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Original Research

Next-Generation Patient Education: Pilot Program Introduces Virtual Reality for Men's Preventive Health

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Abstract

Background: Preventive interventions designed to educate men to embrace healthier lifestyles are urgently needed to mitigate the risk of diseases correlated to lifestyle and habits. Virtual reality (VR) technologies offer an immersive visual, tactile, and kinesthetic educational experience, for which male learning style preference may exist. We developed a VR-based cardiovascular health educational session, embedded within a comprehensive annual physical examination, under the hypothesis that VR is both engaging, and effectively educates patients about heart disease. **Methods**: 208 male patients presenting to a preventive health center were invited to participate in a VR educational session for cardiovascular health and risk education. Exclusion criteria included claustrophobia, light-induced migraines, dizziness, and seizure disorder. Before participating, subjects answered a brief cardiovascular health knowledge assessment. Following the session, they answered an equivalent knowledge assessment, and a survey regarding the experience. **Results**: Of potential enrollees, 179 (86%) elected to proceed with the VR experience. Reasons for decline included time constraints, apprehension, and no interest. Among participants, 7 (4%) aborted due to: headache (2), claustrophobia (1), and discomfort related to wearing large glasses in the VR headset (4). The initial proportion of correct responses by question demonstrated a median of 56.7% (range 17.7% to 79.7%); following the VR session, a significant rise to 96.7% (range 93.5% to 98.7%) was detected ($p = 0.016$). Survey results were uniformly positive; 100% of respondees strongly agreed (78%) or agreed (22%) that the VR experience was enjoyable and worthwhile, on a 5-point Likert scale. **Conclusions**: A VR-based educational program has been incorporated into an annual comprehensive physical examination session, and ultimately may provide education benefits for men. The VR experience was rated very positively and resulted in statistically significant improvements in knowledge around cardiovascular health. Future direct comparisons between these next-generation and traditional patient education methods will establish whether VR approaches offer benefits over traditional patient education methods.

Keywords: men's health; preventive health; virtual reality patient education; cardiovascular disease

1. Introduction

Preventing disease development and/or progression is a primary goal of health care providers. Educational tools which help patients better understand their health conditions, and behaviors that affect them, have become increasingly sophisticated. Traditional one-on-one provider-to-patient education, which represented the standard model during routine health visits for decades, has been augmented by a large number of innovative patient teaching strategies. Examples include web- and media-based educational platforms, group appointments, mobile apps, and radio and television initiatives, among others [1–3]. Simultaneously, research has demonstrated gender differences in learning styles; females are typically better auditory learners, whereas males tend to be stronger visual, tactile, and kinesthetic learners [4,5]. Virtual reality (VR) technologies offer an immersive 360-degree visual, tactile, and kinesthetic educational experience, which some have suggested favors male learning styles [6]. In recent years, VR applications have rapidly expanded in engineering, architecture, technological development, psychology, military training, and medicine [7–11]. The effectiveness of patient education using traditional, web- and media-based, and emerging technologies has not been previously compared.

We hypothesized that leveraging the visual, tactile, and kinesthetic nature of VR would serve as an effective tool to educate male patients about heart disease during their routine physical examination. We selected heart disease as a pilot subject because cardiovascular disease (CVD) is the leading cause of death worldwide, and men are twice as likely to die from coronary heart disease (CHD) than women; half of men who die suddenly of CHD have no prior symptoms [12,13]. The American Heart Association estimates that 80% of CVD is preventable through lifestyle modification [14], making it an ideal target for next-generation educational tools.

Herein we describe our preliminary experience with VR education about CVD, present our patient satisfaction data, and review pre-VR and post-VR knowledge testing data to assess patients' learning from the platform. Our goal was to generate basic data on patient experience and preliminary knowledge assessment data, to serve as a preamble for more direct comparison of educational strategies for men's preventative health in the future.

