The Research of Medical Science Review

ISSN: 3007-1208 & 3007-1216 Volume 4, Issue 7, 2026

EFFECT OF MUSIC ON DENTAL ANXIETY AND PHYSIOLOGICAL RESPONSES TO DENTAL EQUIPMENT SOUNDS: A RANDOMIZED CONTROLLED TRIAL

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DOI: https://doi.org/10.5281/zenodo.24558030

Keywords
Dental anxiety; Music; Dental sounds; Modified Dental Anxiety Scale; Physiological responses.

Article History
Received: 20 May 2026
Accepted: 18 October 2026
Published: 13 November 2026

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Abstract

Objective

To investigate the impact of music on dental anxiety and physiological responses when subjected to standardized dental drill and suction noises.

Study Design

Randomized controlled clinical study.

Place and Duration of Study

21 Military Dental Center, Quetta, Pakistan, from September *2025*-January 2026.

Methodology

The participants were randomized to either the music therapy group or the no-music group. Each group was subjected to the standardized dental drill and suction noise for the same period. Music in the treatment group was applied via over-the-ear headphones during the 5-minute exposure to music, while the control group underwent the procedure without music. The MDAS test was employed to measure dental anxiety, while HR, SBP, and DBP were measured at certain time points.

Results

The effect size for reducing dental anxiety was much higher in the music group compared to the control group. The MDAS score declined by 2.38 ± 0.64 in the music group, whereas in the control group, it declined by 0.08 ± 0.89 (between-group differences in change −2.30, 95% CI −2.66 to −1.94; $p<0.001$). While there was no statistically significant difference in mean time-averaged HR, SBP, and DBP between the two groups, a statistically significant interaction of Time×Group for HR, SBP, and DBP was noted (all $p<0.001$, partial $\eta^2=0.28–0.55$). HR, SBP and DBP rose from baseline in the no-music group but remained practically unchanged in the music group.

Conclusion

In conclusion, it can be stated that music was effective in reducing dental anxiety

during exposure to the sound of a dental drill and suction.

INTRODUCTION

Dental anxiety is another type of psychological issue that may impair dental health care practice due to its connection with fear of the expected treatment process, clinic setting, and the sound of dental equipment, which is considered to be auditory stimuli.[1,2] Specifically, squealing noise of the drill and constant sucking sound may become auditory stimuli that cause fear and autonomic arousal, despite lack of an invasive procedure.[3,4] Moreover, the manifestation of the dental anxiety may occur not only in the form of subjectively felt fear but also in physiological arousal such as heart rate and increased blood pressure, which may be negative for patients' comfort and treatment tolerance.[5,6] Overall, there are 15.3% of adults with dental fear and anxiety (DFA), of which 12.4% suffer from high DFA and 3.3% suffer from severe DFA.[7] Thus, simple and non-pharmacological ways of reducing anxiety and stress responses may be useful for dentists.

