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The effect of listening to the sound of running water on pain and anxiety experienced during cannulation by hemodialysis patients: A randomized, controlled, open-label study

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Abstract

Introduction: This study was conducted to determine the effect of the sound of running water, which we had not previously encountered being used in dialysis patients, on invasive pain and anxiety experienced during cannulation.

Methods: The research was conducted as a randomized, controlled study. A descriptive form, a VAS pain scale, and state–trait anxiety scales were used as a data collection form. The data were analyzed on SPSS version 22.00 for Windows software. The independent groups *t*-test was applied to compare descriptive statistics such as mean, standard deviation, number, and percentage in independent groups, while categorical data were compared using the chi-square test. The effect of an independent variable on a dependent variable was tested using linear regression analysis. p values < 0.05 were considered statistically significant.

Results: The study was completed with 32 experimental and 33 control group patients. There was no significant difference in pre-intervention pain and anxiety between the groups. The pain levels of the patients after the first and 12th cannulations were significantly lower in the experimental group ($p < 0.05$). State and trait anxiety levels were also significantly lower in the experimental group at the 12th session ($p < 0.05$).

Conclusion: We conclude that the sound of running water has a significant positive effect on pain and anxiety experienced during cannulation by dialysis patients. We recommend that clinicians apply such a simple method as listening to the sound of running water for reducing pain and anxiety during invasive procedures.

KEYWORDS

anxiety, cannulation, hemodialysis, pain, the sound of water

1 | INTRODUCTION

Chronic kidney disease (CKD) is an important health problem with a growing worldwide prevalence [1]. Hemodialysis is a life-extending therapeutic method for patients with end-stage kidney failure [2]. Despite its stressful nature, hemodialysis is one of the most widespread renal replacement therapy methods. Ensuring safe and permanent vascular access is one of the essential requirements for successful hemodialysis for the survival of patients with CKD [3]. Arteriovenous fistula is the method of choice for safe vascular access in patients receiving long-term hemodialysis, since it permits long-term use with fewer complications and maximizes the effect of the hemodialysis by providing optimal blood flow [3, 4]. This procedure is required for every treatment in patients undergoing hemodialysis. Studies have reported that patients are exposed to an average estimated 312 cannulations a year [2]. Unfortunately, pain associated with arteriovenous fistula puncture is one of the most distressing problems, with more than one-fifth of patients undergoing hemodialysis describing it as unpleasant and unbearable [1]. Indeed, an annual survey of kidney disease patients in the UK reported that cannulation was repeatedly described as the third most unpleasant patient experience [2].

Pain being experienced at every session further exacerbates patients' fear, anxiety, and stress, thus resulting in irritability, depression, and insomnia, and adversely impacting on their quality of life [5, 6]. In addition, continuous pain can lead to patients avoiding cannulation for hemodialysis, preferring central venous catheters, and to non-compliance with treatment [2, 7]. Controlling pain and anxiety in order to increase patient comfort during cannulation and compliance with long-term treatment is therefore an important priority [1, 8].

Pain can be subjective and individual. However, one of the aims of nursing is to ensure patient comfort. Nurses therefore have an important responsibility in terms of the development and application of various approaches for overcoming pain. Effective pain management is an important evaluation index for nursing, and eliminating pain based on individual requirements is an important concept in high-quality nursing care [5]. Pharmacological methods aimed at controlling pain during arteriovenous cannulation in hemodialysis patients include local and topical anesthetics applied to the intervention site. Non-pharmacological methods include peripheral techniques (hot-cold application, therapeutic touching, acupuncture, and transcutaneous electrical nerve stimulation [TENS]), cognitive behavioral techniques (progressive relaxation exercises, distraction, and music), and other techniques (such as acupuncture, aromatherapy, and reflexology) [6, 7, 9, 10]. However, for reasons such as the complexity of the procedures and their time-consuming nature, and limitations posed by the hospital environment, these create difficulties in the clinical setting and are not widely employed [5].

