Original Article

Effectiveness of Computer-Based and Hybrid Simulation in Teaching Intramuscular Medication Administration

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Abstract

Aim: It is significant that students who prepare for the nursing profession must gain correct theoretical and practical knowledge. In this study, it was aimed to determine the effectiveness of different simulations, developed to teach nursing students the proper way to intramuscular medication administration.
Methods: This quasi-experimental research was conducted between January 2017 and June 2017. The students' state-trait anxiety levels, exam scores and psychomotor skills, and their views on the simulation methods were assessed.
Results: There were no statistically significant differences between the groups' pre-post test results (p=0.837; p>0.05). In the computer-based simulation group, students' scores for state anxiety levels were significantly lower (p=0.001; p0.01), however, their skill with intramuscular medication administration was significantly higher (p=0.001; p0.01).
Conclusion: In the study, it was concluded that the computer-based method was more effective in teaching ıntramuscular injection in the cognitive and psychomotor areas whereas the hybrid simulation method was more effective in the affective area.

Keywords: Nursing education, hybrid, computer-based, simulation, ventrogluteal.

Introduction

Nurses have a unique role and responsibility in medication administration (Jones et al., 2021). Simulations are considered as an option in order to teach professional skills and provide students realistic experiences (Jarvill et al., 2018; Lugo et al., 2021). It is estimated that 12 to 16 billion doses of medication are administered intramuscularly across the world each year (Šakić et al., 2012). Considering the complications that may arise if a nurse were to incorrectly administer medication intramuscularly, it is very significant for nursing students to acquire proper knowledge, skills, and attitude (Gulnar & Ozveren, 2016).

Generally, nurses use the dorsogluteal site in their practices (Tugrul &D enat, 014; Gulnar & Caliskan, 2014; Sari et al., 2017). However, current evidence suggests the ventrogluteal site would be a better solution for intramuscular injection (Su & Bekmezci, 2020). A manikin or partial task trainer that anatomically represents the hip is used as a teaching aid when this skill is taught. There is no common teaching tool specific to ventrogluteal site in nursing education. Moreover, there are uncertainties regarding whether teaching methods used to teach intramuscular administration of medications are sufficient (Mcnett, 2012).

It is very essential for students to be prepared for procedures and gain experience in cognitive, affective and psychomotor aspects during their nursing education in order to ensure and maintain patient safety (Aldridge & Hummel, 2019; Kemery & Morrell, 2020). Simulation, one of the interactive teaching methods that are now widely used, allows students to acquire many skills in an actual patient care setting as part of a safe learning environment (Shearer, 2016; Aldridge, 2017; Smart et al., 2020). Simulation also enables students to assess incorrect practices, reduce their

anxiety and enhance their confidence (Uys & Treadwell, 2014; Cant & Cooper, 2017).

Hence, the objective of this study was to investigate the effectiveness of using computer-based simulation (CBS) and hybrid simulation (HS) in teaching the skill of intramuscular administration of medication into the ventrogluteal site to nursing students. As a result of the study, nursing students would be able to learn the intramuscular injection skill, which is an invasive administration of medicines. This experience could enhance the confidence of nursing students and contribute to performing safe administration of medicines in a clinical setting.

Methods

Design and Participants: This study was designed as a quasi-experimental and includes pre-test and post-test control group. The research was conducted between January and June 2017 in a state university under the course 'Fundamentals of Nursing'. The research population was comprised of first-year undergraduate nursing students (N=109). The sample included the students (n=81) who were willing to participate voluntarily in the research and met the sampling criteria. The inclusion criteria were as follows: attendance of students in the compulsory course, the willingness to participate in the study, non-graduate of health vocational high school, and does not have any previous education and experience about intramuscular medication administration.

G*Power (v3.1.7) software program was used to identify the sample size and perform a power analysis. Thirty-nine students were randomly assigned to the CBS group and 40 students were randomly assigned to the HS group.

Materials: The nursing students' demographic data was collected using the *'Student Information Form*. The form included questions about students' age, gender, academic success average, knowledge on intramuscular administration of drugs, ability to use computers and simulation education.

An exam with 25 questions was generated to evaluate the students' level of knowledge of the ventrogluteal site. The highest score is 100, and the lowest score is 0. The content validity of the exam was 0.942. The reliability of the exam was 0.791, as calculated by the Kuder Richardson-20 (KR-20) formula.

