

A smartphone application to educate undergraduate nursing students about providing care for infant airway obstruction



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ABSTRACT

Purpose: This study had two aims: (a) to develop a smartphone-based application and (b) to evaluate the effectiveness of the application by measuring nursing students' knowledge, skills, and confidence in simulated performance when providing that care.

Design: We conducted a randomized trial using a pre- and post-test design at a university in Korea. Seventy-three junior nursing students participated.

Methods: A smartphone-based app using a video was developed for the experimental group and one time lecture-based education was designed for the control group. We provided the app and information about its use to the experimental group, and we encouraged its use. We provided classroom instruction to the control group. Then, learning outcomes were evaluated. **Results:** The smartphone-based education group showed significantly higher scores on skills ($t = 4.774, p < 0.001$) and confidence in performance ($t = 2.888, p = 0.005$) than the control group. The scores on knowledge ($t = 0.886, p = 0.379$) and satisfaction with the learning method ($t = 0.168, p = 0.867$) for the experimental group were higher than for the control group, but the differences were not statistically significant.

Conclusion: This study suggests that smartphone-based education may be an effective method to use in nursing education related to teaching infant airway obstruction.

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1. Introduction

Advances in medical technology and improved living standards have contributed to an overall decrease in the worldwide child mortality rate; however, unexpected accidents still cause disability or mortality in children (Kim et al., 2011). In the United States, from 1999 to 2014, nearly 2500 deaths occurred that were related to obstruction of the respiratory tract among children aged 0 to 14 years (Centers for Disease Control and Prevention, 2015). In South Korea, from 2012 to 2015, 7200 accidents were related to foreign body aspiration out of 74,600 reported accidents involving a child under the age of 14 (Korea Consumer Agency, 2015). In South Korea in 2014, 37 child deaths occurred because of obstruction of the respiratory tract and of those, 62% were infants (Statistics of Korea [SK], 2015). Despite improvements,

children worldwide continue to suffer airway obstructions, and some of these children will die.

Airway obstruction can occur for various reasons including aspiration of foreign bodies into the airway. An airway obstruction can result in acute difficulty in breathing, which can lead to cardiac arrest; thus, early recognition and emergency care and management are essential (Korea Association of Cardiopulmonary Resuscitation [KACPR], 2011). The most dangerous age range for choking-related accidents is <3 years old, and >50% of choking victims are younger than 2 years old (Committee on Injury, 2010; Shah et al., 2010). Aspiration can occur in infants and toddlers less than three years of age as they explore their environments and occasionally insert objects into their mouths. That action combined with immature swallowing coordination can lead to foreign body obstruction (Shah et al., 2010). The purpose of this study was (a) to develop a smartphone application (app) designed to teach Korean nursing students information about preventing and managing infant airway obstruction and developing their related skills and (b) to compare the knowledge skills and confidence of students using the app with those receiving traditional lectures about infant airway obstruction.

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2. Literature

In 2015, 83% of the total Korean population (Korea Telecom Economic Research Institute, 2015) and 64% of adults in the US were smartphone users (Smith, 2015). A smartphone has advanced capabilities compared to a traditional phone including Internet access and real time video communication (Boulos et al., 2011). Electronic health (e-health) uses information technology to improve the health of persons through training health care workers (World Health Organization [WHO], 2016). Health-related smartphone apps are being actively studied in both countries for their use in a variety of clinical and other health-care situations, and medical professionals are being encouraged to develop and use apps as a new communication method in healthcare (Pandey et al., 2013; Terry, 2010).

Smartphone-based education can provide a self-directed learning environment that allows users to repeatedly access information and practice skills without any space and time limitations. Nursing students might feel pressure while learning and practicing nursing procedures in a lab or hospital. However, smartphone-based education could provide a non-judgmental learning environment, so students can practice several times without being anxious about making errors (Pyo et al., 2012). Moreover, using electronic technology in health-care delivery is cost-effective (Phillips et al., 2013). Thus, a smartphone-based app for teaching infant airway obstruction relief strategies could be an efficacious, accessible and cost-effective teaching strategy for nursing students.

