Research Paper
Enhancing Compassionate Care: Virtual Reality Boosts Medical Students' Empathy Toward Hypertensive Patients

Seyed Farzin Mircheraghi[1], Majid Khadem-Rezaiyan[2,3], Abbas Ali Zeraati[4*]

1. Department of Internal Medicine, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.
2. Medical Sciences Education Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.
3. Department of Community Medicine, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran.
4. Kidney Transplantation Complications Research Center, Faculty of Medicine, Mashhad University of Medical Science, Mashhad, Iran.

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ABSTRACT

Background: Hypertension is a major public health problem that may lead to cardiovascular, renal, visual, and auditory complications. According to previous studies, besides pharmacological treatments, other factors are also effective in controlling hypertension, such as healthcare providers' empathy toward patients. As an innovative tool, virtual reality (VR) has been used in recent years to promote empathy. This study aimed to investigate the effects of VR on the empathy of medical students, medical residents, and fellowship students toward hypertensive patients.

Methods: In this experimental study, 198 medical learners, after stratification based on their program level, were randomly assigned to the VR (intervention) group and the pamphlet (control) group. At first, both groups filled out the Jefferson scale of empathy (JSE) questionnaire. Seven days later, participants in the VR group were exposed to a VR scenario under normal audiovisual conditions for the first minute, followed by exposure to visually simulated glaucoma, macular edema, cataract, and vitreous hemorrhage, accompanied by a simultaneous tinnitus sound as visual and auditory complications of hypertension. The participants in the control group were exposed to a written pamphlet about visual and auditory complications of hypertension. Afterward, both groups answered the JSE Questionnaire again. Finally, 93 participants from the VR group and 88 participants from the control group were eligible for analysis.

Results: The results showed that although there was no statistically significant difference between both groups in the empathy scores at the pre-intervention phase (P=0.706), after exposure to VR and pamphlet, the empathy scores of the VR group (112.46±12.67) were significantly higher than those of the control group (108.17±12.59) at the post-intervention phase (P=0.024).

Conclusion: This study showed that innovative technologies, like VR, can promote empathy among future healthcare providers toward patients, which may lead to more effective hypertension control.

Keywords: Virtual reality (VR), Hypertension, Empathy

*** Corresponding Author:**
Abbas Ali Zeraati, Professor.
***Address:** Kidney Transplantation Complications Research Center, Faculty of Medicine, Mashhad University of Medical Science, Mashhad, Iran.*
***Phone:** +98 (915) 5037124*
***E-mail:** zeraatia@mums.ac.ir*

Introduction

Hypertension (HTN) is regarded as a major public health problem [1, 2]. According to estimates, more than 1.2 billion people around the world are suffering from HTN [3], and HTN is the cause of death in more than 7.8 million people per year worldwide [4]. On the other hand, HTN is considered the most common modifiable risk factor for cardiovascular disease [5] and the second most common cause of chronic kidney disease (CKD) [6]. It is also regarded as a predisposing factor for many other complications, including stroke [7], retinopathy [8], cataracts [9], and hearing disorders [10].

According to recent studies, the prevalence of HTN in the Iranian population is estimated to be about 25% in adults and 42% in the elderly [11]. Despite the high importance of blood pressure control, various factors prevent its implementation. These factors are classified as factors related to healthcare providers, the patient, and the health system [12]. In this regard, the empathy of healthcare providers toward hypertensive patients is considered one of the factors that affect the performance of healthcare providers [13]. Empathy is generally conceptualized as the capacity to perceive and share the feelings of another person [14]. Some researchers have shown that enhancing the empathy of physicians and nurses toward hypertensive patients has a positive effect on controlling their blood pressure level [13]. Thus, it seems that improving the empathy in healthcare providers could be a reasonable non-pharmacologic approach to the management of HTN.

In recent years, new technologies, such as virtual reality (VR) simulators, have allowed physicians and medical students to experience situations in an immersive way [15] that was not possible before. Some researchers have used VR simulators to evaluate their effect on the empathy of physicians and medical students toward patients [16]. The potential of exploiting VR to increase empathy is so promising that several researchers have referred to VR technology as the "Empathy Machine" [17]. So far, there has been no research investigating the possible effects of VR technology on empathy toward hypertensive patients. Therefore, the present study was conducted to evaluate the effects of VR simulators on the empathy of medical students, internal medicine residents, and fellows toward hypertensive patients. Due to previous reports about the possible positive effects of enhanced empathy on patients' blood pressure control [13], the results of this study could have important implications for the non-pharmacologic management of HTN.