The '*Intramuscular Medication Administration Checklist (Skill Checklist)*' with 25 skill steps was used to assess the ability of nursing students to intramuscularly administer medications into the ventrogluteal site. For the assessment, the options qualified (4 points), required to improve (2 points) and unqualified (0 points) were marked as the student performed each step. The highest score was 100 and the lowest score was 0. The content validity of the skill checklist was 0.988. The reliability of the form was 0.762 and was calculated using the Kuder Richardson-20 (KR-20) formula as well.

The ***'State-Trait Anxiety Inventory'*** was used to determine the anxiety levels of students. It was developed by Spielberger et al. (1970) to measure levels of anxiety in normal individuals at the age of 14 years and older, and includes two parts with a total number of forty items. The two parts are named ***'State Anxiety Inventory'*** and ***'Trait Anxiety Inventory'***. These inventories include 20 items and are rated on a 4-point Likert scale. The lowest score is 20 and the highest score is 80. Higher scores indicate a higher level of anxiety and lower scores indicate a lower level of anxiety. The validity and reliability study for the inventory was performed by Öner in 1977. In the validity and reliability study, the reliability coefficient ranged from 0.26 to 0.68 for the ***'State Anxiety Inventory'*** and 0.71 to 0.86 for the ***'Trait Anxiety Inventory'*.** In the present study, it was 0.922 and 0.887, respectively.

Finally, the ***'Post-simulation Evaluation Questionnaire for Students'*** assesses the different simulation methods achieved by integrating ventrogluteal site-specific tools. Part I of the questionnaire includes 10 statements based on a 5-point Likert scale. In Part II, the effect of the student experience in the simulation is rated between 1 and 10 points, and a comments section was provided. The reliability of the questionnaire was 0.862, as calculated by the Kuder Richardson-20 (KR-20) formula.

Ethical Considerations: The verbal and written consent was obtained from students who were willing to volunteer to participate in the study. The person who played the standardized/simulated patient role was informed about the HS method and provided their written consent. To use 'State-Trait Anxiety Inventory' as a data collection tool, the consent of investigators who performed the Turkish validity and reliability study was obtained via email; the institutional permission of the university (45334981-04-E.750) where this study

was conducted was obtained, and the research ethics committee approval was obtained to carry out the study on September 7, 2017.

Data Collection: The data were collected following steps in the 'Research Plan **(Figure 1)**'. The course subject ***'Intramuscular Medication Administration Skills'*** was delivered to all the students by the investigators in the classroom at the date and time in the student's program while taking the course '*Fundamentals of Nursing'*. After the theoretical class, the students were instructed to watch the skills video produced by the investigators in the laboratory. The skill was demonstrated on the 'Hip Manikin for Intramuscular Medication Administration' that is conventionally used in nursing education. Each student was allowed to repeat the skill.

The students who were willing to participate in the study one week after the theoretical class was asked to complete the 'Student Information Form'. The students' levels of anxiety were assessed by the 'Trait Anxiety Inventory'. Furthermore, an exam was performed as a pre-test for students.

In the study, the students were randomly assigned to two experimental groups (CBS and HS). Each student was asked to provide a written commitment that they would not exchange information regarding their method with students in the other group in order to prevent students from affecting each other in practice.

Intervention: In both simulation methods, an orientation session was held for the students on the settings and steps to be performed. A pre-briefing was provided on intramuscular medication administration skills. The students were allowed time to express themselves. The simulations were performed on separate dates to enable each student to stay in the simulation setting for a maximum of 15 minutes. The students were allowed into the simulation setting one by one to prevent their performance from being affected by other factors and to permit them to be assessed objectively. Upon completion of the simulation, the students were advised repeatedly not to communicate with each other, in line with the written commitment they had provided earlier.

In the CBS**,** the 'Computer-based Simulation Training Program' developed by the investigators was used. This is visually enhanced, 3D animated software containing interactive skills videos. The success of each student at performing the skill was rated between 0 and 100 points at the completion of the simulation. This rating was based on the skills checklist mentioned above.

In this study, the students were able to perform the skill of intramuscular medication administration into the ventrogluteal site as in an actual setting through the simulation program. A meeting was held with the students at the end of the simulation and they were asked to evaluate the method.

