Investigating the effect of virtual reality on reducing the anxiety in children: A systematic review

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INTRODUCTION

Many children may experience anxiety in therapeutic settings, especially in situations such as preoperative surgery, dentistry, and radiology [1-3]. These feelings often affect not only medical procedures, but also unintended consequences such as trying to escape treatment and lack of cooperation, eating and sleeping disorders, and increased stress symptoms [4-6]. Some of the symptoms of increased stress include anxiety, distraction, agitation, fear, and increased heart rate [7]. Preoperative anxiety is a potential threat to the patient due to changes in...
psychological responses, including increased blood pressure and heart rate, and may endanger the patient’s health [8].

Children, especially in the early years of life, are vulnerable to this issue because it changes the health of the child as well as the safe and familiar environment for the child. Children, on the other hand, have limited coping mechanisms to resolve stressful situations [9]. In addition, since pain and anxiety can lead to avoidance of health care, intervention is needed to relieve pain and anxiety in pediatric patients [10].

Attention is a common intervention during medical procedures, known for managing behavior during short invasive procedures. Attention is a cognitive-behavioral approach that seeks to divert the child’s attention from unpleasant stimuli to more pleasurable stimuli [11]. For example, using music, movies, and television, reading stories, and playing with toys have been shown to reduce children's pain and anxiety [12-14]. Virtual reality (VR) is a relatively new technique for creating distractions and may be more effective than traditional methods. VR consists of a computer environment in which three-dimensional orientation and interaction is possible. VR technology can provide a platform for reducing children’s anxiety by creating a sense of presence in an unreal world [15].

Recently, VR exposure has been used as a more preventative method to make patients feel comfortable and increase their familiarity with medical methods and environments. However, studies evaluating the effectiveness of VR technology have not yet been fully developed. Therefore, the purpose of systematic review was to investigate the effect of virtual reality technology on reducing anxiety in children.

MATERIAL AND METHODS

Study design

This systematic review is based on PRISMA 2020 guidelines [16, 17]; to report the evidence from the input studies to this systematic review. The text was searched on September 21, 2021 in PubMed, Embase, Scopus and Web of Science databases. The keywords and phrases MeSH and Emtree in the following two categories were used to search the databases:

1. "Anxiety", "Anxiousness", "Nervousness"
2. "Virtual reality", "Virtual Reality Exposure Therapy", "Virtual Reality Immersion Therapy", "Virtual Reality Therapy"

This review was limited to randomized and controlled trials so that we could evaluate the studies with the highest quality of evidence. The study population also included children who used VR technology to control treatment anxiety, which was applied when reviewing the abstract and full text of the articles in this filter. All articles were collected from the literature search and duplicate articles were removed from the review. Titles and abstracts were screened independently based on eligibility criteria. Articles that did not meet the inclusion criteria were excluded from this review. Complete texts were then retrieved and screened by two separate researchers based on eligibility criteria. Disagreements between researchers were resolved through discussion.

Eligibility criteria

Criteria for including studies in this systematic review included the following:

1) Randomized clinical trial studies using VR technology to reduce anxiety before and during treatment in children (under 18 years of age). 2) The full text of the articles was available in English.

On the other hand, exclusion criteria included: 1) studies including books, review articles, letters, studies that were in the form of letters to the editor and conference summaries; 2) Lack of availability of the full text of the articles in English; 3) Lack of relevance of the title, abstract or full text of the articles for the purpose of reading.

Data extraction and synthesis

The same checklist was used to extract the data. Data elements of this checklist included study title, year of publication, country, number of participants, study method, duration of intervention, technology-based approach, study objectives and main findings of the study.

Quality control

In order to evaluate the quality of the input studies to this study, the JBI quality evaluation checklist for randomized controlled trials was used [18]. This checklist included 13 questions to evaluate the quality of the studies. If the answer to a question was yes, he would get a score of 1 and otherwise a score of zero. Therefore, the maximum quality assessment score that each study could achieve was 13. Studies with a score less than 7 were excluded from this study.

RESULTS

Study selection

The process of identifying and selecting studies based on PRISMA diagrams is shown in Fig 1. A total of 197 related documents were selected for review. After reviewing the articles and eliminating duplicate studies (66 articles), 131 articles were obtained and their screening was evaluated based on the titles and
abstracts of the article. At the end of the review, 100 articles that had nothing to do with the purpose of this study were deleted. Then, 31 articles were selected to review their full text, of which 21 articles were deleted and finally 10 main articles were included in the study.

Quality Control
The quality assessment results shown in Table 1 show that there was no significant bias in the studies and all quality studies were included in our study.