Methods

Sampling strategy

This experimental research was conducted from 2023 to 2024 in Ghaem and Imam Reza Hospitals of Mashhad University of Medical Sciences in Iran. The subjects were selected from medical students, internal medicine residents, and fellows who had a clinical course from 2023 to 2024 in the internal medicine wards of the mentioned hospitals.

In this study, the stratified randomization technique was used. Accordingly, stratification was done based on the educational program, including the general medicine program, internal medicine residency, and internal medicine-related subspecialty fellowship program. The samples in each stratum were randomly assigned to VR or pamphlet groups based on the numbers created by Random Number Generator Software, version 1.4. Due to the large number of students in the general medicine program, the calculation of the required sample size in this stratum was based on the statistical parameters of the most relevant study [16], considering α: 0.05 and β: 0.20 (80% statistical power), along with an estimated dropout rate of about 10%. This led to the determination of 45 samples for each group (90 samples for both groups) as the minimum requirement. Owing to the limited number of internal medicine residents and internal medicine-related fellows, all eligible participants in these two strata were considered potential participants and were randomly assigned to the VR and pamphlet groups.

Study design

Eligible participants who completed the informed consent form were included in the study. After entering the study, the participants were placed in one of the control (pamphlet) or intervention VR groups utilizing the stratified randomization technique. Subsequently, the participants in both groups completed the Jefferson scale of empathy (JSE) [18]. A week after the study's first phase, the second phase was implemented. The participants of the control group were given an educational pamphlet about visual and auditory complications of HTN, and the JSE was given to them again. The participants of the intervention group were exposed to the VR simulator of visual and auditory complications of HTN. After this encounter, the JSE was given to the intervention group as well. Finally, the JSE related to the study's second phase was also collected from the participants of both groups, and along with the JSE of the first phase, entered the analysis stage.

Inclusion criteria

This study enrolled medical students, internal medicine residents, and fellows experiencing a clinical educational course at Ghaem and Imam Reza Hospitals of Mashhad University of Medical Sciences between 2023 and 2024.

Exclusion criteria

Confirmed diagnosis of HTN in candidates, previous experience in educational courses using medical VR simulators, and withdrawal from the research were exclusion criteria of this study. Owing to the unknown safety profile of VR for pregnant women, the potential risk of falling due to immersion in the VR environment, and to prevent probable bias that may result from the density of pregnant women in the control group, pregnancy was also considered an exclusion criterion.

Blinding strategy

Due to the apparent differences between the tools used in the intervention and control groups, it was impossible to blind the participants and researchers. However, the data analyzer was blinded during the analysis.

Intervention materials

In this study, depending on the randomization results, each participant was placed in one of the VR or pamphlet groups.

The VR simulator for visual and auditory complications of HTN was developed using the C# programming language in the Unity3D game engine. The virtual environment and 3D models were designed using Blender and 3ds Max software before being transferred to the Unity3D game engine. In order to produce the visual effects related to macular edema, cataracts, vitreous hemorrhage/retinal detachment, and glaucoma in the virtual environment of the VR simulator (Figure 1), the images and descriptions presented in the articles and scientific sources were applied as a guide [19-21]. After obtaining permission from the "British tinnitus association" and its official website [22], authentic tinnitus sample sounds available on this website was used as the source of tinnitus sound applied in the VR simulator [23]. The HTC Vive head-mounted display, along with its controllers, was used to run the VR simulation in a secure 2×3 m area (Figure 1). An assistant was present in the simulation room as a safety observer throughout the entire duration of the VR simulator's use to prevent possible accidents and assist the participants. However, no accidents occurred during the use of the VR simulator throughout the study.

In the VR scenario, the kitchen environment of a house was displayed, with several dishes on the table and some cabinets, and the learner had to transfer them to the sink. In the first minute, this process was done with normal sound and images representative of normal audiovisual conditions; in the second minute, the tinnitus sound was active. In the next 4 minutes, the images of the kitchen environment were published with the simulation of impaired vision based on "macular edema", "glaucoma", "cataracts" and "vitreous hemorrhage/retinal detachment" without any abnormal sounds, and in the last minute of the simulation, the learners could experience the visual abnormality of "vitreous hemorrhage/retinal detachment" and tinnitus sound, simultaneously (Figure 1). The termination of the VR simulation was set for the end of the 7th minute.

