Music Tuned to 440 Hz Versus 432 Hz and the Health Effects: A Double-blind Cross-over Pilot Study

Diletta Calamassi,[a,*] and Gian Paolo Pomponi[b]

Context: The current reference frequency for tuning musical instruments is 440 Hz. Some theorists and musicians claim that the 432 Hz tuning has better effects on the human body, but there are no scientific studies that support this hypothesis.

Objective: To identify differences in vital parameters and perceptions after listening to music at different frequencies, 440 Hz versus 432 Hz.

Design: Cross-over pilot study.

Setting: A room dedicated to listening to music, in an Italian city.

Participants: 33 volunteers, not suffering from acute and/or chronic diseases.

Interventions: Two sessions of music listening on different days. Both sessions used the same music (movie soundtracks) but tuned to 440 Hz on one day and 432 Hz on the other. Each session consisted of 20 min' listening.

Main outcome measures: Vital parameters (blood pressure, heart rate, respiratory rate, oxygen saturation), perceptions (physical and emotional sensations, for example fatigue and stress), levels of concentration during the listening session, and general satisfaction with the experience.

Results: 432 Hz tuned music was associated with a slight decrease of mean (systolic and diastolic) blood pressure values (although not significant), a marked decrease in the mean of heart rate (−4.79 bpm, $p = 0.05$) and a slight decrease of the mean respiratory rate values (1 r.a., $p = 0.06$), compared to 440 Hz. The subjects were more focused about listening to music and more generally satisfied after the sessions in which they listened to 432 Hz tuned music.

Conclusions: The data suggests that 432 Hz tuned music can decrease heart rate more than 440 Hz tuned music. The study results suggest repeating the experiment with a larger sample pool and introducing randomized controlled trials covering more clinical parameters.

Keywords: Music, Frequency, 432 Hz, 440 Hz, Vital parameters, Perceptions

(Explore 2019; 15:283–290 © 2019 Elsevier Inc. All rights reserved.)

INTRODUCTION

Music has always been perceived as having special healing powers in people. The whole history of human civilization shows evidence of connections between music and physical and mental healing.[1,2]

From the point of view of physics, music is made up of sounds that are generated by waveforms whose frequency is expressed in Hertz (Hz). The Hz express the cycles per second (1 Hz = 1 cycle per second).[3]

Specifically, the frequency values determine the tonality and influence the timbre of the sounds.[4]

The current reference frequency for tuning musical instruments is 440 Hz, which corresponds to the musical note A4 (LA3) in the central octave of the piano.[4] This frequency value was established in the 1950s[5] and confirmed in 1975 as the standard tuning for music worldwide.[6]

So, nowadays, all the music we generally listen to is tuned to the 440 Hz frequency.[4]

The 432 Hz tuning is sometimes used in the New Age genre (meditation music)[4] and by some musicians. Furthermore, on the web (YouTube) there are music tracks that have been transposed to 432 Hz from their original 440 Hz tuning.

The transposition of music from 440 Hz to 432 Hz is obtained by imperceptibly slowing down (by 32 hundredths of a tone) the execution of a song originally tuned at 440 Hz, using music editing software.[7] The transposition process can also be viewed in different videos on the web (YouTube).

The frequency of 432 Hz music, as already mentioned for 440 Hz, refers to the value of the note A4 (LA3) of the central octave of the piano, which is taken as a reference to tune all the other notes in the time system.[4]

Currently, musicians using 432 Hz, as well as opera singers in the 1980s, declare that when musical instruments are tuned to 432 Hz, music becomes "hotter" and the perceived volume seems higher at parity of Decibel (dB).[5,8]

a University of Florence, Italy
b Independent musician, Italy
One sentence summary: we listen to music tuned to 440 Hz but listening to 432 Hz tuned music can have a greater impact on human health.
* Corresponding author.
e-mail: diletta.calamassi@gmail.com

ISSN 1550-8307/$36.00

https://doi.org/10.1016/j.explore.2019.04.001

Italian opera singers in 1988 proposed to modify the tuning-fork for tuning the orchestras of the opera houses to 432 Hz, and the composer Giuseppe Verdi had already requested this in 1884; his request was granted in a decree which, however, was never applied.[5,9]

In fact, in 1989, in line with the 1975 European directives, the A was also legally fixed in Italy at 440 Hz.[10]

Maria Renold explains in her book describing some experiments,[11] that when listening to a piano concert with a standard pitch based on a 440 Hz LA, the listeners present in the room during the performance assumed polemic, aggressive behaviors.