Table 1: Summary of quality evaluation using JBI evaluation checklist

<table>
<thead>
<tr>
<th>Study</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil [19]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
</tr>
<tr>
<td>Iran [20]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>9</td>
</tr>
<tr>
<td>Netherlands [21]</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
</tr>
<tr>
<td>Saudi Arabia [22]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
</tr>
<tr>
<td>Korea [1]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>11</td>
</tr>
<tr>
<td>Spain [23]</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>9</td>
</tr>
<tr>
<td>China [3]</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
</tr>
<tr>
<td>Korea [24]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>11</td>
</tr>
<tr>
<td>Korea [25]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
</tr>
</tbody>
</table>

Characteristics of the study
The characteristics of all the studies included are reported in Table 2. Out of 10 incoming studies, 3 studies (30%) in Korea [2, 24, 22] and other studies in Brazil [19], Iran [20], Netherlands [21], Saudi Arabia [22], Republic of Korea [1], Spain [23] and China [3]. Studies in two categories of randomized trial (20%) [21, 24] and randomized clinical trial (60%) [1-3, 19, 20, 22, 23, 25] were classified. Input studies included 882 participants. The mean age of participants was from 5.5 [24] to 7.9 [21, 23] years.

Table 2: The studies included

<table>
<thead>
<tr>
<th>Reference</th>
<th>1st author</th>
<th>Mean age of participants</th>
<th>Type of intervention media</th>
<th>Number of participants</th>
<th>Objectives</th>
<th>Outcome of the intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>[19]</td>
<td>Natálio Baschirotto Custódio</td>
<td>7.66</td>
<td>Audio-visual glasses (virtual reality)</td>
<td>44</td>
<td>Evaluation of the effectiveness of auditory and visual distraction using VR glasses in comparison with conventional behavior management techniques was during the stages that require local anesthesia.</td>
<td>AVEs were a pleasurable method for distraction, without side effects, mean heart rate in both similar groups (p = 0.47), but a significant increase was observed during treatment in the control group.</td>
</tr>
<tr>
<td>[20]</td>
<td>Fateme Dehghan</td>
<td>7.35</td>
<td>Virtual reality glasses and headphones</td>
<td>40</td>
<td>Investigating the effect of virtual reality on preoperative anxiety in children</td>
<td>Virtual reality reduced preoperative anxiety in children (p &lt; 0.05).</td>
</tr>
<tr>
<td>[21]</td>
<td>Robin Bijlers</td>
<td>7.9</td>
<td>VR Exposure (VRE)</td>
<td>191</td>
<td>Evaluation of the effect of virtual reality exposure for surgical preparation for selective day care in children and anxiety in the control group receiving routine care.</td>
<td>VRE had no beneficial effect on anxiety. But after more painful surgery, the children in the intervention group needed significantly less analgesia. The difference between the two groups was not significant.</td>
</tr>
<tr>
<td>Reference</td>
<td>1st author</td>
<td>Mean age of participants</td>
<td>Type of intervention media</td>
<td>Number of participants</td>
<td>Objectives</td>
<td>Outcome of the intervention</td>
</tr>
<tr>
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<td>-----------------------------</td>
</tr>
<tr>
<td>[22]</td>
<td>Osama M Felemban</td>
<td>8.4</td>
<td>VR Goggles</td>
<td>50</td>
<td>investigate the effect of virtual reality distraction on anxiety and pain during buccal infiltration anesthesia in sick children.</td>
<td>The use of virtual reality glasses has a similar effect on screen distraction on heart rate during buccal anesthesia in pediatric patients.</td>
</tr>
<tr>
<td>[1]</td>
<td>Sung-Hee Han</td>
<td>5.6</td>
<td>Virtual reality glasses</td>
<td>99</td>
<td>The effect of virtual reality education for sick children on anxiety in chest radiography</td>
<td>Decreased anxiety, discomfort and operation time (p = 0.004) and increased parental satisfaction in the intervention group were reported.</td>
</tr>
<tr>
<td>[23]</td>
<td>Cristina Gómez-Polo</td>
<td>7.9</td>
<td>Virtual reality headset</td>
<td>80</td>
<td>Evaluating the effectiveness of using a VR headset as a distraction factor for managing anxiety and behavior of pediatric patients during dental treatment</td>
<td>The use of VR headsets during dental treatment significantly reduced anxiety (95% of happy children) and improved behavior (100% positive behavior) compared to the control group (40% and 57.5%, respectively). A virtual reality headset can effectively distract the child's patient and help reduce anxiety and manage behavior during dental treatment.</td>
</tr>
<tr>
<td>[3]</td>
<td>Longkuan Ran</td>
<td>5.6</td>
<td>Videos with helmets and headphones</td>
<td>120</td>
<td>Investigating the role of VR distraction on behavior management in short-term dental treatments in children</td>
<td>VR in the intervention group significantly reduced anxiety (P&lt;0.05) and pediatric pain (P&lt;0.05) and the length of dental treatment (p = 0.02).</td>
</tr>
<tr>
<td>[2]</td>
<td>Jung-Hee Ryu</td>
<td>6.0</td>
<td>Virtual reality glasses</td>
<td>120</td>
<td>Evaluate the effect of VR compared to standard video on reducing anxiety and discomfort in children with chest radiography</td>
<td>Reducing anxiety in children and increasing the efficiency of methods in the virtual reality intervention group versus the control group by watching video (P = 0.01)</td>
</tr>
<tr>
<td>[24]</td>
<td>Jung-Hee Ryu</td>
<td>5.5</td>
<td>Gamification through a Virtual Reality</td>
<td>69</td>
<td>Evaluation of the effectiveness of gamification in the preoperative process through play (VR) in reducing preoperative anxiety in children</td>
<td>Preoperative anxiety (p&lt;0.01) was lower in the gamification group than in the control group. As a result, the VR experience can reduce preoperative anxiety and improve compliance during induction of anesthesia in children undergoing elective surgery and general anesthesia.</td>
</tr>
<tr>
<td>[25]</td>
<td>J-H Ryu</td>
<td>6.0</td>
<td>VR Tour</td>
<td>69</td>
<td>Investigating the effect of virtual reality in reducing preoperative anxiety</td>
<td>VR tour in the operating room was effective in reducing preoperative anxiety and increasing adaptation during induction of anesthesia in children undergoing surgery. (P&lt;0.001)</td>
</tr>
</tbody>
</table>