Despite the many advantages of using smartphones to provide education, there is limited research on this teaching strategy. Fewer than ten research studies using smartphones in health education have been published in South Korea and in the U.S. the last five years (Cho et al., 2013; Einspruch et al., 2007; Park and Cho, 2015). In these studies, the app was found to be an effective method for increasing knowledge and improving skills. However, no studies have used a smartphone-app to educate nursing students about providing care for infant airway obstruction.

3. Methods

3.1. Design

This study used a pre- and post-test quasi-experimental design with an experimental and a control group. We measured knowledge, skills, and confidence in performance and evaluated each group's satisfaction with the learning method (see Fig. 1).

3.2. Ethical Considerations

Prior to the start of the study, approval was granted by the H University's Institutional Review Board in Korea (HIRB-2015-84). Students were informed about all aspects of the study and assured that there were no negative consequences for non-participation. After students were informed, they were asked to sign a consent form if they wanted to participate and also if they granted permission for videos to be recorded while testing the skills instrument.

3.3. Participants and Setting

We chose third year nursing students in Korea because they have previously primarily focused on basic care of children and are not trained to provide care for infant airway obstruction. Therefore, we considered these nursing students as representative of typical adults, who might not know how to provide emergency care for infants with an airway obstruction. The inclusion criteria were (a) junior-undergraduate, (b) completion of a three-credit Child Health Nursing course, (c) not having been exposed to child CPR education, and (d) no previous experience with smartphone-based learning in healthcare. Based on power analysis (G^* Power 3.0; Faul et al., 2007) using a medium effect size of 0.50, a power of 0.80, and a significance level of 0.5, a sample size of 26 participants was required for each group. The study's purpose, procedures, and information about confidentiality were explained on a student bulletin board in a nursing

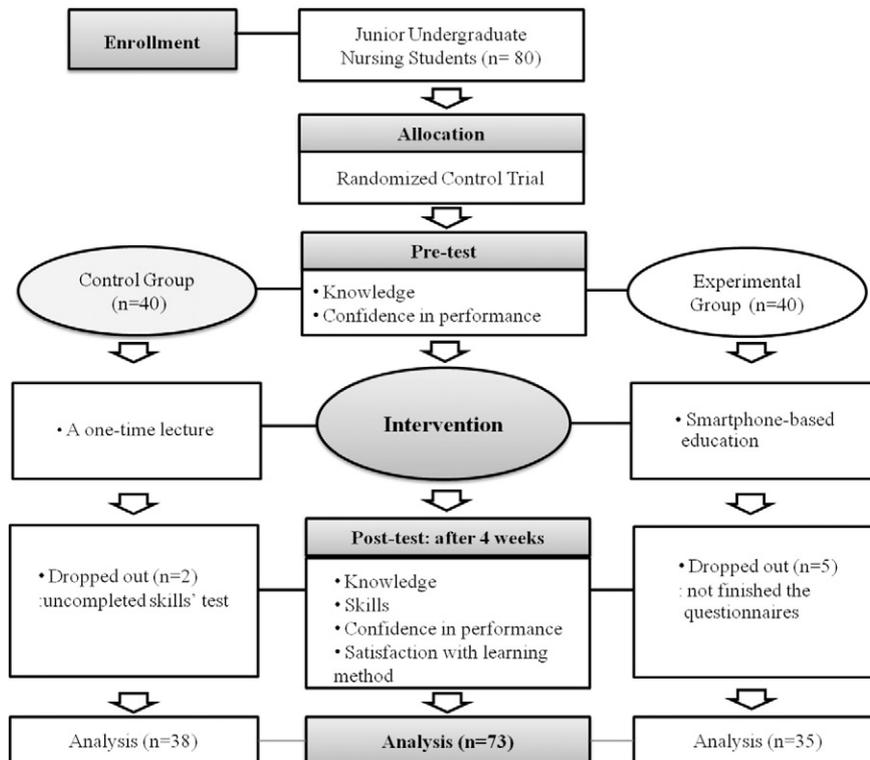


Fig. 1. Research process.

school via online and offline. Students who wanted to volunteer to participate in the study were asked to provide written informed consent and to sign a consent form. Ninety-five junior nursing undergraduate students from a university in Chuncheon, South Korea were recruited for this study. Among them, 80 (84.2%) agreed to participate in this study, and the final sample size ($N = 80$) was considered acceptable. Forty students were randomly assigned to each group. We prepared an envelope that contained slips of paper with a number from 1 to 80. If a student picked an odd number, the student was assigned to the control group. A total of 73 participants (91.3%) completed pre- and post-measurements. Five students were eliminated from the experimental group because they did not answer more than half of the questions on the questionnaires. Two students were eliminated from the control group because they did not take the skills test.