Being present in and looking at nature are known to have a positive effect on the individual's well-being and self-confidence [11]. Studies have reported that natural sounds have a positive impact on states such as pain, anxiety, and stress [12, 13]. This suggests that listening to the sounds of nature may represent a simple and easily available intervention capable of positively affecting basic human stress systems. While several non-pharmacological methods have been used in the literature to reduce the invasive pain and anxiety experienced by hemodialysis patients during cannulation, this study was intended to determine the effect of the sound of running water, the recent use of which we did encounter but which has not been widely employed for hemodialysis patients, on cannulation-related pain and anxiety in that patient group. The present study is the first to use the sound of running water in hemodialysis patients.

1.1 | Objectives

Primary outcome: The primary outcome was the improvement of pain levels (the change in pain scores from pre-intervention to the 12th session for each patient).

Secondary outcome: The secondary outcome was the improvement of anxiety levels (the change in anxiety scores from pre-intervention to the 12th session for each patient).

2 | PATIENT AND METHODS

2.1 | Trial design

Patients undergoing hemodialysis (n:74) 3 days a week in two dialysis units in the west of Türkiye between December 15, 2023, and March 15, 2024, were included in this randomized, controlled open-label study.

2.2 | Participants

Prospective participants were included in the study if they were (1) aged 18 or over, (2) entering dialysis 3 days a week for at least 6 months, (3) had no communication problems, (4) were not using any psychiatric medication, and (5) consented to take part. Prospective participants (1) aged under 18, (2) with installed catheters, (3) with respiratory diseases, (4) with histories of allergies, (5) with

