Effect of Virtual Reality on Pain Intensity Associated with Arteriovenous Fistula Puncture among Children Undergoing Hemodialysis

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Abstract

Background: *Arteriovenous Fistula (AVF) puncture is a crucial component of Hemodialysis (HD) that is often accompanied by significant pain, particularly among pediatric patients. Mitigating this pain using promising adjunctive non-pharmacological therapy such as Virtual Reality (VR) is pivotal. The study* ***aimed*** *to determine the effect of VR on pain intensity associated with AVF puncture among children undergoing HD.* ***Settings:*** *The study was conducted at the HD units of Smouha Children's University Hospital and Sporting Students' Hospital in Alexandria, Egypt.* ***Subjects****: A convenient sample of 30 children undergoing HD through AVF comprised the study subjects. Children's ages ranged from 6 to 12 years. All subjects were assigned to the control and then to the VR group cross overly.* ***Tools:*** *Three tools were used to collect the necessary data namely, Characteristics of Children and their Medical and Physiological Data Assessment Sheet, Modified Children's Hospital of Eastern Ontario Pain Scale, and Wong-Baker Faces Pain Rating Scale.* ***Results:*** *it was found that 76.7% of children in the control group were suffering from severe pain during AVF puncture compared to 33.3% of children in the VR group. Also, most children in the VR group experienced mild pain (93.3%) immediately after the AVF puncture, compared to one-third of the control group (33.3%) as 60.0% experienced moderate pain.* ***Conclusion:*** *It was concluded that the VR technique minimized pain responses significantly during and immediately after AVF puncture among children undergoing HD.* ***Recommendation:*** *Virtual reality should be incorporated into the HD units' care protocols to alleviate children's pain.*

Keywords: Arteriovenous Fistula, Children, Hemodialysis, Pain, Puncture, Virtual Reality.
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Introduction

Chronic Kidney Disease (CKD) is considered a growing public health problem worldwide due to the high morbidity and mortality rates (Carney, 2020). It refers to the inability of the kidneys to perform excretory functions, resulting in the retention of nitrogenous waste products in the blood. It is also associated with a declined glomerular filtration rate to less than 60 mL/min per 1.73 m^2 of body surface area for more than 3 months (Stevens et al., 2024). End Stage Renal Disease (ESRD) is the final stage of CKD, which necessitates dialysis or kidney transplantation (Zhang et al., 2020).

The global prevalence of CKD among children aged from 5 to 12 years was estimated to be around 30-40 cases per million children (Amanullah et al., 2022). Furthermore, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK, 2023) estimated that the incidence of ESRD among children under 18 years was approximately 11 cases per million populations. Moreover, the percentage of children aged from 13 to 17 years who underwent dialysis procedures was 12.8% for those who received Hemodialysis (HD)

and 9.7% for those undergoing peritoneal dialysis (NIDDK, 2023). In Egypt, the estimated annual incidence rate of ESRD was approximately 74 per million children, and the total prevalence of children on dialysis was approximately 264 per million populations (El-Arbagy et al., 2016).

Hemodialysis is considered the most prevalent alternative therapy for renal function among children with ESRD (Pecoits-Filho et al., 2020). It encompasses the removal of extraneous fluids and wastes from the bloodstream through the process of solute diffusion across a semi-permeable membrane, commonly referred to as a dialyzer (Zain-ELdin et al., 2018). A crucial factor that underpins the effectiveness of HD is the presence of properly functioning vascular access such as Arterio-Venous Fistula (AVF) (Preka et al., 2021). The AVF is a surgically created connection between vein and artery usually in the forearm or upper arm to create access to the vascular system (Montelongo et al., 2023).

Pain inflicted by the AVF is a significant concern for both children and their caregivers (Radisic et al., 2022). Hence, improper pain management results in avoidance and refusal of the treatment leading to deterioration of children's condition (Atzori et al., 2022). Pain is defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or both". It is often referred to as the fifth vital sign that should be assessed regularly and frequently by nurses (Pozza et al., 2021). As a result of the intricate and multifaceted nature of pain, its assessment is rigorous and challenging mainly among the pediatric population due to its subjectivity (Grunauer et al., 2021).