Quite a number of researches have tried using music as a non-pharmacological intervention for dental anxiety and autonomic arousal. According to Silveira et al., the prevalence of dental fear and anxiety globally is 15.3% (95% CI: 10.2–21.2%). High dental fear has a prevalence of 12.4% (95% CI: 9.5–15.6%), while severe dental fear has a prevalence of 3.3% (95% CI: 0.9–7.1%).[8] The study by Ghaffar et al. involved 297 subjects, who were assessed with respect to dental handpiece sounds. According to the study, dental handpiece sounds increase dental anxiety and heart rate in patients who do not have any previous dental treatments. The mean Dental Anxiety Scale score is 7.63 ± 2.92. The mean score of novice patients is 8.00 ± 2.66, which is higher than the mean score of experienced patients, which is 7.00 ± 3.03. In addition, the mean heart rate of novice patients (87.70 ± 7.72 beats/min) than experienced patients (80.17 ± 9.36 beats/min).[9] Tan et al. analyzed 12 studies with a sample size of 1,028 patients, it was found that heart rate decreased considerably by an average of 7.33 beats per minute post-procedure (CI 95%: −10.07 to −4.58, $p<0.0001$; $I^2=81.2\%$). Additionally, findings from the same study revealed that systolic pressure and diastolic pressure reduced significantly (WMD: −6.10 mmHg; $I^2=85.6\%$ and WMD: −4.29 mmHg; $I^2=79.7\%$, respectively).[10] However, there is still significant controversy about the issue of whether music helps to reduce the dental anxiety and physiological reaction to the standardized auditory stimuli related to dentistry and not to the dental procedure itself. The available clinical trials were mostly conducted during the restorative and endodontic therapy procedures where other factors like pain, injection, interaction with the dentist, and anticipation of the procedure can influence anxiety and physiological responses. Therefore, the isolated effect of music on the physiological responses to the sounds of dental drill and suction was poorly studied. A standard exposure paradigm involving a standardized auditory stimulus may be useful in investigating this issue. Hence, the aim of this randomized controlled clinical trial was to evaluate the effect of music on dental anxiety and physiological response to sound of dental drill and suction in comparison with sound exposure without music.

Methodology

This research study was carried out as a two-arm parallel group randomized controlled trial, for which the ethical approval was sought and received from the ethical committee of 21 Military Dental Center (21 MDC), Quetta, Pakistan (letter no 021/Mil/Trg/01/2026 dated 14th January, 2025). This research was conducted from September 2025-January 2026. This trial was registered in the clinicaltrials.gov (NCT07827118). The sample size was calculated using the online sample size calculator, OpenEpi (version 3.01), Sample Size for Comparing Two Means for a two-arm randomized controlled trial with equal allocation. This was done based on the results of Karapıçak et al. who assessed the effect of music on dental anxiety and showed a mean MDAS score of 11.0±3.1 in the control group and 8.7±2.3

in the music group, thus an expected difference of 2.3 MDAS points.[11] Given an α of 0.05 (two-tailed test), 90% power, allocation ratio 1:1, mean of 11.0 and 8.7, and standard deviation of 3.1 and 2.3, the sample size of 31 subjects per group (total of 62 subjects) was required. The sample size was increased to 74 subjects (37 subjects per group) considering 15% drop-out rate or non-evaluable subjects (Fig 1). The trial ended when the target sample size was reached.

