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Mindful Jazz and Preferred Music Interventions Reduce Pain Among Patients with Chronic Pain and Anxiety: A Pilot Randomized Controlled Trial

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Abstract

Background: A mindfulness-based intervention (MBI) focused on listening to music might reduce chronic pain and provide a new type of MBI to overcome challenges from traditional (e.g., breathing) MBIs. Due to the potential unpredictability and unfamiliarity of jazz, an MBI focused on listening to improvisational jazz music might be a particularly efficacious pain reduction intervention. This pilot study explores whether mindfully listening to music, including jazz, can reduce pain-related outcomes.

Methods: Chronic musculoskeletal pain (CMP) participants (n=30 per group, N = 120 total) were enrolled online between 12/7/2023 and 2/8/2024. Participants were randomly assigned to one of four conditions in a 2 (Mindful Music Listening/Intervention vs. Music Education/Control) X 2 (Preferred Music (choose their own music genre) vs Improvisational Jazz (assigned to listen to jazz)) experiment. Patients in each condition were provided with training in either mindful listening to music (Mindful Music/Intervention conditions) or music education (Music Education/Control conditions) and given 4 sets of weekly recordings related to their condition for daily listening/practice. Patients completed online surveys on demographics and pain-related outcomes (e.g., pain catastrophizing, pain intensity, and anxiety) pre-and post-training (to assess immediate outcomes), as well as throughout a 4-week period (to assess longer-term change). The main outcomes analyses compared the intervention and control groups, with secondary sub-analyses among participants who listened to at least 2/3 of their recordings (10 minutes), and among those who experienced a clinically meaningful (20%) reduction in pain.

Results: Mindful Jazz and Mindful Preferred Music (Intervention) participants reported significantly less pain intensity ($p < .01$) and pain unpleasantness ($p < .01$) immediately after the training relative to the Jazz Education and Music Education (Control) participants. Similarly, throughout the 4-week period, Mindful Jazz participants reported significantly less pain intensity relative to both control groups (Jazz Education and Music Education participants); Mindful Preferred Music participants reported significantly less pain intensity relative to only the Jazz Education participants. Mindful Jazz participants reported a >20% decrease in pain intensity more frequently than Jazz Education ($X2=48.71$, $p<.001$), Music Education ($X2=65.13$, $p<.001$), and Mindful Music ($X2=8.74$, $p=.003$) participants. Similarly, among the instances when a participant listened to at least 10 minutes of their audio recording, the proportion that achieved a >20% decrease in pain intensity differed significantly by group (($X2=84.03$, $p<.001$): Jazz Education, 29%; Music Education, 26%, Mindful Jazz, 50%; Mindful Music 41%).

Conclusion: Results suggest that mindfully listening to music can help to reduce pain-related outcomes. Both music education (i.e., music listening without mindfulness training) and mindfully listening to music (i.e., a music listening with mindfulness training) helped to decrease patients' pain and anxiety from baseline to follow-up. However, the mindful listening conditions reduced pain to a greater amount compared to music education, suggesting that mindfully listening to music is a more impactful pain reduction intervention compared to music listening without mindfulness training. Future research is warranted with a larger sample to further study this question.

Categories: Psychology, Integrative/Complementary Medicine, Pain Management
Keywords: : anxiety, listening to music, mindfulness-based interventions, music intervention, chronic pain management

Introduction

Chronic musculoskeletal pain (CMP), including spinal pain and osteoarthritis, is the leading cause of years lived with disability world-wide and the most expensive health condition in the United States [1], [2], [3]. Compounding these concerns, opioid analgesics remain the primary pharmacological treatment for CMP [4], [5]. Troublingly, it is estimated that almost 30% of chronic pain patients receiving long-term opioid therapy develop opioid misuse [6], which can further lead to addiction and overdose [7], [8], [9]. CMP patients therefore need better, non-addictive treatment options.

Music listening interventions, and mindful breathing interventions, have both been found, independently, to reduce pain and related symptomology. For example, meta-analytic results suggest that listening to music can reduce acute and chronic pain [10], [11], pain-related emotional distress, as well as use of pain medication [10]. Music interventions have demonstrated these positive effects on pain across settings, including surgical, in-patient, and community settings [10], [11], [12]. Importantly, due to the ubiquity of music - especially freely available online music - music interventions are easily accessible and highly scalable, making it important to further study their potential impact on health.

Similarly, many studies, including multiple meta-analyses, have found that mindfulness-based interventions (MBI) reduce chronic pain and pain-related symptomology [13], [14]. For example, in a randomized controlled trial on 250 chronic pain patients, a MBI significantly reduced chronic pain-related functional interference ($p<.001$, $d=.58$) and pain intensity ($p=.003$, $d=.36$) through the nine-month follow-up, with 50% of patients reporting clinically significant pain reductions [15]. Numerous studies have been conducted and found consistent results with MBI's demonstrating similar positive results on pain reduction.