Given the adverse effects of medications, particularly among the pediatric population, a plethora of literature highly recommends non-pharmacological pain relief approaches such as electrical nerve stimulation, cryotherapy, and several forms of distraction as Virtual Reality (VR) (Friedrichsdorf & Goubert, 2020; Mendes-Neto & Santos, 2020). Virtual reality entails the creation of a simulated environment to generate a sense of authentic experiences for children. It allows children to enjoy the sensation of being, acting and living inside a virtual world during painful procedures such as AVF puncture (Shetty et al., 2019).

Provision of comfort and prevention of pain among children undergoing HD are two primary goals in the field of pediatric nursing. Therfore, pediatric nurses have a central role in assessing and recording the pattern, intensity, and nature of pain (Cahyani et al., 2018). They should also reassess the adverse effects of any intervention used in pain control (Loeffen et al., 2020). Nurses must also maintain updated knowledge and skills regarding non-pharmacological pain management. In this respect, the current study highlighted the effectiveness of non-pharmacological modalities such as VR in reducing AVF puncture-related pain among children undergoing HD.

Aims of the Study

The present study aimed to determine the effect of virtual reality on pain intensity associated with arteriovenous fistula puncture among children undergoing hemodialysis.

Research Hypothesis

Children undergoing AVF puncture who receive virtual reality exhibit lower pain score than those who do not.

Materials and Methods

Materials

Design: A quasi-experimental cross-over research design was used to conduct this study.

Settings: The study was conducted in the HD units of Smouha Children's University Hospital (SCUH) and Sporting Students' Hospital (SSH) at Alexandria. The HD unit of SCUH consists of two rooms with a capacity of 12 beds. It provides HD services

for children with CKD in Alexandria and the surrounding governorates all days of the week from 9:00 am to 1:00 pm. Regarding the SSH, the capacity of the HD unit is 22 beds which provides HD services for students with CKD in Alexandria and the surrounding governorates all days of the week except Friday from 7.00 am to 6:00 pm. It is covered by the health insurance system.

Subjects: The study subjects comprised a convenient sample of 30 children undergoing HD through AVF. Their ages ranged from 6 to 12 years and they were free from vascular or neurological diseases. They didn't receive any analgesics before the AVF puncture. All subjects were assigned to the control and the VR groups cross-overly as children were allocated to the control group first and then the VR group.

Tools: Three tools were used for data collection.

Tool one: Characteristics of Children and their Medical and Physiological Data Assessment Sheet. This tool was developed by the researcher. It included three parts; **Part 1** was about demographic data of children such as age and gender. **Part 2** included medical data of children as diagnosis, duration of disease, treatment, number of HD sessions per week and duration of the session. Whereas, **Part 3** was about physiological parameters which included heart rate, respiratory rate and oxygen saturation.

Tool two: Modified Children's Hospital of Eastern Ontario Pain Scale (CHEOPS). The scale was adopted from McGrath et al. (1985) to assess behavioral responses to painful procedures among children from 4 months to 17 years. It consists of five items namely; crying, facial expression, verbal complaints, torso and legs movements. The score of each item ranges from 0 to 2. The total score of pain ranges from zero to 10 and is classified as follows; no pain (zero), mild pain (1-3), moderate pain (4-6), and severe pain (7-10).

Tool Three: Wong-Baker Faces Pain Rating Scale (WBFPRS). It is a self-report scale that was adopted from Wong and Baker (1988) to measure the subjective pain intensity perceived by children from 3 to 18 years. The scale includes six drawn faces expressing various degrees of pain severity ranging from "not hurt" to "hurts worse" **Figure (1)**. Children were required to choose the face that best describes their level of pain. These faces were assigned with scores ranging from 0 to 10 and were classified as follows; no pain (zero), mild pain (1-3), moderate pain (4-6) and severe pain (7-10).

