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Original Article

Effect of Play Therapy versus Virtual Reality on Reducing Anxiety in Children Pre-Cardiac Catheterization: A randomized Single-Blind Trial

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Abstract

Objective: This study aimed to compare the effectiveness of virtual reality (VR) versus play therapy in reducing pre-procedural anxiety among children scheduled for cardiac catheterization, and to evaluate parental satisfaction with these interventions.

Method: A randomized, assessor-blinded, pretest-posttest comparative trial was conducted at Al-Nasiriyah Heart Hospital between December 2025 and February 2026. A total of 75 children aged 3-7 years with congenital heart defects were randomly allocated into three equal groups (n = 25 each): VR (15 minutes of immersive 3D video), play therapy (15 minutes of coloring activity), and control (standard care). Anxiety was assessed using the Modified Yale Preoperative Anxiety Scale (mYPAS) at four time points (two pre-intervention and two post-intervention measurements). The outcome assessor was blinded to group allocation. Data were analyzed using analysis of covariance (ANCOVA) with Bonferroni-adjusted post-hoc comparisons to control for baseline age and anxiety differences.

Results: The VR group demonstrated the lowest mean anxiety score post-intervention (mean = 5.04 ± 0.20), followed by the play therapy group (mean = 5.88 ± 1.33), while the control group maintained consistently higher anxiety levels (mean = 12.24 ± 1.39). ANCOVA, controlling for baseline anxiety and age, revealed a statistically significant main effect of intervention group on post-intervention anxiety scores [F 2, 70) = 38.24, $P < 0.001$, $\eta^2 = 0.52$]. Post-hoc pairwise comparisons with Bonferroni correction showed that, compared with the control group, both VR ($P < 0.001$) and play therapy ($P < 0.001$) significantly reduced anxiety. Furthermore, VR produced significantly greater anxiety reduction than play therapy ($P = 0.03$, Cohen's d = 0.83). Parental satisfaction was uniformly high across both intervention groups, with no significant difference between them ($P = 0.568$).

Conclusion: Both VR and play therapy are effective non-pharmacological interventions for reducing pre-catheterization anxiety in children. VR demonstrated superior anxiolytic effects compared to play therapy, with a large effect size. Integrating VR-based distraction into routine pre-procedural nursing care may enhance pediatric procedural experiences and improve clinical outcomes.

Key words: *Anxiety; Pediatrics; Preschool Child; Play Therapy; Randomized Controlled Trial; Virtual Reality*

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Cardiac catheterization is an essential diagnostic and therapeutic intervention for children with congenital heart defects and other cardiovascular conditions (1). While this procedure is life-saving, it represents a significant source of psychological distress for pediatric patients. Surgical and invasive procedures are inherently threatening experiences for children, often eliciting fear, perceived loss of control, anticipation of pain, and anxiety over separation from their parents (2, 3). Epidemiological evidence indicates that approximately 60-80% of children experience clinically significant anxiety before invasive procedures, with preoperative anxiety rates in pediatric populations ranging from 65% to 80% (4, 5). Preprocedural anxiety in children is not merely a transient emotional response. It has measurable physiological and psychological consequences. Elevated anxiety activates the hypothalamic-pituitary-adrenal axis and sympathetic nervous system, leading to increased heart rate, blood pressure, and cortisol levels (6). These physiological changes can compromise hemodynamic stability during catheterization, increase the risk of procedural complications, and negatively impact recovery trajectories (7, 8). Furthermore, anxious children often exhibit poor cooperation during procedures, necessitating greater sedation, prolonged procedure times, and increased healthcare resource utilization (9).

Given these concerns, effective anxiety management before cardiac catheterization is paramount. Strategies are broadly categorized into pharmacological and non-pharmacological approaches. Pharmacological interventions, including anxiolytics and sedatives, are effective but carry risks of adverse effects, respiratory depression, and prolonged recovery (10). Non-pharmacological interventions offer a safer alternative, providing anxiolytic benefits without pharmacological side effects. These include preoperative education, music therapy, therapeutic play, storytelling, and distraction techniques (11, 12). Among distraction-based interventions, virtual reality (VR) has emerged as a particularly promising modality. VR creates immersive, three-dimensional environments that engage multiple sensory channels simultaneously, diverting the child's attention away from threatening procedural stimuli (13, 14). Studies have demonstrated that VR effectively reduces pain and anxiety during various pediatric procedures, including venipuncture, wound care, and dental procedures (15-17). By transforming children from passive recipients of care into active participants in a virtual world, VR enhances coping and emotional regulation (18, 19). Therapeutic play is another well-established non-pharmacological intervention in pediatric healthcare. Play is fundamental to children's development, enabling them to process experiences, express emotions, and gain a sense of control in unfamiliar situations (20). Structured therapeutic play activities, such as coloring, drawing, and medical play, have been shown to reduce preoperative anxiety, improve cooperation, and enhance psychological well-being (21, 22). Coloring activities, in particular, promote relaxation and emotional expression, serving as an effective coping mechanism for stress and anxiety (23).

