

Development and Effect of Prenatal Education Programs Using Virtual Reality for Pregnant Women Hospitalized with Preterm Labor: An Experimental Study

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Development and Effect of Prenatal Education Programs Using Virtual Reality for Pregnant Women Hospitalized with Preterm Labor: An Experimental Study

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Abstract

Background: Pregnant women hospitalized due to Preterm labor experience anxiety, stress, and physical discomfort, which may affect uterine contractions and cervical changes, highlighting the need for effective prenatal management. Virtual reality-based prenatal education programs offer enhanced interaction and engagement for these women. Cox's Interaction Model of Client Health Behavior (IMCHB) is appropriate for nursing interventions targeting their complex needs. This study developed a virtual reality prenatal education program based on IMCHB and evaluated its effectiveness.

Objective: We aimed to develop, implement, and evaluate the effects of a prenatal educational program using VR technology for pregnant women hospitalized Preterm labor.

Methods: This program was based on Cox's (2003) Interaction Model of Client Health Behavior (IMCHB) as the theoretical basis. To develop VR prenatal education programs, we applied the ADDIE model which was conducted in five stages: analysis, design, development, implementation, and evaluation. The study comprises a pre-and post-test design with a non-equivalent control group. A total of 15 subjects were analyzed in the experimental group, while 16 subjects were analyzed in the control group, both comprising pregnant women in hospitalized Preterm labor. Data collected from these hospitals were analyzed using descriptive statistics, a pre-test of homogeneity, Chi-square test, Fisher's exact test, and independent t-tests analysis of variaThe experimental group that participated in the prenatal education program using VR was measured significantly lower than the control group in terms of state anxiety ($p<.009$), stress of Preterm labor ($p<.002$), the frequency of uterine contractions ($p<.004$), and uterine contraction intensity ($p<.001$), and significantly higher in terms of the degree of change in cervical length ($p<.009$). Practice behavior ($p<.047$) and self-efficacy of pregnancy health care ($p<.001$) were found to be significantly high. nce.

Results: The experimental group that participated in the prenatal education program using VR was measured significantly lower than the control group in terms of state anxiety ($p<.009$), stress of Preterm labor ($p<.002$), the frequency of uterine contractions ($p<.004$), and uterine contraction intensity ($p<.001$), and significantly higher in terms of the degree of change in cervical length ($p<.009$). Practice behavior ($p<.047$) and self-efficacy of pregnancy health care ($p<.001$) were found to be significantly high.

Conclusions: Prenatal education using VR was confirmed to be effective in physical, emotional, and educational aspects by providing professional and integrated educational intervention according to the complex nursing needs of hospitalized Preterm labor patients.

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stress of Preterm labor ($p<.002$), the frequency of uterine contractions ($p<.004$), and uterine contraction intensity ($p<.001$), and significantly higher in terms of the degree of change in cervical length ($p<.009$). Practice behavior ($p<.047$) and self-efficacy of pregnancy health care ($p<.001$) were found to be significantly high.

Conclusions: Prenatal education using VR was confirmed to be effective in physical, emotional, and educational aspects by providing professional and integrated educational intervention according to the complex nursing needs of hospitalized Preterm labor patients.

Keywords: Nursing, Pregnancy, Preterm Labor, Prenatal Care, Health Education, Virtual reality

Introduction

Preterm labor is accompanied by cervical changes and uterine contractions and occurs between the 20th and 37th weeks of pregnancy, and is a major cause of premature birth [1-3]. Factors causing Preterm labor include maternal age, multiple pregnancies, history of premature birth, intrauterine infection, cervical malformation, cervical damage, amniotic fluid and placental abnormalities, and fetal malformations [4,5]. Currently, the general management of pregnant women in Preterm labor is hospitalization, bed rest, and administration of painkillers to prolong pregnancy[2]. During this process, pregnant women in Preterm labor are separated from their families and have to adapt to an unfamiliar hospital environment, and experience anxiety, stress, physical discomfort, and fatigue due to restrictions on activity due to absolute rest, the possibility of premature birth, and concerns about the well-being of the fetus. It is known [6,7]. Pregnant women in Preterm labor have higher anxiety and more stressors than normal pregnant women [8] and often experience confusion because the exact cause of Preterm labor is unknown [6]. Since there is no ideal treatment method other than bed rest and administration of analgesics after diagnosis of Preterm labor, pregnant women in Preterm labor experience uncertainty regarding the maintenance of pregnancy and prognosis [9,10]. Therefore, nurses should be able to minimize confusion by providing knowledge related to pregnancy and Preterm labor to pregnant women in Preterm labor and providing prenatal education to relieve psychological anxiety [9]. Pregnant women who acquire prenatal knowledge can improve their self-management skills and gain confidence related to pregnancy, so prenatal education is important for pregnant women's health management [11,12]. To promote physical, psychological, and physiological relaxation and deliver information to high-risk pregnant women, systematic education through experts and the use of various media are necessary [13,14]. As a prenatal education method, relaxation therapy is often used to relieve physical, psychological, and physiological tension related to the patient's anxiety and stress [15,16]. Among relaxation therapies, abdominal breathing is a commonly used method that can be applied in an integrated manner [17], and imagery therapy is a relaxation therapy that reduces stress or anxiety by recalling visual images and expressing physical and emotional responses [15]. Hospitalized pregnant women in Preterm labor experience anxiety and stress in unexpected situations and become nervous in an unfamiliar hospital environment, which causes the release of prostaglandins through a physiological mechanism related to psychological reactions, which promotes cervical softening and uterine contraction [5]. Therefore, applying relaxation therapy to pregnant women in Preterm labor can have a positive effect on the degree of cervical changes and contractions. Recently, attempts to apply technology using virtual reality are expanding in the