On the other hand, the educational pamphlet on the visual and auditory complications of HTN consisted of a 6-page text featuring color images that depicted normal vision as well as images of the visual complications of HTN, such as cataracts, glaucoma, macular edema, and vitreous hemorrhage/retinal detachment. Additionally, a section of the text included the definition and descriptions of tinnitus as an auditory complication of HTN. The allowable time to read the pamphlet was 7 minutes, and its scientific content was equivalent to that presented in the VR simulator.

Data collection tool

To evaluate the participants' empathy in this study, the Persian version of the Jefferson scale of empathy for physicians and health professionals (JSE-HP) [24] was used. The original form of this questionnaire was designed by Hojat et al. [18]. Shariat et al. translated this questionnaire into Persian and confirmed its validity and reliability [24]. The JSE is a questionnaire consisting of 20 questions, each with 7 response options based on the Likert scale, ranging from strongly disagree (1 point) to strongly agree (7 points). The scores from both positive and negative questions are summed, and each participant's final empathy score is obtained by adding the scores of all 20 questions. Therefore, the final score can range from 20 to 140 [18].

Statistical analysis

Data analysis was done using SPSS software, version 16. The Kolmogorov–Smirnov test was used to check the data for normal or non-normal distribution. Quantitative variables were described using Mean±SD, median, and quartiles. Qualitative variables were described using frequency and percentages. Subsequently, a paired t-test and an independent t-test were used to compare parametric data, and the Mann-Whitney U and Wilcoxon tests were used to compare and analyze non-parametric data. Cronbach's α was also used to confirm the reliability of the questionnaire. All tests were two-tailed, and a $P<0.05$ was considered statistically significant.

Results

Initially, 198 learners participated in this research. However, due to reasons, such as the refusal of the participants to continue the study or the emergence of exclusion criteria, 17 of the participants were excluded from the research. Finally, the data of 181 participants reached the analysis stage. Regarding division based on participation in the intervention or control groups, 93 subjects were in the intervention group VR, and 88 were in the control group (pamphlet). Detailed demographic features of participants are shown in Table 1.

In analyzing the results extracted from the pre-intervention phase questionnaires, considering the non-parametric nature of the VR group data and the parametric nature of the pamphlet group data, the Mann-Whitney U test was used to compare the empathy scores obtained from the JSE (Table 2). The test showed no significant difference between the scores of the two groups in the pre-intervention phase (P=0.706).

In contrast, empathy scores derived from the JSE in both the VR and pamphlet groups in the post-intervention phase were normally distributed. Therefore, an independent t-test was used to compare them. Using the independent t-test, it was observed that, in the post-intervention phase, the empathy scores of the intervention (VR) group (112.46±12.67) were significantly higher than those of the control (pamphlet) group (108.17±12.59, P=0.024).

Table 1. Demographic characteristics of participants

Demographics		No. (%)			P[a&]
		All Participants[1]	VR Group[2]	Pamphlet Group[3]	
Gender	Male	92(50.8)	51(54.8)	41(46.6)	0.33
	Female	89(49.2)	42(45.2)	47(53.4)	
Age (y)[b]	20-30	132(72.9)	71(76.3)	61(69.3)	0.55
	30-40	45(24.9)	20(21.5)	25(28.4)	
	>40	4(2.2)	2(2.2)	2(2.3)	
Family history of HTN	Yes	57(68.5)	64(68.8)	60(68.2)	0.99
	No	124(31.5)	29(31.2)	28(31.8)	
Educational Program	General medicine program	95(52.5)	50(53.8)	45(51.1)	0.90
	Internal medicine residency	71(39.2)	36(38.7)	35(39.8)	
	Fellowship Program	15(8.3)	7(7.5)	8(9.1)	

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[&]The difference between the VR and pamphlet group; [a]No significant differences were observed in any of the demographic factors between the VR and pamphlet groups (the chi-square test of independence was performed); [b]The mean and median ages of all individuals in the VR group were 27.62±4.96 and 26 years, respectively, and the mean and median ages of all individuals in the pamphlet group were 28.25±5.67 and 27 years, respectively. Using the Mann-Whitney U test (given the non-normal distribution of the data), no significant difference was observed between the two groups (P=0.59); [1]Both groups; [2]Intervention; [3]Control.