Despite the individual evidence supporting VR and play therapy, comparative studies specifically in the context of pediatric cardiac catheterization are notably scarce. To our knowledge, no study has directly compared the anxiolytic efficacy of VR versus play therapy in children undergoing cardiac catheterization. This knowledge gap limits evidence-based decision-making regarding which non-pharmacological strategy to prioritize in clinical practice. The present study addresses this gap by systematically comparing both interventions within a rigorous methodological framework. The primary objective of this study was to compare the effectiveness of VR and play therapy in reducing preprocedural anxiety among children undergoing cardiac catheterization. Secondary objectives included evaluating parental satisfaction with these interventions and examining the feasibility of integrating these strategies into routine nursing care. We hypothesized that both VR and play therapy would significantly reduce anxiety compared to standard care, and that VR would demonstrate superior anxiolytic effects due to its higher immersive capacity and multisensory engagement.

Materials and Methods

This study employed a randomized, assessor-blinded, pretest-posttest comparative trial design conducted at Al-Nasiriyah Heart Hospital, Thi-Qar Governorate, Iraq, specifically within the Congenital Heart Defects Unit. This tertiary referral center performs approximately 200 pediatric cardiac catheterization procedures annually. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The trial was registered with the local institutional review board (approval number: 1608, dated April 25, 2025). The researchers obtained ethical clearance from the Ethics Committee of the College of Nursing, University of Baghdad, Iraq. Written informed consent was obtained from the parents or legal guardians of all participating children prior to enrollment.

Participants

The target population comprised 90 children diagnosed with congenital heart defects and scheduled for elective cardiac catheterization during the study period (December 10, 2025 to February 7, 2026). Of these, 85 children were assessed for eligibility. Ten children were excluded based on predefined criteria, resulting in a final sample of 75 children who met the inclusion criteria and whose parents provided written informed consent. No participants withdrew or were lost to follow-up, resulting in a 0% attrition rate. Children were eligible for inclusion if they were aged 3 to 7 years, medically diagnosed with a congenital heart defect, scheduled for

elective cardiac catheterization, conscious and alert at the time of enrollment, and if they had a parent or legal guardian willing to provide written informed consent. Exclusion criteria included diagnosed mental or psychological disorders, visual or hearing impairments that prevented participation in VR or play activities, previous cardiac catheterization experience (to control for prior exposure effects), concurrent anxiolytic or sedative medications (excluding routine premedication), or developmental delays affecting comprehension or cooperation.

Sample size was determined using G*Power software (version 3.1.9.7) for a repeated measures analysis of variance (ANOVA) with three groups and four measurement time points. Based on previous studies reporting medium to large effect sizes (Cohen's f = 0.30-0.40) for distraction interventions on pediatric anxiety (8, 24), with $\alpha = 0.05$, power = 0.85, and an assumed correlation among repeated measures of 0.5, a minimum of 22 participants per group was required. To account for potential attrition and missing data, we recruited 25 participants per group (total N = 75).

Randomization and allocation concealment

Following recruitment and baseline assessment, eligible children were randomly allocated into three equal groups (n = 25 each): VR group, play therapy group, and control group. Randomization was performed using a computer-generated random numbers table by an independent researcher who was not involved in data collection or outcome assessment. Allocation concealment was maintained using sequentially numbered, sealed, opaque envelopes. Envelopes were opened immediately before the intervention session by the interventionist. This process ensured that neither the researchers responsible for recruitment nor the outcome assessor could predict group assignment.

Blinding

Due to the distinct nature of the interventions, blinding of participating children and interventionists was not feasible. Children in the VR group were aware they were wearing a headset, while those in the play therapy group knew they were coloring. However, the outcome assessor (i.e., the researcher responsible for administering the Modified Yale Preoperative Anxiety Scale [mYPAS]) was blinded to group allocation throughout the study. The outcome assessor did not observe any intervention sessions and had no contact with the interventionist. Children were instructed not to disclose their activity to the assessor. Data analysis was also performed by a statistician blinded to group codes to further reduce analytical bias. This assessor-blinded design minimized detection bias and strengthened the internal validity of the anxiety measurements.

Interventions

All interventions were delivered in a quiet, private room adjacent to the cardiac catheterization suite, on the day of admission, and then again, the following day, approximately 60-90 minutes before the scheduled procedure. Parents were present throughout the intervention period to provide emotional support and comfort. Children in the VR group received a 15-minute immersive distraction experience during both sessions using a commercially available VR headset (Oculus Quest 2). The content consisted of two three-dimensional video clips: a 7.5-minute animated journey through a coral reef featuring colorful fish, sea turtles, and gentle ocean sounds (Underwater Adventure), and a 7.5-minute animated tour through a magical forest with friendly animals, butterflies, and calming nature sounds (Forest Exploration). Both videos were dubbed in Arabic using a child's voice to ensure linguistic and cultural appropriateness. The VR headset was adjusted for each child's head size and comfort. Children were encouraged to look around and explore the virtual environment freely. The interventionist remained present to monitor the child and ensure safety.

