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The Effect of Virtual Reality Application on Pain in Port Catheter Access in Pediatric Oncology Patients: Systematic Review and Narrative Synthesis

Pediatrik Onkoloji Hastalarında Port Kateter Erişiminde Sanal Gerçeklik Uygulamasının Ağrı Üzerine Etkisi: Sistematik Derleme ve Anlatı Sentezi

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ABSTRACT

Objective: This study aims to determine the impact of virtual reality (VR) on pain levels during port catheter access in children aged 4-19 years. The secondary objective is to evaluate the effects of VR on pain catastrophizing, fear, anxiety/distress levels, and heart rates.

Methods: This descriptive systematic review includes studies from databases like PubMed, Medline, Cochrane Library, Scopus, ScienceDirect, and others, using keywords such as "oncology," "leukemia," "virtual reality," "pain," "children," and "pediatric." Nine studies were selected based on the PICOS criteria, with a sample of 544 children. The review followed the PRISMA guidelines, and the data were synthesized using a narrative synthesis method.

Results: The studies showed that VR applications significantly reduce pain during port catheter access compared to standard care and other distraction techniques. Additionally, VR effectively reduces pain catastrophizing, fear, anxiety, distress, and heart rates. The application was found to be both effective and safe in managing pain for pediatric oncology patients.

Conclusion: The evidence quality from the included studies ranges from moderate to strong. While the results are promising, further research is necessary to explore the long-term effects of VR on pain management and psychological factors in pediatric oncology patients undergoing chemotherapy. This review is registered with PROSPERO (CRD42023441761).

Keywords: Child, Virtual reality, Oncology nursing, Pain

ÖZ

Amaç: Bu çalışmanın birincil amacı, 4- 19 yaş arası çocuklarda port kateter erişimi sırasında sanal gerçeklik (SG) uygulamasının ağrı düzeyleri üzerindeki etkisini belirlemektir. İkincil amaç ise SG uygulamasının çocukların ağrı felaketleştirme davranışı, korku, anksiyete/stres düzeyleri ve kalp atış hızları üzerindeki etkilerini değerlendirmektir.

Yöntemler: Bu tanımlayıcı sistematik derlemenin kapsamını PubMed, Medline, Cochrane Library, Scopus, ScienceDirect, Clinical Key, Ulakbim, Web of Science, CINAHL ve OVID veri tabanlarından "onkoloji", "lösemi", "sanal gerçeklik", "ağrı", "çocuk", "çocuklar", "ergen", "pediatrik" ve "hemşire" anahtar kelimeleri kullanılarak erişilen çalışmalar oluşturmaktadır. Sistematik derlemenin örneklemi, tarama süreciyle PICOS kriterlerine göre seçilen 9 çalışmadan oluşmaktadır. Bu sistematik derleme PROSPERO veri tabanına (CRD42023441761) bir protokol ile kaydedilmiştir ve PRISMA akış şeması adımları kullanılarak yürütülmüştür. Çalışmalardan elde edilen verileri sentezlemek için anlatı sentezi yöntemi kullanılmıştır.

Bulgular: Dokuz çalışmaya 4-19 yaş arası toplam 544 çocuk dahil edilmiştir. Port kateter erişimi sırasında SG uygulamalarının ağrı üzerindeki etkilerini standart bakım ve farklı dikkat dağıtma teknikleriyle karşılaştıran çalışmalar, SG uygulamasının pediatrik onkoloji hastalarında bu işlem sırasında ağrıyı azaltmak için etkili ve güvenli bir yöntem olduğu sonucuna varmıştır. Ayrıca, SG uygulamasının ağrı felaketleştirme davranışını, korkuyu, anksiyete/stres düzeylerini ve kalp atış hızlarını azaltmada etkili olduğu görülmüştür.

Sonuç: Çalışmalardaki kanıt kalitesi orta ile güçlü arasında değişmektedir. Port kateter girişi sırasında SG uygulamalarının ağrı üzerindeki etkilerini araştırmak için daha fazla araştırma yapılması gerekmektedir ve bu alanda daha fazla araştırmaya ihtiyaç olduğunu göstermektedir. Ek araştırmalar, Sanal Gerçekliğin kemoterapi gören kanser hastaları üzerindeki etkilerine ilişkin belirsizliği azaltmak için önemli bir potansiyele sahiptir. Bu çalışma PROSPERO'ya CRD42023441761 olarak kayıtlıdır.

Anahtar Kelimeler: Çocuk, Sanal gerçeklik, Onkoloji hemşireliği, Ağrı.

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INTRODUCTION

Childhood cancers are a major public health problem today. Childhood cancers represent 0.5% to 4.6% of all cancer cases and account for 1% of cancer deaths, with the highest rates found in low-development countries. The World Health Organization estimates that approximately 400,000 children aged 0-19 are diagnosed with cancer each year. Advances in diagnostic and treatment methods have improved early detection and intervention. In high-income countries, over 80% of diagnosed children are cured, while the cure rate is below 30% in low- and middle-income countries.[1,2]

In recent years, advancements in the treatment processes of childhood cancers have led to positive developments in their prognosis. However, despite being regarded as a promising advancement, the prolonged duration of cancer treatments results in children and parents frequently encountering medical procedures.[3,4]

One particularly painful and anxiety-inducing procedure in pediatric oncology is the frequent need for intravenous access, which is essential for administering treatments. [5] A specific type of central venous catheter, particularly port catheters, reduces the need for needle procedures in pediatric oncology patients requiring long-term treatment, thereby making intravenous access procedures—a typically painful and stressful experience—more tolerable. However, the insertion of these catheters under the skin and the routine replacement of the needle, typically every 5-7 days, can be significant sources of discomfort and fear for the child.[6,7]