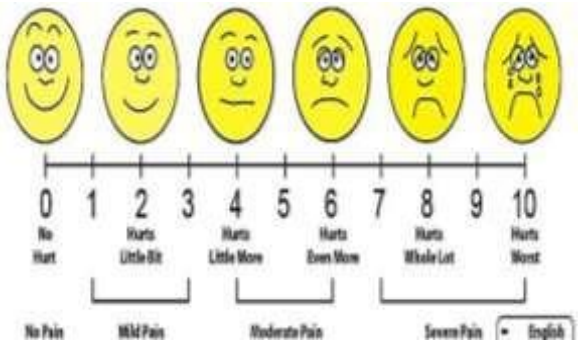

Figure (1): Wong-Baker FACES Pain Rating Scale.

(**Source**: Mittal, S., Sharma, A., Sharma, A. K., Gupta, K. K., Gaur, A., & Pathania, V. (2018). Banded versus single-sided bonded space maintainers: A comparative study. *Indian Journal of Dental Sciences, 10*(1), 29. https://doi.org/10.4103/ijds.ijds-76-17)

Method

Approval from the Research Ethics Committee of the Faculty of Nursing at Alexandria University was obtained. An official letter was directed from the Faculty of Nursing, Alexandria University to the responsible administrative authorities of the previously mentioned settings to facilitate data collection after explaining the aim and nature of the study. Tool I was developed by the researcher and was tested for its content validity by a jury of five experts in the field of pediatric nursing and necessary

modifications were made. The validity was 98%. A pilot study was carried out on 10% of the study subjects (6 children) to test the feasibility, applicability and clarity of the tools. Those children were excluded from the study subjects.

At the initial contact, children's characteristics and medical data were recorded by the researcher using parts 1 & 2 of Tool I. Before AVF puncture, physiological parameters and behavioral responses to pain were assessed and recorded by the researcher as baseline data for the two groups using Part 3 of Tool I and Tool II. Every child in the two groups was assessed for two consecutive HD sessions.

The AVF puncture was done by the dialysis nurse for the **control group** according to the routine care of the unit without applying any interventions for pain. Whereas, the children of the **VR group** and their parents were oriented initially by the researcher about the VR headset before the HD sessions. The VR headset was placed on the child's head and an animated cartoon was displayed 5 minutes before the AVF puncture and continued till 2 minutes after the procedure.

Physiological parameters and pain behavioral responses were assessed and recorded again during and immediately after AVF puncture by the researcher for the two groups. Children's perception of pain was assessed using Tool III after the AVF puncture by asking each child in the two groups to choose the face that best describes his/her pain, and the appropriate score was recorded by the researcher.

A comparison was done between the two groups to evaluate the effect of virtual reality on pain associated to AVF puncture among children undergoing HD. Data were collected over 12 months starting from the beginning of January 2021 to the end of December 2022.

Ethical Considerations:

Written informed consent was obtained from children's parents after explaining the aim of the study. Children and their parents had the right to refuse to participate in the study or to withdraw at any time. Parents were ascertained about the confidentiality of their children's data. Privacy and anonymity of children were considered.

Statistical analysis

The Statistical Package for Social Sciences (SPSS version 23) was utilized for both data presentation and statistical analysis of the results. Kolmogorov – Smirnov test was used to examine the normality of data distribution. The chi-square test and Monte Carlo test were used to test the significance of results of qualitative variables. Comparison of pain level among the two groups was done using Chi-Square Test (χ^2). For normally distributed quantitative variables, one way ANOVA test was used to compare between more than two groups. The 0.05 level was used as the cut off value for statistical significance (significant at $P \leq 0.05$).

Results

Table (1) portrays the characteristics and medical data of children undergoing hemodialysis. It is revealed from the table that the age of more than half of children was from 11 to 12 years (56.7%) with a mean age 10.53±1.20 years. Moreover, slightly more than half of children were females (53.3%). Regarding medical data, all children were diagnosed as CKD (100.0%). Forty percent of them were suffering from CKD since 2 to less than 5 years and nearly two-thirds of them started hemodialysis 2 years ago (60.0%). The majority of children have undergone HD three times per week (90%).

Table (2) highlights the effect of VR on the physiological parameters of children undergoing AVF puncture. The value of oxygen saturation was more than 95.0% among all children in the VR and control groups before, during and after the AVF puncture (100% in each). Concerning heart

rate, only 13.3% of children in the VR group had tachycardia compared to 40% of the control group during AVF puncture. Unpredictably, it was found that VR had no effect on respiratory rate as 96.7% and 100% of VR and control groups respectively demonstrated tachypnea during AVF puncture. These percentages decreased to 63.3% and 66.7% respectively after AVF puncture. No statistically significant differences were found between the two groups regarding physiological parameters during and after AVF puncture.