2. Methods

2.1 Study Sample and Design

The study was performed under institutional review board approval. During the period from December 2020 to November 2021, 208 male patients presenting for their annual physical examination at a preventive health center were invited to participate in a VR educational session for cardiovascular health and risk education. Inclusion criteria were male sex, age range 18–80, no visual or auditory impairment, and English-speaking. Patients were excluded if they had conditions with the potential to be aggravated by their participation in a VR experience; claustrophobia, seizure disorder, motion sickness, and light-induced migraine symptoms. Patients were also excluded if after the VR experience was explained, they indicated non-interest in participating.

2.2 Intervention

Consenting patients were first administered a seven-question cardiovascular health knowledge assessment (see Appendix Fig. 4 for the questions), which focused on the prevalence of CVD and CVD risk factors. The assessment was provided in the testing suite, via secure email link to a Google forms document. Patients provided answers through their smart phones. Responses were obtained digitally, and the teaching session undertaken.

For the VR educational session, patients met with a clinical research coordinator (CRC) in a dedicated conference room referred to as "Planet Human". The space was equipped with a desktop computer, two large screen monitors, and a comfortable lounge chair. The CRC provided patients with a brief overview of the VR experience. Patients were asked to immediately report the onset of any problems during their VR session, such as dizziness, claustrophobia, and/or headache, and were informed they could discontinue the VR experience at any time during the session. Participants were given personal protective equipment, including surgical caps, gloves, and facemasks. VR headsets and hand controls were cleansed with germicidal disposable wipes before and after individual use. Each patient was seated comfortably, and fitted with a VR headset (Oculus Quest 2, Facebook Technologies, Menlo Park CA, USA). Patients were instructed regarding how to use the VR hand controls to navigate through a high-resolution digital app (Sharecare YOU, Sharecare Inc, Atlanta GA, USA) that features an immersive 360-degree, photorealistic simulation of the human body and its diseases. Using the app, the CRC first reviewed basic anatomy and physiology of a healthy heart, including structural and functional features, valves, and endovascular views (Fig. 1). Next, patients were guided through three-dimensional VR images of changes resulting from heart disease, including coronary artery disease, heart failure, and diabetic cardiomyopathy. During the viewing of these disease states, patients navigated at their own pace to explore the 360-degree imagery. The CRC (who was simultaneously viewing a two-dimensional image of frames that were being shown through the VR headset) provided appropriately timed corresponding scripted verbal education (Fig. 2) regarding risk factors for CVD, including unhealthy diet, sedentary lifestyle, obesity, dyslipidemia, and diabetes. Using this patient/CRC partnered approach, the patient was able to navigate to areas of interest in a self-directed manner, with the CRC providing scripted timely information (see **Supplementary Videos** for examples of educational session). Each VR session lasted approximately 30 minutes.

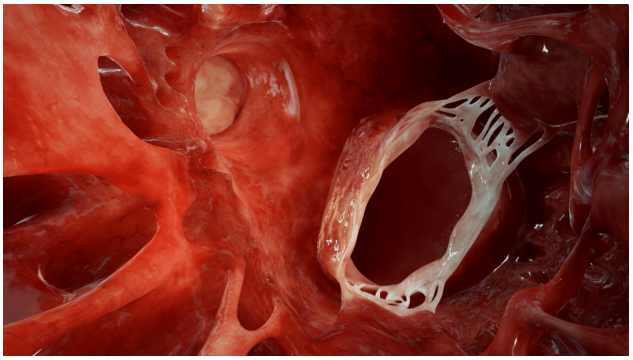

Fig. 1. Image of VR application. Normal mitral valve. Permission for all images given by Sharecare YOU.

Fig. 2. Patient learning about coronary heart disease risk factors during a VR session.

2.3 Measures

Immediately following the VR session, patients were electronically administered a seven question knowledge assessment equivalent to the pre-VR assessment. The assessment was provided in the testing suite, via secure email link to a Google forms document. At the conclusion of their visit, patients were emailed a separate satisfaction survey on

a Google platform containing general questions involving their experience (see Appendix Fig. 5 for survey questions). This latter survey also included opportunities for open responses and feedback. The calculated value for Cronbach's Alpha reliability coefficient for the survey (questions 3–10) was $\alpha = 0.78$ (95% CI, 0.73–0.84), indicating acceptable internal consistency [15]. Completed pre- and post-VR knowledge assessments were compared. Satisfaction survey data were compiled in aggregate for descriptive analysis.