Medical procedures frequently induce pain, distress, and anxiety, which can significantly affect comfort levels in children. Consequently, interventions are needed to address pain and anxiety in pediatric patients.[5] Recent years have seen the increasing use of non-pharmacological distraction techniques to alleviate pain, fear, and anxiety during injection procedures in pediatric patients.[8–10] This technique distracts the child from the pain, diverts her attention elsewhere and reduces fear of pain. These methods are especially useful in pediatric oncology as they offer a complementary approach to managing distress without the side effects of medications.[11] Tools such as kaleidoscopes, distraction cards, bells, music listening, and video games effectively manage pain perception. Additionally, recent studies have demonstrated that virtual reality (VR) can serve as an effective distraction method for reducing procedural pain in children.[12,13]

VR technology is a distraction method that provides real perceptual stimuli with various visual, auditory, tactile and olfactory stimuli in the field of health.[13,14] In this way, virtual reality provides non-pharmacological management of variables such as pain, anxiety and fear by diverting the attention of the individual.[15,16] VR has been used in children to manage the experience of injections, intravenous access, burn dressings and postoperative pain. [8,9,12,15]

As seen, the use of non-pharmacological methods in painful procedures in pediatric oncology patients is effective both in the successful completion of the procedure and in the control of pain and many factors. These methods become vital tools in managing pain and anxiety associated with the procedure and contribute to a more positive experience for both patients and healthcare providers.[11]

AIM

The primary objective of this systematic review and narrative synthesis was to evaluate the impact of virtual reality applications on pain levels during port catheter access in pediatric oncology patients aged 4 to 19 years. In addition to examining pain levels, we also aimed to assess the children's pain catastrophizing behaviors, fear, anxiety/distress levels, and heart rate changes. Through this investigation, we sought to contribute valuable insights into the efficacy of VR as a non-pharmacological intervention for improving the experiences of pediatric patients undergoing painful medical procedures.

Research questions

- Are virtual reality applications effective in reducing pain levels during port catheter access in pediatric oncology patients aged 4 to 19 years?
- What are the effects of virtual reality applications on pain catastrophizing behaviors, fear, and anxiety/distress levels in pediatric oncology patients?
- How do virtual reality applications used during port catheter access impact heart rate changes in pediatric oncology patients?

METHODS

Desing

In this systematic review, in order to minimize the risk of bias, literature search (3 researchers), article selection (4 researchers), data retrieval stage (4 researchers), and quality evaluation of the articles (4 researchers) were performed independently by the researchers. In order for the research process to take place in the appropriate format and quality, a review was performed with a keyword (“virtual reality”) within the scope of the study in the Pubmed database and an article was selected in a session where all researchers were together. After the pilot study, each stage was checked again in a single session with

the researchers (4 researchers) and a consensus was reached regarding the differences in opinions and knowledge.

Selection Criteria and Selection of Studies

Studies eligible for this systematic review were selected according to PICOS criteria [17,18] According to these criteria;

1. **Study group (P):** Pediatric oncology patients aged 0-19 years with port catheters.
2. **Intervention (I):** Using VR goggles during port catheter access.
3. **Comparison (C):** Usual care (not using VR during port catheter access) and using a method other than VR goggles (Ipad, Guided Imagery).
4. **Outcomes (O):** The primary outcome of the study was pain (pain intensity or presence of pain, reaction to pain, as reported in studies). Secondary outcomes will be the results of measurements of anxiety, fear and pulse rate.
5. **Types of Studies (S):** Randomized controlled trials.

In line with this research, systematic, traditional review and meta-analysis studies, case reports, studies with unclear methodology, studies whose full text could not be accessed, studies that were not experimental and studies that did not report results on pain management through VR application were excluded. In this study, the PRISMA flow diagram (2020) was utilized, and the JBI Critical Appraisal Checklist for Randomized Controlled Trials was applied.[19,20]

Screening Strategy

The searches related to the systematic review were conducted between August 1, 2024 and September 1, 2024. Searches were made from Pubmed, Medline, Cochrane Library, Scopus, Sience Direct, Clinical Key, Ulakbim, Web of Sience, CINAHL and OVID databases using the keywords "oncology", "leukemia", "Virtual reality", "pain", "child", "children", "adolescent", "pediatric" in accordance with medical subject headings (MeSH). For additional searches, the reference lists of the available sources were also examined.

Data Extraction

In this study, the 'Publication Classification Form on Using Virtual Reality for Pain Management During Port Access in Children' developed by the researchers, taking into account the systematic review studies conducted by Cheng et al.[21] and Tran Thi et al.[22] in the field of nursing with experimental studies using VR application for pain management in pediatric oncology patients, was used as a data collection tool (Table 1). Expert opinion was obtained for the form and the usability of the form was ensured. With the developed form, data on the authors, publication year, countries, methods, sample sizes, number of cases, average age, intervention types, and the effect of virtual reality goggles on pain and additional outcomes were collected.

Methodological quality assessment

The methodological quality assessment of the studies included in this systematic review was performed using the critical appraisal checklist published by the Joanna Briggs Institute.[20] This list for randomized controlled trials consists of 13 items. Each item on the list was evaluated using the options "yes, no, uncertain and not applicable" (Figure 1). The methodological quality level of the included studies was considered "mediocre" when less than 50% of the items were rated "yes", "moderate quality" when 51-80% of the items were rated "yes", and "good quality" when more than 80% of the items were rated "yes". [23]

Synthesis of Data

In the study, narrative synthesis method was used to synthesize the data obtained from the studies. Narrative synthesis is defined as a systematic review and synthesis of findings from multiple studies, based on the use of words and text to summarize and explain findings. The aim of the narrative synthesis approach is not to "examine what works" but to "examine how the intervention works". In addition to all these, this synthesis is to ensure the systematic evaluation of process-based study results.[24] Narrative synthesis is a method that can be used to synthesize both quantitative and qualitative studies and can be used when the findings of experimental studies included in a systematic review are not similar enough for meta-analysis. [25] In this systematic review, meta-analysis of the studies could not be performed because the data collection methods and the parameters evaluated in the studies examined differed. The findings were presented with narrative method.