Table (3) represents the effect of virtual reality on pain behavioral responses among children undergoing AVF puncture. Regarding crying, 66.7% of children in the VR group didn't cry during AVF puncture compared to only 3.3% of the control group. Most of children in the control group exhibited facial grimaces in addition to verbal pain complaints during AVF puncture (96.7% and 90% respectively) compared to only one-third of the VR group (33.3% in each). Concerning torso and legs movements, nearly two-thirds of children in the VR group had neutral movements during AVF puncture (60% and 66.7% respectively) compared to 3.3% and 26.7% of the control group respectively. Concurrently, only 33.3% of the VR group demonstrated tense torso and squirmed or kicked their legs compared to 80% and 73.3% of the control group respectively. Statistical significant differences were evident between the two groups regarding all behavioral responses of pain during and after AVF puncture ($P<0.001$ in each).

The effect of virtual reality on the total score of pain experienced by children undergoing AVF puncture is illustrated in **Table (4)**. It is observed from the table that 76.7% of children in the control group were suffering from severe pain during AVF puncture compared to 33.3% of children in the VR group. Immediately after the AVF puncture, it was apparent that most of the children in the VR group experienced mild pain (93.3%) compared to one-third of the control group (33.3%) as 60.0% of them experienced moderate pain. It is also noticed from the table that the total mean scores of pain among the control group before, during and after AVF puncture 1.87±0.51, 6.83±1.23 and 3.10±1.24 respectively were higher than the VR group 0.47±0.51, 3.73±2.36 and 1.53±0.63 respectively with significant differences ($P < 0.001$ for each).

Table (5) reveals the effect of virtual reality on pain perception among children undergoing AVF puncture. It is noticed from the table that VR has an amazing effect on pain as reported by children. Since, only 23.3% of children in the VR group reported that they had severe pain during the AVF puncture with mean pain score (4.93±2.02) compared to 83.3% of children in the control group with mean pain score (7.93±1.11). A highly significant statistical difference was found between the two groups regarding their perception of pain where $p < 0.001$.

Discussion

Pain is an unavoidable experience of AVF puncture among children undergoing HD. Untreated pain caused by such procedures may have long-term consequences, such as needle phobia, pre-procedural anxiety, and avoidance of medical care, resulting in increased morbidity and mortality (Alsbrooks & Hoerauf, 2022). Thus, appropriate pain management is crucial to enhance children's tolerance by utilizing non-pharmacological approaches such as the VR technique (Osmanlliu et al., 2021).

Recently, VR has come under the umbrella of cognitive-behavioral interventions for pediatric pain management. It involves the active participation of children in a task that requires cognitive and behavioral functions, thereby distracting the brain from pain (Gao et al., 2022). The subjective and objective parameters of pain

in the current study were consistent regarding the amazing effect of VR on pain response **(Table 4, 5)**. Based on the observation of behavioral responses of pain, one-third of children in the VR group exhibited severe pain compared to three-quarters of the control group during the AVF puncture **(Table 4)**. Regarding the pain reported by the children, nearly one-quarter of children in the VR group reported that they had severe pain during AVF puncture, compared to the majority of the control group **(Table 5)**. These findings could be attributed to the distraction effect induced by the VR approach which combines visual, auditory, and cognitive stimulation at the same time (Wong & Choi, 2023). In addition, the distracting activities of VR can successfully compete with the neural signals of the noxious stimuli such as AVF puncture, and thus limit the brain's ability to focus attention on the painful stimulus and redirect it to another attractive stimulus (Colloca et al., 2020). The results of the present study are in line with Dawood et al. (2021) who found that the severity of pain was reduced from moderate to mild after the use of VR technique in children undergoing AVF puncture. In the same vein, Wong and Choi (2023) cited that there was a significant reduction in pain among children during needle puncture in the VR group compared to the control group in the emergency department.