Children in the play therapy group received a 15-minute structured coloring activity on both occasions. Each child was provided with a set of 12 non-toxic colored pencils, a coloring book featuring age-appropriate images (animals, cartoon characters, nature scenes), and a blank sheet of paper for free expression. Children were encouraged to color freely while the interventionist engaged them in supportive conversation about the images. The therapeutic interaction focused on creating a calm, safe environment and facilitating emotional expression through art. This duration was selected based on previous studies demonstrating optimal engagement periods for young children (21, 25). Moreover, children in the control group received standard care, which consisted of routine preprocedural preparation by the nursing staff, including verbal explanation of the procedure (age-appropriate), vital signs monitoring, completion of preprocedural checklists, and parental presence and comfort measures. No additional structured distraction or therapeutic activity was provided during the 15-minute period corresponding to the intervention sessions. The control group was included to account for natural fluctuations in anxiety over time and the effect of standard nursing care.

Outcome measures

The primary outcome was preprocedural anxiety, assessed using the mYPAS, a validated observational tool designed specifically for evaluating anxiety in pediatric patients (26). The mYPAS assesses anxiety through five behavioral domains: activity (motor activity level), emotional expressivity (facial expressions and emotional state), state of arousal (alertness and vigilance), vocalization (speech patterns and volume), and interaction with parents (engagement and seeking comfort). Each domain is scored on a 4-point scale (1-4), with total scores ranging from 5 (minimal anxiety) to 20 (severe anxiety). Higher scores indicate higher anxiety levels. The Arabic version of the mYPAS was translated and back-translated by bilingual experts, and content validity was confirmed by a panel of five pediatric

nursing specialists. Inter-rater reliability was established through independent scoring of 15 pilot sessions (intraclass correlation coefficient = 0.89, 95% CI: 0.82-0.94), and internal consistency was acceptable (Cronbach's α = 0.81).

Additionally, parental satisfaction was assessed using a 10-item structured questionnaire developed by the researchers, covering aspects of intervention acceptability, perceived effectiveness, and overall satisfaction. Responses were recorded on a 4-point Likert scale (1 = strongly disagree to 4 = strongly agree), with total scores ranging from 10 to 40. Higher scores indicated greater satisfaction. The questionnaire was reviewed for content validity by five experts and demonstrated acceptable internal consistency (Cronbach's α = 0.78). Parental satisfaction data were collected from parents in the intervention groups only (VR and play therapy).

Procedure

Data collection was conducted by trained research assistants who were not involved in intervention delivery. The outcome assessor, who was blinded to group allocation, completed the mYPAS assessments at each time point. Demographic and clinical data were collected from medical records and parental interviews. Intervention sessions were conducted by a separate research assistant who was not involved in outcome assessment. All data were recorded on standardized data collection forms and entered into a secure database. Anxiety was assessed at four time points: two pre-intervention measurements (Day 1, pre-intervention and Day 2, pre-intervention) and two post-intervention measurements (Day 1, post-intervention and Day 2, post-intervention). The Day 1 measurements were taken upon admission (approximately 24 hours before the procedure), and Day 2 measurements were taken approximately 60-90 minutes before the catheterization, immediately before and after the intervention.

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 27. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to summarize demographic and clinical characteristics. Between-group comparisons of categorical variables were performed using the Chi-square test or Fisher's exact test, as appropriate. For continuous variables, the Shapiro-Wilk test was used to assess normality, and Levene's test was used to assess homogeneity of variances. Because age differed significantly across study groups at baseline ($P < 0.001$), analysis of covariance (ANCOVA) was performed with age as a covariate to control for its potential confounding effect on anxiety outcomes. The primary analysis used a one-way ANCOVA to compare post-intervention anxiety scores across the three groups, with baseline anxiety scores and age as covariates. The assumption of homogeneity of regression slopes was verified by testing the interaction between group and covariates ($P > 0.05$ for all). Normality of residuals was confirmed using the Shapiro-Wilk test ($P > 0.05$), and homogeneity of variance was confirmed using Levene's test ($P > 0.05$). Post-hoc pairwise comparisons were conducted using Bonferroni correction for multiple comparisons to control the family-wise error rate. Effect sizes were calculated using partial eta-squared (η^2) for ANCOVA and Cohen's d for pairwise comparisons. A P-value of less than 0.05 was considered statistically significant, and all tests were two-tailed. Missing data were minimal (< 2%) and were handled using listwise deletion, as the missingness was determined to be completely at random (Little's MCAR test, $P = 0.67$).

