Research Article

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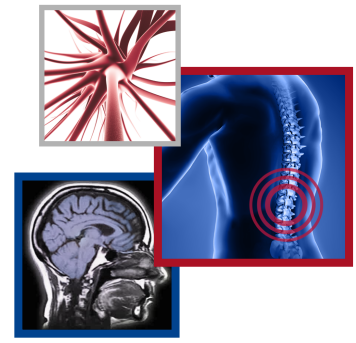

Effect of virtual reality headset for pediatric fear and pain distraction during immunization

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Practice points

- Needle phobia is one of the most common fears among children.
- Movies, music and games have been used as distraction techniques prior to and during pediatric immunizations to mitigate pain and fear.
- Virtual reality (VR) is a newer distraction technique used in chemotherapy, burn treatment, venipuncture and psychology.
- Our study found that VR headset use is feasible in an outpatient community pediatric setting.
- Anticipated versus actual pain and fear was reduced in 94.1% of pediatric subjects in our study.
- Parents of the study subjects also reported lower perception of pain and fear in their child following VR use.
- Future studies are needed to determine effectiveness in larger populations and whether pain and fear continue to be reduced following multiple vaccinations in the same visit.

Aim: Fear of needles is a well-known phobia among children and adults. This study presents the rationale, feasibility and results of a pilot study applying a virtual reality (VR) headset as a fear reduction and pain distraction during immunizations. **Patients & methods:** 17 subjects and 17 parents rated their fear and pain level pre- and postimmunization using Wong-Baker pain scale and McMurtry children's fear scale. Immunization was provided, while subject was wearing a VR headset. **Results:** Ratings of anticipated versus actual fear and pain due to immunizations improved following use of the VR headset in 94.1% of pediatric subjects. **Conclusion:** The use of a VR headset was well received and reduced overall fear and pain in children receiving immunizations.

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Fear of needles is a well-known phobia among children. Children receive vaccines and are exposed to needles on numerous occasions in their lifetime, which causes many children fear, anxiety and pain [1]. In a study of 1024 children, 63% reported a fear of needles. In some cases, needle phobia or needle anxiety caused parents to delay scheduled visits with their child's doctor in order to postpone vaccinations due to this phobia [2]. To combat fear of needles and potentially reduce pain, several distraction techniques have been used such as deep breathing exercises, watching videos, listening to music or playing video games. More recently, virtual reality (VR) has been shown to reduce mental stress and pain in chemotherapy, venipuncture and long-term hospitalizations [3]. With the success of VR in recent years, it has become a nonpharmacologic method to reduce pain and fear that the patients feel prior to, during and after painful medical procedures. It is also noted that for some children and adults, severe needle phobias may require regular therapy with a trained psychologist and such phobias may not be reduced with simple distraction techniques [2,3].

The incidence of fear of needles and associated pain has led to the development of protocols and clinical practice guidelines for reducing the pain of childhood vaccination [4–6]. Despite guidelines and various fear- and pain-reducing techniques currently in practice, pediatric fear and pain during immunization remain. The intent of this pilot study is to determine the rationale, feasibility and effectiveness of utilizing a VR headset for fear reduction and pain distraction during pediatric immunization.

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Design

A total of 17 pediatric aged subjects and 17 parents/guardians were included in this study. For the subjects included in the study, the research assistant presented the Wong-Baker pain scale [7] and McMurtry children's fear scale [8] to both the subject and the parent/guardian independently with appropriate dialogue, respectively and had both the subject and parent proclaim their anticipated fear and pain level from the needle before goggle use without discussion between the subject and parent/guardian. Parent/guardians were unable to hear or see the responses given by the subject. The subjects were recruited with convenience sampling based on the order of previously scheduled appointment date. Informed consent was obtained and no subjects or parents declined participation. The vaccine administered to the subject was dependent on the routine immunization schedule for the subject.