Pain affects children physiologically by exacerbating the autonomic neurohumoral stress response, which triggers the sympathetic nervous system. Consequently, the physiological responses such as heart rate, blood pressure, and respiratory rate are increased (Wyns et al., 2023). Concerning physiological parameters in the current study, there were no statistically significant differences between the two study groups during and after AVF puncture **(Table 2)**. These findings could be related to children's adaptation to the prolonged and repeated nature of pain associated with AVF puncture. As, two-fifths of the children in the present study have been suffering from CKD for 2 to 5 years, and almost two-thirds of them had started HD 2 years ago **(Table 1)**. These findings of the present study are in agreement with Barad et al. (2021), who cited that there wasn't a statistically significant difference between the VR and control groups with regard to oxygen saturation during and after venipuncture. Conversely, the same study showed that there was a statistically significant difference between the two groups concerning heart rate. Also, the results of the current study are inconsistent with the findings of Orhan and Gozen (2023), who reported the presence of a statistically significant difference between the VR and control groups regarding oxygen saturation. This discrepancy between the results of the current study and these studies may be related to increased pain tolerance among children in the present study as most of them underwent HD three times a week. Thus, they become accustomed to the repeated painful experience of AVF puncture **(Table 1)**.

Children express pain through a variety of behaviors, including crying, facial expressions, verbal complaints, torso and leg movements (Mencía et al., 2022). The current study findings clarified that two-thirds of children in the VR group didn’t cry during AVF puncture, however, two-thirds of the control group were crying **(Table 3)**. The results of the present study may be justified by the distracting effect of VR, which draws the children's attention away from the noxious stimuli and engages them in a pleasant activity. Consequently, the perception of pain was modified, and the internal mechanism of pain inhibition was initiated leading to decreased behavioral responses to pain as depicted in the gate control theory (Melzack & Wall, 1965). This finding is congruent with the finding of Elsharkawy et al. (2022) who concluded that none of the children in the VR group cried

compared to two-thirds of those in control group during peripheral cannulation.

Most of the children in the control group exhibited facial grimace, verbal pain complaints, tensed torso, and legs kicking or squirming during the AVF puncture compared to one-third of the VR group. **(Table3)**. These findings are consistent with the findings of Burns-Nader and Goldstein (2023), who reported that children in the VR group were displaying less behavioral pain responses pertaining to body positioning, verbalization, and facial grimacing compared to the control group. Similarly, a study conducted by Lee et al., (2021) and Mokbel et al., (2022) showed similar findings, where they concluded that there was a significant reduction in behavioral pain responses among the VR group compared to the control group during the AVF puncture.

Although the efficacy of numerous interventions for pain management has been evaluated in several studies (Merino-Lobato et al., 2023; Tas et al., 2022; Niaz et al., 2023). Pain management is often suboptimal in the pediatric population. Therefore, the current study addressed the effect of VR as a key modality in decreasing pain associated with AVF puncture among children undergoing HD.

Conclusion

Based on the findings of the present study, it can be concluded that virtual reality technique was effective in minimizing pain responses during and immediately after AVF puncture among children undergoing HD. As children who received VR experienced less pain than those in the control group.

Recommendations

Based on the previous findings and conclusion, the following recommendations are suggested:

- Educational training programs should be provided continuously for pediatric nurses to enrich their knowledge and skills about non-pharmacological measures of pain relief such as VR intervention.
- Pediatric nurses should use reliable and valid tools such as CHEOPS scale for assessing pain associated with AVF puncture among children undergoing HD.
- Written guidelines about pediatric pain management should be available for healthcare providers working in HD units.

Table (1): Characteristics and Medical Data of Children Undergoing Hemodialysis.

Socio-demographic and Medical Data	No.	%
Age (Years)		
▪ 9 -	9	30
▪ 10 -	4	13.3
▪ 11 – 12.	17	56.7
Mean ± SD		**10.53±1.20**
Gender		
▪ Male	14	46.7
▪ Female	16	53.3
Diagnosis		
▪ CKD	30	100
Onset of disease (years)		
▪ 2 -	12	40.0
▪ 5 -	7	23.3
▪ 10 or more.	11	36.7
Onset of HD (years)		
▪ 1 -	4	13.3
▪ 2 -	18	60.0
▪ 3 – 4.	8	26.7
Number of HD sessions/ week		
▪ Twice	3	10.0
▪ Three times	27	90.0
Duration of HD session		
▪ 3 Hours/ Session.	9	30.0
▪ 4 Hours/ Session.	21	70.0

Table (2): Effect of Virtual Reality on Physiological Parameters of Children Undergoing Arteriovenous Fistula Puncture.