medical field, and among them, it is being used as a new educational method in the clinical field [18,19]. Looking at previous studies using virtual reality technology, it was reported that virtual reality relaxation meditation programs have a positive effect on pain control in clinical patients [20,21]. It was found to be effective in controlling anxiety and depression in patients with bipolar disorder [22]. It was reported that a virtual reality cognitive behavioral program was effective in controlling the anger of juvenile criminals [23], and a virtual reality imagery relaxation program was found to be effective in reducing anxiety in dental patients [24]. Therefore, virtual reality technology is useful as an educational and therapeutic tool by reconstructing one's knowledge or cognitive structure through interaction with the subject [19,25] and is effective by inducing a high sense of immersion through the provision of realistic information [23]. In addition, education using virtual reality technology induces interaction with the subject, enables experiential learning with a high level of realism, and is an educational method that enables self-directed learning and is applied together with information delivery and relaxation [15,19,26]. Therefore, in this study, a professional approach is required to reflect the unique characteristics of high-risk pregnant women in Preterm labor and to increase their pregnancy healthcare practices, and Cox's Subject Health Behavior Interaction Model is an appropriate nursing intervention approach. Based on the (Interaction Model of Client Health Behavior [IMCHB]), we developed a prenatal education program using virtual reality for hospitalized pregnant women in Preterm labor and verified its effectiveness.

Purpose of Study

We aimed to develop, implement, and evaluate the effects of a prenatal educational program using VR technology for pregnant women hospitalized Preterm labor.

Methods

Research Design

The study was quasi-experimental study used pre-test and post-test designs with a nonequivalent control group.

Setting and Sample

The sample size was determined based on a previous study that had educated women before stress and anxiety in Preterm labor [27]. We calculated the sample size using G* Power 3.1.9.2, (Heinrich-Heine-University, Düsseldorf, Germany) based on a significance level of 0.05, power 0.80, and effect size of 0.97 [28]. The appropriate sample size for both the experimental and control groups was determined to be 14, based on previous findings [27]. Thus, each group comprised 17 participants considering a dropout rate of 20%. Women (n = 34) with pregnant women

hospitalized in Preterm labor at two hospitals and who met the inclusion criteria participated in the study via convenience sampling. The control (n = 17) and experimental (n = 17) groups comprised patients from the Mirae and Hyosung Women's hospitals respectively. The author distributed questionnaires to the participants before and after the prenatal educational program. All participants completed the questionnaire before the prenatal educational program, but, two in the experimental group (one transferred to another hospital, one complained of discomfort with the HMD equipment) and one in the control group who gave insincere answers were excluded. Therefore, we analyzed data from 31 (control, n = 16; experimental, n = 15) participants.

Ethical Considerations

The Institution Review Board (IRB) at university that author works approved this study (IRB No. 40525-202007-BR-036-01). After receiving an explanation of the purpose, methods, intervention details, and the survey content, the women voluntarily provided written informed consent before participating in the study. Confidentiality was guaranteed and the participants could withdraw from the study at any time without negative consequences. We advised sufficient rest and withdrawal from the VR training program if any of the participants experienced discomfort or dizziness during the intervention.

Measurements

The study utilized a structured questionnaire survey consisting of general and obstetric characteristics, state anxiety, stress of Preterm labor, uterine contractions, cervical length, Practice behavior, and self-efficacy of pregnancy healthcare.

State anxiety

State anxiety was measured using the State-Trait Anxiety Inventory (STAI) [29] translated into Korean [30]. The STAI consists of 20 questions on a 4-point Likert scale ranging from 1 (not at all) to 4 (very high). The total score range was 20–80, with high scores indicating significant anxiety. The reliability of the STAI [30] (Cronbach's α) and the present study was 0.92.

Stress of Preterm labor

The stress of Preterm labor was measured using an instrument developed by Kim[31]. The survey consisted of 17 questions on a 5-point Likert scale, where the total score ranged from 17 to 85. High scores indicated increased stress. Kim [31] identified Cronbach's α values of 0.79, whereas this value was 0.79 in the present study.