3.4. Instruments

All instruments were written in Korean and the content of all instruments is represented in Fig. 2.

3.4.1. Knowledge

The instrument used to assess student knowledge about preventing and managing infant airway obstruction was developed by study authors based on the guidelines for providing emergency care for infants from the American Heart Association [AHA] (2011) and the standards of the Korean Academy of Child Health Nursing (2012). It consists of eight multiple-choice questions and six true or false questions and assesses knowledge about the causes and characteristics of infant airway obstruction, signs of responsive and non-responsive infants, and chest compressions and backslaps for non-responsive infant care. Each correct response receives a score of one, and the highest score is 14 points.

3.4.2. Skills

The instrument used to assess student skills related to taking care of infant airway obstruction was developed by study authors and was also based on the guidelines for providing emergency care for infants from the AHA (2011). The checklist consists of 22 actions, 18 actions for responsive infant care and four actions for unresponsive infant care. Each skill performed accurately receives a score of one, and the highest

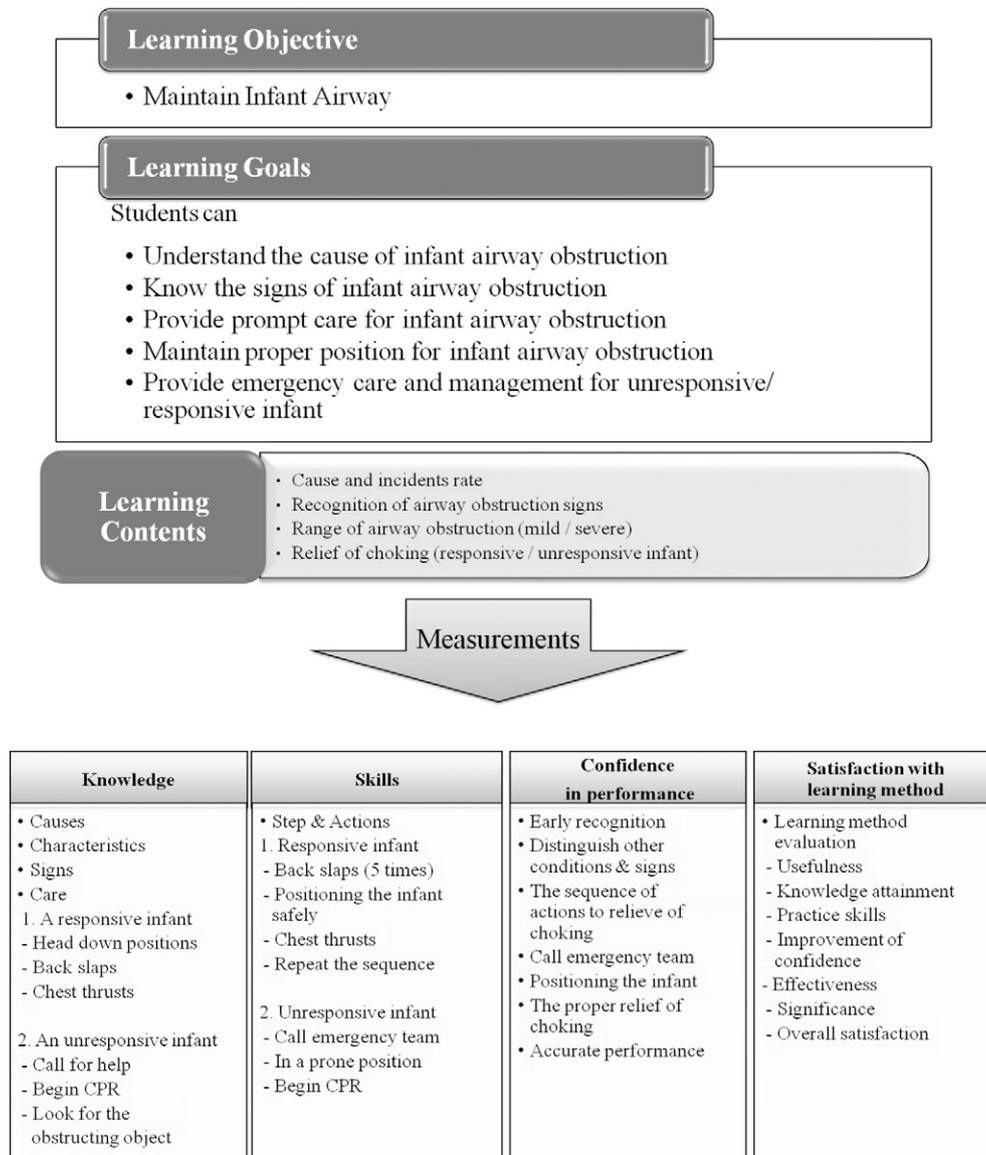


Fig. 2. Educational interventions and measurements.

score possible is 22 points. The Cronbach's alpha (ICC: Intraclass correlation coefficient) for the scale was 0.959. Each student was evaluated by two researchers (Kim and Lee) for an average of four minutes.

3.4.3. Confidence in Performance

The instrument used to assess student confidence in performance related to responding to an infant with airway obstruction was developed by study authors. This tool had 11 actions that were scored using a four-point Likert scale. This tool assesses a student's confidence in the following three areas: (1) doing back slaps and chest compressions, (2) beliefs about own skills, and (3) performance accuracy. The higher the score, the greater the level of confidence. In this study, Cronbach's alpha for the scale was 0.848.

3.4.4. Satisfaction

The instrument needed to assess student satisfaction with the learning method based on Otieno et al. (2007) satisfaction scale. After obtaining permission, the instrument was revised by study authors to be culturally appropriately and was translated from English to Korean for usage. This instrument consists of eight, four-point Likert scale items. The scale assesses or evaluates student satisfaction with the learning method, feelings related to knowledge improvement, and feelings associated with the learning method's importance. The higher the score, the greater the level of satisfaction. Cronbach's alpha was not mentioned in the original study and was 0.924 in this study.

