 1 compared to females (F = 6.961, p = 0.014). In Group 2 males the STAI X1 decreased more than in females after listening to music at 432 Hz (t = 5,435, p = 0.028). In Group 3 females, SBP increased more than in males (t = 7,915, p = 0.010).

Perceived productivity after study intervention

Subjects in Group 1 and 2 subjectively felt more productive after study intervention vs Group 3 (Table 7: Group 1 vs Group 3: 6.857 vs 4.11, F = 20.358, p = 0.000; Group 2 vs Group 3: 6.286 vs 4.11, F = 2.508, p = 0.004). Notably, no difference was captured between Group 1 vs Group 2 (6.857 vs 6.286, F = 6.601, p = 0.304).

Behavior during intervention, listening volume, and satisfaction

In both Group 1 and 2, while listening, most of the subjects were sitting or lying between two chairs, with their eyes closed. Almost everyone looked out the window when they opened their eyes. Facial expressions, sometimes troubled at the beginning of listening (e.g. frowning, contracted shoulders, folded arms) tended to relax after the first 2-3 minutes of listening (assent with the head, smile, closed eyes with a serene expression).

Music tuned at 432 Hz was listened with a lower mean volume level than 440 Hz music, even if this difference was not statistically significant (20.786, SD±5.21 vs 22.53, SD±5.75, respectively; F= 0.824, p=0.23).

The levels of satisfaction with the listening experience (Tool E) were high and similar in both Group 1 and 2 (mean values 8.82, SD±1.33 and 9.07, SD±1.08, respectively; F = 0.679 p = 0.445).

Perceptions written by the participants

Almost all the participants that listened to music (both 432 Hz and 440 Hz) stated that they liked the

Table 5. Change in Vital Parameters in the three study groups (Overall Observations: N= 83)

Study Group	Vital Parameters	T0 Mean (SD)	T0 Min.-Max.	T1 Mean (SD)	T1 Min.-Max.	Mean of differences (SD of differences)	t, (p)
440 Hz Group 1	**Heart rate**	73.214 (12.7522)	50-91	76.143 (13.5448)	53-99	2.929 (10.77)	1.438, (0.161)
432 Hz Group 2		74.679 (9.0923)	56-92	72.036 (9.8713)	55-95	-2.643 (7.737)	1.807, (0.081)
Control group 3		74.000 (12.2003)	55-100	76.360 (13.708)	57-110	2.370 (9.656)	1.276, (0.213)
440 Hz Group 1	**Respiratory Rate**	18.929 (3.9340)	12-26	17.714 (4.9952)	9-29	-1.214 (3.403)	1.888, (0.069)
432 Hz Group 2		18.964 (3.1445)	14-28	16.250 (3.1225)	11-22	-2.714 (2.580)	5.567, (0.000)***
Control group 3		17.333 (3.3741)	11-23	17.852 (3.6024)	11-23	0.518 (2.887)	0.933, (0.359)
440 Hz Group 1	**Systolic Blood Pressure**	116.179 (14.0107)	90-145	114.071 (13.5836)	90-145	-2.107 (6.740)	1.654, (0.109)
432 Hz Group 2		117.679 (16.9138)	95-160	113.857 (15.8668)	90-155	-3.821 (8.882)	2.277, (0.031)*
Control group 3		123.704 (16.5013)	100-160	128.519 (19.5042)	110-180	4.815 (10.87)	2.301, (0.029)*