Uterine contractions

The degree of uterine contraction was measured by the intensity of uterine contraction and the frequency of uterine contraction. To measure this, a non-stress test (NST) tocodynamometer was used. The electronic fetal monitoring device (Fetal Monitor Device FC 1400, Designed by Bionet, Korea) used in the experimental treatment was measured to be in use at the hospital where the study was conducted. Data on the intensity of uterine contractions and frequency of uterine contractions were collected through nursing records among the medical records. To evaluate the reliability of uterine contraction intensity and frequency, interobserver reliability (Interclass Correlation Coefficient [ICC]) was used. In this study, ICC=.80 (95% CI 0.682~0.894), $p<.001$.

Cervical length

Cervical length was determined as the length (mm) from the internal os to the external os of the cervix measured using a transvaginal ultrasound device [32]. Medison Accuvix (Samsung, Korea) was used as the transvaginal ultrasound device used in the experimental treatment, and data on cervical length (mm) were collected through nursing records among medical records.

Practice behavior of pregnancy healthcare

The Practice behavior of pregnancy healthcare was measured using an instrument developed by Wang & Kim [33]. The tool consists of such sub-elements as prenatal care and education, activity and rest, medication management, physical and hygiene management, nutritional management, and mental health. The survey consisted of 17 questions on a 5-point Likert scale, where the total score ranged from 17 to 85. High scores indicated increased Practice behavior of pregnancy healthcare. Wang & Kim [33] identified Cronbach's α values of 0.72, whereas this value was 0.76 in the present study.

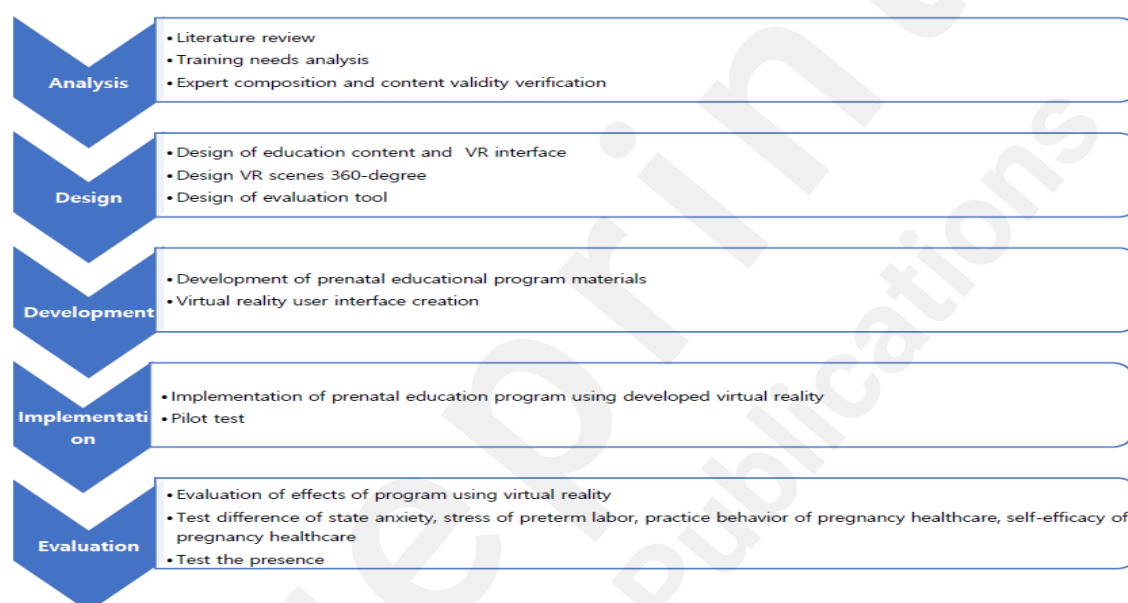
Self-efficacy of pregnancy healthcare

The Self-efficacy of pregnancy healthcare was measured using an instrument developed by Wang & Kim [33]. Based on the 16-questions pregnancy healthcare self-efficacy measurement tool used by Wang & Kim [33], the validity of the tool was verified by a group of experts (6 people in total). As a result, questions with a CVI of .80 or higher were selected, and the CVI for 'Understanding Pregnancy in the Elderly' was measured at .16, so this question was excluded. The survey consisted of 15 questions on a 4-point Likert scale modified and supplemented, where the total score ranged from 15 to 60. High scores indicated increased Self-efficacy of pregnancy healthcare. Wang and Kim[33] identified Cronbach's α values of 0.89, whereas this value was 0.92 in the present study.

Development of the program

This study verified the effectiveness of a prenatal education program with the use of virtual reality (VR) for pregnant women hospitalized in Preterm labor. This program was based on Cox's [13] Interaction Model of Client Health Behavior (IMCHB) as the theoretical basis (Fig. 1). To develop VR prenatal education programs, we applied the ADDIE model [34] which was conducted in five stages: analysis, design, development, implementation, and evaluation.