However, despite the success of these traditional MBIs, many of them are inaccessible for CMP patients due to both formatting and content barriers. Greater adherence to MBIs is associated with better clinical outcomes, but traditional mindfulness practices (e.g., teaching patients to mindfully attend to their breathing) can be difficult, boring, or even uncomfortable for some CMP patients [16], [17], [18], [19], [20], [21], [22], [23]. For example, some MBI studies of broader patient populations have had dropout rates as high as 47% [20]. One study found that more than 25% of participants said their MBI experience was unpleasant and/or boring [21]. Mindfulness apps have attempted to address this problem by making mindful breathing practices more accessible to users, but these apps still struggle to retain users in the practice. For example, despite mindfulness apps being the most commonly downloaded wellness apps [24], user retention is only 50% two days after installation and approximately 5% thirty days after installation [25]. Developing MBI formats that teach CMP patients to practice mindfulness in ways that are more familiar, gentle, and consistent for their lifestyles (e.g., mindfully listening to music) may increase mindfulness practice engagement and allow more CMP patients to benefit from MBIs.

Combining these two interventions, music listening and mindfulness-based interventions, by teaching people how to mindfully listen to music, may help to leverage the successes of both interventions while also addressing the limitations of MBIs by allowing patients to mindfully attend to something easier and more comfortable than their breathing (i.e., music).

Although most music listening studies have allowed participants to choose their own preferred styles of music, certain styles, or components (e.g., rhythms, chord progressions) of music, such as improvisational jazz, might be particularly effective when incorporated into a mindful listening intervention to reduce pain. For example, unfamiliar music may be particularly well-suited for mindful music listening by calling the listener's attention to the present moment, curiosity, and openness. Jazz is one of the least familiar genres of music to most Americans [26], [27], and therefore a reasonable genre to include when testing this theory on the impact of mindfully listening to unfamiliar music. A specific style of jazz, improvisational jazz, may be especially relevant for testing this hypothesis in a study as the often rapid and unpredictable musical changes invite the listener to stay in the present moment, much as the musicians must be when improvising. For example, although there are jazz "standards" that have the same familiar beginning melody (e.g., "My Favorite Things"), musicians play these improvisational jazz songs completely different each time depending on their immediate emotions. Improvisational jazz is therefore a truly present-minded experience for the musician (and possibly for the listener too, if they can be taught to attentively follow the music's improvisation). Taken together, mindfully listening to jazz might be especially helpful in reducing patients' pain and anxiety, and increasing their present-mindedness. However, little to no research has explored this topic.

This pilot study seeks to assess whether being trained to mindfully listen to music, particularly jazz, compared to not receiving mindful listening training, leads to reduced pain and anxiety among patients with chronic pain. Because most music listening studies have allowed participants to choose their own style of music, we have created 2 music conditions, participant's choice/preferred music and improvisational jazz. This study was also designed to test the broader impact of "mindful music listening" compared to traditional music listening (with added music education, as a control for amount of time spent in training) on pain-related outcomes.

Materials And Methods

Methods

One hundred and twenty participants with chronic pain were recruited using paid online advertisements (e.g., Facebook, Instagram). Those who clicked on the ad were routed to an online screening website to screen for eligibility. Inclusion criteria were: self-reported 18 years of age or older, little to no experience listening to jazz, lives in the United States, English-proficient adult with a chronic pain diagnosis, has a pain rating of five or greater in average pain on a 0-10 numeric rating scale in the preceding week, has had pain for at least 3 months and for at least 15 days in the preceding 30 days. Exclusion criteria were: currently

using or has used prescription opioids for more than 3 months (to reduce interactions with other forms of medical treatment), current cancer diagnosis, or experience with mindfulness. Those found preliminarily eligible received an online written information sheet (informed consent) and completed an online baseline survey on demographics and chronic pain-related outcomes (e.g., pain catastrophizing, pain self-efficacy, anxiety).

Participants who completed the baseline survey were then called by a research associate to further confirm eligibility by making sure they're a real person and not a bot/invalid responder [28] randomly assigned to a treatment condition, and called to schedule a training for that specific condition. Participants were randomly assigned to one of four conditions in a 2 (music education vs. mindful music listening) X 2 (preferred music vs improvisational jazz) experiment. This 2 x 2 design allowed us to both compare mindfully listening to jazz to the other conditions, but also allowed us to combine mindfully listening to jazz with mindfully listening to a one's preferred musical genre and test whether mindfully listening to any type of music might reduce pain compared to listening to it without training in mindfulness. The training sessions for each condition (mindfulness and music education/control) were 20 minutes in length, conducted in an individual format, and were led by a trained research associate via a secure video-conferencing platform.

The music education conditions were designed to be similar to traditional research on music and health, by allowing participants to listen to music. Because the intervention condition taught participants how to mindfully listen to music, we also included a time-matched "teaching" portion of the music education conditions where the research associate read a script to teach participants about music history and education. Participants then watched an educational video about music (preferred music, https://www.science.edu/acellus/wp-content/uploads/2023/07/Music-Appreciation-Kindergarten-Eileen-1.mp4?_=1) or specific to improvisational jazz (jazz group, https://youtu.be/BMgKXbtQwoo) that was designed to inspire them to want to listen to music.

The mindfulness groups were similar to the music education groups but included instructions in mindfulness training instead of music education. Those in the mindfulness groups were read a time-matched script that was designed to teach them about mindfulness and how to mindfully listen to music. Participants in the mindfulness conditions saw a video created by a study team member that provided participants with audio-guided instruction for how to mindfully listen to a song ("Thrushes in Parc Eric Satie" by David Patterson for the preferred music group), ("Have You Met Ms. Jones" by the Oscar Peterson Trio for the improvisational jazz group).