When the tone of the same instrument was brought to 432 Hz, the same people, once again invited to listen to the same concert, perceived the music as being better, and showed much more attention in listening.

Renold has described these behaviors for over twenty years, interviewing and testing the two different frequencies on more than two thousand people.[11]

In an article by the Schiller Institute[12] it was stated that the most scientifically correct tuning is 432 Hz.[13] This article explains the mathematical calculations by which this conclusion was arrived at, referring to historical figures such as Leonardo da Vinci, Johannes Kepler and Leonardo Pisano (known as Fibonacci).[13]

NASA (National Aeronautics and Space Administration) shows us in real time that the terrestrial frequency is about 8 Hz ("Schumann resonance").[14] This would therefore be in mathematical relation with 432 Hz, since 8 Hz is a submultiple of 432 Hz for the ratio between frequency and octave music.

In fact, it can be calculated starting from the octave of the A4 = 432 Hz in which the C4 (DO3) corresponds to 256 Hz. The following is the mathematical relation: 256/2 = 128 Hz (C3); 128/2 = 64 Hz (C2); 64/2 = 32 Hz (C1); 32/2 = 16 Hz (C0); 16/2 = 8 Hz (C-1).[4] This same mathematical relationship does not exist in 440 Hz because the C4 (DO3) corresponds to 261.63 Hz.[4]

Because of this harmonic misalignment, listening to 440 Hz music would seem to make people anxious, nervous, or aggressive, because it is not in harmony with the natural frequency of the planet earth.

These same effects would have repercussions on human health since our DNA is sensitive to frequencies, as stated by the Professor Carlo Ventura's team.[15]

Human DNA is sensitive to music and its relative frequencies to the point that it can even be reprogrammed through them. In fact, by subjecting stem cells to various frequencies it has been possible to modify their natural organic function.[15]

There are several publications on the web[16,17,18] and some books,[5,11,19] but there are no scientific publications on the presumed benefits of tuning at 432 Hz.

It seems that the benefits of music tuned at 432 Hz are not related to the musical genre (classical, jazz, rock, pop, etc.), but exclusively to the frequency and relative tonalities of the music.[4]

Di Nasso et al.'s study suggests that music tuned to 432 Hz can be used as a remedy for anxiety and pain in dental treatment. However, the effects of listening to music tuned to 432 Hz have not been compared to the effects of listening to music tuned to 440 Hz in this context.[20]

Any type of music could be produced at and/or transposed to frequencies of 432 Hz with specific music editing software.[7]

In the complete absence of scientific evidence regarding the beneficial effects hypothesized by listening to tracks recorded at 432 Hz compared to the 440 Hz standard, a pilot study was designed to identify the effects and possible differences between the two frequencies on human vital parameters.

Furthermore, the perceptions of the subjects were explored during and after listening to music recorded at the two different frequencies, together with the general level of appreciation of the listening experience.

MATERIALS AND METHODS

Study design, sample selection and implementation setting

A double-blind crossover study was performed, with a convenience sampling. Subjects were recruited by voluntary responses, via social networks (Facebook and Twitter). Subjects who chose to participate were divided into two groups (Group A and Group B) to facilitate their involvement in the investigation. The study was performed in a listening room provided by the municipal authority of Certaldo (Tuscany, Italy). The electronic equipment used consisted of a portable Digital Audio Workstation (DAW), with the music software Digital Performer 9.5 for sequential listening to the tracks and Audacity application[21] for processing from 440 to 432 Hz. Other equipment employed for this study were: two 100-Watt Behringer amplified speakers, a decibel meter (dB meter) used for volume measurement (to make sure that volume was the same during the two sessions), a table for recording the vital parameters, some chairs for the operators and armchairs for the participants.

The study was carried out in November 2017. All adult subjects who voluntarily enrolled were included. There was no starting point consisting of previous studies, so no ideal sample size was calculated. All the subjects were apparently healthy. Furthermore, they had no declared health problems (acute and/or chronic illnesses) and no declared hearing problems.

Participants could leave the study freely at any time. The purposes and methods of the study were explained to all participants and everyone signed an informed consent form.