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Table 2. Mean±SD, median, and quartiles of the intervention (VR) and control (pamphlet) group in the pre- and post-intervention phases of the study

Indices Related to Scores Obtained From the JSE	VR[1]				Pamphlet[2]				P[3]
	Mean±SD	Q1	Median (Q2)	Q3	Mean±SD	Q1	Median (Q2)	Q3	
Before intervention	107.26±12.69	99.50	109.00	116.00	106.77±13.38	98.00	108.00	117.00	0.706[&]
After intervention	112.46±12.67	103.50	114.00	122.00	108.17±12.59	100.25	109.50	116.50	0.024[*^]
P[4]	<0.001[*$]				0.117[#]				

Abbreviations: Q1: Quartile 1; Q2: Quartile 2; Q3: Quartile 3.

[*]Significant; [1]Intervention group, [2]Control group, [3]The difference between groups, [4]For the difference between before and after intervention inside each group, [&]Mann–Whitney U test, ^Independent t-test, [$]Wilcoxon test, [#]Paired t-test.

Note: For comparison between groups, move horizontally in the table. For comparison of pre- and post-intervention in each group, move vertically in the table.

In comparing the pre- and post-intervention findings in the intervention (VR) and control (pamphlet) groups, the indices related to the JSE scores of the VR group in the post-intervention stage were significantly higher than those in the pre-intervention stage (P<0.001), but in the pamphlet group, the indices related to the JSE scores in the pre- and post-intervention stages did not differ significantly (P=0.117). These results were consistent with the findings mentioned in the previous section (Table 2).

To address the unequal dropout of male and female participants in the VR and pamphlet groups, a subgroup analysis based on participants' gender was conducted, although the resulting inequality was not statistically significant (P=0.33). In this subgroup analysis, it was observed that exposure to the VR simulator significantly improved the post-intervention scores of the JSE for both males and females compared to their pre-intervention scores (P=0.017 for males and P<0.001 for females) (Table 3).

Also, as shown in Table 3, when comparing the differential scores (JSE score after the intervention minus its score before the intervention), there was no statistically significant difference between the male and female subgroups, whether exposed to VR (P=0.315) or the pamphlet (P=0.744).

In addition, the reliability of the questionnaires related to the pre- and post-intervention stages was evaluated using Cronbach's α coefficient, which was calculated as 0.84 for the pre-intervention questionnaire and 0.85 for the post-intervention questionnaire.

Discussion

As mentioned in the previous sections, HTN is a major public health problem [1, 2] with numerous cardiovascular [5], cerebral [7], renal [6], visual [8, 9], and auditory [10] complications. It is of great concern to health systems around the world. Numerous pharmacological and non-pharmacological factors play a role in controlling HTN, including the empathy of physicians and healthcare providers toward patients [13].

To improve the empathy of physicians toward hypertensive patients, training courses must be designed, especially for young learners. However, it should be noted that with the generational changes that have occurred in recent decades, the learners present in medical schools, hospital wards, and also young physicians who play an essential role in advancing the goals of the health system in the present and future, mainly belong to generations Y and Z [25]. Researchers believe that the various characteristics of these two generations are significantly different from those of previous generations, such as Generation X, baby boomers, and the builders' generation [25, 26]. In the field of education, there is a clear tendency among Generation Z to use digital equipment, gamification, and advanced technologies such as VR, augmented reality, and mixed reality [25, 26].

The results of the present study are also in line with the above statements. Specifically, the use of simple text and color images depicting the complications of HTN did not significantly change the learners' empathy toward patients. However, utilizing the VR simulator for

Table 3. Comparison of the results in gender subgroups

Variables			Before Intervention	After Intervention	P[1]	Difference Between Pre and Post-intervention
VR group	Male	Mean±SD	107.74±14.20	111.88±12.52	0.017*&	4.13±11.54
		Q1	99	104		-3
		Median (Q2)	112	114		4
		Q3	117	122		11
	Female	Mean±SD	106.69±10.71	113.16±12.98	<0.001*$	6.47±10.72
		Q1	100	103		0
		Median (Q2)	106	113		5
		Q3	114	121		12
	P[2]		0.295@	0.631#		0.315#
Pamphlet group	Male	Mean±SD	107.29±14.37	109.00±13.46	0.179$	1.70±7.98
		Q1	98	100		-2
		Median (Q2)	109	110		1
		Q3	119	121		3
	Female	Mean±SD	106.31±12.60	107.44±11.88	0.375$	1.12±8.62
		Q1	95	99		-5
		Median (Q2)	107	108		1
		Q3	115	114		7
	P[2]		0.738#	0.570#		0.744#

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Abbreviations: Q1: Quartile 1; Q2: Quartile 2; Q3: Quartile 3.