**The effects of virtual reality on children’s anxiety**

In 7 of the studies (70%), virtual reality has helped to reduce children’s anxiety in the treatment process [1-3, 20, 23-25]. The mechanism of all studies focused on children's distraction in order to reduce their anxiety. However, in one study, virtual reality was used as an educational tool [1]. In 3 cases (30%) reduction of anxiety in the two groups of control and intervention was not significantly different [19, 21, 22]. In all studies, the control group received routine care, including routine behavior management techniques and anxiety control pills. In 7 of the studies, children and parents were satisfied with the virtual reality intervention in reducing anxiety, and in all 7 cases, users were highly satisfied [1-3, 19, 23-25]. In 3 cases...
of studies found from virtual reality technology in reducing pediatric anxiety in dentistry [3, 19, 23], 4 cases before surgery [20, 21, 24, 25], 2 cases related to anxiety before shelf radiography of breasts [1, 2] and one case were used during preoperative anesthesia [22].

**DISCUSSION**

The purpose of this systematic review was to investigate the effect of virtual reality technology on reducing anxiety before and during treatment in children. The results of systematic review show that in 7 cases (70%) of virtual reality studies, it has helped to reduce the anxiety of children before and during treatment [1-3, 20, 23-25]. In all of these studies, the mechanism of action of virtual reality focused on children's distractions in order to reduce their anxiety. However, in one study, virtual reality was used as an educational tool [1]. In 3 cases (30%) of virtual reality technology studies, there was no significant difference in reducing children's anxiety [19, 21, 22]. In one of the studies to reduce preoperative anxiety in children, the virtual reality game intervention group and the control group underwent routine training. The results of their study showed that virtual reality play is significantly effective in reducing anxiety before surgery and during anesthesia [24]. In 70% of the studies, the level of parental and child satisfaction was measured by virtual reality technology to control children's treatment anxiety, and in all of these studies, their high level of satisfaction was reported [1-3, 19, 23-25].

In line with the results of this study, Ioannou et al. conducted a systematic review to evaluate the effect of VR intervention on symptoms such as anxiety, depression, fatigue and pain in cancer patients. The results of their study showed that VR, as an emotion-focused distraction intervention, reduces the severity of these symptoms [26]. In another study, Oing et al. conducted a systematic review to determine the effectiveness of VR-based therapy for anxiety-related disorders, as well as to explain how modern VR systems need to address the shortcomings of older VR systems.

They concluded that VR technology as a diagnostic tool for paranoid thoughts has been effective in most studies, although previous studies have shown promising and emerging effectiveness in using VR as a therapeutic and diagnostic tool for anxiety-related disorders. VR technology in general needs to be improved to provide a fully immersive and interactive experience that is able to bridge the gap between the real and virtual worlds [27].

In addition, López-Valverde et al. in their meta-analysis study aimed at evaluating the effectiveness of VR on reducing pain and anxiety in dental patients without age restrictions concluded that VR is an effective distraction method for reducing pain and anxiety in patients undergoing various treatments. Are placed dental [28].

One of the limitations of this study was the difference in the type of consequences under consideration and the heterogeneity in the software and platforms under virtual reality, according to which the results will be different under their influence. One of the inclusion criteria was the studies of the population we were studying, which included studies of children under 18 years of age; Therefore, the impact of virtual reality on the adult population is unclear and requires further study.

However, these interventions seem to be more effective in children; because children have more therapeutic anxiety [29] and on the other hand children have more imagination, which increases their level of immersion in virtual reality [30]. In addition, given that studies have used different methods to measure the results of anxiety reduction; therefore, it was not possible to perform meta-analysis or study the effect of these studies as a group.

**CONCLUSION**

The results of systematic review show that virtual reality can make the treatment process more satisfactory and help manage their behavior by creating calm and attention while reducing anxiety in children. However, due to the small sample size (small number of input studies), the evidence is not sufficient to prove the effectiveness of virtual reality in reducing pediatric treatment anxiety. Future studies are proposed to compare the effect of virtual reality technology on reducing treatment anxiety in different age groups.

**AUTHOR’S CONTRIBUTION**

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

**CONFLICTS OF INTEREST**

The authors declare no conflicts of interest regarding the publication of this study.

**FINANCIAL DISCLOSURE**

No financial interests related to the material of this manuscript have been declared.

**REFERENCES**

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