The research assistant then placed the VR goggles, Tepoinn 3D VR Headset, on the subject. Technical specifications for the VR headset included: support for smartphone size: 3.5–6 inches; refraction adjustment range from -500 to +200°; focal adjustment range: 56–70 mm/2.1–2.5 inches; field of angle: 100–120°. Glasses are not required to be removed as this VR headset fits over a person's prescription eyewear. A smartphone VR enable smartphone app (iPhone 6) was inserted into the goggles with the subject choosing a roller coaster ride, helicopter ride or hot-air balloon ride VR experience prior to VR headset placement. At the time of this pilot study, there were a limited number of available VR applications available through the iPhone app store. The applications for subjects to choose from were chosen for the study based on the likelihood of pediatric subjects wanting to experience at least one of the offerings. Once the VR headset was set in place, the physician administered a single injection with aseptic technique to the deltoid with a 23g × 1 inch needle. Total time from subjects' initial VR exposure with the headset until after immunization was completed was less than 30 s. After each immunization, the VR headset was cleaned and sanitized with standard infection control procedures for an outpatient office setting. The vaccines administered during this study were based on routine visits and included: Boostrix, Gardasil or Kinrix. The headset was removed and the crying time post needle injection was noted by the research assistant. After crying (if any) was resolved, the research assistant then presented the same fear and pain scale and asked the subjects to choose the one that shows their fear level and pain level toward needles after the VR headset was used. Children were instructed to rate the amount of fear and pain they had experienced with the immunization that was just provided to them. The parent/guardian was asked to choose which face they believed resembled the child's actual fear and pain level from the needle usage post VR headset use.

Results

A total of 17 pediatric aged subjects were studied with all but two being over the age of 6 years. The study group demographics for the pediatric subjects included 64.7% males (n = 11), 35.3% females (n = 6); 70.6% Caucasians (n = 12), 11.8% Hispanics (n = 2), 11.8% Asian/Pacific Islanders (n = 2) and 5.9% African–Americans (n = 1). The study group demographics for the parent/guardian of the pediatric subjects included 94.1% females (n = 16), 5.9% males (n = 1); 76.5% White (n = 13), 11.8% (n = 2) Asian, 5.9% Hispanics (n = 1), 5.9% African–Americans (n = 1). Ages ranged from 32 to 46 years for the parent/guardian. Highest education levels obtained by the parent/guardians were 76.5% bachelor's degree (n = 13), 11.8% post-graduate degree (n = 2) and 11.8% high school diploma or equivalent (n = 2).

Ratings of anticipated versus actual fear and pain due to immunizations improved following use of the VR headset in 94.1% of pediatric subjects. Fear levels were measured using the McMurtry Children's Fear scale which ranged from 0 to 4, with 4 being rated as the most fear. The average anticipated fear level due to immunization before goggle use as perceived by the parent (n = 17) was 2.82 (standard deviation [SD] = 1.13). The average fear level due to immunization after goggle use as perceived by the parent decreased to 0.64 (SD = 1.06). There was a 77% (p = 0.05) decrease in fear score as perceived by the parent.

Pain levels were measured using the Wong-Baker pain scale which ranged from 0 to 5, with 5 rated as the most pain. The average anticipated pain level due to immunization before goggle use as perceived by the parent was 3.34 (SD = 1.30). The average pain level due to immunization after goggle use as perceived by the parent decreased to 0.76 (SD = 1.06). This was an 83% (p = 0.02) decrease in fear score as perceived by the parent (Table 1).

Subjects over the age of 6 (n = 15) rated their anticipated fear level before goggle use upon immunization as well as actual fear level after goggles use. The average anticipated fear level due to immunization before goggle use was 2.86 (SD = 1.23). The average actual fear level due to immunization after goggle use decreased to 0.5 (SD = 1.00). This was near-marginal significance with a 90% (p = 0.43) decrease in fear score as denoted by the subject.

Table 1. Perceived pain/fear in child as measured by child and parent.