Physiological Parameters	Before AVF Puncture				During AVF Puncture				After AVF Puncture			
	Control Group (n = 30)		VR Group (n = 30)		Control Group (n = 30)		VR Group (n = 30)		Control Group (n = 30)		VR Group (n = 30)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Oxygen Saturation (%)												
▪ > 95 %	30	100	30	100	30	100	30	100	30	100	30	100
χ^2_{MC} p	- -				- -				- -			
Heart Rate (b/m)												
▪ Normal	25	83.3	28	93.3	18	60.0	26	86.7	24	80.0	28	93.3
▪ Tachycardia	5	16.7	2	6.7	12	40.0	4	13.3	6	20.0	2	6.7
Min –Max	**76.0 – 131**		**75.0 – 135.0**		**75.0 – 132.0**		**75.0 – 131.0**		**77.0 – 129.0**		**80.0-125.0**	
Mean ± S.D	**104.4±17.2**		**102.5±15.2**		**105.9±19.3**		**104.6±15.6**		**105.0±16.0**		**107.0±11.0**	
χ^2_{MC} p	F= 0.357 0.701				F= 0.108 0.898				F=1.024 0.364			
Respiratory Rate (c/m)												
▪ Normal	22	73.3%	16	53.3%	0	0.0%	1	3.3%	10	33.3%	11	36.7%
▪ Tachypnea	8	26.7%	14	46.7%	30	100%	29	96.7%	20	66.7%	19	63.3%
Min –Max	**18.0 – 32.0**		**18.0 – 33.0**		**18.0 – 33.0**		**20.0 – 33.0**		**19.0 – 33.0**		**18.0 – 33.0**	
Mean ± S.D	**23.2±4.1**		**25.5±4.4**		**28.6±3.8**		**29.6±3.0**		**26.6±4.3**		**25.8±4.5**	
χ^2_{MC} p	F=5.050* **0.008***				F=0.844 0.433				F=0.348 0.707			

χ^2: Chi square test. MC: Monte Carlo F: ANOVA test *: Statistically significant at p ≤ 0.05

Table (3): Effect of Virtual Reality on Pain Behavioral Responses among Children Undergoing Arteriovenous Fistula Puncture.