Results

A total of 75 children participated in the study, with 25 in each of the three groups (VR, play therapy, and control), as shown in Figure 1. The overall mean age of participants was 5.0 ± 1.5 years, with the highest proportion (37.3%) falling within the age group of 3 to less than 5 years, followed by the age group of 5 to less than 7 years (36.0%). Male children constituted 62.7% of the sample, with a male-to-female ratio of approximately 1.7:1. Birth order—defined as the child's position among siblings—was distributed as follows: 37.3% were first-born, 34.7% were second-born, 22.7% were third-born, and 5.3% were fourth-born or later. Most children (64.0%) had 1 to 3 siblings, while 28.0% had 4 to 6 siblings, and 8.0% had no siblings. Table 1 presents the sociodemographic characteristics of the total sample. The sex distribution did not differ significantly between groups ($\chi^2 = 1.600$, $P = 0.209$). Important baseline differences were observed in age distribution across groups. The VR group had a higher mean age (6.4 ± 0.6 years), while the play therapy group had a lower mean age (4.0 ± 0.8 years) and the control group had an intermediate mean age (5.0 ± 1.6 years). These age differences were statistically significant (Kruskal-Wallis $H = 25.141$, $P < 0.001$). The number of siblings also differed significantly between groups ($\chi^2 = 7.028$, $P = 0.002$), with the VR group having a higher proportion of children with no siblings (48.0%) compared to the play therapy (8.0%) and control (16.0%) groups. Birth order did not differ significantly between groups ($\chi^2 = 2.478$, $P = 0.092$).

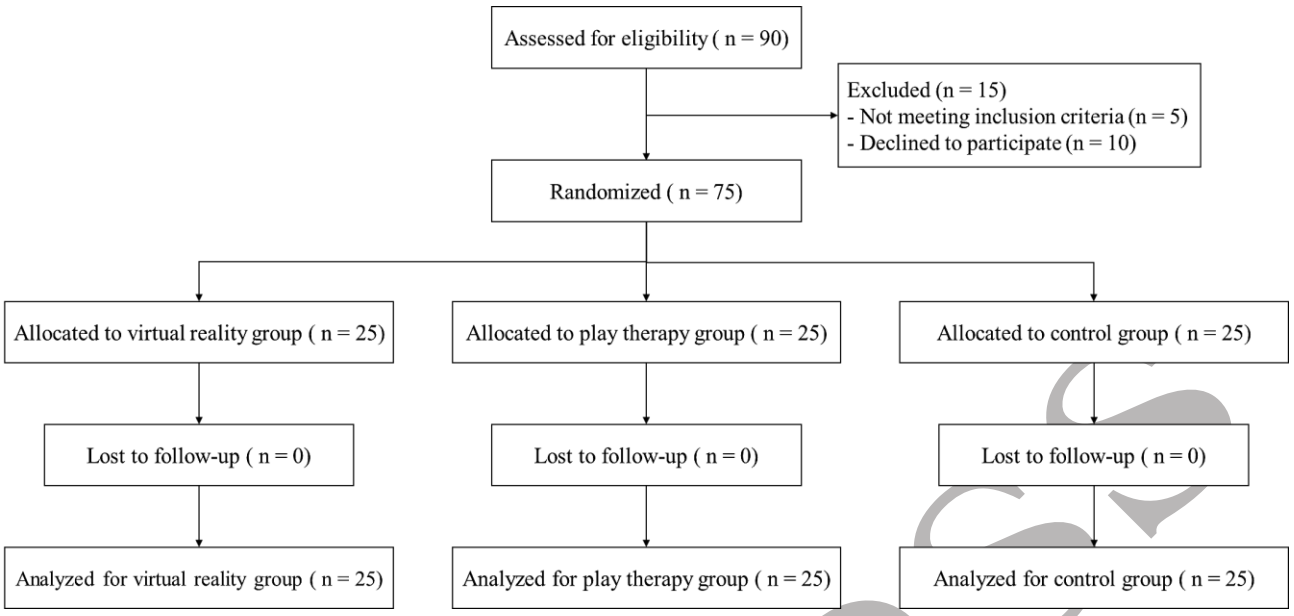

Figure 1. Consort Flow Diagram of Different Steps Involved in This Trial to Compare the Effect of Virtual Reality and Play Therapy on Reducing Anxiety in Children Pre-Cardiac Catheterization

Table 1. Sociodemographic Characteristics of Children (N = 75) Participating in the Trial to Reduce the Pre-Procedural Anxiety Using Virtual Reality or Play Therapy

Variable	Category	Control (n = 25)	VR (n = 25)	Play Therapy (n = 25)	Test Statistic	P-value
Age (years)	3 – < 5	9 (36.0%)	0 (0.0%)	19 (76.0%)	H = 25.141	< 0.001*
	5 – < 7	8 (32.0%)	13 (52.0%)	6 (24.0%)		
	≥ 7	8 (32.0%)	12 (48.0%)	0 (0.0%)		
	Mean ± SD	5.0 ± 1.6	6.4 ± 0.6	4.0 ± 0.8		
Sex	Male	19 (76.0%)	13 (52.0%)	15 (60.0%)	χ^2 = 1.600	0.209
	Female	6 (24.0%)	12 (48.0%)	10 (40.0%)		
Birth Order	First	11 (44.0%)	9 (36.0%)	8 (32.0%)	χ^2 = 2.478	0.092
	Second	11 (44.0%)	3 (12.0%)	12 (48.0%)		
	Third	3 (12.0%)	11 (44.0%)	3 (12.0%)		
	Fourth +	0 (0.0%)	2 (8.0%)	2 (8.0%)		
Siblings	None	4 (16.0%)	12 (48.0%)	2 (8.0%)	χ^2 = 7.028	0.002*
	1–3	17 (68.0%)	13 (52.0%)	19 (76.0%)		
	4–6	4 (16.0%)	0 (0.0%)	4 (16.0%)		