Participants in all four conditions were asked to listen to at least 10 minutes of music each day for the first 4 weeks after finishing their training. No upper limit to the amount of daily music listening was set. To encourage standardized listening experiences, participants in the preferred music conditions were provided with four playlists (one for each follow-up week) of songs from their preferred genre (e.g., rock, hip hop, classical). Similarly, participants in the improvisational jazz group were provided with four playlists (one for each follow-up week) of jazz songs. Jazz playlists included instrumental versions of songs such as "Take the A Train," "St. Thomas," and "Kind of Blue." All playlists across were approximately 15 minutes in length. Each day, before and after listening to their playlist, participants were asked to complete single-item measures of pain intensity, pain unpleasantness and anxiety, scored on an 11-point numeric rating scale. After 4 weeks, all participants were invited to complete a final survey. Participants were paid in Amazon gift cards for completing the baseline ($20) and final ($25) survey. This study was deemed self-exempt by the University of California, Irvine Institutional Review Board (IRB). This study was registered on clinicaltrials.gov (NCT05979012) prior to enrollment of first participant (first submitted, July 28, 2023).

Analyses were thematically grouped to examine the primary variables of interest at two different time scales: 1) from immediately before to immediately after intervention exposure (i.e., testing for immediate outcomes occurring the same day as they received their training), and 2) during the 4-week follow-up period (i.e., follow-up outcomes). First, generalized linear mixed modeling (GLMM) was used to analyze the immediate clinical outcomes: pain intensity, pain unpleasantness, and anxiety. In each of these mixed models, outcome variables were regressed on condition (Jazz Education vs. Music Education vs. Mindful Jazz vs. Mindful Music) and the respective baseline value in accordance with the classical analysis of covariance approach for analyzing clinical trial outcomes [29]. Next, t-tests were used to examine within-group changes in the immediate outcome variables. A responder analysis was also performed by calculating the proportion of participants with a ⩾20% (i.e., minimally clinically important, based on prior research) improvement in pain intensity from baseline [30]. A chi-square test was used to determine whether the number of responders differed by group. Finally, bivariate correlation analysis was used to examine relations among residualized change scores created for each clinical and mechanistic outcome.

Second, GLMM was used to analyze the 4-week follow-up outcomes: daily pain intensity, pain unpleasantness, and anxiety during independent, "at home" listening. In each of these mixed models, the outcome variable (e.g., pain intensity after listening to the provided music playlist) was regressed on condition (Jazz Education vs. Music Education vs. Mindful Jazz vs. Mindful Music), time (Day 0 through Day 28), a condition X time interaction term, the respective baseline value (e.g., pain intensity before listening to the provided music playlist), and time spent listening to the playlist to account for "dosage". Additionally, t-tests were used to examine within-group changes in the follow-up outcome variables for instances when at

least 10 minutes of the provided playlist (i.e., 2/3 of the recording) was listened to by a participant. A responder analysis was conducted using the same criteria as above (i.e., ≥20% decrease in pain intensity).

All tests and confidence intervals were two-sided and statistical significance was defined as a p value less than .05. The path model was conducted in AMOS version 29; all other statistical analyses were conducted in SPSS version 29.

Results

Results

All study participants (n=120) were enrolled between 12/7/2023 and 2/8/2024. Participants' demographic and clinical characteristics did not differ significantly by condition (See Table *1*). The majority of participants were white (74%) and female (80%). Moderate pain levels (mean =7.22, SD=1.21) were reported in the week prior to intervention exposure and 84% of participants reported experiencing chronic pain for more than a year. Regardless of condition, all participants completed their entire intervention.

	Jazz Education	Music Education	Mindful Jazz	Mindful Music	Test Statistic	p
Primary Pain Condition					X^2=18.23	.44
Back	12 (40%)	11 (37%)	11 (37%)	11 (37%)		
Fibromyalgia	7 (23%)	2 (7%)	4 (13%)	2 (7%)		
Head	-	3 (10%)	4 (13%)	5 (17%)		
Joint	8 (27%)	8 (27%)	4 (13%)	6 (20%)		
Neck	-	2 (7%)	3 (10%)	1 (3%)		
Nerve	2 (7%)	2 (7%)	-	2 (7%)		
Other	1 (3%)	2 (7%)	4 (13%)	3 (10%)		
Average Pain, mean (SD)	7.23 ± 1.31	7.07 ± 1.23	7.33 ± 1.12	7.23 ± 1.22	F=0.25	.86
Pain Duration > 1 year, n (%)	27 (90%)	23 (77%)	26 (87%)	25 (83%)	X^2=4.87	.56
Age	46.47 (11.83)	40.20 (12.05)	46.70 (14.17)	45.83 (14.78)	F=1.63	.19
Sex					X^2=4.08	.67
Female	25 (83%)	24 (80%)	26 (87%)	25 (83%)		
Male	5 (17%)	6 (20%)	3 (10%)	5 (17%)		
Intersex	-	-	1 (3%)	-		
Gender					X^2=3.00	.81
Female	24 (80%)	22 (73%)	26 (87%)	24 (80%)		
Male	5 (17%)	5 (17%)	3 (10%)	5 (17%)		
Other	1 (3%)	3 (10%)	1 (3%)	1 (3%)		
Sexual Orientation					X^2=12.53	.40
Bisexual	2 (7%)	5 (17%)	6 (20%)	-		
Gay	2 (7%)	1 (3%)	1 (3%)	1 (3%)		
Heterosexual	23 (77%)	20 (67%)	21 (70%)	27 (90%)		
Questioning	1 (3%)	2 (7%)	-	-		
Other	2 (7%)	2 (7%)	2 (7%)	2 (7%)		
Hispanic or Latino	3 (10%)	5 (17%)	5 (17%)	4 (13%)	X^2=3.84	.70
Race					X^2=11.39	.72