Pain Behavioral Responses		Before AVF Puncture				During AVF Puncture				After AVF Puncture			
		Control Group (n = 30)		VR Group (n = 30)		Control Group (n = 30)		VR Group (n = 30)		Control Group (n = 30)		VR Group (n = 30)	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Crying	▪ No crying.	30	100	30	100	1	3.3	20	66.7	21	70.0	30	100
	▪ Crying, moaning.	0	0.0	0	0.0	20	66.7	10	33.3	9	30.0	0	0.0
	▪ Scream.	0	0.0	0	0.0	9	30.0	0	0.0	0	0.0	0	0.0
	Mean ± S.D	**0.0±0.0**		**0.0±0.0**		**1.27±0.52**		**0.33±0.48**		**0.30±0.47**		**0.0±0.0**	
	χ^2 / MC p	- / -				F = 63.187* / **<0.001***				F = 12.429* / **<0.001***			
Facial Expression	▪ Smiling.	0	0.0	20	66.7	0	0.0	0	0.0	1	3.3	12	40.0
	▪ Composed.	29	96.7	01	33.3	1	3.3	20	66.7	29	96.7	18	60.0
	▪ Grimace.	1	3.3	0	0.0	29	96.7	10	33.3	0	0.0	0	0.0
	Mean ± S.D	**1.03±0.18**		**0.07±0.36**		**1.97±0.18**		**1.33±0.48**		**0.97±0.18**		**0.60±0.50**	
	χ^2 / MC p	F = 3.273* / **0.043***				F = 14.702* / **<0.001***				F = 8.277* / **0.001***			
Verbal Complaints	▪ Positive.	0	0.0	26	86.7	0	0.0	0	0.0	0	0.0	2	6.7
	▪ None or other complaints.	30	100	4	13.3	3	10.0	20	66.7	12	40.0	28	93.3
	▪ Pain complaint.	0	0.0	0	0.0	27	90.0	10	33.3	18	60.0	0	0.0
	Mean ± S.D	**1.0 ± 0.0**		**0.13±0.35**		**1.90±0.31**		**1.33±0.48**		**1.60±0.50**		**0.93±0.25**	
	χ^2 / MC p	F =132.675* / **<0.001***				F = 17.424* / **<0.001***				F = 38.809* / **<0.001***			
Torso Movements	▪ Neutral.	30	100	30	100	1	3.3	18	60.0	20	66.7	30	100
	▪ Shifting, upright, tense.	0	0.0	0	0.0	24	80.0	10	33.3	10	33.3	0	0.0
	▪ Restrained.	0	0.0	0	0.0	5	16.7	2	6.7	0	0.0	0	0.0
	Mean ± S.D	**0.0±0.0**		**0.0±0.0**		**1.13±0.43**		**0.48±0.63**		**0.33±0.48**		**0.0±0.0**	
	χ^2 / MC p	- / -				F = 20.112* / **<0.001***				F = 14.500* / **<0.001***			
Leg movements	▪ Neutral.	30	100	30	100	8	26.7	20	66.7	18	60.0	28	93.3
	▪ Kicks, squirm, drawn up.	0	0.0	0	0.0	22	73.3	10	33.3	12	40.0	2	6.7
	▪ Restrained.	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Mean ± S.D	**0.0±0.0**		**0.0±0.0**		**0.73±0.45**		**0.33±0.48**		**0.40±0.50**		**0.07±0.25**	
	χ^2 / MC p	- / -				F = 20.407* / **<0.001***				F = 13.221* / **<0.001***			

χ^2: Chi square test. MC: Monte Carlo F: ANOVA test *: Statistically significant at p ≤ 0.05

Table (4): Effect of Virtual Reality on the Total Score of Pain Experienced by Children Undergoing Arteriovenous Fistula Puncture.

Total Pain score (CHEOPS)	Control Group (n = 30)		Virtual Reality Group (n = 30)		Tukey
	No.	%	No.	%	
Before puncture					
▪ No pain	2	6.7	16	53.3	
▪ Mild pain	28	93.3	14	46.7	
▪ Moderate pain	0	0.0	0	0.0	
▪ Severe pain	0	0.0	0	0.0	
Mean ± SD	**1.87±0.51**		**0.47±0.51**		**<0.001***
During puncture					
▪ No pain	0	0.0	0	0.0	
▪ Mild pain	1	3.3	20	66.7	
▪ Moderate pain	6	20.0	0	0.0	
▪ Severe pain	23	76.7	10	33.3	
Mean ± SD	**6.83±1.23**		**3.73±2.36**		**<0.001***
After puncture					
▪ No pain	2	6.7	2	6.7	
▪ Mild pain	10	33.3	28	93.3	
▪ Moderate pain	18	60.0	0	0.0	
▪ Severe pain	0	0.0	0	0.0	
Mean ± SD	**3.10±1.24**		**1.53±0.63**		**<0.001***

Tukey: Post Hoc for ANOVA test ***: Statistically significant at p ≤ 0.05.**

Table (5): Effect of Virtual Reality on Pain Perception among Children Undergoing Arteriovenous Fistula Puncture.

Average of WBFPRS	Control Group (n = 30)		Virtual Reality Group (n = 30)		χ^2	^{MC}p
	No.	%	No.	%		
▪ No pain	0	0.0	0	0.0		
▪ Mild pain	0	0.0	4	13.3		
▪ Moderate pain	5	16.7	19	63.3		
▪ Severe pain	25	83.3	7	23.3		
Mean ± SD	**7.93±1.11**		**4.93±2.02**		F = 37.443*	**<0.001***

χ^2: Chi square test **MC: Monte Carlo** **F: ANOVA test** ***: Statistically significant at p ≤ 0.05**

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