*significant, [1]The difference between before and after intervention inside each subgroup, [2]For the difference between subgroups, (males and females),&Wilcoxon test, $Paired t-test, #Independent t-test,@Mann-Whitney U test.

Note: For comparison between subgroups, move vertically in the table. For comparison of pre- and post-intervention phases in each subgroup, move horizontally in the table.

visual and auditory complications of HTN significantly improved the participants' empathy toward hypertensive sufferers.

It should be noted that the absence of a significant difference between the VR and pamphlet groups in the pre-intervention phase partially confirms the correct implementation of appropriate measures to eliminate or adjust confounding factors, including randomization and stratification of participants. This indicates that the differences observed in the post-intervention phase were not due to inherent differences between the intervention and control groups and that these differences were more likely related to the interventions.

Also, the results of the analysis of male and female gender subgroups showed that the positive effect of VR on improving empathy and its superiority to the traditional method (pamphlet) are evident in both genders, and there was no significant difference between the two genders in improving empathy using VR. Although previous studies have produced inconsistent and incon-

Figure 1. VR simulator of visual and auditory complications of hypertension

Note: The upper and middle rows show the 3D and immersive images presented in this VR simulator: The upper right image simulates normal vision, the upper left image simulates the vision of people with glaucoma, the middle right image simulates the vision of people with macular edema, and the middle left image simulates the vision of people with cataracts. The pictures of the lower row show an internal medicine resident experiencing the VR simulator of visual and auditory complications of hypertension using an HTC Vive headset.

clusive results regarding the effect of VR on different genders, it is suggested that larger populations of both genders be examined in future studies.

Regarding VR, it should be noted that immersion of learners in simulated environments provides a strong connection between them and these environments, creating a suitable opportunity for them to experience situations that could not be achieved under normal conditions [15, 17, 27, 28]. For example, learners with good vision and hearing cannot understand the frustrating problems of patients with visual and hearing disorders unless they experience the same disorders. Currently, VR is a powerful technology that allows users to experience some situations that patients face without causing significant risks. Thus, utilizing VR, users have an excellent opportunity to understand some of the patients' disorders and problems [15, 17, 27, 28]. This unique opportunity, which has received more attention in recent years, has introduced VR as a very suitable tool for promoting empathy [15, 17, 27, 28], so that some experts have dubbed VR technology the "empathy machine" [17]. Also, recent studies have shown VR's positive effects in promoting empathy toward patients with various diseases [16, 29]. The present study's finding, which shows the superior effect of VR compared to traditional educational methods in promoting empathy toward hypertensive patients, can be considered a new confirmatory evidence for the importance of using VR as an "empathy machine" in various diseases.

It should also be noted that empathy questionnaires are composed of various components. For example, the JSE has categorized its questions into three subcategories: "walking in the patient's shoes", "perspective taking", and "compassionate care" [18]. By carefully examining the titles of these subcategories, it can be seen that at least two subcategories, "Walking in the Patient's Shoes" and "Perspective Taking", can be achieved by using VR simulators, and these simulators are superior to traditional educational methods in this regard. Therefore, it can be expected that VR simulators exert a more positive impact on empathy and improve scores more in empathy scales compared to written methods, such as pamphlets.

Currently, there is no similar study investigating the effect of VR simulators on promoting empathy toward hypertensive patients. However, VR simulators have been used for some other diseases, such as empathy toward patients requiring organ transplants and empathy toward patients with psychosis. For instance, in a study published in 2021 on 128 Singaporean students aimed to investigate the effect of VR-based experiences on creating empathy and cooperation among Singaporean students in order to encourage kidney donation, Lee and Kim noted that the use of VR to experience being in the shoes of a patient in need of organ donation (kidney) improved empathy and willingness to participate in organ donation-related activities among the participants [29, 30]. Also, in a study by Zare-Bidaki et al. in 2022, which was conducted on 150 Iranian medical students, it was observed that using a VR simulator of psychosis in medical students led to improved students' knowledge and empathy toward psychosis, compared to traditional educational methods [16].