American Indian or Alaska Native	-	1 (3%)	-	-		
Asian	1 (3%)	1 (3%)	1 (3%)	2 (7%)		
Black or African American	3 (10%)	6 (20%)	3 (10%)	6 (20%)		
White	23 (79%)	21 (70%)	25 (83%)	20 (67%)		
Unknown	-	1 (3%)	-	-		
Two or more	2 (7%)	-	1 (3%)	2 (7%)		
Education					X^2=14.82	.67
Upper Secondary	-	-	-	1 (3%)		
Diploma or Equivalent (GED)	5 (17%)	2 (7%)	3 (10%)	2 (7%)		
Some College/Certificate	8 (27%)	10 (33%)	12 (40%)	7 (23%)		
Vocational/Trade School	2 (7%)	2 (7%)	2 (7%)	1 (3%)		
Bachelor’s Degree	5 (7%)	8 (27%)	5 (17%)	11 (37%)		
Some Graduate or Professional School	2 (7%)	1 (3%)	4 (13%)	1 (3%)		
Completed Graduate or Professional School	8 (27%)	7 (23%)	4 (13%)	7 (23%)		
Employment					X^2=8.91	.71
Full-time Employment	14 (47%)	13 (43%)	8 (28%)	14 (47%)		
Not Employed	11 (37%)	9 (30%)	15 (52%)	8 (27%)		
Part-time Employment	4 (13%)	5 (17%)	4 (13%)	7 (23%)		
Contractor/Consultant	1 (3%)	2 (7%)	1 (3%)	-		
Student	-	1 (3%)	1 (3%)	1 (3%)		
Relationship Status					X^2=13.50	.33
Divorced	6 (20%)	2 (7%)	9 (30%)	8 (27%)		
Married	10 (33%)	12 (40%)	7 (23%)	11 (37%)		
Never Married	11 (37%)	16 (53%)	11 (37%)	10 (33%)		
Separated	2 (7%)	-	1 (3%)	-		
Widowed	1 (3%)	-	2 (7%)	1 (3%)		
Household Size	2.33 ± 1.32	2.83 ± 1.64	2.57 ± 1.61	2.60 ± 1.40	F=0.56	.64
Household Income					X^2=14.00	.30
< $24,999	10 (33%)	6 (20%)	6 (20%)	2 (7%)		
$25,000 to $49,999	5 (17%)	5 (17%)	8 (27%)	6 (20%)		
$50,000 to $99,999	10 (33%)	13 (43%)	7 (23%)	12 (40%)		
> $100,000	5 (17%)	4 (13%)	6 (20%)	9 (30%)		
Prefer not to answer	-	2 (7%)	3 (10%)	6 (3%)		

TABLE 1: Demographic Differences by Condition.

Statistical tests used: one-way ANOVA, chi-squared test.

Average Pain measured by a 0 to 10 numeric rating scale item adapted from the Brief Pain Inventory

Immediate Clinical Outcomes

Significant between-group effects on pain intensity and pain unpleasantness were observed. Mindful Jazz and Mindful Music participants reported significantly less pain intensity and pain unpleasantness immediately after the intervention relative to the Jazz Education and Music Education participants (Tables 2 and 3). The remaining contrasts were not significant. No effect of condition was observed for anxiety.

	Jazz Education	Music Education	Mindful Jazz	Mindful Music	F	p
Pain Intensity	5.50 (5.05 to 5.94)	5.46 (5.01 to 5.90)	4.51 (4.06 to 4.95)	4.54 (4.10 to 4.99)	6.03	< .001
Pain Unpleasantness	5.09 (4.55 to 5.64)	4.87 (4.32 to 5.42)	3.72 (3.18 to 4.27)	3.71 (3.16 to 4.26)	7.04	< .001
Anxiety	3.34 (2.79 to 3.90)	3.25 (2.69 to 3.80)	2.41 (1.85 to 2.96)	2.94 (2.38 to 3.50)	2.26	.09

TABLE 2: Estimated marginal means by treatment group for immediate outcomes.