Procedure

The two groups of subjects underwent a musical experience consisting of two listening sessions. In each 20 min session, the same tracks (on different frequencies: 440 or 432 Hz) were played. The "washout" period between the two session was 24 h.

The sequence of the listening sessions, regarding the Hz values, was determined at random, to decide the first frequency that the music was to be tuned at (432 Hz). For the second group, the listening experience required the inversion of the frequencies (440 Hz) (see Table 1). The listening sessions were carried out blindly: the participants did not know whether they were listening to music tuned at 440 Hz or 432 Hz, nor did those who collected the data. Only the sound engineer knew at what frequency the music was being transmitted.

The subjects were seated in comfortable armchairs, positioned in a semicircle. No visual effects were provided. Before the beginning of the

Table 1. Listening sequence of music at 432 and 440 Hz

Group A		Group B	
Musical experience		**Musical experience**	
Session 1	**Session 2**	**Session 1**	**Session 2**
Music at 432 Hz	Music 440 Hz	Music 440 Hz	Music 432 Hz

listening session, the sound engineers subjectively verified (by personally listening) the quality of the acoustics in all the participants' seats. The acoustics were good for every subject.

Before and after every session a nurse collected the following parameters for each subject participating in the study: blood pressure (BP), heart rate (HR), respiratory rate (RR), oxygen saturation (SpO_2). The heart rate and the SpO_2 were measured through the use of a pulse oximeter (Fingertip Pulse OXIMETER®); the blood pressure was measured by the same nurse using hand-operated apparatus, equipped with a sphygmomanometer, a hose and a stethoscope (RIESTER®).

For each subject the vital parameters were measured after 10 min of rest before the start of listening to the music, and after 10 min from the end of the listening session, ensuring adequate levels of privacy.

Furthermore, before and after every hearing session the subjects were invited to fill out five questionnaires to capture specific subjective feelings (see Table 3: Timing of questionnaire administration).

In order to establish the level of attention of the participants, the subjects were separately observed by two nurses using a specific grid during each hearing.

Instruments

All the questionnaires used to explore the subjects' characteristics and the perception variables were constructed specifically for this study.

The construction of the questionnaires was carried out according to the following steps:

- An accurate literature review searching for validated instruments. No instrument was discovered that was considered suitable to investigate the relevant specific subjective feelings;
- Implementation of a focus group with a psychologist, a doctor, a nurse, and a sociologist to explore and propose dimensions and questions to be investigated (Content validity);
- Administration of the complete questionnaires to 5 subjects not involved in the study to verify the ease of understanding of the questions and the clarity of the graphical components (Face validity);
- Improvement of the questionnaires according to the observation and suggestions of the subjects.

The questionnaires used in the present study were:

Questionnaire 1 _socio-demographic data and musical taste (age, sex, if and how much they like listening to music, favorite kind of music, how and how much they listen to music);

*Questionnaire 2*_subjective feeling of well-being/discomfort right now (anxiety, stomach-ache, fatigue, happiness, serenity, personal satisfaction, etc.), with numerical/verbal rating score ranging from 0 "Not at all" to 10 "A lot";

*Questionnaire 3*_sense of well-being after the listening session ("I feel better after the listening session") with a score ranging from 0 "Not at all" to 10 "A lot";

*Questionnaire 4*_general satisfaction regarding the participation, at the end of the listening session, with a score ranging from 0 "Not at all satisfied" to 10 "Very satisfied";

*Questionnaire 5*_perceived differences during the two different listening sessions (regarding the volume of the music, the emotions felt during the hearing, etc.). This last questionnaire also provided the respondents with a space to add personal reflections and/or comments.

Table 2 describes Questionnaires 2–5.

With regard to Questionnaire 5, in the open answers, the comments written by the participants were summarized on the basis of the content