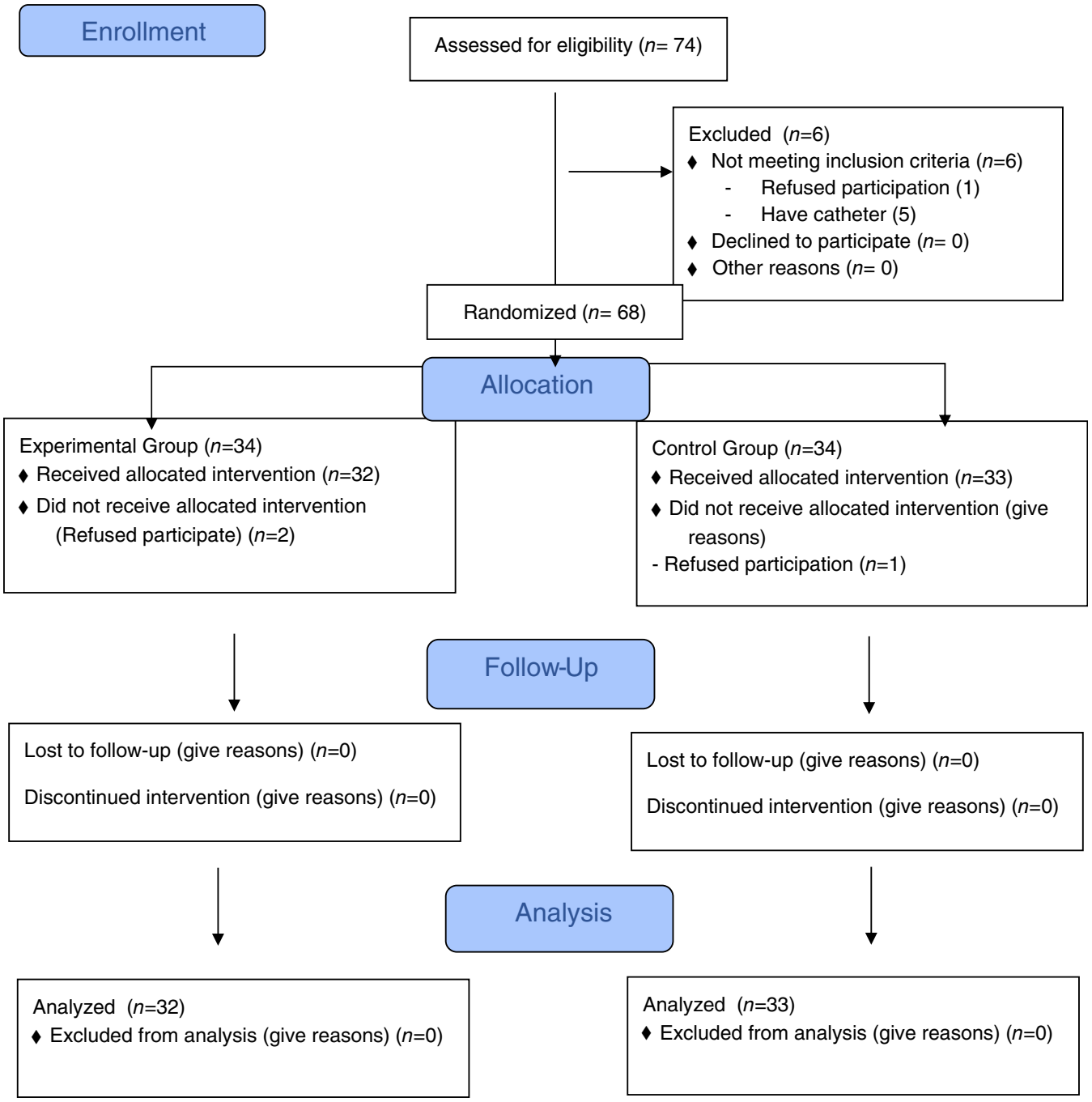

FIGURE 1 Consort diagram.

neuropathy or peripheral vascular disease, (6) who were using analgesic drugs at least 3 h prior to the hemodialysis session, (7) who were using any integrative method, (8) with infection in the fistula area, or with more than one cannulation applications, and (9) pregnant women were excluded from the study.

Sixty-five patients were screened for eligibility, and three were excluded based on the criteria above. At the end of the study, two members of the experimental group and one of the control group declined to take part, and the research was finally completed with 32 experimental and 33 control patients (Figure 1).

Written consent was obtained from participants. Ethical approval for this study was obtained from the Kirklareli University Medical Faculty ethical committee (E-37844677-199-104 984), and permission for the study was granted by the institutional chief physician's office. Written and verbal consent was obtained from the patients. The entire research was conducted in line with the principles of the Declaration of Helsinki.

2.3 | Interventions

The dialysis sessions were held on 3 days a week, Monday–Wednesday–Friday and Tuesday–Thursday–Saturday between 08.00 and 16.00 h. All patients consenting to take part were included in the scope of the research.

2.3.1 | Experimental group

The members of the experimental group listened to the sound of running water via Youtube with the assistance of the researcher's smartphone throughout the cannulation procedure (through earphones). The cannulation was performed by the same nurse in order to avoid any variation between the two hospitals.

The VAS scale was applied after each cannulation procedure, and the State and Trait Anxiety Inventory before the first session and after the 12th session. The patients were informed how to complete the pain scale and anxiety scales in the data collection tools. The forms on which these data were to be completed were given to the patients for them to do so. During that process, the researcher left the patients alone for a brief period. The data forms were then collected by another nurse in the unit. Blinding was thus performed, and we ensured that the patients would not give biased responses.

2.3.2 | The control group

This group received only standard care. Each group was observed for a total of 12 sessions.

2.4 | Outcomes

The study data were collected using a semi-structured questionnaire developed by the authors based on the previous literature [2, 9, 10] and consisting of 13 questions investigating the participants' descriptive characteristics, a Visual Analogue Scale (VAS), and the Spielberger State–Trait Anxiety Inventory. Data were collected using the face-to-face interview method, a process lasting approximately 20–25 min.

2.4.1 | The questionnaire investigating the participants' descriptive characteristics

This form investigating the participants' sociodemographic and clinical characteristics consisted of 13 questions. This form was completed at face-to-face interviews by the researchers in the second hour of hemodialysis therapy.

2.4.2 | Visual Analogue Scale (VAS)

A scale similar to that in previous studies was employed to measure pain levels [10, 14]. The patients were asked to evaluate the pain experienced immediately after fistula cannulation between 0 and 10, on which 0 = I experienced no pain and 10 10 = I experienced very severe pain.