3.4.5. Content Validity

The content validity of all the instruments was examined by six experts. The experts included four pediatric nurses in three different hospitals with at least five years of experience each, and two faculty experts from the emergency medical department of one college in Kyunggi-do, Korea. Each expert rated content validity using a 4-point Likert scale. The mean content validity score for each instrument ranged from 3.06 to 4.00. The content validity index (CVI) of the instruments was above 80%, which is considered acceptable (Waltz and Bausell, 1981).

3.5. Development of the Smartphone-based App for Infants with Airway Obstruction

The learning objectives and goals for providing emergency care for infant airway obstruction were based on the standards of the Korean Academy of Child Health Nursing (2012) and the AHA guidelines (2011). Instructional content consisted of causes, frequency, suspicious signs, and emergency care and management of infant airway obstruction (see Fig. 2). The smartphone-based app was developed to educate undergraduate nursing students. We reviewed child health nursing textbooks and several nursing journals to verify updated information about infant airway obstruction. The content of the smartphone-based app is presented in Table 1. The app was developed to be compatible with both Android phones and the Apple iOS (iPhone operating system). We used text, graphic-based materials, characters, and instructions that were appropriate reading level for undergraduate nursing students. A researcher (Kang) narrated the content of the video in Korean. The validity of the app content was confirmed and approved by the same six experts who approved content validity of the instruments. We hired a technician team to develop the app based on the approved content. The final app was uploaded to the Apple App Store and Google Play Store (see Fig. 3).

3.6. Data Collection Procedure

Data were collected from August 29, 2015 to October 15, 2015. A pre-test was administered to test each participant's knowledge and confidence about providing care for an infant with an airway obstruction. A research assistant who was not informed about the student group

Table 1
Content of smartphone-based app.