In the HS**,** a healthy actor played a standardized patient role. He pretended to be a patient who was in the hospital and in need of intramuscular medication administration. He was instructed to wear the 'Model for Intramuscular Medication Administration into Ventrogluteal Site' developed by the investigators. The 'Model' is made of foam and is worn like normal underwear. The adhesive tapes on the sides of the model allow adjustment of the size based on the actor, and the anatomic protrusions can be felt. The medication can be injected into the right-left ventrogluteal site, and the skill steps to be followed can be performed in cooperation with the actor. A significant feature of this model is the alarm system that alerts the student when the medication is injected into the correct site.

In the HS group, the student's injecting skill into the standardized patient was assessed by two observers, based upon the skills checklist. A meeting was held with the students at the end of the simulation and they were asked to evaluate the method.

The skill of administering medication into the ventrogluteal site was assessed for all the students as a control group on the manikin at the final step of the simulation. The same observers carried out this task in accordance with the skills checklist. The post-test of the exam was conducted one week later in order to complete the study data.

Data Analysis: To ensure the content validity of all the forms developed by the investigators for this study, all forms were submitted to eight academic experts specializing in Fundamentals of Nursing to obtain their opinions. A pilot study was carried out prior to the study (n=19). The Kuder Richardson-20 (KR-20) formula was used to ensure the internal validity and reliability of each form. The Number Cruncher Statistical System (NCSS) 2007 was used for the other statistical analyses. The Student's t-test was used for the comparison of normally distributed parameters in two groups in the comparison of quantitative data. The Mann-Whitney U test was used for the comparison of non-normally distributed

parameters in two groups. The paired samples t-test was used for the intragroup comparison of normally distributed parameters. The Pearson's Chi-squared test and Fisher-Freeman-Halton test were used for the comparison of qualitative data. The intraclass correlation coefficient (ICC) was used to measure the agreement between two observers for the purpose of calculating the skill scores. The significance level was considered as $p<0.05$.

Results

Demographic Data of Students: The mean age of first-year nursing students was 19.76±2.62 years, and 69.6% of students were female. In the demographic characteristics, there were no statistically significant differences between the CBS and HS groups ($p>0.05$).

Students' Pre-test and Post-test Scores for Exam

Table 1 shows that the students' mean pre-test and post-test scores on the skill of administering medication into the ventrogluteal site. There were no statistically significant differences between the pre-test scores of the groups ($p=0.837$; $p>0.05$). Similarly, there were no statistically significant differences between the post-test scores of groups ($p=0.056$; $p>0.05$); however, the group receiving CBS had higher scores.

State-Trait Anxiety Levels

The mean scores of students' trait anxiety levels (43.99±08.82) were moderate. In these analyses of students' mean scores for the trait anxiety levels, it was 44.13±9.38 for the CBS group and 43.85±8.36 in the HS group, and no statistically significant differences were identified between the two groups ($p>0.05$).

The nursing students' mean scores for the state anxiety were 38.46±8.34 in the CBS group and 45.43±9.19 in the HS group. The students' scores for state anxiety levels in the CBS group were significantly lower than in the HS group ($p=0.001$; $p<0.01$).

The students' state anxiety levels, before the practice on the manikin and one week after the simulation training, averaged 50.82±11.49 in the CBS group and 51.68±10.19 in the HS group. There were no statistically significant differences between the mean scores for the state anxiety levels in the two groups ($p>0.05$).

Skill Scores

The mean scores for the skill of administering medication into the ventrogluteal site were 75.62±6.82 for the CBS students. According to the first and second observer of the HS, the students' mean scores were 66.7514.41 and 70.2912.27, respectively. The skill scores were significantly higher in the CBS group ($p=0.001$; $p<0.01$) **(Table 2).** In addition, there was a statistically significant agreement between the skill scores as rated by the first observer and second observer (ICC=0.969; $p=0.001$; $p<0.01$).

During the evaluation of check practice on the manikin one week after the simulation training, the mean skill scores were 70.30±13.80 as calculated by the first observer and 68.84±13.34 as calculated by the second observer. There was a statistically significant agreement between the skill scores calculated by the first and second observers (ICC=0.891; $p=0.001$; $p<0.01$).