Statistical test used: generalized linear mixed modeling

		Music Education	Mindful Jazz	Mindful Music
Pain Intensity	Jazz Education	0.04 (-0.59 to 0.67)	0.99** (0.36 to 1.61)	0.95** (0.33 to 1.59)
	Music Education	-	0.95** (0.32 to 1.58)	0.91** (0.29 to 1.54)
	Mindful Jazz	-	-	-0.03 (-0.66 to 0.60)
Pain Unpleasantness	Jazz Education	0.22 (-0.46 to 1.00)	1.37*** (0.60 to 2.15)	1.38*** (0.61 to 2.16)
	Music Education	-	1.15** (0.37 to 1.93)	1.16** (0.38 to 1.94)
	Mindful Jazz	-	-	0.01 (-0.76 to 0.79)
Anxiety	Jazz Education	0.09 (-0.69 to 0.88)	0.93* (0.15 to 1.72)	0.40 (-0.39 to 1.19)
	Music Education	-	0.84* (0.05 to 1.62)	0.31 (-0.48 to 1.09)
	Mindful Jazz	-	-	-0.53 (-1.32 to 0.26)

TABLE 3: Table 3. Pairwise between group comparisons for immediate outcomes.

Variables are presented as pairwise between group comparisons

Statistical test used: t test

* p<.05 **<.01 ***p< .001

Significant within-group effects were observed for all variables of interest across all experimental conditions. Effect size estimates were generally in the large range for the Mindful Jazz and Mindful Music conditions; Effect size estimates were generally in the medium-to-large range for the Jazz Education and Music Education conditions (Table 4).

Variable	Condition	Pre-intervention	Post-intervention	Δ	t	p	d
Pain Intensity	Jazz Education	6.10 ± 1.47	5.53 ± 1.72	-0.57	3.80	< .001	0.69
	Music Education	6.03 ± 1.40	5.43 ± 1.72	-0.60	2.98	.006	0.55
	Mindful Jazz	5.93 ± 1.89	4.40 ± 1.99	-1.53	5.59	< .001	1.02
	Mindful Music	6.17 ± 1.49)	4.63 ± 1.90	-1.53	5.87	< .001	1.07
Pain Unpleasantness	Jazz Education	5.83 ± 1.64	5.10 ± 1.85	-0.73	3.43	.002	0.63
	Music Education	5.40 ± 1.96	4.57 ± 2.08	-0.83	2.93	.006	0.54
	Mindful Jazz	5.93 ± 2.23	3.80 ± 2.07	-2.13	6.25	< .001	1.14
	Mindful Music	6.13 ± 1.70	3.93 ± 2.12	-2.20	7.05	< .001	1.29
Anxiety	Jazz Education	5.00 ± 2.77	3.50 ± 2.52	-1.50	3.86	< .001	0.70
	Music Education	4.60 ± 2.71	3.17 ± 2.52	-1.43	4.87	< .001	0.89
	Mindful Jazz	5.17 ± 2.72	2.67 ± 1.90	-2.50	6.98	< .001	1.28
	Mindful Music	4.17 ± 2.49	2.60 ± 1.79	-1.57	5.00	< .001	0.91

TABLE 4: Within group changes in the primary variables of interest for immediate outcomes.

Statistical test used: t test

Δ = change in value from pre- to post-intervention d= standardized effect size

The number of participants that achieved a ⩾20% decrease in pain intensity differed significantly by group (X2=13.35, p=.004): Jazz Education, n=9 (30%); Music Education, n=8 (27%), Mindful Jazz, n=20 (67%); Mindful Music, n=16 (53%). There was a significantly higher percentage of Mindful Jazz participants that reported a ⩾20% decrease in pain intensity relative to Jazz Education (X2=8.08, p=.004) and Music Education (X2=9.64, p=.002) participants. Additionally, significantly more Mindful Music participants reported a ⩾20% decrease in pain intensity than Music Education participants (X2=8.08, p=.004). The remaining contrasts were not significant.

Follow-up Clinical Outcomes

Significant between-group effects on daily pain intensity and pain unpleasantness during the 1-month follow-up period were observed. Mindful Jazz and Mindful Music participants reported significantly less pain intensity and pain unpleasantness relative to the Jazz Education participants. Additionally, the Mindful Jazz participants reported significantly less pain intensity relative to both control groups (Jazz Education and Music Education participants, Tables *5* and 6). Although not significant, Mindful Jazz participants reported less pain intensity and anxiety compared to Mindful Music participants. The remaining contrasts were not significant. No effect of condition was observed for anxiety.

	Jazz Education	Music Education	Mindful Jazz	Mindful Music	F	p
Pain Intensity	4.72 (4.37 to 5.07)	4.61 (4.26 to 4.96)	4.05 (3.68 to 4.42)	4.16 (3.80 to 4.53)	3.63	.013
Pain Unpleasantness	4.41 (4.01 to 4.80)	4.00 (3.61 to 4.40)	3.62 (3.20 to 4.05)	3.60 (3.19 to 4.01)	3.61	.013
Anxiety	3.51 (3.12 to 3.89)	3.35 (2.97 to 3.73)	2.98 (2.57 to 3.39)	3.02 (2.62 to 3.42)	1.01	.39

TABLE 5: Estimated marginal means by treatment group for follow-up outcomes.