Study Group	Vital Parameters	T0 Mean (SD)	T0 Min.-Max.	T1 Mean (SD)	T1 Min.-Max.	Mean of differences (SD of differences)	t, (p)
440 Hz Group 1	**Diastolic Blood Pressure**	66.964 (13.8336)	50-100	69.036 (15.0468)	50-110	2.071 (10.24)	1.070, (0.294)
432 Hz Group 2		68.214 (13.8921)	50-100	68.143 (14.9288)	50-100	-0.0714 (6.098)	0.061, (0.951)
Control group 3		73.704 (13.6292)	50-100	76.296 (12.904)	55-110	2.593 (11.13)	1.211, (0.236)
440 Hz Group 1 (N=4)	**Pain Visual Analog Scale**	5 (1.633)	3-7	2.5 (3.317)	2-7	-2.500 (2.082)	2.402, (0.095)
432 Hz Group 2 (N=8)		4 (2.070)	2-7	2.5 (2.449)	0-7	-1.500 (1.852)	2.291, (0.055)
Control group 3 (N=3)		4.333 (0.881)	3-6	2.667 (1.202)	1-5	-1.667 (1.155)	2.500, (0.129)
Study Group		**T0 Median** (IQR)	**T0 Min.-Max.**	**T1 Median** (IQR)	**T1 Min.-Max.**		**Z, (p)**
440 Hz Group 1 (N=4)	**STAI X1 Score**	34.5 (29-40.75)	22-61	32 (25.25-37)	20-54		-3.869 (0.000)***
432 Hz Group 2 (N=8)		34 (30-41.5)	20-52	29 (25.25-35.75)	20-62		-3.399 (0.001)**
Control group 3 (N=3)		33 (31-86)	23-46	31 (28-91)	23-44		-2.198 (0.028)*

tracks (tool F). Moreover, the music listening allowed them to have a "real" break from the work, and "visualize positive images" during the ten minutes pauses. Only 3 participants (two from group 1 and one from group 2) did not feel whole positive emotions during the experience of listening.

Among the 27 subjects of the group 3 (no music listening), only two reported their perceptions: one underlined the need to spend his/her pause from work outdoor and one the importance to have a break from work.

No adverse effects or discomfort symptoms were recorded during and after listening of music in the study groups.

Discussion

In the present pilot study, the level of state anxiety decreased significantly in the 3 groups, confirming the importance of work 'breaks' for the well-being of employees (20). In our study, however, music was associated with a greater reduction of state anxiety, suggesting an even greater role for music in stressful environments like clinics (21-23) and jobs like nursing (12). These results are of particular interest in light of preliminary data that suggest that breaks not only may relieve stress but also positively affect productivity (24).

Only 15 subjects reported pain at the time of study intervention. Even though limited in number of observations, pain levels showed a decreasing trend after listening to music tuned at 432Hz (p=0.055). Although early evidence suggest that music may be associated with pain reduction (25) when selected by study subjects, to our knowledge, this is the first study which assessed pain with new tunes or tunes not selected by study participants.

Recently, it was shown that participants had a significant reduction in mean HR after listening to music

Table 6. Gender related differences in vital parameters and STAI X1

	Mean (SD)			Mean (SD)			Mean (SD)		
	Group 1 (n=28)			Group 2 (n=28)			Group 3 - control (n=27)		
	Men	Women	F (p)	Men	Women	F (p)	Men	Women	F (p)
Heart Rate (bpm)									
T0	70.727 (13)	74.824 (12.719)	0.237 (0.630)	75.167 (11.543)	74.313 (7.128)	3.333 (0.079)	72.167 (12.604)	75.467 (12.1)	0.416 (0.525)
T1	76.182 (13.819)	76.118 (13.792)		73.417 (10.033)	71 (9.223)		72.417 (11.453)	79.533 (14.894)	
Respiratory rate (b/min)			6.961 (0.014)*			0.622 (0.438)			0.728 (0.402)
T0	18.545 (4.107)	19.176 (3.924)		20.333 (3.524)	17.938 (2.462)		16.833 (3.588)	17.773 (3.261)	
T1	15.273 (4.101)	19.294 (4.984)		17.833 (2.552)	15.063 (3.0434)		16.583 (4.337)	18.867 (2.615)	
SBP (mmHg)									
T0	116.818 (8.447)	115.765 (16.917)	1.091 (0.306)	115.833 (12.216)	119.063 (20.018)	0.004 (0.950)	127.917 (15.293)	120.333 (17.161)	7.915 (0.010)*
T1	114.545 (6.501)	113.765 (16.275)		116.083 (13.953)	112.188 (17.508)		129.583 (18.148)	127.667 (21.117)	
DBP (mmHg)									
T0	65.909 (12.809)	67.647 (14.802)	0.220 (0.643)	70.833 (13.953)	66.250 (13.964)	0.25 (0.875)	73.333 (14.195)	74 (13.653)	1.747 (0.199)
T1	67.273 (13.484)	70.176 (16.275)		72.500 (14.222)	64.865 (15.051)		77.5 (9.885)	75.333 (15.173)	
STAI X1									
T0	33.909 (7.006)	38.235 (10.526)	0.144 (0.707)	37.083 (7.585)	34.188 (9.289)	5.435 (0.028)*	31.583 (3.679)	34.6 (5.913)	1.715 (0.2039)
T1	31.636 (5.731)	32.765 (9.236)		32.333 (7.992)	31.063 (11.328)		29.5 (3.503)	33.533 (5.604)	
SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.									