Students' Views on the Simulation Methods

In the analysis of findings from the evaluation questionnaire used after both simulation methods, 90% of nursing students stated that the duration education was sufficient, 86% stated that the methods used allowed them to reinforce what they had learnt. 91.1% stated that simulation contributed to their education and 87.3% stated that their confidence had improved. These findings are shown in Table 3. Additionally, the students' mean scores for evaluation of the simulation method in the CBS group were 8.05±1.88 and 8.80±1.16 in the HS group.

Table.1: The Comparison of the Intramuscular Medication Application Exam Scores (N=79)

Scores		Total	CBS (n=39)	HS (n=40)	[c]p
Pre-Test	*Min-Max (Medyan)*	40-85 (70)	40-85 (70)	50-85 (67,5)	***0,837***
	Average±SD	66,90±9,78	66,67±10,28	67,13±9,40	
Post-Test	*Min-Max (Median)*	55-90 (75)	65-90 (75)	55-90 (70)	***0,056***
	Average±SD	74,56±7,93	76,28±6,76	72,88±8,69	
[d]p		***0,001****	***0,001****	***0,001****	
Difference Pre-Test – Post-Test		-25-35 (5) 7,66±10,12	-15-35 (5) 9,62±10,35	-25-25 (5) 5,75±9,64	[a]0,197

[a]*Mann Whitney U Test* [c]*Student t Test* [d]*Paired Samples t Test* **p<0,01*

Table.2: The Comparison of Student State Anxiety Levels Before Ventrogluteal Intramuscular Medication Application (N=79)

	State Anxiety Scores		[c]p
	Min-Max (Median)	*Average±SD*	
Computer based simulation	23-59 (39)	38,46±8,34	***0,001****
Hybrid simulation	23-63 (46,5)	45,43±9,19	
Total	23-63 (43)	41,99±9,40	

[c]*Student t Test* **p<0,01*

Table.3: The Comparison of Ventrogluteal Intramuscular Medication Application Scores Given by First and Second Observer (N=79)

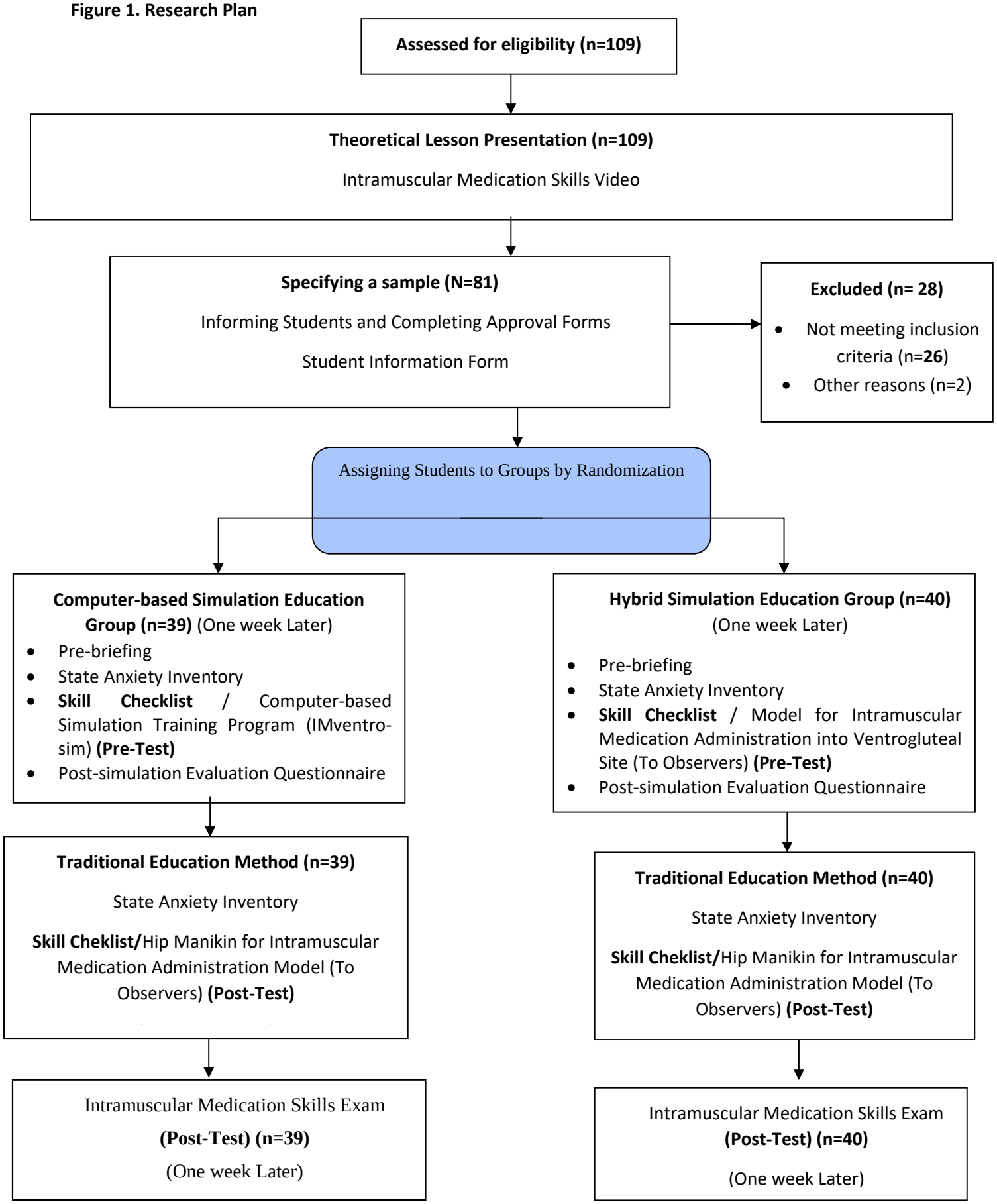
		Total	CBS (n=39)	HS (n=40)	[c]p
Researcher	*Min-Max (Median)*	32-96 (73)	53-90 (75)	32-96 (66)	***0,001****
	Ort±SS	71,13±12,10	75,62±6,82	66,75±14,41	
Observer	*Min-Max (Medyan)*	30-96 (72)	53-90 (75)	30-96 (66)	***0,001****
	Average±SD	70,29±12,27	75,62±6,82	65,10±14,14	
Difference Between Observers			-	1,65±3,56	