Title	Running time	Content
Overview	2 min 5 s	<ul style="list-style-type: none"> • Learning objectives and goals • Causes of infant airway obstruction • Global incidence rates • Signs of airway obstruction • Levels of choking (mild/severe)
Relief of choking in a responsive infant	2 min 32 s	<ul style="list-style-type: none"> • Back slaps • Head-down position • Supporting the head and neck • Chest thrusts
Relief of choking in a unresponsive infant	2 min 2 s	<ul style="list-style-type: none"> • Repeating the sequence • Calling emergency medical services (911) • Placing the infant in a prone position • Looking for the obstructing object • If seen removing the object • Beginning CPR
Summary	32 s	
Total	7 min 11 s	

assignment distributed the pre-test questionnaires to the participants. One week after the pre-test, intervention occurred to both group on the same day. Instructional content was the same for both groups. Researcher (Lee) provided a traditional 90 min lecture and a skills demonstration in a classroom to the control group. The researcher (Kim) instructed the students in the experimental group on how to download and use the app, set up a password to allow only the experimental group to use it. The control group only was required to attend the one-time lecture before the post-test, but the experimental group was encouraged to use the app for a month. Both before and after the intervention, each group of students participated in separate scheduled classes and practica to prevent them from sharing information. Also, researcher (Kim) asked all students to avoid sharing their experiences during the intervention.

Four weeks after the intervention, a post-test was administered to each group on topics including knowledge, skills, confidence in performance, and satisfaction with the learning method. Students' performance was video-recorded while testing the skills of addressing infant airway obstruction. Two researchers (Kim and Lee) evaluated each student's performance separately and wrote their rationales. Neither researcher was informed of the participants' group assignments. The two researchers cross-rated the other group using the video-recordings and then, three researchers (Kim, Lee, and Kang) compared differences in rationales and negotiated until there was agreement on the score for each student. We calculated the average score of the three raters. After the post-tests, the researcher corrected any errors of knowledge and skills of any student regardless of the assigned group.

3.7. Data Analysis

Data analyses were performed using SPSS version 21.0 (SPSS Inc., Chicago, IL). Descriptive and inferential statistics were used to describe demographic characteristics and scores on the measurements. One-way analyses of variance, independent samples *t*-tests, and paired samples *t*-tests were used to test for differences in scores between the experimental group and the control group. Statistical significance was set at *p* value < .05.

4. Results

4.1. Descriptive Results and Baseline Equivalence Between Groups

Of the 73 participants, 93.2% (*n* = 68) were females, 6.8% (*n* = 5) were males, and their ages ranged from 20 to 23 years old, with a