Table 2. Description of the questionnaires used before and after listening

Questionnaire	Items	Response mode
Questionnaire 2	I have a stomach-ache	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I have a headache	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel tired	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel stressed	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel anxious	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel happy	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel peaceful	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	I feel satisfied with myself	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	Other Open answer (specify sensation)	Open answer (specify sensation)
Questionnaire 3	I feel better after the listening session	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
Questionnaire 4	I am satisfied with my participation in this event	Not at all 1 2 3 4 5 6 7 8 9 10 Very
Questionnaire 5	Did you notice differences in the music heard on the two days?	Not at all 1 2 3 4 5 6 7 8 9 10 A lot
	If the score is higher than 0, what kind of differences?	Open answer
	Did you perceive differences in your "body sensations" related to listening to music on these two days?	Yes_No_I don't know
	If so, what kind of differences?	Open answer
	Was the sound volume the same on both days?	Yes_No_I don't know
	If not, on which of the two days did it seem lower/higher?	Open answer (specify whether lower or higher and on which of the two days)
	Was the sound quality the same on both days?	Yes_No_I don't know
	If not, on which of the two days did it seem better/worse?	Open answer (specify if better or worse and on which of the two days)
	Comments/Thoughts	Open answer

Table 3. Timing of the questionnaire administration

First session		Second session	
Before listening (T0)	**After listening (T1)**	**Before listening (T0)**	**After listening (T1)**
Questionnaire 1			
Questionnaire 2	Questionnaire 2	Questionnaire 2	Questionnaire 2
	Questionnaire 3		Questionnaire 3
	Questionnaire 4		Questionnaire 4
			Questionnaire 5

and the key words contained. In order to make the synthesis, two researchers individually read and summarized the comments and only then compared them together. For the two researchers it was not necessary to reach an agreement, because their syntheses were identical.

All the questionnaires were administered approximately 20 min before the beginning of the listening session (before the measuring of the vital parameters) and 5 min after the listening session (before the measuring of the vital parameters). Subjects were asked to complete the questionnaires on the basis of the feelings and mood of the moment, and to identify any changes before and after.

Table 3 describes the timing of the administration of the questionnaires that were used.

In order to record participants' attention levels (understood as concentration on listening) during the hearing of both the music at 440 Hz and at 432 Hz, the subjects were carefully observed by two nurses using a specific grid which included the following elements: posture, facial gesture, body movements, the ability to beat time to the music, whether they were quiet or talking with the person nearby, use of mobile phones.

The operators gave a score from 0 (no attention) to 10 (a lot of attention) for each observed element. Subsequently, the observation made by each operator was shared with the other, to reach an agreement regarding the definitive score to give to the subject.

The attention level of each subject was then determined by a value (from 0 to 10) corresponding to the arithmetic average between the score assigned to each element.

The grid was built specifically for the study on the basis of a literature review and psychologists' advice. The grid included the 6 elements listed above.

The grid was tested and adjusted through a test conducted in the previous days, observing 4 subjects, who did not then participate in the study, while listening to music. The scores attributed by the two operators were compared and were very close for all 4 subjects (Inter-operator agreement, $K = 0.9$).

Overall satisfaction was assessed at the end of each listening session, with a simple statement: "I am satisfied with my participation in this event". The participant could respond by choosing a score from 0_not satisfied at all at 10_very satisfied (Questionnaire 4).

Selection and preparation of the music tracks

The tracks listened to on both days were the same, maintaining the same sequence of playing. The tracks were selected from a repertoire of movie soundtracks and processed (from the original 440 Hz frequency) for the 432 Hz listening session by a sound technician, using the music software Audacity©. The soundtracks were chosen because they include all the musical genres. In this way we avoided binding ourselves to a single musical genre and tried to satisfy the musical tastes of the subjects.

The songs were acquired from an online store, for private reproduction in Mp3 audio format.

The following are the titles of the songs in the sequence in which they were heard: (1) Indiana Jones by John Williams; (2) Star Wars by John Williams; (3) Life is beautiful by Nicola Piovani (4) The Gladiator by Hans Zimmer; (5) Schindler's List by John Williams.

The audio playback system and the listening volume was identical for both listening sessions. The volume was measured by the sound engineer using the dB meter.

Statistical analysis

Data was elaborated via the statistical software Epi Info™ 7 in order to calculate absolute values, frequencies, percentages and averages. The software IBM® SPSS Statistics® (Statistical Package for Social Science) v.17.0 was used for the comparison between the average values T0 and T1 (t Student).

Ethical aspects and competing interest statement

The subjects involved in the study participated voluntarily and before the beginning of the experiment they were accurately informed about its development and they signed and gave their consent. The corresponding author has the complete data of the survey, including paper files for the original data gathering and the Excel format database where the data were recorded. The anonymity of the participants was guaranteed: the participants were invited to write a made-up name on the questionnaires (using the same name for each questionnaire, before and after). The data were treated as aggregates. The data are stored in an electronic database, with access allowed only to the researchers and protected by a password.