Statistical test used: generalized linear mixed modeling

		Music Education	Mindful Jazz	Mindful Music
Pain Intensity	Jazz Education	0.11 (-0.38 to 0.60)	0.67* (0.16 to 1.18)	0.55* (0.05 to 1.06)
	Music Education	-	0.56* (0.05 to 1.07)	0.45 (-0.06 to 0.95)
	Mindful Jazz	-	-	-0.11 (-0.63 to 0.41)
Pain Unpleasantness	Jazz Education	0.40 (-0.16 to 0.96)	0.78** (0.21 to 1.36)	0.81** (0.24 to 1.38)
	Music Education	-	0.38 (-0.20 to 0.96)	0.41 (-0.17 to 0.98)
	Mindful Jazz	-	-	0.03 (-0.57 to 0.62)
Anxiety	Jazz Education	0.15 (-0.39 to 0.70)	0.53 (-0.03 to 1.09)	0.49 (-0.07 to 1.04)
	Music Education	-	0.37 (-0.19 to 0.93)	0.33 (-0.22 to 0.89)
	Mindful Jazz	-	-	-0.04 (-0.61 to 0.53)

TABLE 6: Pairwise between group comparisons for follow-up outcomes.

Variables are presented as pairwise between group comparisons

Statistical test used: t test

* p<.05 ** p>.01

During the follow-up period, there was no difference in the number of times a participant listened to >10 minutes of their audio recording by condition (X2=2.14, p=.55): Jazz Education, k=456 (70%); Music Education, k=439 (72%), Mindful Jazz, k=350 (69%); Mindful Music, k=409 (70%).

Among the instances when a participant listened to 10 minutes of their audio recording (Table 7), the proportion that achieved a ⩾20% decrease in pain intensity differed significantly by group (X2=84.03, p<.001): Jazz Education, 182 listens out of a total of 456 listens (i.e., 29%); Music Education, 154 listens out of a total of 439 listens (26%), Mindful Jazz, 234 listens out of a total of 350 listens (50%); Mindful Music, 233 listens out of a total of 409 listens (41%). Mindful Jazz participants reported a ⩾20% decrease in pain intensity more frequently than Jazz Education (X2=48.71, p<.001), Music Education (X2=65.13, p<.001), and Mindful Music (X2=8.74, p=.003) participants. Mindful Music participants also reported a ⩾20% decrease in pain intensity more frequently than Jazz Education (X2=17.59, p<.001) and Music Education (X2=28.95, p<.001) participants. The remaining contrasts were not significant.

Variable	Condition	Pre-intervention	Post-intervention	Δ	T	p	d
Pain Intensity	Jazz Education	5.27 ± 1.69	4.56 ± 1.82	-0.72	14.25	< .001	0.67
	Music Education	4.95 ± 2.37	4.31 ± 2.30	-0.64	11.26	< .001	0.54
	Mindful Jazz	5.82 ± 2.29	4.28 ± 2.27	-1.54	17.37	< .001	0.93
	Mindful Music	5.18 ± 2.23	4.04 ± 2.36	-1.14	16.17	< .001	0.80
Pain Unpleasantness	Jazz Education	4.99 ± 2.08	4.18 ± 2.05	-0.81	13.40	< .001	0.63
	Music Education	4.51 ± 2.45	3.67 ± 2.28	-0.85	11.88	< .001	0.57
	Mindful Jazz	5.34 ± 2.72	3.65 ± 2.36	-1.69	16.64	< .001	0.89
	Mindful Music	4.94 ± 2.42	3.48 ± 2.25	-1.45	17.98	< .001	0.90
Anxiety	Jazz Education	4.33 ± 2.44	3.40 ± 2.34	-0.93	16.38	< .001	0.77
	Music Education	4.11 ± 2.69	3.25 ± 2.47	-0.87	11.88	< .001	0.57
	Mindful Jazz	4.54 ± 2.88	2.78 ± 2.20	-1.75	15.89	< .001	0.85
	Mindful Music	3.77 ± 2.71	2.51 ± 2.20	-1.25	17.38	< .001	0.86

TABLE 7: Within group changes in the primary variables of interest for follow-up outcomes.

Statistical test used: t test

Δ = change in value from pre- to post-intervention

d= standardized effect size

Discussion

Results suggest that mindfully listening to music can help to reduce pain, anxiety, and increase measures of mindfulness among patients with chronic pain. As expected, based on prior research, listening to music after music education (i.e., a music listening intervention) and mindfully listening to music (i.e., a mindful listening intervention) both helped to decrease patients' pain and anxiety from baseline to follow-up. However, both conditions of mindful listening (preferred music and jazz) reduced pain to a greater amount compared to music education, suggesting that mindfully listening to music is a more impactful pain reduction intervention compared to just listening to music without training in how to mindfully attend to it.

Importantly, mindful listening to music may help to increase engagement for patients who are less willing or able to participate in other types of pain-reductions interventions, including traditional MBIs. The entertaining nature of music, along with its ubiquity (i.e., music heard throughout the day, in cars/buses/trains, elevators, on the television, phone, etc) make it so that people can easily sustain a mindful listening practice throughout different parts of the day, every day, leading to potentially high engagement and retention in mindful listening practice. We expect that not all participants in the mindfulness conditions practiced daily mindfulness when listening to the music. There may be multiple reasons if people were still not engaged in mindful listening, but the high engagement rates found and relationship between engagement and pain intensity shed light on the need for future research to study how mindful listening may reduce pain.