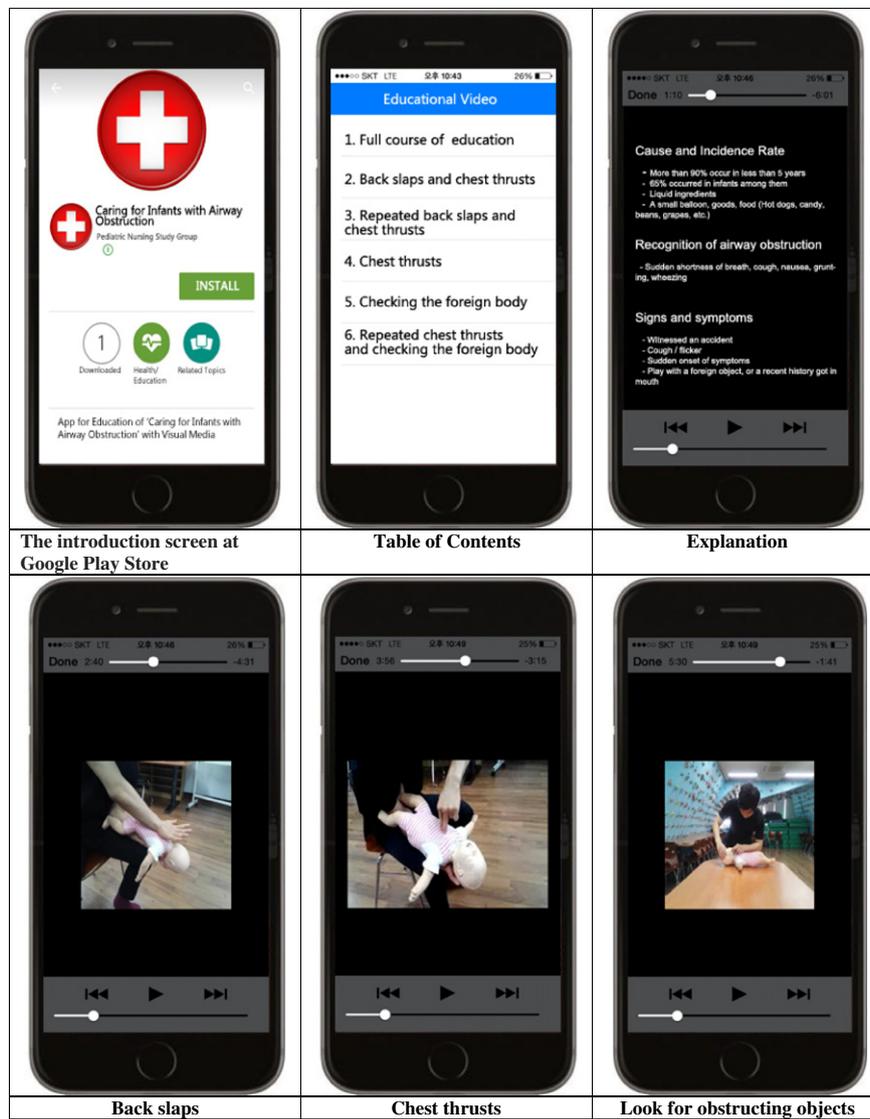


Fig. 3. Screenshot of smartphone-based app.

mean of 21.4 (± 1.10) years. The demographic characteristics of both groups are presented in Table 2. There were no statistically significant differences between the experimental and control groups in academic achievement using grade point average (GPA; $t = -0.158, p = 0.875$) and the grade for the pediatric nursing course ($t = 0.932, p = 0.355$). Also, there were no statistically significant differences between the groups on mean pre-knowledge scores ($t = -1.121, p = 0.266$) or pre-confidence in performance scores ($t = -0.824, p = 0.412$). Therefore, the groups are considered homogeneous.

4.2. Mean Differences in Dependent Variables Between Groups

The mean differences between the two groups' knowledge, skills, and confidence in performance are presented in Table 3. Before the intervention, the mean knowledge score was higher in the control group (9.10 ± 1.57) than in the experimental group (8.69 ± 1.62), but this is not statistically significant ($t = -1.121, p = 0.266$). After the intervention, the mean of knowledge improvement was higher in the experimental group than in the control group, but there was no

Table 2
Baseline equivalence of the dependent variables between the groups (N = 73).

Variables	Classification	Exp (n = 35) n (%) or M ± SD	Con (n = 38) n (%) or M ± SD	Total n (%) or M ± SD	χ^2 or t	p
Gender	Male	2 (5.7)	3 (27.9)	5 (6.8)	0.136	1.000
	Female	33 (94.3)	35 (92.1)	68 (93.2)		
GPA		3.65 ± 0.26	3.66 ± 0.39	3.65 ± 0.33	-0.158	0.875
Nursing pediatric class scores		90.29 ± 7.21	88.63 ± 7.90	89.42 ± 7.57	0.932	0.355
Knowledge		8.69 ± 1.62	9.10 ± 1.57	8.90 ± 1.60	-1.121	0.266
Confidence in performance		2.50 ± 0.36	2.57 ± 0.42	2.53 ± 0.39	-0.824	0.412

Exp = experimental group, con = control group.
GPA = grade point average.

Table 3
Mean differences between the groups' knowledge, skills, and performance confidence ($N = 73$).

Variables	Groups	Pre-test		Post-test		Difference	
		M \pm SD	t (p)	M \pm SD	t (p)	M \pm SD	t (p)
Knowledge	Exp	8.69 \pm 1.62	-1.121	11.80 \pm 1.32	-0.128	3.11 \pm 1.78	0.886
	Con	9.10 \pm 1.57	(0.266)	11.84 \pm 1.48	(0.899)	2.74 \pm 1.86	(0.379)
Confidence in performance	Exp	2.50 \pm 0.36	-0.824	2.95 \pm 0.25	2.810	0.45 \pm 0.39	2.888
	Con	2.57 \pm 0.42	(0.412)	2.74 \pm 0.36	(0.006)	0.17 \pm 0.43	(0.005)
Skills	Exp			11.97 \pm 5.07	4.774 (<0.001)		
	Con			6.71 \pm 4.34			

Exp = experimental group ($n = 35$), Con = control group ($n = 38$).

statistically significant difference between the two groups ($t = 0.886$, $p = 0.379$). However, the difference in the mean scores for skills ($t = 4.774$, $p < 0.001$) and confidence in performance ($t = 2.888$, $p = 0.005$) were statistically significant between the groups. Thus, the experimental group showed improved skills and confidence in performance compared to the control group.