Figure 1. The development process of the program.



During the analysis step, they comprised a literature review and interviews with pregnant women hospitalized in Preterm labor. The contents of the education included knowledge of Preterm labor, relaxation, examination and treatment, symptoms and health management, nutrition and weight management, discharge education, and daily life management which consisted of six subject areas and 19 detailed items. The program of education was designed to include Cox's IMCHB, based on the analyzed prenatal education contents (Table 1).

Table 1. Prenatal education content for pregnant women hospitalized for Preterm labor based on the Cox's IMCHB.

Session	Goal	Contents		Methods	Time
1	- Understanding Preterm labor - Recognition of the necessity and	Affective support	- Orientation - Emotional management (anxiety and	- VR imagery relaxation - Face-to-face, phone, Message	40Min

	importance of prenatal education		stress management) •Praise and Listen	consultation	
		•Provision of health information	• Introduction to educational programs •Importance of pregnancy health care	• VR & Brochure	
		•Decisional control	•Identifying health behaviors resulting from Preterm labor •Consultation	•Pre-test •Face-to-face, phone, Message consultation	
		•Professional or technical competencies	• Understanding Preterm labor • Definition and causes of Preterm labor • Changes in hospitalization conditions due to Preterm labor	• VR & Brochure	
2	•Recognizing that physical and mental problems experienced due to Preterm labor can be alleviated through VR-based prenatal education programs	•Affective support	•Emotional management (anxiety and stress management) •Praise and Listen	• VR imagery relaxation •Face-to-face, phone, Message consultation	40Min
		•Provision of health information	•Types, purpose, and methods of testing	• VR & Brochure	

		•Decisional control	• Health problems caused by Preterm labor(uterine contraction, vaginal bleeding) • Consultation	• VR & Brochure •Face-to-face, phone, Message consultation	
		•Professional or technical competencies	•Check uterine contractions and labor •Check fetal condition	• VR & Brochure	
3	• Understanding early labor reduces anxiety and stress and increases self-care performance and self-efficacy.	•Affective support	•Emotional management (anxiety and stress management) •Praise and Listen	• VR imagery relaxation •Face-to-face, phone, Message consultation	40Min
		•Provision of Health information	•Weight management • Bed stability management	• VR & Brochure	
		•Decisional control	• Health problems caused by Preterm labor (labor pain, labor pain, rupture of membranes) • Consultation	•Pre-test • VR & Brochure •Face-to-face, phone, Message consultation	
		•Professional or technical	• Daily life and discharge management (Hospital visit situation)	• VR & Brochure	

		competencies	• Check uterine contractions and labor. • Check fetal condition		
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During the design step, the educational program was designed based on COX IMCHB's subject-expert interaction elements: emotional support nursing, health information provision nursing, decision-making participation, and professional/technical nursing. The prenatal education program using virtual reality was designed to be applied for 3 days through 1:1 face-to-face education. The order of training was introduction (5 min), development (30 min), and end (5 min), with a total time of 40 minutes. Therefore, the application time of the prenatal education program applied to pregnant women in Preterm labor during each intervention was 40 minutes.

In the introduction stage, emotional support nursing was provided through orientation, support, and encouragement to induce the subject to participate in education and sharing of past educational experiences.

In the development stage, prenatal education programs using virtual reality consisted of a situation-based education program that could occur during hospitalization, discharge, and daily life for pregnant women who Preterm labor. Specialized content on professional and technical nursing (classification of labor pain, labor pain, symptoms of ruptured membranes, hospital visit situations, etc.) was designed so that the subject's condition, uterine contractions, fetal movements, etc. could be checked. In addition, a relaxation meditation program using virtual reality was designed to be performed every time to reduce anxiety and stress for pregnant women who are hospitalized in Preterm labor. The relaxation meditation program using virtual reality provided in each session was 10 minutes long included breathing and imagery relaxation therapy, and was intended to provide emotional support nursing. Imagery relaxation provides comfort in the mind by inducing a deep level of relaxation by applying imagery relaxation along with breathing based on the natural environment, and imagery relaxation using virtual reality provides visual imagery relaxation to hospitalized pregnant women in Preterm labor.

In the final stage, the next training was announced in advance, and emotional support including questions, praise, listening, and encouragement was repeated for three days. Through this, interaction was promoted so that pregnant women in Preterm labor could independently select and repeatedly learn the necessary information in each session. During each intervention, the researcher continuously checked whether the pregnant women in Preterm labor were performing the training well and whether there was any pain or discomfort.