Interestingly, and providing support for the argument for unfamiliar music, or at least improvisational jazz, Mindful Jazz participants who had listened to at least 2/3 of their audio recording were significantly more likely to have a 20% reduction in pain intensity compared to all other groups, including Mindful Music participants. Additionally, although not significant perhaps due to the small sample in this pilot, we found a trend suggesting that mindfully listening to jazz reduces anxiety and pain intensity compared to mindfully listening to one's preferred choice in music. As improvisational jazz musicians are "living in the moment" by spontaneously composing their music, learning how to listen to these notes might help listeners to similarly live in the moment and reduce anxiety. However, due to the small sample size from this pilot study, as well as potential confounders in combining multiple types of improvisational jazz songs and components of those songs together, future research is needed to further explore this hypothesis. Specifically, it is unclear whether and how certain types of improvisational jazz songs or components within the songs might be more effective than preferred or other styles of music for inducing this present-minded listening and reducing anxiety.

This study was limited by a small sample size (pilot study), lack of prior research on mindful listening interventions, and jazz and health, and having recruited a convenience sample of online participants. Given the high prevalence of internet/social media use in the United States, and the benefits in being able to easily and rapidly scale and implement studies using online sample and online interventions, we do not believe the online sample is a major limitation. Future research with a larger sample will help to better highlight and confirm the findings from this pilot study. Additional research is needed on mindful listening interventions, as well as the potential benefits of listening to improvisational music (including identifying the specific components/theoretical framework for this pathway). Future research can also include patients on opioid therapy to better understand how the intervention might affect their therapy progress and needs.

Conclusions

Mindfully listening to music may help to reduce pain, decrease anxiety, and increase mindfulness among patients with chronic pain. Due to the lack of effective non-pharmacological treatments for chronic pain, identifying alternative treatments for pain reduction are highly needed, especially those that are highly accessible, scalable, and have the potential for high engagement, such as mindful listening. However, prior to implementation, future research is needed in a larger sample to more definitively assess the impact of mindful listening on pain. Additional research is needed to better understand the mechanisms behind how different components of music (e.g., components of improvisational jazz) might strengthen a mindful listening intervention.

Appendices

January 2024

THE EXEMPT SELF DETERMINATION PROCESS AT UCI

To Whom it May Concern: The Exempt Self-Determination process may be used to self-determine certain types of exempt research at UCI, including exempt research conducted through the Undergraduate Research Opportunities Program (UROP). Exceptions do apply. Please refer to the Exempt Self Determination webpage on this topic. The Exempt Self-Determination process is initiated through Kuali Research Protocols (KRP). As part the Exempt Self-Determination process, if a study is eligible for selfdetermination, UCI IRB review is not required and will not be provided. In an effort to reduce administrative burden, the IRB has delegated this responsibility for specific exempt categories, to UCI Faculty Researchers. Should a sponsor inquire if the Exempt Self-Determination process, once complete, equates to an official UCI IRB confirmation of exemption, the answer is, “yes.” For studies that are submitted to the IRB where the Exempt Self-Determination process may be used instead, the study will be returned to the researcher to selfdetermine. In addition, amendments to studies that have undergone the self- determination process are to be maintained independently. No amendments should be submitted in KRP unless a change to the self-determined protocol results in the study no longer being eligible for self-determination. For exempt or expedited studies that require UCI IRB review, Lead Researchers must submit an IRB Application in KRP. UROP students using the Exempt Self-Determination process in KRP to conduct exempt research should contact UROP for questions related to the use of the tool. As part of using the Exempt Self-Determination process at UCI, Lead Researchers and Faculty Sponsors (as applicable) provide their assurance that they will follow relevant Human Research Protection Program (HRPP) policies and procedures, among other criteria.

For a copy of the assurance, please review the following page.

If you have any questions or comments, please contact HRP Staff.

AS PART OF THE EXEMPT SELF DETERMINATION PROCESS AT UCI, THE LEAD RESEARCHER AND FACULTY SPONSOR (AS APPLICABLE) ASSURES THE FOLLOWING:

As Primary Lead Researcher and Faculty Sponsor, we have ultimate responsibility for the performance of this study, the protection of the rights and welfare of the human subjects, and applicable UCI policies, as well as state statutes for research involving human subjects.

I hereby assure the following:

1. The information provided in this application is accurate to the best of my knowledge.

2. The information provided in this application has been discussed and shared with my Department Chair. Any requests for changes based on this discussion are included in this application upon submission.

3. All named individuals on this project have read the procedures outlined in the protocol, are aware of and have reviewed relevant HRPP Policies and Procedures and understand their role on the study.

4. All named individuals on this project have completed the required electronic educational research tutorials and have been made aware of the "Common Rule" (45 CFR Part 46) and acknowledge the importance of the Belmont Principles - Respect for Persons, Beneficence and Justice in conducting research involving human participants. Also, UCI has signed the Federalwide Assurance (FWA) that is available for review on the Human Research Protections (HRP) website.

5. Minor changes to the research that do not increase risk to participants, or significantly alter the study aims or procedures, such as the addition or removal of students researchers, do not require additional self-confirmation of exemption or approval from the IRB. Major changes that increase risk or constitute substantive revisions to the research including procedural changes will require a new self- confirmation of exemption or approval from the IRB.