4.3. Satisfaction with Learning Methods

The mean score for students' satisfaction with the learning method between the two groups is presented in Table 4. Overall, the total mean score of satisfaction was higher in the experimental group than the control group (2.95 ± 0.46), but there was no statistically significant difference between the two groups ($t = .168$, $p = 0.867$).

5. Discussion

We developed a smartphone-based app and provided smartphone-based education to the experimental group. When compared to the control group who attended a lecture, those in the experimental group showed greater improvement in their skills in managing an infant airway obstruction and in their performance confidence. We think that these results may be associated with the ability to review the instructional program repeatedly combined with knowledge and skills education and using familiar technology.

Media-based education such as video self-instruction might make learning new information more accessible to some people since learning is enhanced through repetition and since media-based methods may help learners understand complex concepts and focus better on the topic (Park, 2012). Park (2012)'s study showed that students who used video self-instruction, and were able to watch a video repeatedly learned and retained more than those who were only exposed to the information through a one time traditional lecture. Park (2012) suggested that student interest in the teaching method could encourage them to actively engage in learning, which is related to improved knowledge. Repetition using the smart-phone app may have been helpful to students' practice and could have improved students' confidence. In studies using media (e.g., DVD's, online video) and a traditional lecture, both groups showed increased knowledge, but the accuracy of skills was higher in the group that was educated through the media (Ahn and Park, 2009; Einspruch et al., 2007).

Table 4
Difference between the groups' satisfaction with the learning methods ($N = 73$).

Categories	Exp.($n = 35$) M \pm SD	Con.($n = 38$) M \pm SD	t	p
Total	2.95 \pm 0.46	2.93 \pm 0.53	0.168	0.867

Exp = experimental group, Con = control group.

"Smart learning" refers to the use of various types of media in education; a smartphone app is one such type and could encourage learners to study beyond memorization and strengthen their ability to solve problems creatively (Ministry of Education, Science & Technology, 2011). Online learning tools provide a self-directed learning environment based on individual's perceived needs or interests (Lim and Kim, 2013). In our study, smartphone-based education provided an easily accessible environment and allowed for self-review. In one study, 80% of medical students owned a smartphone and used it for educational purposes (Payne et al., 2012) and more than half of nursing students ($n = 60$) used smartphones at least two hours a day including for studying purposes (Cho et al., 2013). In the same study, Cho and colleagues provided a smartphone app that was used as a reference for making nursing plans for patients during nursing practica. The satisfaction rate of using the app was as high as 85%. As many undergraduate students are already familiar with using smartphones, using a smartphone to learn infant airway obstruction could be an effective educational method. While there are definitely advantages of using smartphones in education, disadvantages also exist, among these are the small screen and limited battery life. Also, as smartphones have various functions, including texting and the ability to connect to social media, these potential distractions could lead to problems with concentration during the learning process (Jung, 2012).

In our study, we did not provide feedback while learning, but in two studies, instructors provided advice on students' performance (Kim, 2009; Yoon and Baek, 2012). Two groups used self-directed learning by watching a video several times and only one group was provided instructor's advice on students' skills after the video education. The skills were significantly improved in both groups, but the group with an instructor's advice had significantly higher skill scores (Kim, 2009; Yoon and Baek, 2012). Thus, providing feedback could affect the accuracy of learning skills when added to educational methods. Smartphone-based education is comparable to using video learning in that it encourages self-directed learning. A different study provided feedback with a smartphone-based app called "Pocket CPR" (Park and Cho, 2015). Both group's participants watched a CPR animation through a smartphone and then practiced using a CPR mannequin. Then, only the experimental group received feedback from the "Pocket CPR" app on their performance. The "Pocket CPR" has alarms to remind users to maintain a pressure of depth during chest compressions. After the intervention, both groups improved several skills; whereas, the accuracy of chest compressions was improved only in the experimental group. Thus, smartphone education apps coupled with feedback on skills performance may be important for helping students increase both knowledge and skills performance accuracy.