During the development step, scenarios, flow charts, and scenes were created based on educational content verified by an expert group consisting of obstetricians, clinical nurses, and nursing professors. The development of a prenatal education curriculum for pregnant women hospitalized in Preterm labor was produced for each

session according to the goals, details, program content, education method, and time required for each session of the designed prenatal education program. In VR, a 360° camera was used for filming, where each scene was formed in a 3D space. The VR educational programs were developed to enable training using a head-mounted display (HMD). Because relaxation meditation is difficult to induce relaxation without a helper, the researcher directly participated in the virtual reality video to promote breathing and relaxation meditation of pregnant women hospitalized in Preterm labor. The virtual reality prenatal education program was created as an educational program and a relaxation meditation program.

The educational virtual reality program is titled 'Virtual Reality Prenatal Education Program for Pregnant Women in Preterm labor' and has a total running time of 20 minutes. The relaxation meditation program is titled 'Virtual Reality Relaxation Meditation Program with a Nurse' and has a total running time of 10 minutes (Fig. 2).

Figure 2. Contents of prenatal education program using virtual reality.

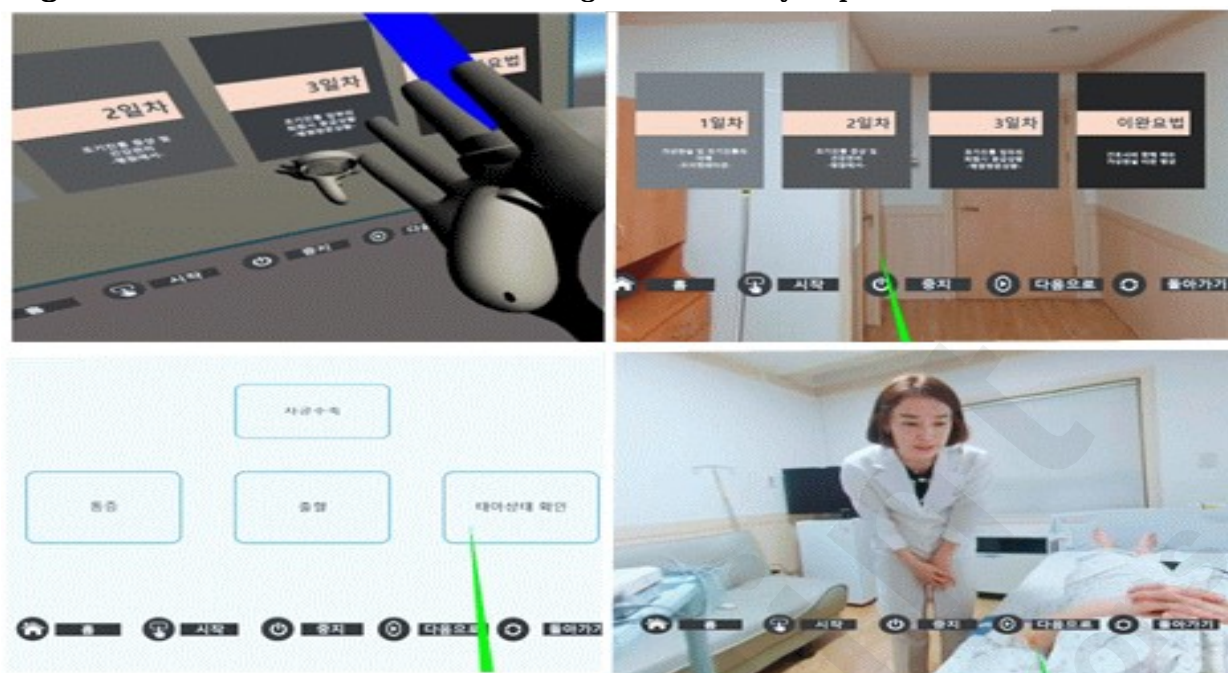


A user interface was used to maximize interaction in VR by recognizing the movement of fingers [35]. This allows interventions in anxiety and nursing education to be independent. The screen configuration of the virtual reality user interface was developed to automatically move from the first screen to the next screen according to a flow chart designed with four main menus and five selection menus at the bottom of the screen (Fig. 3).

During the implementation step, a preliminary survey was conducted before the evaluation stage to confirm the feasibility of operating and applying the developed prenatal education program using virtual reality to actual clinical practice. The expert group consisted of one virtual reality expert and one nursing professor, and it consisted of one head nurse working at a women's specialty hospital. As a result, the subtitle location and font size of the educational content on the implementation screen, and the icon image of the interface menu button were modified symbolically and intuitively to make the final correction and supplement.

During the evaluation step, Lee's presence evaluation tool [36] was used to evaluate the presence of the prenatal education program using VR. The total score of the expert group was 180.20 ± 1.78 out of 190 points, and the user evaluation was conducted on a total of 3 pregnant women in Preterm labor, and the total score was 181.66 ± 10.11 , which was evaluated as appropriate.

Figure 3. User Interface screenshot using virtual reality of prenatal



Data collection

Data were collected before and after prenatal education by a self-reporting face-to-face method. The pre-and post-prenatal education questionnaires required ~ 20 min to complete and included questions about the general and obstetric characteristics, state anxiety, the stress of Preterm labor, practice behavior of pregnancy healthcare, and self-efficacy.