Legend: *=p value≤0.05; **=p value≤0.01; ***=p value≤0.001

Table 7. Perceived change in productivity

	"I feel more productive" (from 0 – not at all to 10 – very much)	**Differences in productivity**	
	Mean (SD), Range	**Group Comparison**	**F, p**
440 Hz Group 1	6.857 (1.556), 3-10	**Group 1 vs Group 3 (control)**	F=20.358, p=0.000**
432 Hz Group 2	6.286 (2.462), 1-10	**Group 1 vs Group 2**	F=6.601, p=0.304
Group 3 (control)	4.11 (2.913), 0-8	**Group 2 vs Group 3 (control)**	F=2.508, p= 0.004**

Legend: *=p value≤0.05; **=p value≤0.01; ***=p value≤0.001

tuned at 432 Hz (15). Our study expands this finding by showing an improvement in vital parameters such as respiratory rate (p<0.001) and blood pressure (p=0.032), with an effect for people who listened to music tuned at 432Hz but not at 440 Hz.

Albeit remarkable, this should not lead to conclude that music tuned at 440 Hz bears no hemodynamic effect: as a case in point, music tuned at 440 Hz was shown to decrease values of blood pressure in patients diagnosed with ischemic heart disease (26). Furthermore, in 60 healthy young subjects, listening to music at 440 Hz (irrespective of its type [classical vs. non classical]) was associated to lower levels of circulating cortisol, heart rate and blood pressure when compared to 60 controls (27).

Furthermore, our results suggest that the effect of music on vital parameters and anxiety may be irrespective of genre and more closely related to the 432 Hz frequency: this is in line with recent evidence showing that human cells may be more sensitive to certain type of frequencies with potential biological benefits (28).

By contrast, the increase in blood pressure observed in Group 3 could be explained by the fact that, despite 5 minutes of rest granted before the survey, during the break participants talked, smoked or walked, leading to insufficient time to stabilize VP.

Last but not least, in our study we observed gender-related differences: in Group 1, RR remained stable in women but decreased in men. A greater improvement of state anxiety was recorded for men in Group 2, while a greater increase in SBP was recorded for women in Group 3. Taken altogether, these results suggest that important differences exist between sexes – which may be accounted for by both biological and social/cultural aspects for daily living and stress-mediated responses (29-30).

Taken as a whole, listening to music during work breaks was appreciated and well tolerated. One could argue that implementing the simple music listening could potentially be a successful strategy to implement stress control and improve productivity in specific environments, such as those related with healthcare.

Conclusion

In our pilot study, listening to music for 10 minutes with an mp3 player was associated with an overall improvement in vital parameters and state anxiety in a medical emergency response unit, particularly if tuned at 432Hz. Our results suggest that implementation of such strategies could be successful to improve stress control for healthcare providers.

Our study has some limitations. The restricted study sample and the single center design may influence its external validity. Furthermore, music preferences were not assessed: this could have led to changes in the autonomic nervous system potentially leading to change in vital parameters. On the other hand, this aspect may suggest that the overall positive effect of specific tracks could be more closely related to frequency and not as much to genre. Clinical status was assessed only by chronic prescription drugs. Last, differences in vital parameters were not analyzed by time of day.

Further study should be performed on influence exerted by the music listening during the work-breaks on the healthcare professional performance during their management of the emergency calls (eg. effects on vital signs and anxiety levels).

Conflict of interest: The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

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