Research Ethics

This study is a systematic review and is based on studies published in the literature with references cited. Therefore, approval from any institution or individual and ethics committee is not required. Our study was conducted in accordance with the Declaration of Helsinki Principles.

RESULTS

The study findings encompass research on the effect of VR on pain during port access in pediatric oncology patients in the literature. The study population consisted of 1047 studies. Out of these studies, 843 were excluded due to title and abstract mismatch. The full texts of the remaining 204 studies were examined, and based on content inconsistency, 195 studies were excluded, forming a

sample of nine research studies.

Quality Assessment Results of the Studies

When the quality assessment results of the studies were examined, it was determined that one of the randomized controlled experimental studies had a good quality assessment score, while the other six studies had a moderate level of quality (Table 2).

Evaluation of Findings According to the Identified Themes

Characteristics of the studies and participants

The studies included in this systematic review were conducted between 2004 and 2024. Gershon et al.[26] in the USA, Woltzky et al.[27] in Atlanta, Nilsson et al.[28] in Sweden, Semerci et al.[2], Gerçeker et al.[9] and Savaş et al.[29] in Türkiye, Hundert et al.[8] in Canada, Caballero et al.[30] in Italy and Reitze et al.[31] in Germany. The studies included 544 children aged 4-19 years.

Characteristics of interventions

In 77.7% (n=7) of the studies included in this systematic review, VR application was compared with standard care. In the study by Wolitzky et al.[27] , which involved 20 children aged 7-14 undergoing cancer treatment, the effects of VR application on pain, anxiety, fear, and pulse were observed. Nilsson et al.[28] included 42 children ged 5-18 undergoing cancer treatment to study the effects of VR application on pain and anxiety. Semerci et al.[2] included 61 children aged 7-18 undergoing cancer treatment to investigate the

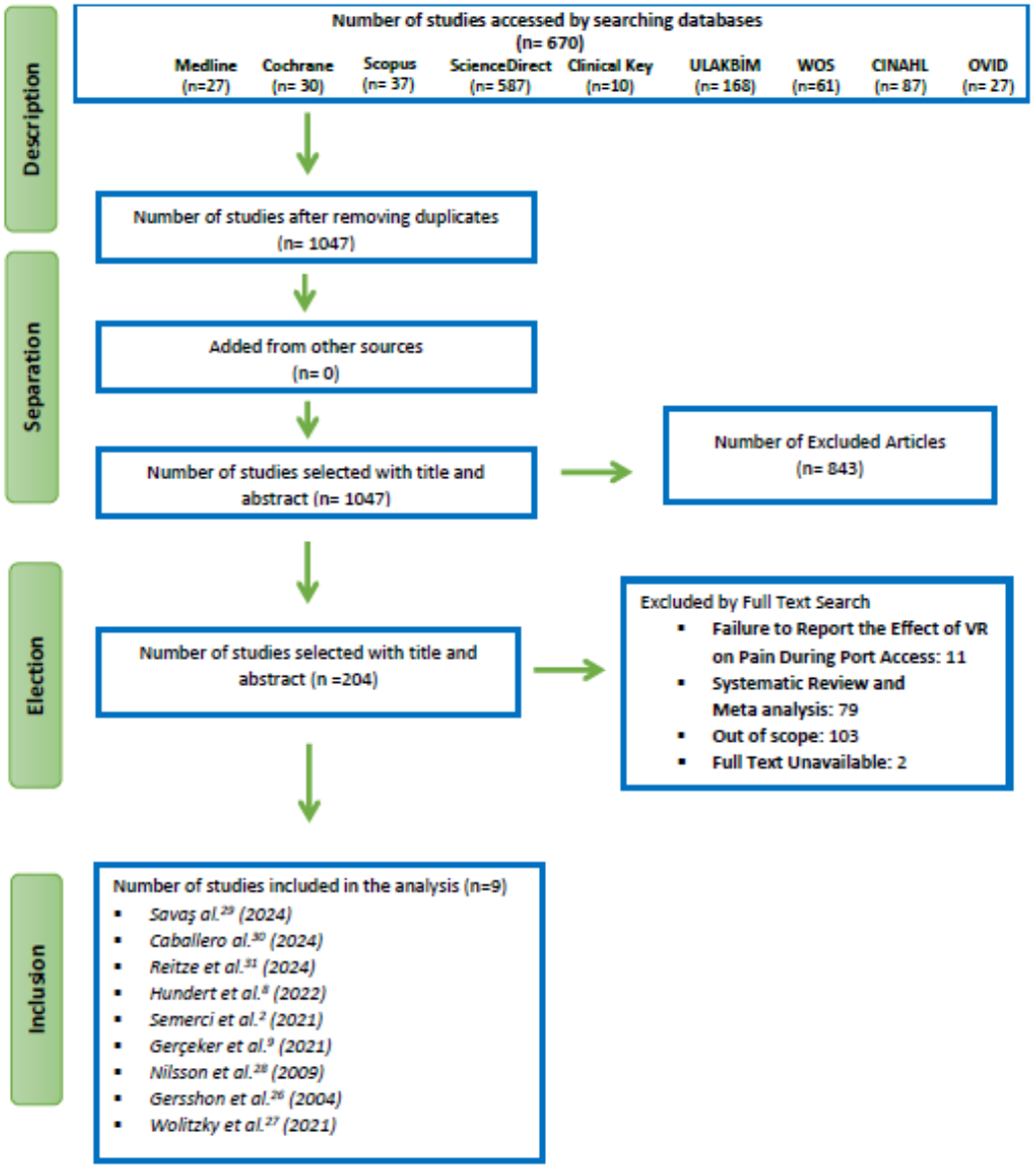

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram

Table 1. Publication Classification Form on Using Virtual Reality (VR) for Pain Management During Port Access in Children