*H = Kruskal-Wallis test statistic; VR = Virtual Reality; χ^2 = Chi-square test statistic; Statistically significant (P < 0.05)

Table 2 and Figure 2 present the anxiety levels and scores among children across all three groups at each measurement time point. In the control group, children consistently demonstrated moderate anxiety levels throughout the study period. At the first pre-intervention measurement at Day 1, 100.0% of children exhibited moderate anxiety, with a mean score of 11.20 ± 1.32. At Day 1 post-intervention, anxiety scores showed a slight increase to 12.32 ± 1.464, with 96.0% in the moderate category and 4.0% in the severe category. At Day 2 pre-intervention, all children remained in the moderate anxiety category (mean = 11.48 ± 0.91), and at Day 2 post-intervention, all 25 children (100.0%) continued to exhibit moderate anxiety (mean = 12.24 ± 1.39). This pattern indicates no spontaneous reduction in anxiety over time without active intervention. In contrast, the VR group demonstrated substantial and clinically significant anxiety reduction. At baseline (Day 1 pre-intervention), 96.0% of children exhibited moderate anxiety, with a mean score of 10.80 ± 1.19. Following the VR intervention, a complete shift occurred: at Day 1 post-intervention, all 25 children (100.0%) moved into the mild anxiety category, with a mean score of 5.24 ± 0.43. This reduction was sustained at Day 2 post-

intervention, where all children remained in the mild anxiety category with a mean score of 5.04 ± 0.20. Notably, 40.0% of children in the VR group were already in the mild anxiety category at Day 2 pre-intervention (mean = 8.84 ± 1.37), indicating sustained carryover effects from the previous day's intervention. The play therapy group also demonstrated significant anxiety improvement. At baseline, the majority (88.0%) exhibited moderate anxiety, while 12.0% showed severe anxiety, with a mean score of 12.56 ± 1.68. Following the intervention, 92.0% of children moved to the mild anxiety category at Day 1 post-intervention (mean = 6.60 ± 1.32), and 92.0% remained in the mild anxiety category at Day 2 post-intervention (mean = 5.88 ± 1.33). Both intervention groups showed sustained anxiety reduction, but the VR group achieved consistently lower scores and a greater proportion of children in the mild anxiety category at all post-intervention time points.

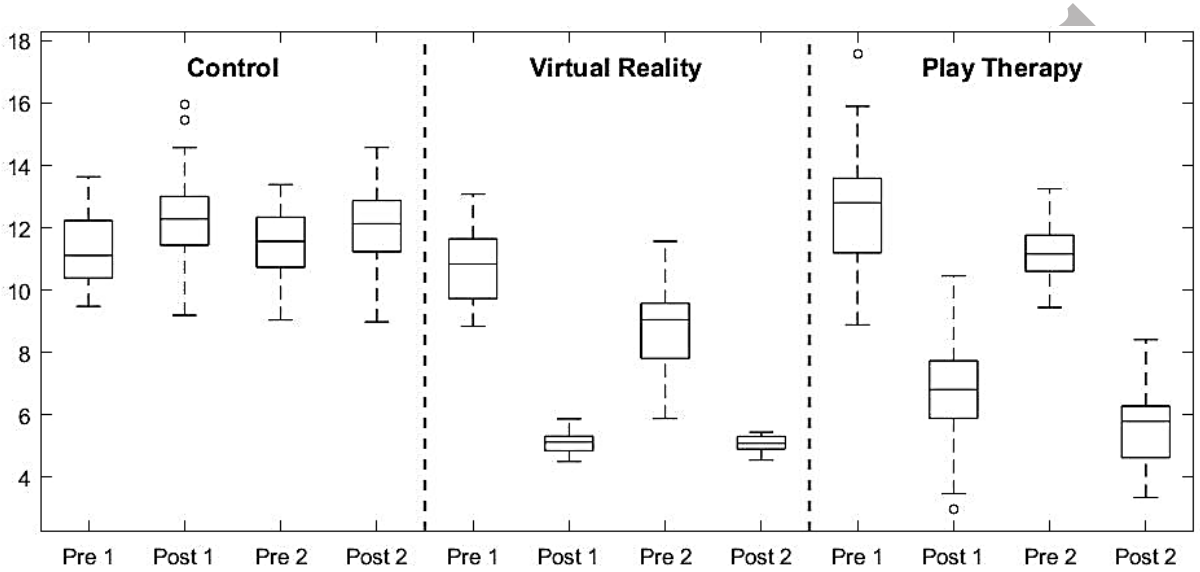

Figure 2. Boxplots of Anxiety Scores Across Virtual Reality and Play Therapy Groups at Different Time Points