2.4.3 | State–Trait Anxiety Inventory

The state anxiety scale determines how the individual feels at a specific moment and under specific conditions, while the trait anxiety scale determines the anxiety that the individual feels generally. Positive scores are given to Items 3, 4, 6, 7, 9, 12, 13, 14, 17, and 18 on the inventory (these increase total anxiety scores), while negative scores are awarded to Items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20 (which reduce total anxiety scores). During evaluation, each item is given a score between 1 (or −1) and 4 (or −4) depending on its positive or negative character. A constant value of 50 is added to the total obtained. The highest possible score is 80, and the lowest possible score is 20. The higher the total anxiety score, the higher the level of anxiety of the individual completing it. High scores indicate a high level of anxiety, and low scores a low level. The validity and reliability of the scale were investigated by Öner and Le Comple. Cronbach alpha values ranged between 0.83 and 0.92 for the State Anxiety Inventory and between 0.83 and 0.87 for the Trait Anxiety Inventory [15]. In the present study, Cronbach alpha values were 0.74 for the State Anxiety Inventory and 0.86 for the Trait Anxiety Inventory.

2.5 | Sample size

Power analysis was applied to calculate the minimum number of samples required in the research. This was performed using G*Power 3.1.9.4 software [16]. The relevant literature was examined in order to determine the effect size for the study. A study involving 60 individuals found a significant difference between experimental and control group mean VAS values [17]. Power analysis based on that study determined an effect size of 0.97 (Cohen's $d = 0.97$). No significant difference was observed between experimental and control group

anxiety levels in Çetinkaya and Karabulut's study of adult patients. In that study, the effect size was calculated at 1.82 [18]. Since that value represents a large effect size, we decided that a moderate effect size would be more appropriate in the present research (Cohen's $d = 0.50$). In this study, for the two-tailed hypothesis, with an effect size of 0.50 (Cohen's d), margin of error of 0.05 (α err probability), and power of 0.90 (1-β), the minimum number of samples required in the study was calculated at 60 individuals, 30 in the case group and 30 in the control group.

2.6 | Randomization

An open-label research population of 74 individuals was determined, 68 of whom met the inclusion criteria. These were assigned to an experimental group (34 patients) and a control group (34 patients) by an independent statistician with the assistance of appropriate computer software (randomizer. org). There is no blinding in the study.

2.7 | Statistical methods

The study data were analyzed on SPSS version 22.00 for Windows software. Mean plus standard deviation ($X \pm$ SD), number (n), and percentage (%) values were used to express descriptive statistics. The data were found to be normally distributed, and the independent groups t-test was applied for comparisons between the groups. The chi-square test was used to compare categorical variables.

Two-way analysis of covariance was used to analyze differences between two or more groups by controlling for the effect of a covariate on the dependent variable. All analyses were evaluated at a 95% confidence interval. p values < 0.05 were regarded as statistically significant.

3 | RESULTS

3.1 | Baseline characteristics

The demographic characteristics of the patients taking part in the study are shown in Table 1. Group analysis showed that men represented 65.6% of the experimental group, 62.5% used the puncture area cannulation technique, the fistula was in the brachiocephalic region in 68.8% of cases, fistula needle insertion was retrograde in 53.1% of cases, and that 62.5% of patients received standard hemodialysis. Men represented 57.6% of the patients in the control group. The rope ladder technique was applied in 90.9% of cases, the fistula was located in the brachiofacial region in 69.7% of cases, fistula needle insertion was retrograde in 60.6% of cases, and 78.8% of patients received standard type hemodialysis. No significant differences were observed between the groups' sociodemographic characteristics ($p > 0.05$). No significant difference was determined between the two groups in terms of age, or duration of hemodialysis or fistula ($p > 0.05$), and the groups exhibited similar characteristics. Analysis revealed no significant difference between the groups in terms of pre-cannulation pain and state or trait anxiety ($p > 0.05$) (Table 1). However, the cannulation technique variable differed significantly between the two groups ($p < 0.05$). In the light of the difference in cannulation techniques between the experimental and control groups, two-way covariance analysis (general linear model) was applied to determine whether that difference affected the final test scores. The effect of the cannulation technique on the final test scores was examined by keeping the pre-test scores for the experimental and control groups constant. The findings revealed that the effect of the group × cannulation technique on VAS was not significant (common effect f_{VAS} (1;59) = 0.100; $p = 0.753$). The common effect of the group*cannulation technique on state and trait anxiety was also determined to be insignificant (common effect for f_{state} anxiety (1;59) = 1.103; $p = 0.298$; common effect for f_{trait} anxiety (1;59) = 1.461; $p = 0.232$).