Researchers used a smartphone app to teach experts such as health care providers (Pyo et al., 2012). This study examined the use of a smartphone app to teach advanced cardiac life support (ACLS) to nurses. The experimental group nurses downloaded a smartphone app and learned using the English version of the 'ACLS simulator,' whereas the control group nurses were provided with Korean educational materials about ACLS information for one hour (Pyo et al.,

2012). Although, the ACLS knowledge score was higher in the control group, satisfaction with the education method was higher in the group using smartphones. English content might not be easy to understand within a limited timeframe, for the non-native speaker, and the one time intervention might not be sufficient for learning a complex topic like ACLS. While using an interesting teaching strategy like a smartphone app can be appealing to learners, it is important that content also be accurate, complete, and clear to the users, in a language they readily understand. Also, it is important that learners have sufficient time to study and practice the content in order to master it (Pyo et al., 2012).

5.1. Implications

Nurse educators and healthcare providers have the responsibility for providing instruction in many aspects of nursing care. This study's results can help educators recognize the potential roles of smartphone apps as an effective aid to learning, which they can recommend to their students to achieve learning goals. In the near future, smartphones may play a greater role in the education of nurses. For example, smartphones can be used as an additional way to learn or as adjunct to more traditional ways of learning. More understanding about the cost effectiveness of introducing smartphones to nursing education is necessary. Smartphone based apps could be a cost-effective, student-friendly and effective way to augment nursing education and the education of other health care professionals (Robinson et al., 2013).

5.2. Limitations

There were several limitations in our study. First, we did not check how many times students in the experimental group watched the video using the app, which might have influenced the results. Second, we did not use standardized measures. Although we used measures that demonstrated good validity and reliability, these measures were developed by study authors and had not been previously tested. Thus, psychometric analysis of the developed measures or using standardized measures could increase the reliability of this study's findings. Third, the sample size was statistically sufficient to compare results between the two groups, but was relatively small. It is necessary to test this app with a bigger sample size. It remains unclear whether true associations exist between improved skills and confidence in performance when using the smartphone app. Also, the long-term retention of knowledge and skills using the app is uncertain. Thus, longitudinal design is necessary to clarify the causal effects and to know the retention effects of the app. We did not provide feedback while self-learning through the app, but future studies might need to be designed with feedback provided through an app. The app with feedback guides the students' practice, and it can help the students effectively learn infant airway obstruction care. Additional studies, which might correct the weaknesses found in this study, are recommended.

6. Conclusion

Effective care skills are positively related to patient survival rates in emergency situations. We developed an app to educate undergraduate nursing students in how to provide emergency care for an infant with an airway obstruction. The app was designed to attract students' learning interests and included content that was carefully developed. The app is currently available to anyone who wants to use it and can be downloaded from Google play or Apple App Store. It is in the Korean language, but it is possible to translate the content into other languages. The intuitive approach allows the experienced smartphone user to easily learn how to use the app. We believe that the smartphone app developed in this study may be helpful to Korean-speaking nursing students to increase their knowledge, skills, and confidence in performance in providing emergency care for infants with an airway obstruction.

Also, the app could be widely used to educate about this procedure for laypersons and caregivers of infants. In children, foreign body aspiration can occur while under the supervision of caregivers or parents. As an effective learning method, health-related smartphone apps could be used in teaching nursing students in many content areas.

Conflict of Interest

The authors report no actual or potential conflicts of interests.

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Authorship Contributions

Authorship roles are delineated below.

Conception and design: Kim, Lee, Kang & Shin.

Administrative support: Kim, Lee & Kang.

Provision of study materials or participants: Kim, Lee & Kang.

Data collection: Kim, Lee & Kang.

Intervention implementation: Kim & Lee.

Data analysis and interpretation: Kim, Lee, Shin & Bartlett.

Manuscript writing and or revision of the manuscript: Kim, Lee, Kang, Shin & Bartlett.

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