Author (Publication Year)	Country	Intervention(s)	Sample Size	Mean age, years	Group Feature	Data Collection Tools	Main Results
Gershon et al.[26] (2004)	USA	Virtual reality application during needle insertion into port catheter Non-VR distraction during needle insertion into port catheter	VR (n=22) Non-VR (n=15) Control group (n=15) treated as usual without distraction	7-19 years old Mean= 12.7	Paediatric group with leukaemia, lymphoma, solid tumours No cognitive impairment	VAS (Visual analog scale) CHEOPS (Children's Hospital of Eastern Ontario Pain Scale) Questionnaire form (Cardiac rate)	Virtual reality application during port access is effective in significantly reducing pain and anxiety levels of children. Virtual reality application during port access is effective in reducing the pulse values of children.
Wolitzky et al.[27] (2005)	USA - Atlanta	Virtual reality application during needle insertion into port catheter	VR (n=10) Control group (n=10)	7-14 years old Mean= 10.50 Mean VR= 11.20 Mean - Control= 9.8	Various paediatric oncology patients	CHEOPS (The children's hospital of eastern ontario pain scale) How-I-Feel VAS (Visual analog scale) Questionnaire form (Cardiac rate)	Virtual reality application during port access is effective in significantly reducing pain and anxiety levels of children. Virtual reality application during port access is effective in reducing the pulse values of children.
Nilsson et al.[28] (2009)	Sweden	Virtual reality application during needle insertion into port catheter	VR (n=21) Control group (n=21)	5–18 years old Mean -VR=11 Mean - Control= 11	Leukaemia Paediatric group with brain tumours and solid tumours	CAS (Colour Analogue Scale) FAS (Facial Affective Scale) FLACC (Face, Legs, Activity, Cry, Consolability scale) Questionnaire form (Cardiac rate)	Virtual reality application during port access is not effective in significantly reducing the pain levels of children. Virtual reality application during port access is effective in significantly reducing the distress levels of adolescents. Virtual reality application during port access is not effective in significantly reducing the pulse rate of children.
Gerçeker et al.[9] (2021)	Türkiye	Virtual reality application during needle insertion into port catheter	VR (n=21) Control group (n=21)	6-17 years old Mean - VR= 11.2±3.1 Mean - Control= 11.7±3.2	Various paediatric oncology patients No visually impaired No cognitive impairment Huber Port pin not inserted before	Wong-Baker Faces Pain Rating Scale (WBS) The Child Fear Scale (CFS) The Children's Anxiety Meter-State (CAM-S)	Virtual reality application during port access is effective in significantly reducing pain, fear and anxiety levels of children.
Semerci et al.[2] (2020)	Türkiye	Virtual reality application during needle insertion into port catheter	VR (n=35) Control group (n= 36)	7- 18 years old Mean - VR= 11.69±3.36 (7-18) Mean - Control= 11.67±3.55 (7-17)	Various paediatric oncology patients No cognitive impairment	Wong–Baker FACES Pain Rating Scale.	Virtual reality application during port access is significantly effective in reducing the pain level of children.

Table 1. Publication Classification Form on Using Virtual Reality (VR) for Pain Management During Port Access in Children (Continued)

Author (Publication Year)	Country	Intervention(s)	Sample Size	Mean age, years	Group Feature	Data Collection Tools	Main Results
Hundert[8] (2022)	Canada	Virtual reality application during needle insertion into port catheter Ipad application during needle insertion into port catheter	VR (n=20) Ipad group (n=20)	8-18 years old Mean= 12.4 Mean - VR= 12.1±3.0 Mean - Ipad= 12.6±3.6	Actively receiving oncological treatment (ALL, Brain Tumour, Lymphoma)	NRS (Numeric Rating Scale) CFS (The Child Fear Scale) Pain Catastrophizing Pain Catastrophizing Scale for Children (PCS-C) Pain Catastrophizing Scale for Parents (PCS-P)	Virtual reality application during port access is not effective in significantly reducing the pain levels of children. Virtual reality application during port access is not effective in significantly reducing the likelihood of children experiencing distress. Virtual reality application during port access is effective in significantly reducing children's fear levels. Virtual reality application during port access is effective in reducing the rate of catastrophizing pain.
Caballero et al.[30] (2024)	Italy	Virtual reality application during needle insertion into totally implantable venous access devices (TIVAD).	VR (n=60) Control Group (n=60)	4-18 years old Mean - VR= 10.5 Mean - Control= 9.2	Pediatric oncology patients	Faces Pain Scale-Revised (FPS-R) State-Trait Anxiety Inventory for Children (STAIC) Questionnaire for VR experience Nurse assessment	Children in the intervention group reported higher satisfaction compared to those in the control group. Pain levels were also found to be lower in the group using virtual reality (VR). Older children benefitted more from this method, as they could engage better with the VR experience. Healthcare professionals expressed satisfaction with the assistance provided by VR in managing TIVAD procedures.
Reitze et al.[31] (2024)	Germany (Hannover Medical School)	Virtual Reality (VR) during port/vein punctures	VR (n=17) Control Group (n=21)	6-18 years old Mean- VR+ Control= 11.5	Pediatric Oncology Patient	Pediatric Quality of Life Inventory (PedsQL) Numerical Rating Scale (NRS) (Faces Pain Scale - Revised) FPS-r Modified Yale Preoperative Anxiety Scale - Short Form (mYPAS-SF) Behavioural Approach-Avoidance and Distress Scale (BAADS) Stress Coping Questionnaire for Children and Adolescents (SSKJ3-8R)	Pain levels were measured before, during, and after potentially painful interventions using the FPS-r (for ages 6–9) and NRS (for ages 10–18) scales. In the group receiving CoS, pain levels were found to be high during the intervention, whereas the group using virtual reality (VR) reported lower pain levels. The distress levels in the VR group significantly decreased compared to SoC group. Anxiety levels were also found to be lower in the VR group both before and during the intervention.
Savaş et al.[29] (2024)	Türkiye	VR application and respiratory sensor insertion during needle insertion into port catheter Non-VR application and respiratory sensor insertion during needle insertion into port catheter	VR (n=31) Control group (n=31)	6-12 years old Mean - VR= 9.33 Mean - Control= 9.74	In the pediatric oncology and hematology clinic of a city hospital in Istanbul	Descriptive Information Form Wong-Baker Faces Pain Rating Scale (WBS) Child Fear Scale (CFS) Children's State Anxiety Satisfaction Scoring Visual Analog Scale (VAS), ADXL354 Sensor	Virtual reality application during port access is effective in significantly reducing children's pain and anxiety levels. Virtual reality application during port access is significantly effective in reducing children's fear and anxiety levels. Virtual reality application during port access is effective in reducing respiratory rate. Virtual reality application during port access is effective in decreasing the satisfaction score.