Table 2. Anxiety Scores and Levels at Pre- and Post-Intervention Time Points in the Virtual Reality and Play Therapy Groups

Group	Time Point	Anxiety Level	n (%)	Mean ± SD
Control (n = 25)	Day 1 Pre	Moderate	25 (100.0%)	11.20 ± 1.323
	Day 1 Post	Moderate	24 (96.0%)	12.32 ± 1.464
		Severe	1 (4.0%)	
	Day 2 Pre	Moderate	25 (100.0%)	11.48 ± 0.911
	Day 2 Post	Moderate	25 (100.0%)	12.24 ± 1.393
VR (n = 25)	Day 1 Pre	Mild	1 (4.0%)	10.80 ± 1.190
		Moderate	24 (96.0%)	
	Day 1 Post	Mild	25 (100.0%)	5.24 ± 0.436
	Day 2 Pre	Mild	10 (40.0%)	8.84 ± 1.375
		Moderate	15 (60.0%)	
	Day 2 Post	Mild	25 (100.0%)	5.04 ± 0.200
Play Therapy (n = 25)	Day 1 Pre	Moderate	22 (88.0%)	12.56 ± 1.685
		Severe	3 (12.0%)	
	Day 1 Post	Mild	23 (92.0%)	6.60 ± 1.323
		Moderate	2 (8.0%)	
	Day 2 Pre	Mild	3 (12.0%)	10.60 ± 1.323
		Moderate	22 (88.0%)	
	Day 2 Post	Mild	23 (92.0%)	5.88 ± 1.333
		Moderate	2 (8.0%)	

Table 3 presents the results of the between-group comparisons using the Mann-Whitney U test at each time point. At Day 1 pre-intervention, there were no significant differences in anxiety scores between the control and VR groups ($Z = -3.685$, $P = 0.077$) or between the control and play therapy groups ($P > 0.05$), confirming baseline equivalence in anxiety levels despite age differences. At Day 1 post-intervention, both intervention groups showed significantly lower anxiety scores compared to the control group. The VR group had a mean rank of 13.00 compared to 37.92 for the control group ($Z = -6.072$, $P < 0.001$), and the play therapy group had a mean rank of 13.08 compared to 37.92 ($Z = -6.168$, $P < 0.001$). These differences were sustained at Day 2 post-intervention for both the VR and play therapy groups (mean rank = 13.00 versus 38.00, $Z = -6.168$, $P < 0.001$). Direct comparison between the two intervention groups revealed that VR produced significantly lower anxiety scores at both post-intervention time points. At Day 1 post-intervention, the VR group had a mean rank of 22.50 compared to 28.50 for the play therapy group ($Z = -2.015$, $P = 0.044$). At Day 2 post-intervention, the VR group had a mean rank of 23.00 compared to 28.00 for the play therapy group ($Z = -2.457$, $P = 0.014$). These findings indicate that while both interventions were effective, VR demonstrated superior anxiety reduction.

Due to the significant baseline age differences between groups ($P < 0.001$) and to control for pre-existing variability in anxiety levels, ANCOVA was performed with post-intervention anxiety scores (Day 2 post-intervention) as the dependent variable, intervention group as the fixed factor, and baseline anxiety (Day 1 pre-intervention) and age as covariates. The assumptions of homogeneity of regression slopes (group × covariate interactions: $P > 0.05$ for both), normality of residuals (Shapiro-Wilk test, $P = 0.12$), and homogeneity of variance (Levene's test, $P = 0.23$) were verified and met. After controlling for both baseline anxiety and age, the main effect of intervention group on post-intervention anxiety scores remained highly significant [$F(2, 70) = 38.24$, $P < 0.001$, $\eta^2 = 0.52$]. This large effect size indicates that approximately 52% of the variance in post-intervention anxiety scores was attributable to the intervention type. The adjusted mean anxiety scores were: VR group = 5.08 (SE = 0.17), play therapy group = 5.90 (SE = 0.21), and control group = 12.32 (SE = 0.24). Post-hoc pairwise comparisons with Bonferroni correction revealed that both intervention groups had significantly lower anxiety scores than the control group ($P < 0.001$ for both comparisons). Furthermore, the VR group had significantly lower adjusted anxiety scores than the play therapy group (mean difference = 0.82, SE = 0.27, $P = 0.03$, 95% CI: 0.18-1.46), with a moderate to large effect size (Cohen's $d = 0.83$). These findings confirm that VR was significantly more effective than play therapy in reducing pre-procedural anxiety, even after accounting for the confounding effects of baseline anxiety and age.