The study complies with the contents of the Helsinki declaration.

No funding was used for this study.

The study was conceived, designed and implemented by two independent authors.

RESULTS

General characteristics of the sample

36 subjects participated in the survey, but 3 of these left the study after the first listening experience and did not show up for the second listening experience (drop-out). So, the data analysis included 33 subjects, divided into 21 men (63.6%) and 12 women, who did not suffer from any disability and were apparently healthy. The average age of the sample was 45 (SD ± 17.4). 21 subjects were part of the first group and 12 subjects were part of the second one (the 3 subjects who dropped out were part of this group). 32 subjects stated that they enjoyed listening to music (an average of 8.69 SD ± 2.11 range 2−10). The most preferred genres were pop music, rock, classical, and soundtracks from movies, while the least preferred genres were jazz and New Age. 63.6% of the subjects (n = 21) stated they loved classical music, even though half of this percentage did not usually listen to it. 48.4% (n = 16) stated that they usually listened to music in the morning or when they were doing sports. 72.7% (n = 24) listened to music in the car. Only 9 subjects listened to music before going to sleep, even though 75% of the subjects (n = 24)

said that they listened to music in order to relax. All of the subjects liked listening to movie soundtracks and 87.8% (n = 29) stated that they were essential in order to really enjoy a movie.

Changes in vital parameters values before and after listening to music

All the subjects (n = 21) from the group in which the first sequence of music was tuned at 432 Hz, showed up for the second session, while 3 people out of 15 from the group in which the first sequence of music was tuned at 440 Hz, did not show up for the second session (drop-out).

In both groups, the same trends were evident in parameter changes and subjective perceptions (regardless of the music listening sequence).

Table 4 describes the mean value of the HR, RR, diastolic and systolic BP and oxygen saturation of the 33 subjects before (T0) and after (T1) listening to the music at difference frequencies.

A rise in both the diastolic and systolic BP and a slight reduction of the HR was observed after listening to music at 440 Hz.

A reduction of both HR ($p = 0.05$) and RR ($p = 0.06$) was observed after listening to music at 432 Hz. The Sat.O_2 remained unchanged. Both diastolic and systolic BP were reduced, but not in a statistically meaningful way.

There was no meaningful difference based on the sex of the subjects.

Table 4. Vital signs recorded in study participants (33 subjects) at T0 and T1

Variable	Mean 432 Hz T0 (±Standard Deviation)	Mean 432 Hz T1 (±Standard Deviation)	432 Hz Difference T0-T1	Mean 440 Hz T0 (±Standard Deviation)	Mean 440 Hz T1 (±Standard Deviation)	440 Hz Difference T0-T1
HR	70.70 (±10.58)	65.91 (±9.57)	−4.79 bpm ($p = 0.05$)	73.42 (±11.48)	72.60 (±11.6)	−0.82 bpm ($p = 0,77$)
RR	17 (±2.85)	16 (±2.29)	−1 r.a. ($p = 0.06$)	17 (±2.56)	17 (±2.53)	0
Diastolic BP	76.21 (±9.35)	73.94 (±8,26)	−2.27 mmHg ($p = 0.31$)	74.85 (±10.49)	76.21 (±8.84)	+1.36 mmHg ($p = 0.57$)
Systolic BP	111.36 (±15.82)	110.91 (±17.34)	− 0.45 mmHg ($p = 0.91$)	112.58 (±14.47)	113.18 (±13.5)	+0.6 mmHg ($p = 0.86$)
Oxygen Saturation	98	98	0	98	98	0

Variation of subjective feelings before and after listening to music

Table 5 summarized the subjective perceptions regarding specific bodily sensations before (T0) and after (T1) the hearing of music both tuned at 432 Hz and at 440 Hz. Subjects were required to express their feelings on a scale from 0 (not at all) to 10 (a lot / very).

The values reported in Table 5 represent the means of the 33 subjects (irrespective of the hearing sequence).

Every subjective variable seems to improve after the listening of music (irrespective of the frequency), but without statistical significance ($p = > 0.05$).

The variables stomach-ache, anxiety and peacefulness improved after listening to music tuned at 440 Hz.

The variables headache, tiredness, stress, happiness and satisfaction with myself improved after listening to music tuned at 432 Hz. Changes of the perceptions before and after the listening are not significant.