Table 2. JBI Critical Appraisal Checklist for Randomized Controlled Trials Questions

Studies	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	Quality Score
Gershon et al.[26]	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Middle (69.2)
Wolitzky et al.[27]	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Middle (76.9)
Nilsson et al. [28]	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Middle (69.2)
Gerçeker et al.[9]	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Middle (76.9)
Semerci et al.[2]	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Middle (69.2)
Hundert et al.[8]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Good (84.6)
Cabellero et al.[30]	Y	U	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Middle (69.2)
Reitze et al.[31]	Y	U	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Middle (69.2)
Savaş et al.[29]	Y	N	Y	Y	N	NA	Y	Y	Y	Y	Y	Y	Y	Middle (76.9)
Question Quality Appraisal	100%	11.1%	100%	11.1%	0%	33.3%	100%	100%	100%	100%	100%	100%	100%	

S; Question, Y; Yes, N; No, U; Unclear, NA; Not Applicable

impact of VR application solely on pain. Gerçeker et al.[9] included 42 children aged 6-17 undergoing cancer treatment and examined the effects of VR application on pain, fear, and anxiety. Caballero et al. [30] aimed to evaluate the usefulness of VR in reducing anxiety and pain in children and facilitating the work of the nursing team in a study conducted with 120 pediatric oncology patients (VR=60, Control=60). Reitze et al. [31] examined the interventional reduction of pain, anxiety and distress using VR compared to standard care in a study conducted with 20 pediatric cancer patients (VR=17, Control=21) aged 4-17 in Germany. Savaş et al.[29] investigated the effect of a biofeedback-based virtual reality game on pain, fear and anxiety levels during port needle placement in a study conducted with 62 pediatric cancer patients (VR=31, Control=31).

In this systematic review, 22.2% (n=2) of the studies addressed have compared VR application with different distraction techniques other than standard care. Gershon et al.[26] conducted a study involving 52 children aged 7-19 undergoing cancer treatment, comparing three groups: standard care group (n=15), Non-VR distraction group (n=15), and VR distraction group (n=22). Pain and anxiety parameters were evaluated in these three groups. Similarly, Hundert et al.[8] included 40 children aged 8-18 undergoing cancer treatment and compared VR application with iPad distraction method.

Characteristics of Pain Scales

The effects of VR applications on pain during port catheter access have been examined in the studies included in this systematic review. Gerson et al.[26] and Woltzky et al.[27] used CHEOPS, Caballero et al.[30] used FPS-R (Face Pain Scale-Revised) to scale pain, while Gerçeker et al.[9], Semerci et al.[2] and Savaş et al.[29] used WBS. Nilsson et al.[28] used both the CAS (Color Analog Scale) for self-rating children and the FLACC (Face, Legs, Activity, Crying, Consolation Scale) for scaling pain. Reitze et al.[31] used FPS-r for medications for ages nine and under, and NRS for expenses for ages and above.

Characteristics of other scales

Only 11.1% (n=1) of the studies included in this systematic review have examined the effects of VR, a form of distraction technique, on fear catastrophizing in children undergoing cancer treatment. In the studies conducted Hundert et al.[8], fear catastrophizing scores were measured using the Pain Catastrophizing Scale for Children (PCS-C). Only 44.4% (n=4) of the studies included in this systematic review have examined the effects of VR, a form of distraction technique, on the level of fear in children undergoing canceR treatment. Gerçeker et al.[9] and Hundert et al.[8] utilized the PCS-C to assess fear levels in their studies. While Caballero et al.[30] used the State-Trait Anxiety Inventory for Children (STAIC) to measure the level of fear, Savaş et al.[29] used Children's State Anxiety.

Only 44.4% (n=4) of the studies included in this systematic review have investigated the effects of VR application, another form of distraction technique, on anxiety levels in children undergoing cancer treatment. Wolitzky et al.[27] employed the How-I-Feel scale, Gerçeker et al.[9] used the Children's Anxiety Meter-State (CAM-S), Nilsson et al.[28] employed the Facial Affective Scale (FAS).

33.3% (n=3) of the studies in the systematic review have examined the effect of VR, a form of distraction technique, on the heart rate of children undergoing cancer treatment. In their respective studies, Wolitzky et al.[27] , Gershon et al.[26] and Nilsson et al.[28] evaluated heart rates using pulse monitors by nurses and researchers before, during, and after port catheter access in both VR and non-VR application groups.