Statistical Analysis

All data were analyzed using SPSS 24 (IBM Corp., Armonk, NY, USA). Values with $p < 0.05$ were considered statistically significant. General and obstetric characteristics and homogeneity tests were analyzed as proportions (%) and mean with standard deviations using χ^2 , Fisher exact test, and independent t-test. The Kolmogorov-Smirnov test was used to test normality. The effects of state anxiety, the stress of Preterm labor, uterine contractions, cervical length, practice behavior of pregnancy healthcare, and self-efficacy of were assessed using independent t-tests, Wilcoxon signed rank test, and Mann-Whitney U test.

Ethical Considerations

This research was approved by The Institution Review Board (IRB), IRB No. 40525-202007-BR-036-01. The informed consent was obtained from all of the subjects through a questionnaire. Participants were also informed that they had the option to withdraw at any time. All methods in this study were carried out in accordance with relevant guidelines and regulations.

Results

Characteristics of the participants

General characteristics, obstetric characteristics, and dependent variables did not significantly differ between the experimental and control groups, indicating their homogeneity (Table 2).

Table 2. Homogeneity of characteristics of the two groups(N=31).

Characteristics	Category	Exp.(n=15)	Cont.(n=16)	t or χ^2	p
		N (%) or M±SD	N (%) or M±SD		
Age(years)		30.26±3.63	31.43±2.50	1.50	.302
Spouse	0	0(0)	1(6.3)	0.96	.341
	1	15(100)	15(93.7)		
Level of education	High school	4(26.7)	4(25.0)	0.10	.919
	University	11(73.3)	12(75.0)		
Occupation	Yes	3(20.2)	6(37.5)	1.06	.296
	No	12(80.0)	10(62.5)		
Gestational age		30.05±2.54	30.94±1.94	1.10	.280
Number of children [†]	0	8(53.3)	7(43.7)		.322 [†]
	1	4(26.7)	8(50.0)		
	2	3(20.0)	1(6.3)		
Experience of delivery [*]	Yes	7(46.7)	9(56.6)	0.32	.414 [*]
	No	8(53.3)	7(43.7)		
Method of delivery [‡]	Normal	6(85.7)	6(66.7)	0.83	.471
	C-section	1(14.3)	3(33.3)		
Times of delivery [†]	0	8(53.3)	7(43.7)		.322 [†]
	1	4(26.7)	8(50.0)		
	2	3(20.0)	1(6.3)		
Experience of	Yes	6(40.0)	9(56.3)	0.81	.366 [*]

abortion*					
	No	9(60.0)	7(43.7)		
Times of abortion^{†§}	1	4(66.7)	6(66.7)		1.000 [†]
	2	2(33.3)	2(22.2)		
	≥3	2(0.0)	1(11.1)		
Antenatal care[†]	Not at all	2(13.3)	1(6.3)		.630 [†]
	Irregularly	4(26.7)	3(18.7)		
	Regularly	9(60.0)	12(75.0)		
Planned pregnancy*	Yes	8(53.3)	10(62.5)	0.26	.605*
	No	7(46.7)	3(37.5)		
Knowledge level related to Preterm labor[†]	Very well	0(0.0)	0(0.0)		1.000 [†]
	Well	0(0.0)	0(0.0)		
	Usually	3(20.0)	4(25.0)		
	Not know	9(60.0)	8(50.0)		
	Not at all	3(20.0)	4(25.0)		
Necessity of Preterm labor education[†]	Very necessary	12(80.0)	13(81.3)		1.000 [†]
	Necessary	3(20.0)	3(18.7)		
	Moderate necessary	0(0.0)	0(0.0)		
	Not necessary	0(0.0)	0(0.0)		
	Not necessary at all	0(0.0)	0(0.0)		
Information	Doctors	1(6.7)	4(25.0)		.855 [†]

sources[†]	Nurses				
	Internet	15(100)	15(93.8)		
	Antenatal classes	1(6.7)	4(25.0)		
	Books	0(0.0)	4(25.0)		
State anxiety		58.46±9.03	56.87±10.31	-0.45	.652
Stress of Preterm labor		56.80±7.88	57.25±7.04	0.16	.868
Uterine contractions	Frequency of uterine contraction	3.16±0.87	3.12±0.34	-0.17	.866
	Intensity of uterine contraction	33.33±10.63	35.00±16.12	0.33	.738
Cervical length		30.00±6.48	30.25±7.73	0.09	.923
Practice behavior Of pregnancy healthcare		63.73±6.12	65.43±5.22	0.83	.410
Self-efficacy of pregnancy healthcare		36.66±5.30	35.81±4.83	-0.46	.642

C-section: Cesarean section, M: Mean, SD: Standard deviation; [†]χ² test, [‡]Fisher exact test ; [‡] 16 respondents with delivery experience.; [§] 15 respondents with abortion experience; Information sources in multiple responses