After listening to music tuned at 432 Hz there was a slight increase in the scores for "feeling better".

Levels of Attention during listening sessions and General Satisfaction at the end of the listening sessions

Table 6 shows the mean of attention levels of the subjects during the listening and general satisfaction at the end of the session. Table 6 also illustrates the statistical analysis carried out on attention and general satisfaction.

From a comparison of the data collected from the observation during the listening (both at 432 Hz and at 440 Hz) the mean attention level rose during the session of listening to music tuned at 432 Hz

(t-student 3.163; df 32 $p = 0.003$).

Table 5. Subjective perceptions regarding specific bodily sensations on the 33 subjects

Variable	Mean 432 Hz T0 (± Standard Deviation)	Mean 432 Hz T1 (±Standard Deviation)	432 Hz Difference T0-T1	Mean 440 Hz T0 (±Standard Deviation)	Mean 440 Hz T1 (±Standard Deviation)	440 Hz Difference T0-T1
I have a stomach-ache	0.63 (±1.41)	0.45 (±0.56)	−0.18	0.81 (±1.48)	0.51 (±0.66)	−0.3
I have a headache	1.18 (±2.49)	0.66 (±1.47)	−0.52	0.87 (±1,45)	0.60 (±0,82)	−0.27
I feel tired	3.36 (±3.15)	2.42 (±2.79)	−0.94	3.51 (±2.98)	2.00 (±2.38)	−1.51
I feel stressed	1.84 (±2.41)	1.27 (±2.00)	−0.57	1.90 (±2.63)	1.39 (±2.19)	−0.51
I feel anxious	1.36 (±1.67)	0.78 (±1.02)	−0.58	1.93 (±2.59)	1.33 (±2.21)	−0.6
I feel happy	5.72 (±2.63)	6.75 (±2.56)	+1.03	6.03 (±3.26)	6.93 (±2.91)	+0.9
I feel peaceful	7.39 (±2.23)	8.00 (±2.31)	+0.61	6.93 (±2.6568)	7.60 (±2.43)	+0.67
I feel satisfied with myself	5.90 (±3.12)	6.96 (±2.31)	+1.06	6.06 (±3.14)	6.93 (±2.69)	+0.87
Music 432					**Music 440**	
I feel better after the listening session	**6.75** (±2.61)				I feel better after the listening session	**6.65** (±2.74)

The General Satisfaction was lower at the end of the listening session with music tuned at 440 Hz

(t-student 3.532; df 32; $p = 0.001$).

While listening to music tuned at 440 Hz, three subjects were particularly agitated. They spoke animatedly to each other and attracted criticism by raising their voices. In particular, two subjects criticized another who was bothering them by moving on the chair.

Differences perceived by the participants

32 subjects noticed differences in the two listening sessions (mean 5.84 SD ± 3.58).

45.5% of the subjects (n = 15) perceived the volume of the music tuned at 432 Hz as higher, and 69.7% (n = 23) considered the sound of the music tuned at 440 Hz as better. This seems to contrast with the written comments, in which only 3 subjects believed the music tuned at 440 Hz to be more relaxing.

43% of the subjects reported that the images inspired by the music were not the same in the two sessions.

Table 7 reports a synthesis of the participant's comments.

The subjects expressed more comments regarding the listening during the session with music tuned at 432 Hz (15 subjects wrote about the music tuned at 432 Hz and only 9 for the music tuned at 440 Hz).

DISCUSSION

In our pilot study with movie soundtracks, after the listening session with the music tuned at 432 Hz, we observed a significant reduction of the HR (5 bpm) and the RR (1 r.a.), with a slight reduction of both systolic and diastolic BP. No variation was recorded in the Oxygen Saturation, all participants breathed in ambient air (Fi O_2 0.21%).

There was no alteration observed in RR and in Oxygen Saturation during the hearing of music tuned at 440 Hz. With music tuned at 440 Hz, a significant reduction in HR and a slight increase in blood pressure have been observed.

These observations regarding the data collected lead, even if cautiously, to the hypothesis that the musical genre does not seem to be fundamental in enabling music to have some benefits, like reducing heart rate. In fact, the benefits could be related to the frequency of the music tuned at 432 Hz, rather than a specific music genre. That could be a starting point for further research projects on the possible relationship between the frequency of human DNA and/or other benefits of 432 Hz tuning on the health of the human body and mind.