Statistic	Measured by parent		Measured by child	
	Decrease in perceived pain level in child (range 0–5)	Decrease in perceived fear level in child (range 0–4)	Decrease in pain level in child (range 0–5)	Decrease in fear level in child (range 0–4)
Mean	2.71	2.18	2.5	2.57
p-value	0.02	0.05	0.52	0.43

Subjects over the age of 6 (N = 15) rated their anticipated pain level due to immunization before the use of the VR headset as well as actual pain level after the use of the VR headset during immunization. The average anticipated pain level due to immunization before use of the VR headset was 3.28 (SD = 1.38). Following immunization, pediatric subjects were asked to rate the amount of pain they had experienced with the immunization that was just provided to them. The actual pain level after use of the VR headset decreased by a factor of 2.5. The use of the VR headset provided a 77% (p = 0.52) decrease in pain score as denoted by the subject.

Two-way repeated measure analysis of variance between parent perception of fear and pain and pediatric subject fear and pain postimmunization showed no statistically significant difference between the means (F = 2.16; p = 0.91).

Discussion

The objective of this study was to test the feasibility, efficiency and usefulness of using VR headsets as a means to decrease fear and pain associated with immunizations in pediatric patients. The study focused on fear and pain, both anticipated and actual as reported by the child and their caregiver. Delayed onset pain occurring after the first 10 min of the immunization was not considered in this pilot study. A total of 15 children (ages 6–17) completed a pre- and postquestionnaire evaluating fear using the McMurtry children's fear scale [8] and Wong-Baker scale for pain [7]. The guardians of the 17 subjects also completed a pre- and postquestionnaire assessing their parental perception of fear and pain using the above scales for fear and pain.

In our study, the use of a VR headset was well received and improved reporting of fear and pain in children receiving an immunization. A total of 94.1% of children reported that they would prefer to use the VR headset during their next immunization or injection. Lack of statistically significant results in the pediatric subject group may be related to our small sample size.

The use of VR headsets has been shown to help reduce the level of pain experienced during daily burn wound care procedures and iv. placement in children [1,9,10]. The subject's level of pain, anxiety and estimated time spent thinking about their pain decreased during VR treatment [1]. Recent studies have also proven the effectiveness of using VR as a distraction for children while receiving outpatient chemotherapy and lumbar punctures [11,12]. It was shown to be a valid form of treatment because it allowed the subject undergoing chemotherapy or lumbar puncture to focus on pleasant or interesting stimuli rather than focus on the painful stimuli [11,12]. VR was also used with pediatric cancer patients whose treatment required access to their subcutaneous venous port device (port access), and was shown to decrease the subjects pain and anxiety [13]. Studies have also shown that the use of a VR headset, compared to playing a standard video game, while undergoing cold pressure pain increases the level of distraction in pediatric subjects [14]. Previous research has theorized that humans have a limited capacity for attention and thus if a person is attending to another stimulus (i.e., VR) away from a noxious stimulus, they will perceive the painful stimulus as less severe [15]. Although outside the scope of this discussion, mechanisms for actual analgesia from VR use have been hypothesized and may include intercortical modulation among signaling pathways in the brain [16]. With the sheer number of pediatric patients reporting fear of needles, 63% according to Taddio *et al.*, and parents delaying routine vaccines as a result there is a need for improved distraction techniques during immunizations [2]. To our knowledge, there have been no other studies that look at VR distraction during pediatric immunizations. This pilot study may help other pediatric practices learn that VR is a relatively inexpensive and easy-to-implement method of distraction during immunizations.

The measurements of pain and fear level among pediatric subjects and their parent/guardian were not intended to demonstrate the superiority of VR use for pain and fear reduction in pediatric immunizations. Rather, this study sought to collect information about the feasibility of VR use for pediatric immunizations in an outpatient setting to determine whether or not a larger study would be warranted.

It should be noted that prolonged use of VR (greater than 30 min without a break), is discouraged by some manufacturers. Use in infants and toddlers may be possible in the future. However, with the current size of smartphones and the headset devices that are available at an acceptable price point for individual office use, it is unlikely that our study's design could be used in this young of a population. Safety of VR use in infants and toddlers should also be considered, but is outside the scope of this pilot study. In this study, the subjects had a choice of using a roller coaster ride, hot-air balloon ride or helicopter ride. Those that have a fear of a particular VR setting were discouraged from participating, although all subjects in the study were amenable to at least one of the VR experiences. Subjects who are prone to motion sickness should likely be discouraged from choosing a VR experience where movement is simulated. Others VR enabled smartphone applications available, but not tested in our study, include serene beach scenes which may provide a similar VR distraction during pediatric immunization without simulated motion or adventure.