[c]*Student t Test* **p<0,01*

Table.4: Student Assessment of Intramuscular Medication Application Skills

Simulation Assessment		Total	CBS (n=39)	HS (n=40)
		n (%)	n (%)	n (%)
Skill steps made me easily understand.				
	Strongly Agree	52 (65,8)	28 (71,8)	24 (60,0)
I learned easily the issues that must be attended to during medication application.				
	Agree	41 (51,9)	21 (53,8)	20 (50,0)
	Strongly Agree	34 (43,0)	16 (41,0)	18 (45,0)
At this training, I felt as if I implemented to a real patient.				
	Agree	29 (36,7)	21 (53,8)	8 (20,0)
	Strongly Agree	39 (49,4)	9 (23,1)	30 (75,0)
I think I can easily recognize the focal anatomical area after this training.				
	Agree	37 (46,8)	20 (51,3)	17 (42,5)
	Strongly Agree	28 (35,4)	8 (20,5)	20 (50,0)
I have more self-confidence at taking necessary measures against complications germane to training.				
	Agree	43 (54,4)	22 (56,3)	21 (52,5)
	Strongly Agree	21 (26,6)	9 (23,1)	12 (30,0)
I believe that I can comfortably implement the skill on a patient after the training.				
	Undecided	16 (20,3)	11 (28,2)	5 (12,5)
	Agree	44 (55,6)	21 (53,8)	23 (57,5)
	Strongly Agree	18 (22,8)	6 (15,4)	12 (30,0)

Figure 1. Research Plan



The number of educational materials that can be used to acquire the skill of administering medication into the ventrogluteal site in nursing education is very limited. Hence, two different teaching tools were developed for this study. Nursing students experience anxiety during their schooling for many reasons. The study by Tel et al. (2004) reported that the mean scores for trait anxiety of nursing students were 48.40±5.39, and the study performed by Sabuncu et al. (2008) enunciated a mean score of 47.48±14.26 (medium level). Similarly to what has been found in the literature, the trait anxiety level of students was medium in this study.