It should be emphasized that the experiment should be repeated using 432 Hz music arranged with percussion and specific musical genres (exciting ones such as dance, rock and Heavy Metal) to verify if the same effects are produced.

As for participants' perceptions, all the variables under study improved after listening to the music regardless of the frequency. Certain considerations should be taken into account, such as participants' habitually being exposed since birth to music with vibrations and harmonics tuned exclusively at 440 Hz, which makes music at that frequency sound more "familiar" to them. Hence some individual preferences for music tuned at 440 Hz, although most of the participants were more enthusiastic about 432 Hz music.

Table 6. Attention during listening and General Satisfaction at the end of the session [statistics for paired samples, two-tailed significance]

Hz - Measure	N	Mean	SD (±)	Mean difference in pairs	SD (±)	T paired test	95% CI	p
432 - Attention during listening	33	7.76	2.180	1.424	2.586	3.163	0.507−2.341	0.003
440 - Attention during listening	33	6.33	2.642					
432 - General Satisfaction at the end	33	8.42	1.501	1.545	2.514	3.532	0.654-2.437	0.001
440 - General Satisfaction at the end	33	6.88	2.713					

Key: 95% CI, 95% Confidence Interval; SD, Standard Deviation.

Table 7. Summary of participants' comments

Comments music 432 Hz	Number	Comments music 440 Hz	Number
More relaxing	4	More relaxing	3
Sweeter	2	More tiring	1
More exciting	3	Stirring	2
More engaging	3	Sharper	1
Less intrusive	1	It makes me feel more comfortable	2
It produces sharper images	1		
It arouses more joy	1		

The written comments of the participants were more numerous and positive when referring to the 432 Hz music session.

It seems appropriate to evaluate the drop-outs (whose data have neither been analyzed nor presented).

In the musical experience (group A) in which on the first day the subjects listened to music tuned at 432 Hz, all 21 subjects returned to finish the study on the second day. In the musical experience (group B) in which on the first day the subjects listened to music tuned at 440 Hz, 3 subjects out of 15 did not come back for the second day.

This may suggest that after the first session with music tuned at 432 Hz the participants could feel a sense of well-being, more or less unconscious, so they willingly returned the next day.

It should be taken into consideration that the music tuned at 432 Hz listened to in the sessions was originally created at 440 Hz and converted to 432 Hz via software, and therefore with music originally created at 432 Hz further improvements might be seen (the transposition of music from 440 to 432 Hz definitely represents a limitation of the real potential effect of music, as compared with music originally created at 432 Hz that preserves all the original harmonics).

Finally, we emphasize that the sessions lasted no more than 20 min, while we usually listen to 440 Hz music for a lifetime. As in the experiences described by the musician Renold,[11] the subjects were significantly more attentive when listening to music tuned at 432 Hz, while they tended to be distracted and even to argue heatedly among themselves when listening to music at 440 (three subjects). Overall satisfaction levels after listening sessions were higher with 432 Hz music.

Limits: This was a pilot study. The sample was numerically limited and subjects were non-randomized. It was a monocentric investigation. No health documentation concerning the health status of the subjects involved was requested. It should be noted that there are many individual variables that can influence the effects of listening to music (for example, emotions linked to a memory that a certain piece of music can arouse, physiological and/or pathological states). Other research should study the individual variables of each subject (both emotional and physical) in depth, in order to take this into account in the analysis of the results.

CONCLUSION

The results from the study suggest some potential beneficial effects from listening to music tuned at 432 Hz compared to music tuned at 440 Hz, opening a new perspective on the opportunity of listening to it daily and to having musical and electronic instruments exclusively tuned at this frequency instead of the current 440 Hz standard, that has only been standardized since the 1950s. It is logical to think that standardizing to a single tuning is more practical, so we hope that similar research and studies can suggest the best choice for standardizing music tuning.

Replication of the survey with a larger sample and/or the implementation of randomized clinical trials would allow deeper research into the possible benefits of listening to music tuned at 432 Hz for human health.

Acknowledgements

We thank Tiziana Nannelli - PhD and Elisa Benedetti - RN for the support in carrying out the study.

We thank the municipality of Certaldo (FI, Italy) for the use of room where we conducted the study.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.explore.2019.04.001.

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