3.2 | Primary outcome measure

The groups' pain levels before and after the first and 12th cannulation sessions are shown in Table 2. No difference in pain levels was determined immediately before the first and 12th cannulations ($p > 0.005$). A comparison of pain intensity between the groups after the first and 12th cannulation sessions revealed that this was significantly lower in the experimental group after the 12th session ($p < 0.05$) (Table 2).

3.3 | Secondary outcome measure

The groups' state and trait anxiety levels before and after cannulation are shown in Table 3. There was no difference in either group in anxiety levels immediately before the 12th cannulation ($p > 0.005$). When state and trait anxiety levels were compared between groups after the 12th cannulation, it was found that they were lower in the experimental group and the difference was significant ($p < 0.05$). (Table 3).

TABLE 1 Distributions of the patients' demographic characteristics ($N = 65$).

Characteristics[a]	Experimental ($n = 32$)		Control ($n = 33$)		p value
	n	%	n	%	
Gender					
Female	11	34.4	14	42.4	0.605
Male	21	65.6	19	57.6	
Presence of chronic disease[d]					
Yes	32	100.0	33	100.0	
No	0	0	0	0	
Marital status[d]					
Married	32	100.0	33	100.0	
Single	0	0	0	0	
Educational status[d]					
Illiterate	4	12.5	6	18.2	0.801
Elementary school	19	59.4	19	57.6	
High school	9	28.1	8	24.2	
Cannulation technique					
Rope ladder	5	15.6	30	90.9	**0.000**
Buttonhole	7	21.9	3	9.1	
Area puncture	20	62.5	0	0.0	
Fistula location					
Brachiocephalic	22	68.8	23	69.7	0.934
Radiocephalic	10	31.2	10	30.3	
Fistula needle insertion					
Antegrade	15	46.9	13	39.4	0.543
Retrograde	17	53.1	20	60.6	
Hemodialysis type					
Na profile	12	37.5	7	21.2	0.149
Standard	20	62.5	26	78.8	

Characteristics[b]	Experimental ($n = 32$) $X \pm SD$	Control ($n = 33$) $X \pm SD$	p value
Age	51.09 ± 10.78	52.15 ± 8.67	0.664
Duration of hemodialysis (months)	64.84 ± 43.99	61.72 ± 47.95	0.786
Fistula age (months)	44.65 ± 38.05	53.09 ± 39.37	0.383
The diameter of the puncture needle[c]	1.00 ± 0.00	1.00 ± 0.00	

Note: Values are presented as number or mean ± standard deviation.
[a]Chi-square test.
[b]Independent sample t-test.
[c]t cannot be computed because the standard deviations of both groups are 0.
[d]No statistics are computed because presence of chronic disease is a constant.

4 | DISCUSSION

The principal limitations of this study are that only hemodialysis patients were included, and that the research was conducted in only two centers. While this study addresses the mechanism of the analgesic and calming effects of listening to the sound of running water, the lack of investigation of the sympathetic

TABLE 2 A comparison of pain severity between the groups before and after cannulation.

Pain severity	Experimental $X \pm SD$	Control $X \pm SD$	*p* value
Pre-procedural pain level	0,25 ± 0,43	0,15 ± 0,36	0.330
Pain severity before the 1st session of cannulation	1.33 ± 1.05	1.35 ± 1.62	0.245
Pain severity after the 1st session of cannulation	4.33 ± 2.05	6.25 ± 1.72	0.000*
Pain severity before the 12th session of cannulation	2.54 ± 1.5	3.79 ± 2.58	0.051
Pain severity after the 12th session of cannulation	3.75 ± 1.43	6.24 ± 1.75	0.000*

Note: Values are presented as mean ± standard deviation. *$p < 0.05$, statistically significant differences, independent groups *t*-test. "As adjustments for multiple comparison were not considered, outcomes other than pain severity after the 12th session of cannulation were exploratory and interpreted with caution."