Effects of the program

The state anxiety ($t = 2.80$, $p < .009$) and stress of Preterm labor ($t = 3.34$, $p < .002$) scores after the prenatal education program using VR were significantly lower in the experimental group than in the control group. The frequency of uterine contractions ($t = 3.08$, $p < .004$) and intensity of uterine contraction ($t = 4.75$, $p < .001$) scores after the prenatal education program using VR were significantly lower in the experimental group than in the control group. Compared to the control group, the degree of change in uterine cervical length ($U = 54.50$, $p < .009$), practice behavior ($t = -2.07$, $p < .047$) and self-efficacy of pregnancy health care scored significantly higher for the experimental group ($t = -4.12$, $p < .001$; Table 3).

Table 3. Differences of state anxiety, stress of Preterm labor, uterine contractions, cervical length, practice behavior and Self-efficacy of pregnancy healthcare treatment among the two Groups (N=31).

Variables	Exp. (n=15)	Cont. (n=16)	t/U	p
	M±SD	M±SD		
State anxiety	44.53±7. 58	52.93±8.9 6	2.80	.009
Stress of preterm labor	48.66±4.82	55.87± 6.91	3.34	.002
Uterine contractions (Frequency)	1.00± 0.75	1.84± 0.76	3.08	.004
Uterine contractions (Intensity)	10.13± 3.97	23.43± 10.11	4.75	<.001
Cervical length	33.93± 5.33	31.62± 7.38	54.50	.009
Practice behavior of pregnancy healthcare	71.60± 5.86	67.37± 5.47	-2.07	.047
Self-efficacy of pregnancy healthcare	46.93± 2.93	40.81± 4.98	-4.12	.001

M: Mean, SD: Standard deviation

Discussion

Principal Findings

This program was based on Cox's (2003) Interaction Model of Client Health Behavior (IMCHB) as the theoretical basis. Also, we developed and verified the effects of a prenatal educational program using VR based on the ADDIE model, for hospitalized pregnant women in Preterm labor. The program was developed through analysis, design, development, implementation, and evaluation.

Nurses must provide professional and specific knowledge and information about Preterm labor to help pregnant women in Preterm labor overcome crises [37,38]. Therefore, this program is significant in that it reflects the educational needs of pregnant women in Preterm labor, utilizes a virtual reality program as an intervention strategy as an element of expert/technical interaction, and attempts an individual intervention approach with experts.

In the first step of program analysis, the educational program was designed based on Cox's Interaction Model of Client Health Behavior, incorporating emotional support, health information, decision-making participation, and professional nursing. It addressed the needs of hospitalized women with preterm labor through six main topics.

The VR-based 1:1 education enhanced engagement and expert-subject interaction, effectively reducing anxiety and promoting positive health behavior changes.

In the design step, the overall educational contents were designed based on the analysis step. During the development of the educational program using VR, we drafted an educational content scenario, and VR scenes were composed and designed. To help participants receiving pregnant women hospitalized with Preterm labor obtain the information efficiently, a user interface program using hand movements was designed. Additionally, educational contents were arranged with consistency based on the analysis to facilitate the ability of the participants to understand the program.

In the development step, the VR prenatal education program was designed to help pregnant women in preterm labor perform self-guided relaxation therapy using immersive, first-person experiences via HMD. Real voice narration, natural soundscapes, and imagery of mountains and the sea enhanced emotional bonding and stress relief. Accordingly, the background screen of relaxation meditation therapy using virtual reality was composed of real mountains and the sea, and imagery relaxation therapy in a natural environment can induce concentration voluntarily and cognitively and is effective by reducing stress and inducing comfort [39,40].

In the implementation step, the program was revised and supplemented by experts to ensure that the educational program using VR could be applied in actual clinical settings. We inserted captions at the bottom of the screen to facilitate understanding and emphasize important content in the video. Including footage of nurses providing care to patients in the video served to alleviate apprehension among viewers. The final video can be viewed with an HMD that can display 360° video clips. The user interface using hand movements can be applied interactively without having to remember the gestures of the participants.

In the evaluation step, the VR prenatal education program was tested with 15 participants in the experimental group and 16 in the control group. Results showed that the experimental group had significantly lower levels of anxiety, preterm labor stress, and uterine contractions, along with higher cervical length, improved pregnancy healthcare behaviors, and greater self-efficacy compared to the control group. As a result of applying the prenatal education program using virtual reality, the experimental group showed significantly lower state anxiety compared to the control group.

This is the result of measuring anxiety in pregnant women for Preterm labor in a previous study by applying an educational program that emphasized interaction elements between subjects and experts based on Cox's subject health behavior interaction model, and the average of the pre-survey was 46.44 points before intervention to 38.89 points after intervention. This was also confirmed in the results of a previous study targeting pregnant women in Preterm labor [15]. Hospitalized pregnant women in Preterm labor experience high anxiety due to uncertainty about symptoms and prognosis, the possibility of labor recurrence, concerns about the fetal condition, and the inability to predict whether the pregnancy will be maintained [8].