In this systematic review, 11.1% (n=1) of the included cases were studied on how children undergoing cancer

treatment, which provided attention distribution methods, were made on breathing, which provided maintenance of virtual reality. Respiratory rates were obtained using the ADXL354 sensor. The main features of the sensor are low sound intensity, high sensitivity and programmable digital high and low pass filters. Data were recorded on a 62 Hz body recording, which is sufficient to obtain a cardiorespiratory signal.

Only 22.2% (n=2) of the studies included in this systematic review examined the satisfaction level of the virtual reality glasses application, which is a distraction method. Caballero et al.[30] examined the satisfaction levels of both patients and nurses using a Likert scale with options such as Preference, Facilitation, Comfort, Usefulness, and Cooperation. Savaş et al.[29] scored the VAS 0 as "Not satisfied at all" and 10 as "Very satisfied" to assess the satisfaction of patients with the port catheter needle placement procedure.

The Effects of virtual reality goggles on pain behaviors

Children diagnosed with cancer benefit from the use of port catheters during their treatment process. Accessing the existing port catheter is a painful procedure for children. Utilizing distraction techniques during port catheter access proves effective in managing pain in this demographic. In all studies included in this systematic review (n=10), the effects of VR applications on pain during port catheter access were examined. In %77.7 (n=7) of these studies, VR application was compared with standard care. The comparison of VR application with standard care was conducted by Wolitzky et al.[27] , Nilsson et al.[28], Gerçeker et al.[9], Semerci et al.[2], Caballero et al.[30] included children aged 7-14 undergoing cancer treatment (n=20) in their study. The evaluation was carried out using the Visual Analog Scale (VAS). Parents, children, and nurses assessed pain levels before and after the procedure. The study results indicated that VR during port catheter access significantly reduced children's pain levels. Nilsson et al.[28] included pediatric oncology patients aged 5-18 (n=59) in their study. Both self-assessment using CAS and nurse assessment using FLACC were employed for evaluation. The study found that VR during port catheter access did not significantly reduce children's pain levels. Gerçeker et al.[9] included children aged 6-17 undergoing cancer treatment (n=42) in their study. The evaluation was conducted using the Wong-Baker Faces Pain Rating Scale (WBS). The study concluded that VR during port catheter access significantly reduced children's pain levels. In the study by Semerci et al.[2], children aged 7-18 undergoing cancer treatment (n=61) were included. The evaluation was done using the WBS. The study found that VR application during port catheter access significantly reduced children's pain levels. Caballero et al.[30] used Faces Pain Scale-Revised (FPS-R) to assess the pain of pediatric oncology patients (n=120). The study found significant distributions in the range of VR opening during the opening of the connection point temperature. Reitze et al.[31] used FPS-r (6-9 years old) and NRS (10-18 years old) before, during and after the intervention to increase the pain level of 38 pediatric oncology patients. Although the pain levels were very low before and after the intervention, there was an increase in pain perception during the intervention. In particular, the control group average pain ranged from 0.22 to 2.5 and 0.33. The VR groups were found to have significantly lower pain during the intervention, from 0.08 to 1.58 and 0.53. (P <0.05): This shows that patients experience significantly lower pain levels when using VR glasses during a painful puncture. Savaş et al.[29] used WBS to listen to the impressive pain written by 6-12 year olds in Türkiye. As a result; the mean pain scores of patients in VR and controls were found to be 1.67 ± 1.13 and 3.48 ± 0.81, respectively, and reported a significant difference (P < 0.001).

In these six studies, various pediatric oncology patients with ages ranging from 4 to 19, who did not have cognitive impairments, were included.[2,9,27–30] When evaluating the pain levels of groups that received VR application during port catheter access and comparing them with groups that received standard care, it was observed that the groups with VR application had significantly lower pain levels. In these studies, VR applications were found to be highly effective interventions in reducing pain during painful procedures when compared to standard care.

In 11.1% of the studies (n=1), a three-group design was used where VR application and standard care were combined with a non-VR distraction technique. Gershon et al.[26] included pediatric oncology patients aged 7–19 (n=52) in their study. The assessment was done using the Visual Analog Scale (VAS). In this study, both nurses, parents, and children were asked to evaluate pain.[27] While no significant differences in pain were observed between groups before the port catheter access procedure, a reduction in pain levels was noted during the procedure in groups where both VR and non-VR distraction techniques were applied.

22.2% (n=2) of all studies included in this systematic review have compared VR application with different distraction techniques other than standard care. In their study, Hundert et al.[8] included children aged 8-18 undergoing cancer treatment (n=40). The study compared VR application with iPad distraction application. In Hundert et al.'s study, when the effect of the iPad application on pain during port catheter access was examined, participants reported feeling three times more pain compared to the VR

application.[8]

The effects of virtual reality on heart rate and respiratory rate

In 33.3% (n=3) of the studies within this systematic review, the effects of VR applications on heart rate, a physiological indicator, were examined. Nilsson et al.[28], Gershon et al.[26] and Wolitzky et al.[27] assessed heart rates using pulse monitors by nurses and researchers before, during, and after port catheter access in both VR and non-VR application groups.[26–28] In Wolitzky et al.'s[27] study, during the procedure, heart rates were found to be significantly lower in the VR application groups among children who showed no difference in heart rates before the procedure in both groups.[27] In Nilsson et al.'s[28] study, heart rates were measured by a nurse using a pulse oximeter before, during, and after the procedure. Although a decrease in heart rate was observed in the VR group, no significant difference was found.[28] In Gershon et al.'s[26] study, heart rate was monitored by researchers during port catheter access. During the procedure, the heart rate of the group in which VR was applied was found to be at the lowest level, showing a lower heart rate compared to the group without VR application.[26]