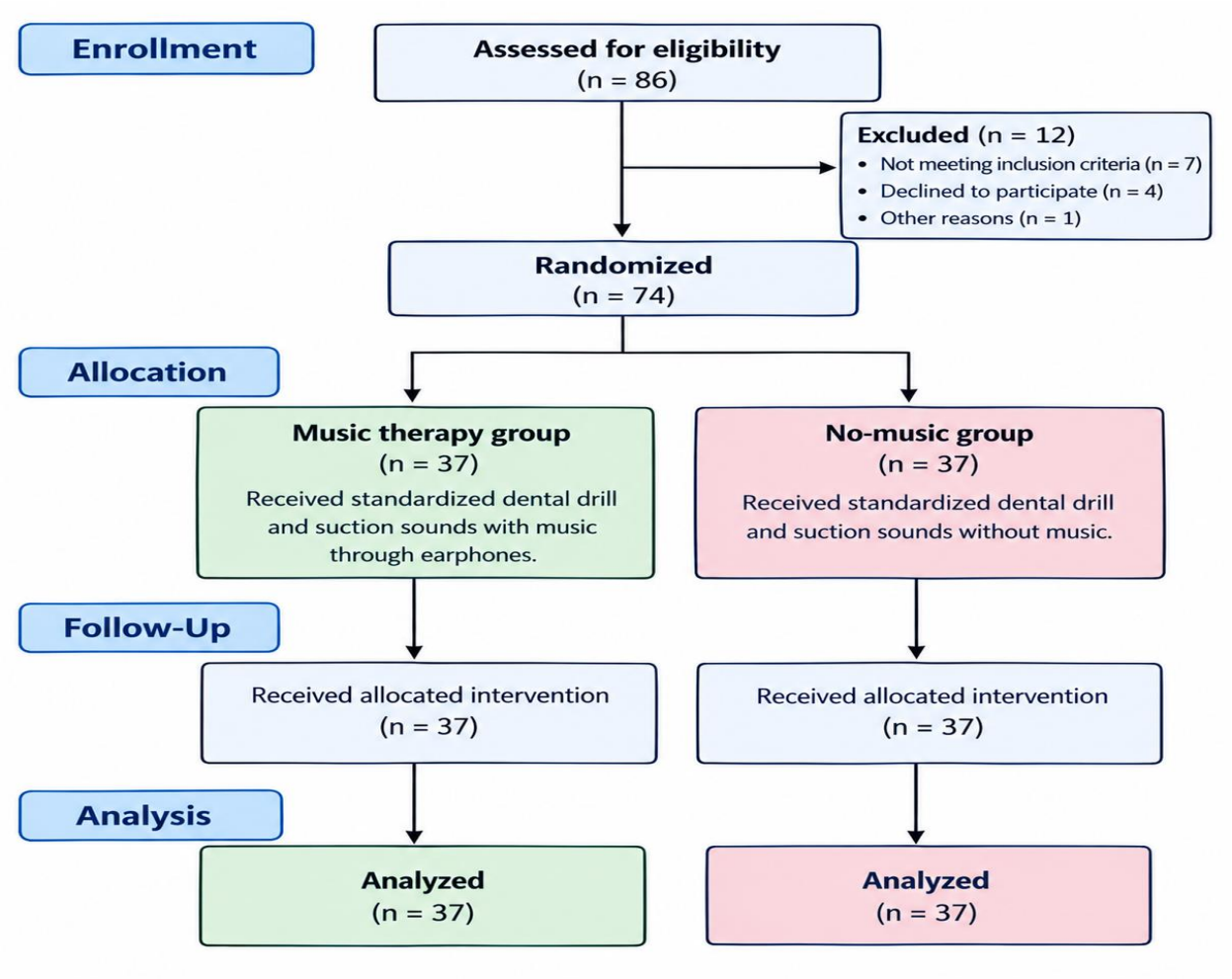

Fig 1. Consort Flow Diagram

Eligible subjects were those age 18 years and older and able to comprehend the study procedures and give informed consent. Subjects with hearing impairment, diseases or drugs significantly affecting heart rate and blood pressure, or with other disease that can affect study results were excluded. In addition, non-evaluable subjects are those unable to undergo sound exposure protocol and/or incomplete measurements of the outcomes. Before enrollment the purpose of the study and study procedures were explained to the subjects and written informed consent obtained. To avoid affecting their physiological measures, subjects were asked to refrain from drinking caffeine, smoking and vigorous exercise prior to testing. No changes were made to the trial methods, including eligibility criteria, after trial commencement.

Subjects sat comfortably in a quiet room following a period of enrollment and rest before baseline measurement. Demographic baseline data, MDAS score, heart rate, systolic blood pressure, and

diastolic blood pressure were recorded. Then, patients were randomly allocated to one of the two groups using a computerized randomization process. Simple randomisation with a 1:1 allocation ratio was used, without blocking or stratification. Concealment of allocation was achieved using opaque, sequentially numbered envelopes. A random allocation sequence was generated by an independent investigator not involved in the trial, participants were enrolled by the principal investigator, and participants were allocated to interventions by a dental assistant who opened the sealed envelopes after baseline measurements. Neither participants nor outcome assessors were blinded to group allocation.