TABLE 3 A comparison of state and trait anxiety levels between the groups.

Anxiety levels	Experimental $X \pm SD$	Control $X \pm SD$	*p* value
Pre-procedural state anxiety level	38.90 ± 4.84	37.54 ± 4.70	0.258
Pre-procedural trait anxiety level	46.62 ± 3.23	44.63 ± 3.29	0.153
State anxiety level before the 12th session of cannulation	37.75 ± 3.74	38.14 ± 3.52	0.063
State anxiety level after the 12th session of cannulation	31.12 ± 5.17	40.75 ± 2.27	0.000*
Trait anxiety level before the 12th session of cannulation	42.17 ± 2.76	43.25 ± 3.58	0.164
Trait anxiety level after the 12th session of cannulation	43.87 ± 2.80	45.03 ± 3.71	0.002*

Note: Values are presented as mean ± standard deviation. *$p < 0.05$, statistically significant differences, independent groups *t*-test. "As adjustments for multiple comparison were not considered, outcomes other than pain severity after the 12th session of cannulation were exploratory and interpreted with caution."

nervous system, anterior and posterior pituitary, adrenocortical hormones, etc., represents another limitation. A further limitation is that patient groups involving different cannulation techniques were not investigated. It is unclear to what extent this impacted on the study results.

The use of the arteriovenous fistula is preferred for safe vascular access in patients receiving long-term hemodialysis therapy because it permits long-term use with fewer complications and provides optimal blood flow [1, 5]. Cannulation is a procedure required for all hemodialysis patients, who are estimated to be subjected to it an average of 312 times a year [2]. One-fifth of patients undergoing treatment describe the pain experiences during the procedure as unbearable and the procedure as unpleasant [1, 9, 19]. In addition, the fact that patients experience pain at every session further exacerbates their fear, anxiety, and stress, resulting in irritability, depression, and insomnia and adversely affecting their quality of life [1, 6]. Moreover, constant pain may result in patents avoiding cannulation for hemodialysis and instead opting for central venous catheters, and in non-compliance with treatment [1, 2, 7]. Controlling pain and anxiety in these patients is therefore highly important in terms of increasing patient comfort during the procedure and enhancing treatment in the long term [1, 2].

Pharmacological methods for controlling pain during arteriovenous cannulation in hemodialysis patients include local and topical anesthetics applied to the intervention site. Non-pharmacological methods include peripheral techniques (hot-cold application, therapeutic touching, acupuncture, and TENS), cognitive and behavioral techniques (progressive relaxation exercises, distraction, fantasizing, and music), and other techniques (acupuncture, aromatherapy, and reflexology) [6, 7, 9]. However, for reasons such as the complexity of the procedures and their time-consuming nature, and limitations posed by the hospital environment, these create difficulties in clinical application and are not widely employed [5].

Examination of pain levels by sessions revealed an increase from the first to the eighth sessions in the experimental group, followed by a decrease after the ninth session. In the control group, pain decreased between the third and seventh sessions, with the exception of the second session, but increased significantly during the later sessions (8–12). Music has been described as a unique stimulus because it elicits both physiological and psychological responses in the listener [20]. Studies have reported that since music represents an abstract and subjective stimulus it can evoke different emotions in everyone, some becoming euphoric, while other feel an

intense sense of longing [21, 22]. This may result in differences in pain between the experimental and control groups.

Studies have reported music being listened to for 30 min for its relaxing effects prior to procedures, after which patients were evaluated in terms of pain and anxiety. Differences in the durations of listening to music are reported to be capable of affecting the response to pain [17, 23, 24]. In the present study, music was played to the experimental group for approximately 3 min prior to each cannulation. We think that adaptation to music exhibited its effects in the later sessions, and that the difference in pain levels between the control experimental groups also emerged during those sessions.

Finally, studies have also reported that differences in the sizes of the needles used and in the skills of cannulation operatives can also affect pain levels [5]. In the present study, however, 16 Gauge needles were used for all patients, and cannulation was performed by the same nurse. However, the procedure could not be performed with the same ease or ability in all patients. We think that patients may experience unsuccessful interventions that result in unwanted pain due to individual differences.