The effects of virtual reality application on pain catastrophizing behavior

Pain catastrophizing experiences can assess the effectiveness of distraction interventions. In 11.1% (n=1) of the studies included in this systematic review, the effectiveness of VR applications on pain catastrophizing behavior was evaluated. Children can report their pain catastrophizing experiences during procedures, and parents can also report their children's pain catastrophizing experiences during procedures. In Hundert et al.'s study, children in the VR group reported lower pain catastrophizing during port catheter access compared to the iPad group. However, parents' reports of their children's pain catastrophizing were higher in both groups than the children's own reports.[8]

The effects of virtual reality application on fear

In 33.3% (n=3) of the studies included in this systematic review, which were among the distraction methods, the impact of VR on the level of fear in children undergoing cancer treatment was examined. Gerçeker et al.[9] conducted a study where fear levels reported by children and parents were evaluated before and after venous port access. According to the study data, there was no significant difference between groups in fear levels before venous port access. However, after the procedure, fear levels reported by children and parents significantly decreased. The study concluded that the VR application during venous port access significantly reduced the fear levels of children.

In the study by Hundert et al.[8] fear levels reported by children were found to be low in both groups (VR-Ipad) according to the study data. Additionally, participants who received the Ipad application had fear scores three times higher than those who received the VR. Fear scores before the procedure in both the VR and Ipad groups were higher than fear scores reported during the procedure.

In the study conducted by Savaş et al.[29] there was no statistically significant difference between the pre-procedure mean fear scores of children in the VR and control groups. However, post-procedure, the mean fear score of children in the intervention group was measured at 1.46 ± 0.50, while that of the control group was 2.80 ± 0.70. This finding indicates that the fear levels of children in the intervention group were significantly lower compared to those in the control group ($P < 0.001$).

The effects of virtual reality application on anxiety/ worry/ distress

In 88.8% (n=8) of the studies included in this systematic review, which were among the distraction methods, the impact of VR on anxiety/worry/distress levels in children undergoing cancer treatment was examined.

Gerçeker et al.[9] evaluated anxiety levels reported by children and parents before and after venous port access in both the control and VR groups. While the control group showed no significant change, the VR group experienced a significant reduction in anxiety levels. In the VR group, self-reported anxiety dropped by 2 points, whereas no significant decrease was noted in the control group, demonstrating the effectiveness of VR in reducing anxiety during port needle insertion.

In their study, Hundert et al.[8] conducted assessments before and after the procedure using an 11-point Numeric Rating Scale (NRS), where children, parents, and nurses participated. Additionally, parents reported their distress levels using the "Parent Distress Questionnaire" following the child's procedure. The study's findings revealed that participants who underwent the Ipad application had a 4.1 times higher likelihood of experiencing distress compared to participants who underwent the VR application.

In their study, Nilsson et al.[28] conducted assessments using the Facial Affective Scale (FAS). During the procedure, the distress level significantly increased in both groups compared to before the procedure. After the procedure, the FAS scores significantly decreased in both groups. It

was found that distress significantly decreased in children who underwent the VR application.

In their study, Wolitzky et al.[27] included children (n=20) aged between 7 and 14 years who were undergoing cancer treatment. The assessment was conducted using the "How I Feel" questionnaire and Visual Analog Scale (VAS) by parents, children, and nurses before and immediately after the procedure. When examining the study findings, no significant difference in anxiety levels between the groups was observed before the procedure ($P > 0.05$). However, during the assessment conducted during port access, it was concluded that the VR significantly reduced children's anxiety levels.

In their study, Gershon et al.[26] assessed anxiety using the Visual Analog Scale (VAS) and the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS) before and after the port access procedure, with retrospective scores due to logistical challenges in obtaining real-time ratings. No significant difference in anxiety levels was found between the groups prior to the procedure ($P > 0.05$). However, children in the non-VR control group exhibited significantly more muscle and leg tension compared to those who underwent VR ($P < 0.05$), despite no significant difference in overall CHEOPS scores. The study concluded that while anxiety levels were similar before the procedures, VR significantly reduced anxiety levels in children during port access.

In the study conducted by Reitze et al.[31] distress and anxiety levels were assessed using VR goggles. The distress measured by the BAADS scale was found to be an average of 2.6 in the intervention group and 3.1 in the standard of care (SOC) group during the procedure, with this difference being statistically significant ($P < 0.01$). Anxiety levels were recorded as an average of 28.6 in the VR group and 33.5 in the SOC group, demonstrating a significant reduction ($P < 0.001$). These findings indicate that VR goggles significantly reduce anxiety during painful procedures.

In the study by Savaş et al.[29] there was no statistically significant difference in pre-procedure anxiety scores between the children in the intervention and control groups. However, post-procedure, the mean anxiety score for children in the VR group was measured at 2.57 ± 1.23, while the score for the control group was 5.38 ± 1.72 ($P < 0.001$). These results indicate that the anxiety levels in the VR group were significantly lower compared to the control group.

In their study, Caballero et al.[30] analyzed anxiety levels using STAIC scores, revealing a significant reduction in the VR group with an average score of 1.25 compared to 2.03 in the control group. This finding indicates a notable 38.52% decrease in anxiety among patients in the VR group. Furthermore, anxiety levels were consistently lower in the VR group compared to the control group across all age groups and genders. However, it is noteworthy that no statistically significant difference in anxiety levels was observed between the groups in the 8 to 11-year-old age group.