The music group listened to standardized relaxing instrumental music through over-ear headphones for 5 minutes' exposure to pre-recorded sounds of a dental drill (4,000–6,000 Hz) and a suction sound (100–1,000 Hz) at 65–70 dB(A). All subjects underwent identical sounds exposure in terms of loudness, timing, and order; music was the only variable factor. Therefore, the sound exposure procedure was the same for both groups, the only difference being the presence or absence of music. Participants stayed seated throughout the procedure without receiving any dental procedure.

Outcomes were assessed at T0 (baseline, following 5 minutes of rest), T1 (2.5 minutes of sound exposure) and T2 (right after the exposure). The primary outcome was the difference between MDAS scores at T0 and T2, with a higher score reflecting a higher level of anxiety. Secondary outcomes included heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) at all time points, which were assessed using the same validated heart-rate monitor and automated sphygmomanometer for all subjects. Outcomes were assessed as planned without any modifications after study start, and the analysis was done according to the allocated groupings (intention-to-treat analysis).

MDAS is a five-question survey, where each question can be rated between 1 (not anxious) and 5 (very anxious), hence a score of 5-25.[23] The MDAS was designed to assess trait rather than state dental anxiety; however, it has been utilized as both a pre and post-exposure outcome in other music interventions in dentistry.[11,13,14] It was chosen as the primary outcome due to the fact that the questions directly relate to the situations encountered by patients in this study (having a tooth drilled); that it provides an opportunity to directly compare results with these studies, particularly the one from which the sample size calculation was made;[11] and that it is short enough to be filled out right after the 5-minute exposure without interfering with the physiological measurements. At T2, participants were asked to indicate their level of anxiety at the point of time related to each of the dental situations; thus, the T2 score represents the level of state dental anxiety right after the sound exposure and not a change in trait dental anxiety. The minimal clinical importance of the MDAS in assessing state dental anxiety over a period of several minutes has not been determined; thus, physiological measurements (HR, SBP and DBP) were taken as objective indicators of acute anxiety.

The data was verified for its completeness and was analyzed in the IBM SPSS Statistics. The continuous variables were analyzed using mean ± SD or median (interquartile range), depending on the distribution of data, whereas the categorical variables were analyzed using frequencies and percentages. Comparison of baseline characteristics of the groups was done. The main statistical analysis involved comparison of the difference in MDAS score between music and control groups. Similarly, the difference in heart rate, systolic blood pressure, and diastolic blood pressure between groups was compared. Change scores were calculated as T2 − T0 for all outcomes, and the between-group difference in change (music minus no-music) was compared using the independent-samples t-test with 95% confidence intervals. For HR, SBP, and DBP, the two-way mixed ANOVA repeated measures design, where Time (T0, T1, T2) serves as within-subjects variable while Group (music/no music) serves as between-subjects variable, is applied in testing the effects of Time, Group, and interaction of time × group. Comparison of independent variables was

done using independent samples t test or Mann-Whitney U test. Comparison of categorical variables was done using chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

No adverse events or unintended effects, such as discomfort from the sound exposure or headphones, were reported in either group. The music and non-music subjects did not differ at the beginning of the experiment concerning age, gender, previous treatment, pre-exposure MDAS, heart rate, systolic blood pressure, and diastolic blood pressure (all p>0.05) (Table 1). MDAS scores post-exposure were lower in the music group as compared to the no music group (8.35 ± 1.92 vs 10.70 ± 1.99; p<0.001), with a greater decrease from baseline (-2.38 vs -0.08; difference -2.30, 95% CI -2.66 to -1.94; p<0.001). However, HR, SBP and DBP were unchanged in the music group but increased in the no music group (+5.33 beats/min, +5.22 mmHg and +2.86 mmHg; between group difference in changes, all p<0.001). SBP and DBP at T2 were lower in the music group (p=0.045 and p=0.020), while HR at T2 and all parameters at T1 were comparable between the two groups (Table 2).