2.4 Data Analysis

Data analysis sought to determine whether knowledge of heart disease improved after the VR session. The proportion of correct responses for each question was compared pre-session and post-session using the paired samples Wilcoxon Signed Rank test (two-sided). The test data were analyzed for normality using the Shapiro-Wilk test.

The satisfaction survey results were assessed for independence using the Chi-square test. Statistical significance (α) was set at 0.05 for all tests.

3. Results

During the study period, 208 male adults presenting for their annual physical examination at a preventive health center, and who met inclusion criteria, were invited to participate in a VR educational session for cardiovascular health and risk education. Of these potential enrollees, 179 (86%) elected to proceed with the VR experience. Reasons for decline included time constraints (20), apprehension (4), and no interest (5). Among participants, the average age was 52 (range 35–75), and did not significantly differ from those declining to participate (average age 55, range 36–69). Nearly all participants completed the VR educational session; 7 participants (4%) aborted the experience; 1 secondary to claustrophobia wearing the headset, 2 due to the onset of headache, and 4 because of difficulty with bulky glasses in the headset.

3.1 VR Knowledge Assessments

The initial proportion of correct responses by question demonstrated a median of 56.7% (range 17.7% to 79.7%); following the VR session, a significant rise to 96.7% (range 93.5% to 98.7%) was detected ($p = 0.016$; Fig. 3). The proportion of correct responses improved for all seven questions (Table 1). The most significant improvement in performance was noted for Question 4, underscoring the important but underappreciated fact that the first manifestation of heart disease is often sudden death; 17.7% of participants correctly answered the question on the pretest compared with 94.8% on the posttest. A remarkable improvement in performance was also noted for Question 3, which emphasized the importance of optimal blood pressure (48.7% pretest vs 96.7% posttest).

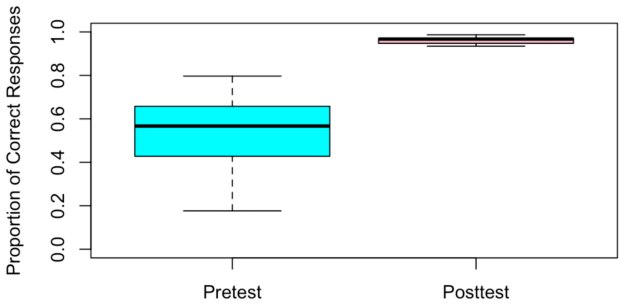

Fig. 3. Proportion of correct responses to test questions before and after the VR session ($p = 0.016$).

Table 1. Comparison of pretest versus posttest percentage correct answers.

Question	Pretest	Posttest
1	62.0	96.7
2	36.9	93.5
3	48.7	96.7
4	17.7	94.8
5	79.7	98.7
6	69.5	97.4
7	56.7	94.8

3.2 Surveys

Of patients who underwent the experience, 104 returned the satisfaction survey (response rate 58%). 100% of participants who completed the survey strongly agreed (78%) or agreed (22%) that their VR experience was enjoyable and worthwhile, on a 5-point Likert scale. 58% of patients reported they had never used VR prior to this session. There was no relationship between prior VR exposure or age of the participant and enjoyment of the VR session based on the Chi-square test of independence. 98% of participants strongly agreed (79%) or agreed (19%) it was helpful having an instructor present to teach how to wear the VR headset and use the hand controls. 92% of patients strongly agreed that they felt comfortable and safe during their VR experience. 93% of participants strongly agreed (71%) or agreed (22%) with the statement, "I learned something important to my health and wellness that I did not know prior to my virtual reality session". 97% of patients strongly agreed (75%) or agreed (22%) the immersive viewing experience helped them better understand how diabetes, elevated cholesterol, and high blood pressure cause heart disease. Importantly, 90% of patients believed their VR experience would help motivate them to embrace a healthy lifestyle going forward, and 91% reported an interested in having VR health education integrated into future physician visits. Multiple participants commented that the VR optics were impactful and memorable, and that they learned more from the VR experience than prior verbal interactions with the physician.