In this study, listening to the sound of running water, which is becoming increasingly popular but which we have not encountered being used in dialysis patients, significantly reduced the severity of post-cannulation pain in several sessions in the experimental group (Sessions 1 and 12). A systematic review examining the reliability and efficacy of various complementary heath approaches in the treatment of several symptoms in intensive care patients also reported that music and natural sounds were beneficial in the management of pain [25]. Inayama et al. determined a significant decrease in pain scores among hemodialysis patients listening to music during cannulation compared to a white noise group ($p = 0.02$) [26]. Other studies have examined other non-pharmacological methods. For example, Lee et al. reported significantly lower mean subjective pain scores following cannulation in an experimental group exposed to vapocoolant spray (1.78 ± 1.66) compared to control and placebo groups [5]. Abunab et al. also reported lower pain levels in an experimental group administered cryotherapy during arteriovenous cannulation (2.12 ± 0.9) compared to a control group [7]. This shows that listening to the sound of water, a cost-effective method entailing no risks or complications, may be effective and beneficial in reducing pain during cannulation in hemodialysis patients.

Anxiety can generally be managed using pharmacological and non-pharmacological methods. However, anxiolytic and analgesic agents cannot always be employed to treat procedural anxiety due to side effects such as sedation, central respiratory depression, arterial hypotension, and bradycardia [27]. In contrast, non-pharmacological methods are inexpensive, easily applied, non-invasive, and entail few side effects. Listening to natural sounds is another relaxation technique reported in the literature. These sounds are emitted by natural sources such as wind, rain, the oceans, rivers, birds, and animals, and result in physical and mental relaxation [28, 29].

In the present study, state and trait anxiety levels were significantly lower in the patients who listened to the sound of running water during the cannulation procedure. Previous studies have revealed that merely listening to the sounds of nature can produce a state of relaxation through stress-lowering effects on the endocrine and autonomous nervous system [12, 27, 30, 31]. Arai et al. allowed a group of patients undergoing surgery under epidural anesthesia to listen to natural sounds, while no acoustic stimulus was applied to the members of the control group [12]. The authors reported that salivary alpha-amylase activity, a sympathetic nervous system marker, was significantly lower in the patients exposed to natural sounds. In another experimental study, listening to the sound of water prior to a major stressful situation significantly reduced the cortisol response, a marker of hypothalamic–pituitary–adrenal axis activation [13]. Annerstedt et al. also reported that parasympathetic activation developed in a healthy group listening to natural sounds in a virtual environment in the laboratory, ad determined that stress can be easily improved by the addition of natural sounds to such settings [30]. Similarly, Çulha et al. reported a significantly lower level of anxiety in patients from an experimental group who listened to the sound of running water on smartphones during pressure-flow investigation compared to a control group during urodynamics (1.83 ± 2.77 and 4.93 ± 1.84, respectively) and after (1.43 ± 2.65 and 5.03 ± 2.03, respectively) ($p < 0.001$) [32]. The fact that the sound of running water during cannulation reduced the patients' anxiety levels in this study may be attributable to the meditation effect of natural sounds, as well as to potential endocrine and autonomic nervous system changes. This also indicates that listening to the sounds of nature in hemodialysis patients may represent a simple and easily available method capable of positively affecting basic human stress systems.

5 | CONCLUSIONS

We conclude that listening to the sound of running water has a positive effect on pain and anxiety levels

experienced by hemodialysis during cannulation. The sound of running water appears to be a method capable of distracting the individual's attention. The application of the sound of running water, a simple and effective technique, will be useful for patients during invasive procedures thought by clinicians to be capable of raising pain and anxiety levels.

We recommend that further studies be performed involving larger patient groups, larger samples, and different methods.

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CONFLICT OF INTEREST STATEMENT

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS STATEMENT

Ethical approval for this study was obtained from the Kırklareli University Medical Faculty ethical committee (E-37844677-199-104984), and permission for the study was granted by the institutional chief physician's office.

PATIENT CONSENT STATEMENT

Written and verbal consent was obtained from the patients. The entire research was conducted in line with the principles of the Declaration of Helsinki.

CLINICAL TRIAL REGISTRATION

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