The dependent variables, namely the heart rate, the systolic blood pressure, and the diastolic blood pressure, had significant time and time × group interactions (all p<0.001). The time effect on the heart rate was F(1.66,119.66)=132.88, partial η^2=0.649, and there was also a significant time × group interaction (F(1.66,119.66)=87.25, partial η^2=0.548). Significant time effects and time × group interactions were also observed for systolic blood pressure (time: F(1.49,106.94)=46.41, partial η^2=0.392; interaction: F(1.49,106.94)=35.69, partial η^2=0.331) and diastolic blood pressure (time: F(1.62,116.66)=17.31, partial η^2=0.194; interaction: F(1.62,116.66)=28.40, partial η^2=0.283). No significant overall between-group effects were found for heart rate, systolic blood pressure, or diastolic blood pressure (p=0.787, 0.446, and 0.154, respectively) (Table 3).

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Table 1. Baseline demographic, dental anxiety, and physiological characteristics of participants according to randomized study group

Characteristics	Music group (n=37)	No-music group (n=37)	p-value
Age, years, mean ± SD	35.84 ± 12.68	38.14 ± 11.62	0.419
Gender			
Female, n (%)	22 (59.46%)	19 (51.35%)	0.483
Male, n (%)	15 (40.54%)	18 (48.65%)	
Dental Treatment			
Previous dental treatment, n (%)	26 (70.27%)	26 (70.27%)	1.000
No previous dental treatment, n (%)	11 (29.73%)	11 (29.73%)	
Baseline MDAS, mean ± SD	10.73 ± 2.08	10.78 ± 2.03	0.910
Baseline HR, beats/min, mean ± SD	80.09 ± 7.56	78.06 ± 6.77	0.228
Baseline SBP, mmHg, mean ± SD	120.89 ± 8.49	120.08 ± 8.02	0.674
Baseline DBP, mmHg, mean ± SD	75.24 ± 5.27	75.54 ± 6.53	0.830

Table 2. Between-group comparison of post-exposure outcomes and changes in dental anxiety and physiological parameters

Variables	Music group (n=37)	No-music group (n=37)	Between-group difference	95% CI	p-value
Post-exposure MDAS (T2), mean ± SD	8.35 ± 1.92	10.70 ± 1.99	-2.35	-3.26 – -1.44	<0.001

Change MDAS (T2 − T0), mean ± SD	-2.38 ± 0.64	-0.08 ± 0.89	-2.30	-2.66 − -1.94	<0.001
Heart rate at T1, mean ± SD	80.69 ± 7.81	81.29 ± 6.92	-0.60	-4.02 − 2.82	0.727
Heart rate at T2, mean ± SD	80.61 ± 7.41	83.38 ± 6.60	-2.78	-6.03 − 0.47	0.093
Heart rate Change (T2 − T0), mean ± SD	0.52 ± 1.42	5.33 ± 1.24	-4.81	-5.43 − -4.19	<0.001
SBP at T1, mean ± SD	121.38 ± 9.13	122.59 ± 8.00	-1.22	-5.19 − 2.76	0.544
SBP at T2, mean ± SD	121.24 ± 8.64	125.29 ± 8.45	-4.05	-8.01 − -0.09	0.045
SBP Change (T2 − T0), mean ± SD	0.35 ± 1.90	5.22 ± 2.51	-4.86	-5.89 − -3.83	<0.001
DBP at T1, mean ± SD	75.14 ± 5.38	77.38 ± 6.73	-2.24	-5.06 − 0.58	0.117
DBP at T2, mean ± SD	74.86 ± 5.66	78.41 ± 7.07	-3.54	-6.51 − -0.57	0.020
DBP Change (T2 − T0), mean ± SD	-0.38 ± 1.55	2.86 ± 1.78	-3.24	-4.02 − -2.47	<0.001

Note: Change = T2 − T0; baseline (T0) values are shown in Table 1. Between-group difference = music minus no-music group; 95% CI and p-values from the independent-samples t-test.