Suggestions offered by participants included personalizing the VR experience by showing how patient-specific tests results and biometrics (elevated lipids, sugar/hemoglobin A1C, blood pressure, etc.) cause heart disease; they commented that this personalization might better motivate them to change their lifestyle. Two patients (1.0%) reported being disturbed by having "learned too much", or felt overwhelmed by the amount of information delivered, especially regarding physiology of the heart. Four patients who completed the session while wearing prescription glasses commented the VR headset was moderately uncomfortable.

4. Discussion

Preventing disease onset and progression is a key tenet of modern primary health care; lack of patient education has been identified as one factor among many which contribute to preventable disease [16,17]. While educational modalities for health and wellness have expanded greatly in the digital era, most physician-patient educational exchanges involve one-on-one narratives during well or sick visits. Data show that patients are heavily influenced by recommendations directly from their health care providers; they are more likely to engage in important health-improving behaviors, such as quitting smoking or losing weight, when directed by their personal health care team [18]. Additionally, gender differences exist among rates of heart disease (male to female death by cardiac disease is approximately 2:1), and possibly learning style, with men generally demonstrating more effective learning through visual, tactile, and kinesthetic approaches than with auditory approaches. Thus, we selected cardiovascular disease as a prime educational target for a group of male patients and applied the teaching through a novel VR platform.

We found that applying VR learning approaches for cardiovascular health education to a group of men presenting for preventative well patient visits over a period of one year resulted in both impressive knowledge transfer and high patient satisfaction. Importantly, an overwhelming majority of patients (93%) felt that they acquired new important knowledge through the teaching intervention. The fact that 90% of respondents felt they were more motivated to embrace healthier lifestyle choices after the VR experience is extremely promising; follow up study to determine whether patients have a higher likelihood of implementing long term lifestyle changes as a result of the teaching intervention is an important future question.

We discovered obstacles to a comfortable VR experience, the most significant of which was wearing glasses with the headset, and learned that there are patients for whom the detailed highly visual experience proved overwhelming. Future approaches to these issues might include headset modifications, counseling about wearing contact lenses or frameless glasses to the visit, and delivery of smaller "packets" of VR learning, with pauses to assess patient comfort with the information.

The study possesses several important limitations. One principal shortcoming was the lack of a control group for knowledge testing, who would be exposed to verbal and traditional patient education mechanisms around CVD, and administered similar pre- and post-education knowledge assessment tools. Additionally, post-testing knowledge may have been affected by patients paying close attention to specific areas for which they recognized knowledge gaps during the pre-test. The satisfaction survey response rate, while acceptable (58%), may also have selected for those who enjoyed the experience. Pursuit of non-responders may have revealed lower satisfaction with the VR experience than our data suggest.

The study did not directly compare the experience of men versus women, since the cohort involved only male participants. Thus, no specific gender-specific comparisons of either satisfaction or knowledge gain can be drawn. However, the data provide a benchmark against which similar tools could be employed in a women's preventive health setting, for comparative purposes.

Finally, only interested patients participated in the VR experience. The exclusion of those with no interest may have selected for individuals who would receive the educational content and the experience more favorably. This confounder could be eliminated in the future by applying the learning session across both interested and uninterested participants.

5. Conclusions

A VR-based educational program incorporated into an annual comprehensive physical examination session may provide educational benefits. The VR experience was universally positive in a cohort of men (although we selected only interested, willing participants), and resulted in statistically significant improvements in knowledge on cardiovascular health. With the rates of preventable disease at all-time highs, establishing effective methods to deliver health education and potentially mitigate disease development and progression are crucial. The explosion of VR materials, and the emergence of gaming as a popular young adult male pastime [19], may represent an opportunity for physicians and other health educators to leverage VR experiences toward improved health. While these data do not provide evidence of the superiority of VR educational approaches against other educational modalities, the fact that there was high satisfaction and improvements in short term knowledge provide a platform against which VR educational tools may now be compared with more traditional educational strategies. Our future research will include measuring longer term knowledge around cardiovascular health, and actual health outcomes (weight, blood pressure, lipids, and cardiac events) against exposure to the VR teaching experience. Additionally, specific gender-based differences in patient satisfaction with the VR experience, and

1) Which of the following statements is **incorrect**?
- A) Heart disease is the leading cause of death for men and women in the U.S. (1 in every 4 deaths).
- B) 90% of heart disease results from harmful lifestyle choices, including poor diet, little or no exercise and smoking.
- C) Coronary artery disease is the most common type of heart disease.
- D) Coronary atherosclerosis (plaque build-up) does not start until after age 50.
- E) A heart attack occurs when plaque build-up within a coronary artery ruptures, causing the formation of a blood clot which blocks the artery.