Parental satisfaction was assessed among parents of children in both intervention groups (Figure 3). Data were available for 15 parents per group, as some parents declined to complete the satisfaction questionnaire or provided incomplete responses. All respondents reported high levels of satisfaction with both interventions. The mean satisfaction score was 36.80 ± 1.265 in the VR group and 37.07 ± 1.163 in the play therapy group, both falling within the high satisfaction range (29.34-40.00). Comparison of satisfaction scores between the two groups revealed no significant difference (Mann-Whitney $U = 99.500$, $Z = -0.572$, $P = 0.568$), indicating that parents perceived both interventions equally favorably. This high level of satisfaction across both groups suggests that parents found both VR and play therapy acceptable and beneficial for their children.

Table 3. Between-Group Comparison of Anxiety Scores at Pre- and Post-Intervention Time Points

Time Point	Comparison	N	Mean Rank	Z-score	P-value
Day 1 Pre	Control vs. VR	25, 25	20.06 vs. 23.36	-3.685	0.077
	Control vs. Play	25, 25	20.06 vs. 30.94	-2.585	0.010
Day 1 Post	Control vs. VR	25, 25	37.92 vs. 13.00	-6.072	< 0.001*
	Control vs. Play	25, 25	37.92 vs. 13.08	-6.168	< 0.001*
	VR vs. Play	25, 25	22.50 vs. 28.50	-2.015	0.044*
Day 2 Pre	Control vs. VR	25, 25	30.54 vs. 14.40	-2.585	0.010
	Control vs. Play	25, 25	30.54 vs. 20.46	-1.500	0.134
Day 2 Post	Control vs. VR	25, 25	38.00 vs. 13.00	-6.168	< 0.001*
	Control vs. Play	25, 25	38.00 vs. 13.00	-6.168	< 0.001*
	VR vs. Play	25, 25	23.00 vs. 28.00	-2.457	0.014*

*ANCOVA with baseline anxiety and age as covariates; Bonferroni correction applied for multiple comparisons; Statistically significant ($P < 0.05$); VR = Virtual Reality

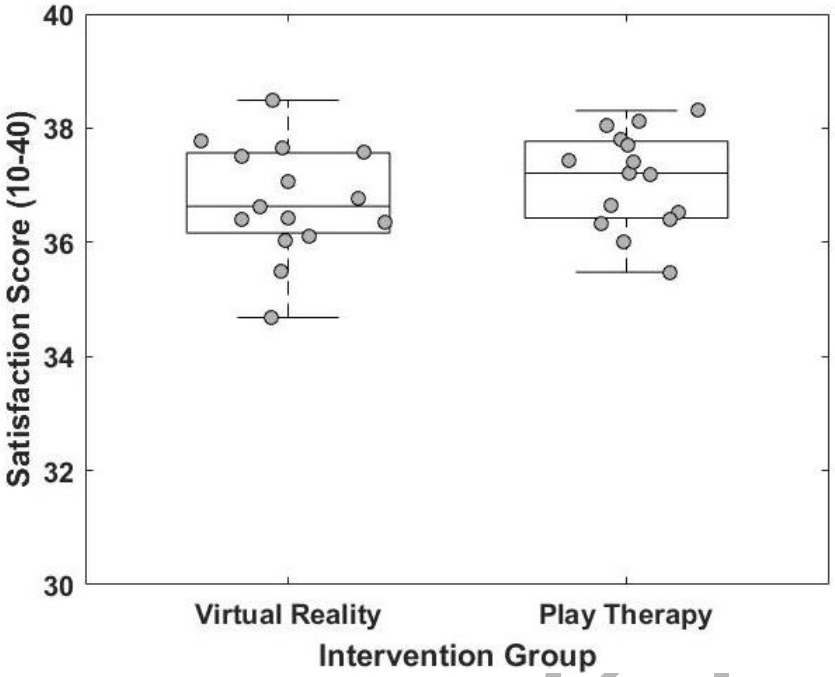

Figure 3. Boxplots of Parental Satisfaction Scores in the Both Virtual Reality and Play Therapy Groups After Intervention

Discussion

The present study provides robust evidence supporting the effectiveness of both VR and play therapy as non-pharmacological interventions for reducing pre-procedural anxiety in children undergoing cardiac catheterization. Our findings demonstrate that both interventions produced statistically and clinically significant reductions in anxiety compared to standard care, with VR showing superior efficacy. These results have important implications for pediatric nursing practice and the optimization of pre-procedural care in cardiac catheterization settings. The observed superiority of VR over play therapy can be understood through multiple theoretical and mechanistic frameworks. VR operates as a high-intensity, immersive attentional distraction modality that simultaneously engages visual and auditory sensory channels, effectively competing for cognitive resources that would otherwise be allocated to processing threatening procedural stimuli (27, 28). This attentional narrowing hypothesis is supported by cognitive load theory, which posits that the human cognitive system has limited processing capacity (29). By overwhelming sensory channels with engaging, novel, and interactive content, VR reduces the attentional resources available for threat detection and rumination. This mechanistic explanation is consistent with neuroimaging studies demonstrating that immersive distraction attenuates activity in brain regions associated with pain and anxiety processing, including the anterior cingulate cortex and insula (30-32). Furthermore, VR may exert its anxiolytic effects through neurophysiological pathways. Immersive distraction has been shown to attenuate hypothalamic-pituitary-adrenal axis activation and reduce sympathetic nervous system arousal, as evidenced by reduced cortisol levels, heart rate, and galvanic skin response (24). The stabilization of anxiety levels observed in the VR group in the present study aligns with these mechanistic explanations.