Table 3. **Repeated-measures analysis of changes in heart rate and blood pressure across study time points according to intervention group**

Outcome	Effect	F (df, Greenhouse–Geisser)	p	Partial η^2
Heart rate	Time	132.88 (1.66, 119.66)	<.001	0.649
	Time × Group	87.25 (1.66, 119.66)	<.001	0.548
	Group (between-subjects, df=1,72)	0.07	.787	0.001
SBP	Time	46.41 (1.49, 106.94)	<.001	0.392
	Time × Group	35.69 (1.49, 106.94)	<.001	0.331
	Group (between-subjects, df=1,72)	0.59	.446	0.008
DBP	Time	17.31 (1.62, 116.66)	<.001	0.194
	Time × Group	28.40 (1.62, 116.66)	<.001	0.283

	Group (between-subjects, df=1,72)	2.08	.154	0.028

Discussion

The dental sounds alone without any invasive procedures may result in dental anxiety. Music therapy during standardized dental drill and suction sound was associated with a 2.30-point greater reduction in MDAS score than in the control group (95% CI 1.94 to 2.66; p<0.001). Even though there were no significant differences between the two groups regarding mean heart rate, SBP and DBP, there were significant interaction effects of Time x Group on the three parameters (all p<0.001; partial η^2=0.28-0.55), since the physiological parameters increased in control group while in music group remained stable or decreased.

The Karapicak et al. study, which involved 70 patients exposed either to music or to no music while undergoing a dental procedure, showed MDAS scores of 8.7±2.3 and 11.0±3.1, respectively (p=0.001). The difference of 2.3 in post-treatment MDAS scores is quite close to that seen in the present study. Nonetheless, unlike the aforementioned study, the present study focused on isolation of the drill and suction sounds that occur during the invasive dental procedure, indicating that music is likely to reduce anxiety caused by sounds from the dental procedures.[11] Likewise, the meta-analysis carried out by Weijden et al., involving 13 controlled trials, showed pooled differences of -1.57 (95% CI -2.93 to -0.22; p=0.02) for total Corah's Dental Anxiety Scale scores and of -2.33 (95% CI -3.55 to -1.11; p=0.0002; I^2=93%) for incremental scores, further supporting the anxiety-reducing effect of music (−6.35, 95% CI −8.61 to −4.09; *p*<0.00001; I^2=0%).[12]

According to Zwiri et al. MDAS scores were significantly reduced from 18.5±2.3 to 12.7±2.1 with music compared to 17.9±2.4 to 16.8±2.5 without music, alongside significant reduction in heart-rate and blood pressure.[13] Yapar et al. found significant reductions in MDAS, heart rate, SBP, DBP, cortisol and alpha-amylase scores with both classical and Turkish music when compared to control conditions.[14]

Physiological parameters should be interpreted carefully because of the existing inconsistencies. According to Lai et al., there were no significant between-group differences in heart rate and blood pressure despite reduced anxiety levels, which is consistent with the absence of a significant overall between-group effect in the present study; in our data, however, the pattern of change over time differed between the groups (significant time × group interaction for all three parameters).[15] Wazzan et al. also reported lower heart rate and blood pressure undergoing oral medicine consultation, found significant pre- to post-consultation reductions in heart rate and blood pressure.[17] According to the results, music might have some effects on anticipatory changes in the autonomic system of an organism, but the changes could also occur without the music experience.

The use of music can help people to have lower levels of anxiety about dental treatment because of its capability to regulate emotional states and attention. Music played through headphones can distract from unwanted dental sounds and help with distraction, relaxation, and increased emotion regulation.[18,19] The latter effect is especially applicable to this study since identical sounds of drills and sucking were used for both groups with the only difference being the presence or absence of music. The significant interaction effects of time × group for heart rate, systolic, and diastolic blood pressure indicate differences in physiological response between groups; however, since there were no significant main effects between the groups, these results should not be considered proof of any cardiovascular benefits of music.