2) True or false: Most heart attacks occur in individuals with **normal** LDL levels.
- A) True
- B) False

3) Which of the following statements regarding high blood pressure (aka hypertension) is **incorrect**?
- A) The cutoff reading for high blood pressure ≥140/90.
- B) Weight loss, a low sodium diet, reduced alcohol consumption (≤ 2drinks / day), and physical activity have been proven to reduce high blood pressure.
- C) Hypertension may cause coronary artery disease, heart failure, and atrial fibrillation.
- D) Hypertension is called the "silent killer" because it typically has no symptoms until after it has done significant damage to the heart and arteries.
- E) Blood pressure tends to rise with aging.

4) What % of people who die suddenly of coronary artery disease have **no** prior symptoms?
- A) 10%
- B) 20%
- C) 30%
- D) 40%
- E) 50%

5) You can significantly reduce your risk of coronary artery disease by:
- A) Not smoking
- B) Achieving a healthy weight
- C) Following a low saturated fat Mediterranean diet (fish, chicken, fruits, veggies, nuts, olive oil, etc.)
- D) Exercising for at least 30 minutes 5 days per week, which includes a brisk walk
- E) Treating high blood pressure and high cholesterol
- F) All of the above

6) Which of the following statements about diabetes is **incorrect**?
- A) Physical inactivity and obesity/overweight status can cause diabetes.
- B) High blood sugar is toxic to blood vessels, resulting in plaque formation.
- C) Diabetes can adversely affect the heart muscle (aka diabetic cardiomyopathy).
- D) Belly fat produces hormones and inflammatory substances that cause diabetes.
- E) Prediabetes always leads to diabetes.

7) True or false: Most heart attacks occur in a coronary artery which is **less than** 50% blocked (with plaque).
- A) True
- B) False

Fig. 4. Pre- and post-VR session cardiovascular health knowledge assessment.

1) I belong to the following age group:
- o 20-29
- o 30-39
- o 40-49
- o 50-59
- o 60 and over

2) I had used a virtual reality headset before this session.
- o Yes
- o No

3) I found the virtual reality experience during my health visit enjoyable and worthwhile.
4) I was able to learn how to use the hand controls to navigate through the virtual reality experience.
5) It was helpful having an instructor present to teach me how to wear the virtual reality headset and use the hand controls.
6) I felt comfortable and safe during my virtual reality experience.
7) I learned something important to my health and wellness that I did not know prior to my virtual reality session.
8) The immersive viewing experience helped me better understand how diabetes, elevated cholesterol, and high blood pressure cause heart disease.
9) I believe my virtual reality experience will help motivate me to embrace a healthy lifestyle.
10) I would be interested in having virtual reality health education integrated into my physician visits in the future.
11) (Optional) Please briefly describe what you learned.
12) (Optional) Please provide any feedback we can use to help improve the virtual reality experience.

Fig. 5. VR survey (for questions 3–10, response options include: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, and (1) strongly disagree.).

knowledge retention, will be explored to establish whether in fact the technology favors male learning style or preferences.

Author Contributions

BC contributed to the study design and manuscript writing; YM contributed to data collection, data analysis, and manuscript writing. Both authors contributed to the editorial changes in the manuscript. Both authors read and approved the final manuscript.

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by the Institutional Review Board of Lahey Hospital and Medical Center (Approval Number 20213006).

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Conflict of Interest

The authors declare no conflict of interest. BC is serving as one of the Editorial Board members of this journal. We declare that BC had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to Roberto Manfredini.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/j.jomh1808162.

Appendix

See Figs. 4,5.

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