It is noteworthy that the mean empathy scores obtained in both VR and pamphlet groups during the pre- (107.26 and 106.77, respectively) and post-intervention (112.46 and 108.17, respectively) phases were within the expected range for Iranian learners. According to previous studies, the mean empathy scores of medical students of the Islamic Azad University of Mashhad, internal medicine residents of Iran University of Medical Sciences, and psychiatric residents of Iran University of Medical Sciences were 73.70, 100.8, and 114.2, respectively [24, 31]. Also, the calculated Cronbach's α of the first and second phases' questionnaires of this study (0.84 and 0.85, respectively), were consistent with previous values mentioned in the study by Shariat et al. (Cronbach's α=0.88) [24] and Hashemipour et al. (Cronbach's α=0.83) [32] regarding the reliability of the Persian version of the JSE, which strengthens the reliability of this tool.

Although the present study has paved the way for studying the effects of using VR technology to promote empathy toward hypertensive patients, it is recommended that additional studies be performed to examine the obtained results more closely and gain more robust evidence in this regard. Like other research, this study has its strengths and weaknesses. Notable strengths of this study were the participation of learners of different educational programs, the focus on the potential effects of VR simulators in enhancing empathy toward hypertensive patients for the first time, and the good reliability of the JSE used as the data gathering tool. On the other hand, the most notable weaknesses of the study were the limited time and budget, the small number of participants in residency and subspecialty fellowship programs, and the unequal dropout of female and male participants in the intervention and control groups.

To address the weaknesses, we recommend involving multiple academic and medical centers in future studies. Utilizing a larger population of participants and the simultaneous participation of multiple academic centers will not only increase the sample size of learners in residency and fellowship programs but also strengthen the generalizability of the results to a broader range of stakeholders across a wider geographical area.

Moreover, it is suggested that other individuals involved in the care of hypertensive patients, including nurses, other health professionals, and patients' family members, also be considered for encounters with VR simulators depicting complications of HTN to examine the effect of these simulators on their empathy.

It is also recommended that, in future studies, the issue of education economics and health economics also be considered regarding the use of VR simulators in education, prevention, and treatment of diseases. In addition to calculating the direct and indirect costs of VR and similar technologies for medical universities and the Ministry of Health, the possible positive effects of these technologies in reducing costs related to disease complications should also be considered so that by calculating the cost/effectiveness ratio, more precise policies could be generated in the field of using new technologies, such as VR in education, prevention, and treatment of crucial public health problems.

In this study, based on existing literature and the "ebbinghaus forgetting curve," which indicates a severe decline in recall after one week [33, 34], the interval between the learners' exposure to the JSE in the pre- and post-intervention phases was set at one week. However, it is recommended that in future studies, in addition to conducting the intervention and measuring its results at the end of one week, the participants' empathy status be reassessed at longer intervals to examine the persistence or changes in empathy caused by the interventions over time.

Conclusion

The present study showed that the use of the VR simulator of visual and auditory complications of HTN has a significant effect on enhancing empathy in medical students, internal medicine residents, and fellows toward hypertensive patients compared to written educational tools. This indicates that this technology has a higher potential than traditional educational methods and tools in enhancing students' empathy toward patients with various diseases. Due to previous studies that showed that enhancing physicians' empathy toward hypertensive patients can lead to more efficacious blood pressure control in these patients, the application of VR as an "Empathy Machine" can be proposed as a potential therapeutic strategy in blood pressure control, in addition to the educational effects of VR. This example explains how innovative educational technologies could be exploited as possible solutions for palliating major public health problems, like HTN.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the Mashhad University of Medical Sciences, Mashhad, Iran (Code: IR.MUMS.MEDICAL.REC.1402.265). All participants filled out the written informed consent before participating in the study.

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Authors' contributions

Conceptualization: Seyed Farzin Mircheraghi and Majid Khadem-Rezaiyan; Study design, coding, and construction of VR Simulator: Seyed Farzin Mircheraghi; Methodology: Majid Khadem-Rezaiyan; Data collection: Seyed Farzin Mircheraghi; Funding acquisition: Abbas Ali Zeraati; Writing, Review, and Editing: Seyed Farzin Mircheraghi, Abbas Ali Zeraati and Majid Khadem-Rezaiyan

Conflict of interest

The authors declared no conflicts of interest.