In addition, these results are clinically significant due to the fact that dental anxiety may influence treatment acceptance and cooperation and,

ISSN: 3007-1208 & 3007-1216 Volume 4, Issue 7, 2026

consequently, oral health behavior. Music is an easy and non-pharmacological method of coping with anxiety in such cases.[20,21] However, the current study evaluated only the acute anxiety and physiological responses and, thus, cannot prove any impact on long-term treatment acceptance.

The between-groups MDAS change score of 2.30 points with a decrease of the score from 10.73 ± 2.08 to 8.35 ± 1.92 among participants in the music group in comparison to the score of 10.78 ± 2.03 to 10.70 ± 1.99 in the control group is similar to findings obtained by Valverde et al. through their meta-analysis proving the statistically significant overall effect in favor of the intervention group ($p = 0.005$), as well as the statistically significant effect in subgroups of anxiety ($p = 0.03$) and anxiety–stress ($p = 0.05$).[22] This means that the statistical effect is definitely present; however, its clinical relevance might differ depending on the baseline anxiety level and patients' expectations. Thus, future research should address patient-centered issues including treatment acceptance, satisfaction, and avoidance.

A number of limitations need to be considered. First of all, restriction to single military centre, adult population limits the generalisability of the study and the patients could not be blinded due to the presence of music. Moreover, the sound-exposure model is not able to replicate the anxiety level in dental procedures including injections, pain, visual stimuli, and the interaction between the patient and dentist. Only acute responses were evaluated in the study. Individual musical tastes and features were not investigated, and only physiological parameters like heart rate and blood pressure were used. The MDAS was designed as a test of trait dental anxiety. While it has been used to detect pre-post differences in prior music experiments, a test of state anxiety (such as the state portion of the STAI, or visual analogue scale of anxiety) would be more sensitive to detect differences following an acute exposure. Hence, the MDAS difference seen in this study must be interpreted as an acute difference in self-reported dental anxiety, and not trait anxiety. The trial was registered retrospectively, after completion of data collection; however, the registered primary and secondary outcomes are identical to those reported in this manuscript.

In clinical practice, headphones-based music therapy is an easy and non-invasive complementary procedure for the management of dental anxiety without alteration of any dental procedure. It can be especially helpful in those cases where drill and suction sounds are recognized as causes of dental anxiety. In future multicentric studies, the comparison between patient-selected music and standardized music in dental operations, as well as the inclusion of additional physiological markers like cortisol and alpha-amylase and more prolonged follow-up periods, is necessary. Greater standardization of reporting of music characteristics, duration of exposure, method of delivery, baseline anxiety, and timing of outcomes would improve comparability across studies.

Conclusion

As a result of these findings, it can be stated that music significantly diminished the experience of subjective dental anxiety in patients when exposed to standardized sounds of the dental drill and dental suction device. While the 2.3-point MDAS score difference was consistent with the findings of the earlier randomized studies, physiological results revealed significant differences in the dynamics but not overall between-group differences. In this way, the only benefit that music brought about in this situation was psychological and not cardiovascular one.

The protocol is available on ClinicalTrials.gov (NCT07827118)

Author Contributions

Ahmed Abdullah: Conceptualization, methodology, investigation, formal analysis, writing—original draft, writing—review and editing, supervision, project administration.

Ehsan Rathore: Data curation, formal analysis, investigation, interpretation of findings, writing—review and editing, supervision, project administration.

Jazib Memon: Methodology/clinical interpretation, supervision, writing—review and editing.

Marhaba Shaikh: Investigation, writing—review and editing, interpretation of findings and project administration.

Nabaa Zahra: Conceptualization, data curation, statistical analysis, and writing—original draft.

Acknowledgement

21 Military Dental Center, Quetta

Conflict of Interest

None

Funding

No funding.

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