Play therapy, while also effective, produced slightly less pronounced anxiety reduction. This can be explained by the differential engagement of cognitive and emotional processes. Play therapy operates primarily through emotional regulation mechanisms, enabling symbolic expression, cognitive reframing of medical experiences, and mastery-based coping (33). Through coloring and creative expression, children externalize their emotions and gain a sense of control over their environment. However, unlike VR, play therapy does not provide the same level of sensory immersion or attentional capture. Coloring requires active participation and cognitive engagement, but it is a unisensory activity that may be more susceptible to distraction by environmental threats. This differential engagement likely accounts for the superior performance of VR. Our findings are consistent with previous research demonstrating the effectiveness of VR in reducing pediatric procedural anxiety. A systematic review and meta-analysis by Wu *et al.* (7) found that VR significantly reduced preoperative anxiety in pediatric patients across multiple surgical settings, with effect sizes ranging from moderate to large. Similarly, studies by Kim *et al.* (34) and Hu *et al.* (17) reported significant anxiety reduction during various pediatric procedures, including venipuncture and dental procedures. Our results extend these findings specifically to the context of cardiac catheterization, a high-stakes invasive procedure where anxiety

management is particularly critical. The efficacy of play therapy in our study aligns with the extensive literature supporting therapeutic play in pediatric healthcare. Mersal *et al.* (33) demonstrated that play therapy reduces anxiety, improves cooperation, and enhances psychological well-being in hospitalized children. Similarly, Abdi *et al.* (20) found that play therapy significantly reduced anxiety in hospitalized children compared to standard care. Our findings contribute to this body of evidence by demonstrating that play therapy is effective even in the stressful context of cardiac catheterization.

The clinical significance of our findings extends beyond statistical significance. The transition of all children in the VR group from moderate to mild anxiety represents a clinically meaningful improvement. In procedural cardiology, even moderate reductions in anxiety are associated with improved cooperation, enhanced procedural compliance, reduced perioperative instability, and decreased sedation requirements (35). The large effect size observed in our study suggests that the interventions are not only statistically significant, but also practically meaningful. Moreover, parental satisfaction was uniformly high across both intervention groups, indicating that parents found both VR and play therapy acceptable, feasible, and beneficial. The absence of significant differences in satisfaction scores suggests that parents valued both interventions, perhaps because they observed tangible improvements in their children's anxiety. This finding has important practical implications, as parental buy-in is critical for the successful implementation of non-pharmacological interventions in clinical practice. Healthcare providers can confidently offer both options, allowing families to choose based on child preference and individual factors.

Limitation

Several limitations must be acknowledged. The inability to blind participants and interventionists due to the nature of the interventions may have introduced performance bias, though the outcome assessor was blinded to minimize detection bias. The significant baseline age differences between groups, despite randomization, represent a potential confounder, though ANCOVA was used to adjust for this. The relatively small sample size may limit the detection of smaller effects and the generalizability of findings. The single-center design limits external validity. Parental satisfaction data were available for only 60% of parents, introducing potential non-response bias. The short follow-up period (limited to pre-procedure) does not capture long-term psychological outcomes. The study did not assess physiological parameters (heart rate, blood pressure, cortisol), limiting our understanding of the biological mechanisms underlying the observed effects. Finally, the specific VR content (underwater and forest animation) and play therapy materials (coloring) may not be generalizable to other content types or play activities.

Conclusion

This randomized single-blind trial provides strong evidence that both VR and play therapy are effective non-pharmacological interventions for reducing pre-procedural anxiety in children undergoing cardiac catheterization. VR demonstrated superior anxiolytic effects compared to play therapy, with a large effect size that remained significant after controlling for baseline age and anxiety differences. Both interventions were highly acceptable to parents, with uniformly high satisfaction ratings. From a clinical perspective, our findings support the integration of VR and play therapy into routine pre-procedural nursing care protocols. VR may be particularly advantageous for children who can tolerate headset use, while play therapy remains a valuable option for younger children or those who prefer more traditional activities. Healthcare providers should consider individual child preferences, developmental readiness, and available resources when selecting interventions. Future research should address the limitations of this study by conducting multi-center trials with larger sample sizes, stratified randomization to control for age, and longer follow-up periods to assess long-term psychological outcomes. Studies examining physiological outcomes (e.g., cortisol levels, heart rate variability) would enhance our understanding of the biological mechanisms underlying the observed effects. Cost-effectiveness analyses would inform resource allocation decisions. Finally, qualitative studies exploring children's and parents' experiences with these interventions would provide valuable insights for implementation and optimization.

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Conflict of Interest

None.

Author’s Contributions

Both authors contributed equally to the conception, design, writing, and final approval of this article.

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