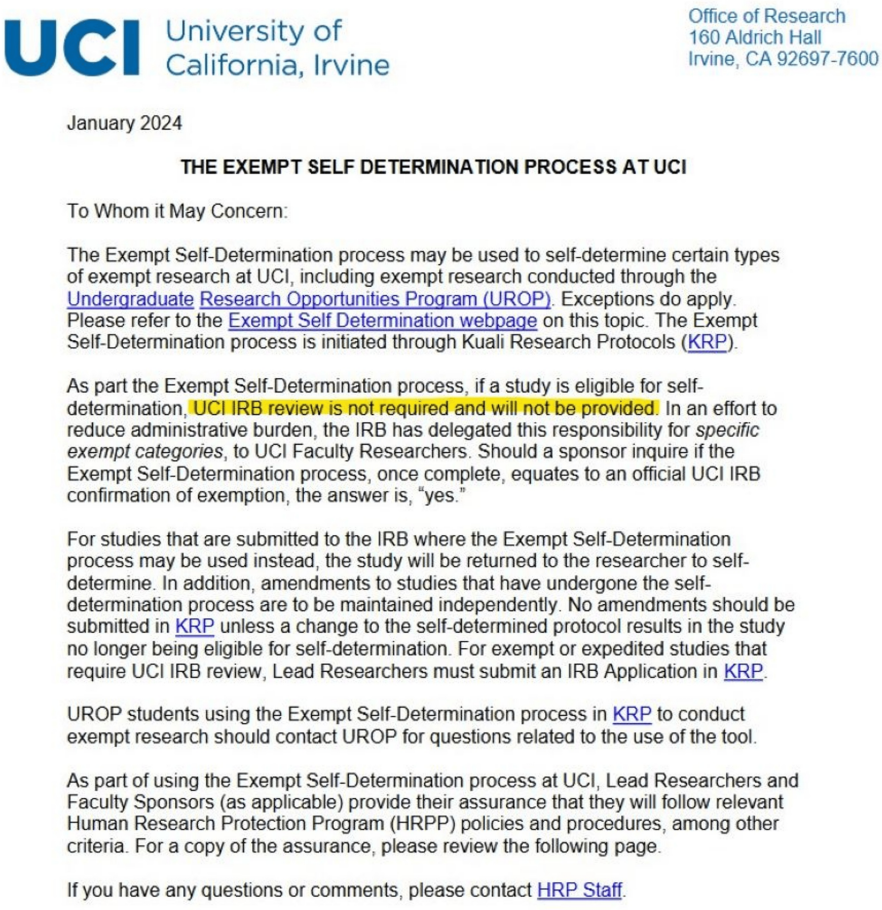
6. When conducting research at a non-UCI location outside of California (but within the United States), Lead Researchers must comply with the requirements and policies of the location and State laws regarding human research procedures.

7. When collaborating with another entity (e.g., another UC, CHOC, CSUF, or a local school district), the collaborators who are engaged in human research activities are responsible for securing their own (non-UCI) IRB exemption/approval.

8. The Exempt Self-Determination, consent documents including recruitment materials and data collection materials will be maintained by the Lead Researcher or Faculty Sponsor for 10 years beyond the completion of the research. If you will cease your affiliation with UCI during this 10-year period and intend to transfer your identifiable data to a new institution, please notify your Faculty Sponsor and Department to determine whether this is permissible.

9. This research study is subject to routine monitoring by the Human Research Protections (HRP) unit of the Office of Research. Through the Education Quality and Improvement Program (EQUIP) program, HRP staff conduct periodic quality improvement monitoring and educational outreach.

Attached in Figure *1* is a copy of this text in letter form from UCI, with the text highlighted showing that UCI documents this study as exempt and will not issue a formal letter specific to this study.



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January 2024

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FIGURE 1: UCI Exemption Letter

Figure *2* shows a screenshot of the status page from Kuali Research Protocols confirming it was submitted.

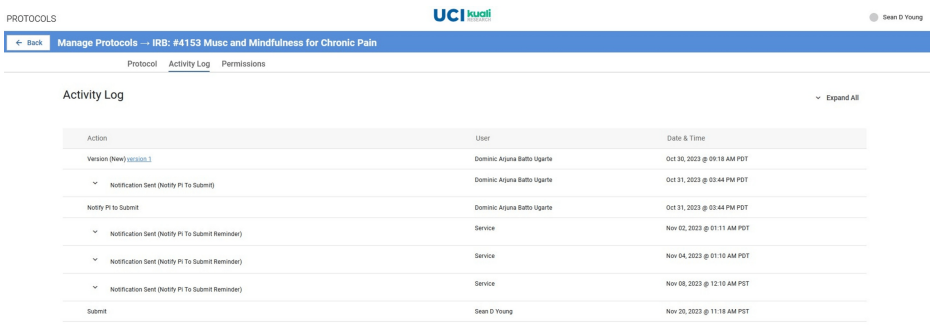

FIGURE 2: Kuali Research Protocols Submission

Additional Information

Disclosures

Human subjects: Consent for treatment and open access publication was obtained or waived by all participants in this study. University of California Irvine issued approval NA. This study was deemed self-exempt by the University of California, Irvine Institutional Review Board (IRB). . **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** Effort for SY was funded by the National Center on Complementary and Integrative Health (NCCIH)

and National Institute on Drug Abuse (NIDA). **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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