DISCUSSION

This systematic review was conducted to investigate the literature on the effect of VR port catheter access on pain level in children aged 4-19 years, and to evaluate children's pain catastrophizing behaviour, fear, anxiety/ anxiety/ distress level and cardiac rate. When the literature was examined, it was found that the effect of virtual reality exposure on anxiety and pain levels in pediatric patients.[5,16,32] The effect of virtual reality on pediatric pain, fear and anxiety during procedures using needles in pediatric patients[33–35] and the effects of distraction on pain reduction during invasive procedures in children with cancer[21], systematic review and meta-analysis studies were found, but no systematic study specifically examining the effects of virtual reality goggles used during port catheter access on pain and fear was found. In this context, this is the first study to examine the effect of virtual reality on the pain and fear of pediatric oncology patients.

Needle procedures, mostly intravenous cannulation, are the most common cause of pain in children in the hospital setting. Although this pain experience in children is repeatedly reported in the literature, its management remains inadequate. Pain management should address the physical and psychosocial process of the child as a whole.[12] The findings of this systematic review show that the use of VR in pediatric oncology patients is effective in reducing the pain symptom during port catheter access. In the included studies, it was found that the pain levels of patients using VR were significantly lower than the control groups. [2,8,9,26–28,30] In addition to pain assessment, pain catastrophizing of pediatric oncology patients was also evaluated in the studies, and it was found that the pain catastrophizing experienced by children was significantly reduced by distraction techniques. While VR significantly reduced pain catastrophizing in children, no significant results were found on parents.[8] VR allows pediatric oncology patients to feel less pain by distracting them through visual and auditory stimuli during port catheter access. In this way, VR can reduce the use of analgesic drugs and provide protection from the side effects of drugs. As a result of the review, the use of VR technology is supported as an alternative treatment method to provide pain

management and control stress levels of pediatric oncology patients.

Children undergoing cancer treatment are exposed to many procedures during their treatment. Children experience fear during access to the venous port, one of these procedures. Due to the fear experienced, disruptions may occur in the treatment process of children. When the literature is examined, there are studies on the effectiveness of distraction methods in managing fear.[5,28] In the studies included in this systematic review, fear levels of pediatric oncology patients were examined in addition to pain. In the studies, it was concluded that the fear levels of the VR-treated groups were lower compared to other groups.[8,9] VR experience can positively affect the emotional state of patients and reduce their sensitivity to fear. In this way, patients' compliance with treatment may increase, their hospital experiences may improve positively, and their psychosocial well-being is positively affected.

Another parameter analysed in the studies included in this systematic review is anxiety/worry/ distress. Anxiety is a common problem affecting many people today. The advancement in technology in recent years has significantly affected the psychological and mental field. In this context, VR technology stands out as an innovative approach in the treatment of anxiety. The findings of this systematic review show that the use of VR in pediatric oncology patients is effective in reducing the anxiety symptom that occurs during port catheter access. In the included studies, it was found that the anxiety levels of patients using VR were significantly lower than the control groups.[8,9,26–31] The literature shows that VR have positive effects on anxiety.[5] However, it is important to better understand the effects of VR through more comprehensive and long-term research. Future studies may provide more information on how this technology can be used in anxiety management and help to develop more effective treatment methods in this field.

Another parameter evaluated in the studies included in the systematic review was cardiac rate. Cardiac rate is closely related to emotional states such as stress and anxiety. Stressful situations may increase cardiac rate, while relaxation and relaxation states may decrease cardiac rate. In the studies included in the systematic review, the effect of standard care and VR goggles application on cardiac rate during port access was evaluated, but the effect of a different distraction technique on cardiac rate was not examined. In line with the study findings, it was observed that VR applications reduced cardiac rates in children during port access.[27–29].

In addition to the benefits of using VR goggles in pain management for pediatric oncology patients in the clinical setting, some difficulties and disadvantages are also noteworthy. Reasons such as the high cost of the application, physical discomfort, weight, feeling of pressure on the head and face or limiting mobility, and personnel training negatively affect the use of VR goggles by patients.[4] Therefore, the use of VR goggles in pediatric oncology patients should be done in accordance with the individual needs and preferences of the patients.

When the evidence quality of the studies included in this systematic review was analysed, it was found to be of good quality. This result is valuable in terms of showing that the information provided by the studies is reliable.

Limitations

Considering the limitations of the systematic review, firstly, in three studies included in the systematic review, the effectiveness of VR application was compared with another distraction method.[8,26] It is thought that this may have affected the results of comparing the pain level in the control groups. Another limitation is that the effect of VR application on pain was evaluated with different measurement tools in the studies included in the systematic review. This situation prevents the statistical analysis of the studies, so it is thought to reduce the level of evidence.

The systematic review concluded that the application of VR glasses is an effective and safe method to reduce pain during port catheter access in pediatric oncology patients. In addition to pain, it was concluded that it was effective in reducing pain catastrophizing behaviour, fear, anxiety/anxiety/distress level and cardiac rates. However, further clinical trials are important to more precisely evaluate the effectiveness of the application and to learn more about its potential disadvantages. Furthermore, further studies are needed on how to integrate VR goggles in the clinical setting and how to incorporate them into management strategies, taking into account patients' preferences and comfort.

Etik Komite Onayı: Bu çalışmada, örneklem kapsamına alınan araştırma makaleleri erişime açık olan arama motoru ve elektronik veri tabanlarından alındığı için etik izin gerektirmemektedir. Ayrıca incelenen makaleler kaynakçada gösterilmiştir.
Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: Fikir- AEÖ, TG, SK; Tasarım- AEÖ; Denetleme-HBY; Kaynaklar- AEÖ, HBY, TG, SK; Veri Toplanması ve/veya İşlemesi AEÖ, HBY, TG, SK; Analiz ve/ veya Yorum- AEÖ, HBY, TG, SK; Literatür Taraması- AEÖ, HBY, TG, SK; Yazıyı Yazan- AEÖ,TG,SK; Eleştirel İnceleme-HBY.
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