With many VR units costing under US$50 and the accompanying smartphone apps less than US$1 for unlimited use, VR headsets are an inexpensive nonpharmacologic technique, which may reduce fear and pain in pediatric patients receiving an immunization. Higher quality VR devices with significantly increased price points are available, but many of them require a cord to be attached to a computer throughout the duration of use. Wireless VR headsets are likely more ideal for an outpatient pediatric immunization setting, based on their ease of use and lower price point. Additionally, in our study, the use of VR headset during scheduled immunization did not require an additional member of the office staff to implement which helps to demonstrate the feasibility of VR use in a typical outpatient pediatric office setting. Time to explain the use of VR headset to a child who has never seen or experienced VR may increase the duration of a typical immunization encounter. However, in our study, each pediatric subject had previously seen VR goggles on television or used them at home, school or a friend's house; and thus, any additional time to the encounter from discussion about what the VR headset was would have been reported as minimal at most. Infection control measures because of the reuse of the VR goggles should be maintained. Nausea or other uncomfortable feelings while wearing the VR goggles is a possibility and should be discussed with the patient and/or parent prior to use. Parents/guardians must also accept/approve the use for the child and physicians or other immunization providers must also accept a new device into their immunization procedure workflow. With the portability and ease of use, the feasibility of implementation of VR goggles during immunizations in a pediatric outpatient setting is likely high. Age and maturity of the subject should be considered as children younger than 4 years of age may be less likely to wear a VR headset. Future studies may further assess this limitation and determine the most appropriate age for VR use in this setting. Previous studies have shown evidence that children experience needle phobia at the time of vaccinations [4]. A limitation of the study was a small sample that limits the ability to generalize results to a larger pediatric population. Randomized controlled studies in larger populations are needed to determine the effectiveness compared with other distraction techniques and determine if using VR reduces delays in immunizations as a result of anticipated fear or pain. An additional limitation may be that decreases in pain/fear levels by the subject may be secondary to the immunization being finished rather than resulting directly from VR goggle use. However, with 94.1% of pediatric subjects reporting that they would like to use the VR goggles again during their next immunization, it can be postulated that the subject's immunization experience was improved from VR goggle use. Future studies with a control group and/or crossover study may be helpful in determining if VR use improves the patient's experience during immunizations. Future studies should also determine whether VR headset leads to similar reduction of anticipated and actual fear and pain when multiple immunizations are provided during the same office visit.

Further studies may show an increase in immunization adherence for the child, rather than delaying vaccination because of fear and/or pain due to the vaccine. Parents may be more inclined to have their child vaccinated on-time rather than delay the vaccine because VR could possibly ease the experience for the child and the parent. From the public health perspective, increasing the number of children who are vaccinated on schedule and on-time may reduce the incidence of vaccine preventable diseases such as: pneumococcal pneumonia, hepatitis A and B, meningitis, measles, mumps, rubella, haemophilus influenzae and varicella. As noted in the study by Taddio *et al.*, 7% of parents report immunization noncompliance with their children because of needle fear [2]. To our knowledge, there are no specific data indicating that needle phobia plays a role in the incidence of vaccine preventable diseases. However, any method to increase the percentage of children vaccinated on-time and on schedule should be sought in primary care pediatrics. With many children crying, kicking and fighting in the exam room in order to avoid injection, future studies may be able to better quantify the time savings (and potential cost savings) for medical

offices from improved efficiency using VR goggles. Overall, this may reduce the mortality and morbidity from vaccine preventable illnesses because children are on schedule with their vaccinations.

Conclusion

The use of a VR headset was easy to implement in an outpatient pediatric office setting. VR headset use during the immunization was well received and reduced overall fear and pain in children receiving immunizations.

Future perspective

As VR continues to evolve and become less expensive for the end user, VR use can be expected to become ubiquitous for many areas of medicine including: pediatrics, pain management, psychiatry, psychology, surgery among others.

Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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