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References

[1] Singh S, Shankar R, Singh GP. Prevalence and Associated Risk Factors of Hypertension: A cross-sectional study in urban varanasi. International Journal of Hypertension. 2017; 2017:5491838. [DOI:10.1155/2017/5491838] [PMID]

[2] World Health Organization. High blood pressure: A public health problem. Cairo: WHO Regional Office for the Eastern Mediterranean; 2013. [Link]

[3] World Health Organization. Hypertension. Geneva: World Health Organization; 2023. [Link]

[4] Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, et al. Global Burden of Hypertension and Systolic Blood Pressure of at Least 110 to 115 mm Hg, 1990-2015. JAMA. 2017; 317(2):165-82. [PMID]

[5] Yusuf S, Joseph P, Rangarajan S, Islam S, Mente A, Hystad P, et al. Modifiable risk factors, cardiovascular disease, and mortality in 155 722 individuals from 21 high-income, middle-income, and low-income countries (PURE): A prospective cohort study. The Lancet. 2020; 395(10226):795-808. [DOI:10.1016/S0140-6736(19)32008-2] [PMID]

[6] Ptinopoulou AG, Pikilidou M, Lasaridis AN. The effect of antihypertensive drugs on chronic kidney disease: A comprehensive review. Hypertension Research. 2013; 36(2):91-101. [DOI:10.1038/hr.2012.157] [PMID]

[7] Ong YT, Wong TY, Klein R, Klein BE, Mitchell P, Sharrett AR, et al. Hypertensive retinopathy and risk of stroke. Hypertension. 2013; 62(4):706-11 [DOI:10.1161/HYPERTENSIONAHA.113.01414] [PMID]

[8] Tsukikawa M, Stacey AW. A review of hypertensive retinopathy and chorioretinopathy. Clinical Optometry. 2020; 12:67-73. [DOI:10.2147/OPTO.S183492] [PMID]

[9] Yu X, Lyu D, Dong X, He J, Yao K. Hypertension and risk of cataract: A meta-analysis. PLoS One. 2014; 9(12):e114012. [DOI:10.1371/journal.pone.0114012] [PMID]

[10] Figueiredo RR, Azevedo AA, Penido NDO. Positive association between tinnitus and arterial hypertension. Frontiers in Neurology. 2016; 7:171. [DOI:10.3389/fneur.2016.00171] [PMID]

[11] Oori MJ, Mohammadi F, Norozi K, Fallahi-Khoshknab M, Ebadi A, Gheshlagh RG. Prevalence of HTN in Iran: Meta-analysis of published studies in 2004-2018. Current Hypertension Reviews. 2019; 15(2):113-22. [DOI:10.2174/1573402115666190118142818] [PMID]

[12] Ahmad N, Khan AH, Khan I, Khan A, Atif M. Doctors' knowledge of hypertension guidelines recommendations reflected in their practice. International Journal of Hypertension. 2018; 2018:8524063. [DOI:10.1155/2018/8524063] [PMID]

[13] Yuguero O, Marsal JR, Esquerda M, Soler-González J. Occupational burnout and empathy influence blood pressure control in primary care physicians. BMC Family Practice. 2017; 18(1):63. [DOI:10.1186/s12875-017-0634-0] [PMID]

[14] Azevedo RT, Macaluso E, Avenanti A, Santangelo V, Cazzato V, Aglioti SM. Their pain is not our pain: brain and autonomic correlates of empathic resonance with the pain of same and different race individuals. Human Brain Mapping. 2013; 34(12):3168-81. [DOI:10.1002/hbm.22133] [PMID]

[15] Belisle B, Roquet P. Guest Editors' Introduction: Virtual reality: Immersion and empathy. Journal of Visual Culture. 2020; 19(1):3-10. [DOI:10.1177/1470412920906258]

[16] Zare-Bidaki M, Ehteshampour A, Reisaliakbarighomi M, Mazinani R, Khodaie Ardakani MR, Mirabzadeh A, et al. Evaluating the effects of experiencing virtual reality simulation of psychosis on mental illness stigma, empathy, and knowledge in medical students. Frontiers in Psychiatry. 2022; 13:880331. [DOI:10.3389/fpsyt.2022.880331] [PMID]