Anxiety in hospitalized pregnant women with preterm labor can negatively affect both mother and fetus, making anxiety-reducing interventions essential. Emotion-focused coping, supported by tailored information and education, is more effective than problem-focused approaches. This study suggests that combining education with relaxation therapy, considering the unique needs of these women, helped reduce anxiety by activating the parasympathetic nervous system.

After applying the VR prenatal education program, stress related to preterm labor was significantly reduced in the experimental group. This aligns with previous studies showing that virtual reality featuring natural scenes, combined with techniques like breathing therapy, effectively promotes mental relaxation and reduces stress [22,41]. These findings support the need for future programs using VR-based relaxation with natural environments to positively influence both physiological and emotional states.

After implementing a prenatal education program using virtual reality, the degree of uterine contraction in the experimental group was found to be significantly reduced compared to the control group. In a previous study, Park and Seong [42] measured the effect on the frequency of uterine contractions by applying music therapy to pregnant women in Preterm labor, the result showed that the average frequency of uterine contractions in the experimental group decreased by 0.35 points from 3.00 before intervention to 2.65 after intervention; The frequency of uterine contractions in the control group decreased by 0.33 points from 2.78 points before the intervention to 2.44 points after the intervention, confirming the tendency for relaxation therapy through music to relax uterine muscles. However, this was not statistically significant, which was different from the results of this study. These findings are supported by previous research indicating that imagery-based interventions and abdominal breathing can promote uterine muscle relaxation and reduce the need for pain relief in women with preterm labor[43,44].

Previous studies have shown that cervical length changes vary based on individual characteristics of women with preterm labor [45]. Psychological interventions like relaxation, when combined with drug therapy, significantly increased cervical length and reduced uterine contractions [46]. Since symptoms of preterm labor are often unrecognized by patients [47], and many report difficulty detecting contractions and a need for clearer education [48,49], this VR-based prenatal program offers effective intervention through education, imagery, and breathing relaxation. The program was found to be beneficial in reducing premature labor risk and promoting cervical stability, suggesting that ongoing, multifaceted nursing interventions tailored to individual symptoms may positively impact physiological outcomes.

After applying the VR prenatal care program, the experimental group showed significantly higher self-efficacy in pregnancy health management compared to the control group. This aligns with previous studies using mobile or expert-led prenatal education programs that enhanced self-efficacy by offering specific information and promoting self-directed learning [33,50]. Providing accurate, tailored education and interactive relaxation

sessions boosted participants' confidence and internal motivation, leading to improved practice behavior and active engagement [33,51].

Pregnant women hospitalized with preterm labor reported that the VR prenatal education program made pain management methods easy to understand and remember, enhancing their coping ability. The immersive, experience-based format improved engagement, self-management, and internal motivation by providing expert interaction and professional information.

Based on Cox's health behavior interaction model [13], this study developed a VR prenatal education program tailored to the complex needs of women with preterm labor, offering individualized support across physical, emotional, educational, and professional domains. The program's effectiveness was validated using both objective and subjective tools, enhancing its reliability. It holds promise as a customized nursing intervention for broader clinical application in the future.

Limitations

This study had a few limitations. The results cannot be generalized because this study proceeded in two hospitals and the participants comprised a convenient sample of pregnant women hospitalized with Preterm labor. Therefore, different contexts and groups should be studied in the future to replicate our results. Blinding was not feasible, potentially introducing bias, though efforts were made to ensure fair intervention delivery. While the wireless HMD allowed mobility, it posed challenges in focus adjustment and user comfort. Despite these limitations, the program effectively reduced anxiety and stress in pregnant women with preterm labor.

Conclusion

This program is a virtual reality prenatal education program that emphasizes subject-expert interaction elements. It takes a 1:1 individual intervention approach to improve the health of hospitalized pregnant women with Preterm labor, and experts continuously provide emotional support and professional and technical capabilities even within a virtual environment. The positive outcomes suggest its potential to inform the development of future prenatal education protocols. As science and technology evolve, the importance of interdisciplinary, convergent research grows. This study is meaningful for integrating VR technology into nursing education, and future research should explore multidisciplinary approaches aligned with advanced care methods.

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Conflict of interest

There were no conflicts of interest.

Abbreviations

VR: Virtual reality

HMD: Head Mounted Display

IMCHB: Interaction Model of Client Health Behavior

NST: Non Stress Test

ICC: Interclass Correlation Coefficient

C-section: Cesarean Section

M: Mean

SD: Standard deviation

Exp: Experimental group

Con: Control group

Data availability

Data will be made available on request.

Author contribution

SAP contributed to conceptualization, methodology, and writing the original draft.

HYK supervised the project and performed review and editing.

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