Virtual reality enhanced mannequin (VREM) that is well received by resuscitation experts

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Simulation and education paper

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Abstract

Summary: The objective of this study was to test acceptance of, and interest in, a newly developed prototype of virtual reality enhanced mannequin (VREM) on a sample of congress attendees who volunteered to participate in the evaluation session and to respond to a specifically designed questionnaire.

Methods: A commercial Laerdal HeartSim 4000 mannequin was developed to integrate virtual reality (VR) technologies with specially developed virtual reality software to increase the immersive perception of emergency scenarios. To evaluate the acceptance of a virtual reality enhanced mannequin (VREM), we presented it to a sample of 39 possible users. Each evaluation session involved one trainee and two instructors with a standardized procedure and scenario: the operator was invited by the instructor to wear the data-gloves and the head mounted display and was briefly introduced to the scope of the simulation. The instructor helped the operator familiarize himself with the environment. After the patient's collapse, the operator was asked to check the patient's clinical conditions and start CPR. Finally, the patient started to recover signs of circulation and the evaluation session was concluded. Each participant was then asked to respond to a questionnaire designed to explore the trainee's perception in the areas of user-friendliness, realism, and interaction/immersion.

Results: Overall, the evaluation of the system was very positive, as was the feeling of immersion and realism of the environment and simulation. Overall, 84.6% of the participants judged the virtual reality experience as interesting and believed that its development could be very useful for healthcare training.

Conclusions: The prototype of the virtual reality enhanced mannequin was well-liked, without interference by interaction devices, and deserves full technological development and validation in emergency medical training.

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participants interested in the issues of CPR and related training, among which a large number of CPR instructors. The goal of this study was to test the acceptance of and interest in a VREM prototype among a sample of congress attendees who volunteered to participate in the evaluation session and to respond to a specifically designed questionnaire.

**Materials and methods**

The VREM was developed at the PERCRO laboratory, Scuola Sant’Anna of Pisa, utilizing a commercial Laerdal HeartSim 4000 mannequin connected with VR technologies (data-gloves, head mounted display and tracking devices) specifically designed for this application. The VREM prototype tested was able to render the main clinical signs and patient’s reactions in an immersive VR scenario and with a first person perspective. The detailed description of VR technologies is available in the e-version of the article.

The subject was able to touch the patient, hold the head of the patient in his hands, and check the carotid pulse. Real-time animations were implemented in order to simulate some of the typical clinical findings indicative of a cardiac arrest, including progressive skin colour changes and mydriasis. These reverted once the manoeuvre of the external cardiac compression was successful.

The evaluation session involved one trainee and two instructors with a standardized procedure and scenario (Figure 1):

1. The operator was invited to wear the data-gloves and the head mounted display and was briefly introduced to the scope of the simulation.
2. The instructor helped the operator become familiarized with the virtual environment in relationship with himself and the patient.
3. The patient’s voice was then heard in the room. The patient said “I am not feeling well, really bad, I think I’m fainting.”
4. The operator was asked to check the patient’s clinical signs.
5. After beginning CPR, the patient started to recover signs of circulation (acute pallor was reverted and the pupils became myotic).
6. The evaluation session was concluded.

Each participant was then asked to respond to a questionnaire. The questionnaire, formulated based on a 7-point Likert scale (LS), was designed to explore the trainee’s perception in the areas of user-friendliness, realism, and interaction/immersion.

**Results**

The VREM was tried by 39 users. The sample consisted of 27 (69.2%) men and 12 (30.8%) women, with an average age of 41.9 ± 10.8 years. Only 20.5% had previous experience with Virtual Reality, 51.3% had a previous experience of training in simulation centres. The sample included 54% medical doctors, 23% nurses and 23% lay rescuers. Sixty-seven percent were CPR instructors. The evaluation for each question is reported in detail in Table 1 and questions are grouped according to three areas: user-friendliness, realism, and interaction/immersion.

**User-friendliness**

The difficulty in using and wearing the devices (Q5) was judged variably with 8 participants judging it difficult (LS > 4), 2 judging it neither easy nor difficult (LS = 4), and 29 judging it easy (LS < 4). The difficulty in practicing the cardiac compression (Q8) was judged as difficult by 11 participants (LS > 4) and easy by 28 participants (LS < 4).

**Realism**

The overall feeling that the patient was present in front of the person (Q6) and that the virtual hands were moving like the real hands (Q7, Q10) were both high. The overall realism of cardiac arrest signs was judged well (Q9) and the hospital environment was judged as good (Q11, Q12).
The perception of the three-dimensional space was evaluated as high (Q13), interaction with the patient was judged realistic (Q15), and the involvement in the intervention manoeuvres high (Q16).

The difficulty in reaching and touching the patient (Q14) was evaluated very variably, but the overall answers judged the interaction/immersion to be high.

Overall, 84.6% of the sample evaluated the VR experience as interesting and believed that it’s development could be very useful for healthcare training.

The VR system was found to be very well-liked, as was the feeling of immersion and the realism of the environment and simulation.

**Discussion**

This study demonstrates the feasibility of combining VR technology with a traditional training mannequin for use during emergency care training. The resulting VREM prototype was able to enhance the perception of realism and extend the physiological response to treatment beyond that available with traditional mannequins used during resuscitation training.

The 39 subjects who participated in the session reported the use of devices to be acceptable, the realism to be very high, and the interaction/immersion realistic, leading to a positive overall evaluation of VREM. Subjects judged the development of this technology as very useful for healthcare training.

The addition of VR to traditional emergency care training may improve diagnostic orientation by adding information by the reproduction of clinical signs in the virtual patient, provide feedback on the effect of treatment (e.g., skin colour as index of perfusion) and help task performance training.

The extensive use of VR for surgical training has been recently reviewed. The review concluded that for laparoscopic surgery, VR training decreased the time needed to complete a task, increased accuracy, and decreased errors compared to no training and standard laparoscopic training, and was more accurate than video training.

Emergency care training, in addition, needs team performance training, which has been shown to be effectively achieved by crisis resource management (CRM) with high-fidelity simulation, with ‘providing feedback’ being the most important feature. The effect of the addition of VR will need to be tested also exploring the hypothesis that feedback provided by changes in clinical signs of virtual patients may improve the effectiveness of the video-assisted debriefing.

The limits of the prototype tested in this study were that only the cardiac compression component of the virtual intervention was developed and that signs of cardiac arrest (skin colour and pupils width) still needed manual activation by the instructor and were not yet synchronized to ECG rhythm changes.

The effect of introducing more complex treatments and physiological responses requires further evaluation. This study limited evaluations to a motivated group of advanced life support instructor volunteers. The acceptability and performance of the system amongst the wider healthcare community warrants further study.

This study opens an entire field of new research to complete the development of VREM, to develop emergency care training with VREM blended with CRM principles and video-assisted debriefing to achieve optimal emergency care training.

**Conclusion**

In conclusion, the addition of VR to existing mannequins is possible and represents an interesting field for future research. The prototype of a virtual reality enhanced mannequin was met with enthusiastic interest, unaffected by the need of utilizing interaction devices and deserves full technological development (for example finger movements, improvement of facial signs, and animation in different clinical scenarios) and validation in emergency care training.

**Conflict of interest**

No relationship exists between any of the authors and any commercial entity or product mentioned in this manuscript that might represent a conflict of interest.

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**Appendix A. Supplementary data**


**References**

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