[17] Barbot B, Kaufman JC. What makes immersive virtual reality the ultimate empathy machine? Discerning the underlying mechanisms of change. Computers in Human Behavior. 2020; 111:106431. [DOI:10.1016/j.chb.2020.106431]

[18] Hojat M, DeSantis J, Shannon SC, Mortensen LH, Speicher MR, Bragan L, et al. The Jefferson Scale of Empathy: A nationwide study of measurement properties, underlying components, latent variable structure, and national norms in medical students. Advances in Health Sciences Education: Theory and Practice. 2018; 23(5):899-920. [DOI:10.1007/s10459-018-9839-9] [PMID]

[19] Mahmoud SA, Ahli HAN, Alahmed H. Smart wearable obstacle detection glasses for low-vision people [bachelor dissertation]. Sharjah: University of Sharjah; 2015. [Link]

[20] Barometer D. The diabetic retinopathy barometer report: Global findings. Toronto: International Federation on Ageing; 2017. [Link]

[21] Khairallah H, Alazzawi L, Sarhan N. Mobile Smart Screening and Remote Monitoring for Vision Loss Diseases.International Journal of Engineering Research & Technology. 2019; 8(10). [DOI:10.17577/IJERTV8IS100332]

[22] No Author. Tinnitus UK [Internet]. 2025 [Update 2025 August 10]. Available from: [Link]

[23] Tinnitus UK. What is tinnitus? [Internet]. 2023 [Update 2025 August 10]. Available from: [Link]

[24] Shariat SV, Kaykhavoni A. [Empathy in medical residents at Iran University of Medical Sciences (Persian)]. Iranian Journal of Psychiatry and Clinical Psychology. 2010; 16(3):248-56. [Link]

[25] McCrindle M, Wolfinger E. The ABC of XYZ: Understanding the global generations. Sydney: UNSW Press; 2009. [Link]

[26] Wiangkham A, Kieanwatana K, Vongvit R. A comparative study of baby boomers and Gen Z on virtual reality adoption for travel intentions: A PLS-MGA and GRNN Model. International Journal of Human–Computer Interaction. 2024; 41(13):1-22. [DOI:10.1080/10447318.2024.2406612]

[27] Louie AK, Coverdale JH, Balon R, Beresin EV, Brenner AM, Guerrero APS, et al. Enhancing Empathy: A role for virtual reality? Academic Psychiatry. 2018; 42(6):747-52. [DOI:10.1007/s40596-018-0995-2] [PMID]

[28] Shin D. Empathy and embodied experience in virtual environment: To what extent can virtual reality stimulate empathy and embodied experience? Computers in Human Behavior. 2018; 78:64-73. [DOI:10.1016/j.chb.2017.09.012]

[29] Li BJ, Kyung Kim H. Experiencing organ failure in virtual reality: Effects of self-versus other-embodied perspective taking on empathy and prosocial outcomes. New Media & Society. 2021; 23(8):2144-66. [DOI:10.1177/1461444821993122]

[30] Yang Y, Zhang S, Sun X, Zhang X, Sun X, Jing Y, et al. Exploring sex differences in collaborative virtual environments for participation equality and user experience. Virtual Reality. 2024; 28(3):152. [DOI:10.1007/s10055-024-01022-y]

[31] Saghi M, Sanjar Mussavi N, Bakhshi Bejestani A, Farajpour A. [A comparative study of the level of empathy of Iranian first-year and final-year medical students according Jefferson questionnaire (Persian)]. Medical Journal of Mashhad university of Medical Sciences. 2024; 67(5):1456-63. [DOI:10.22038/mjms.2024.76109.4463]

[32] Hashempor MS, Karami MA. [Validity and Reliability of the Persian Version of JSPE-HP Questionnaire (Jefferson Scale of Physician Empathy-Health Professionals Version) (Persian]. Journal of Kerman University of medical sciences. 2012; 19(6):201-11. [Link]

[33] Fisher JS, Radvansky GA. Patterns of forgetting. Journal of Memory and Language. 2018; 102:130-41. [DOI:10.1016/j.jml.2018.05.008]

[34] Radvansky GA, Doolen AC, Pettijohn KA, Ritchey M. A new look at memory retention and forgetting. Journal of Experimental Psychology. Learning, Memory, and Cognition. 2022; 48(11):1698-723. [DOI:10.1037/xlm0001110] [PMID]

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