In this study, the mean scores for the exam performed prior to simulation training were 66.67±10.28 in the CBS group and 67.13±9.40 in the HS group. In a study by Midilli et al. (2017), the students' mean exam scores were reported to be 84.29±11.32. The study conducted by Sagkal et al. (2014) concluded that students had a medium level of knowledge (25.74±3.99). The mean exam scores were increased in both groups after the students received simulation training. However, it is notable that the student group receiving CBS had higher mean scores **(Table 1).** A study performed by Pun et al. (2016) indicated that there were no statistical differences in knowledge and skills between the experimental and control groups; nevertheless, the experimental group had higher scores. This study has similar results in regards to the effect of CBS.

The state anxiety levels have been examined in many studies conducted with nursing students. It is observed that the state anxiety level is at different levels due to subject differences (Hutchinson&Janiszewski, 2012; Arabacı et al., 2015; İnce&Çevik, 2017; Kenny, 2018). In the study by Sabuncu et al. (2008), the mean scores for the state anxiety levels of students prior to being taught the intramuscular medication administration skill were 47.09±10.38. Correlatively, the mean scores for the state anxiety levels of students prior to training with simulation methods were 41.99±9.40 (at medium level) in the current study. In the analysis of state anxiety levels by groups, the CBS group had statistically lower mean scores for state anxiety that those of the HS group. This is usually occurs due to the presence of a actual patient in the HS method. The mean scores for the state anxiety of students prior to the assessment of skills on the control practice were 50.82±11.49 in the CBS group and 51.68±10.19 in the HS group. There were no statistically significant differences between the groups ($p>0.05$). The study conducted by Akca et al. (2015) reported that the mean scores for the state anxiety of nursing students prior to simulation were 52.3±3.7 in the experimental group and 52.0±5.3 in the control group. These results are similar to the findings of our study. The study conducted by Terzioğlu et al. (2016) found that levels of state anxiety were reduced in the hybrid simulation and clinical practices.

The study performed by Midilli et al. (2017) reported that the mean scores for the skill of administrating medication into the dorsogluteal site by nursing students were 85.11±.66. The skill scores of the students in the CBS group (a different simulation method) were significantly higher ($p=0.001$; $p<0.01$). Ross carried out a study (2015) to determine the effectiveness of the simulation method in acquiring the skill of intramuscular medication administration and reported no statistically significant differences between the skills of students trained on the HS and skill manikin ($p>0.05$). However, the students skills of trained on the HS method both in the laboratory and clinical practice were reported to be higher. In the study performed by Uys and Treadwell (2014), the mean scores for the care-oriented skills of students who acquired the intramuscular injection skill using the HS method (88%) were higher than the mean scores for the skills of students who acquired the intramuscular injection skill on the manikin (74%). Accordingly, this study compared the effectiveness of simulation methods performed by using different educational materials to the training on the skill manikin. There were no significant differences in skills between the groups ($p>0.05$). This finding may indicate that both methods are equally effective in teaching these skills.

In terms of integrity in education, along with the learning environment, supportive learning tools should also be compatible with reality (Akaike et al., 2012; Sunk et al., 2013; INACSL, 2016). In this study, 65.8% of students specified that their setting assisted them remember the skill steps of their education. It is notable that the students in the CBS group concurred on this proposition more. This can be anticipated given the features of the program used for the simulation. Of all study participants, 94.9% reported that they readily learnt what they needed through the training they received, and 86% stated that they experienced the

feeling of practicing on an actual patient. Herein, the higher percentage of students in the HS group is remarkable. It is considered that it was higher since the HS method addresses the affective area as well as cognitive and psychomotor dimensions.

One of the reasons why the ventrogluteal region is not used is that it is difficult to detect the site (Gülnar&Caliskan, 2014; Sari et al., 2017; Su&Bekmezci,2020). In this study, 82.2% of the students reported that they believed that they would handily locate the ventrogluteal site after their training; 80% stated that they were assertive they had acquired the skills needed to avoid complications during their training and 78.4% remarked that they would readily perform the skill of intramuscular medication administration on the patient after the training. In the analysis of rates between the groups, the HS group had higher participation rates. During the simulation, the students communicated with the standardized patient in order to attain their skill. They were also able to perform many steps addressing the affective skill area. Therefore, it is concluded that the HS method is more effective in the affective area of knowledge.

In the analyses of students' evaluation scores for the simulation methods, both groups had similar mean scores, and there were no statistically significant differences between the groups ($p>0.05$)**.** The students' satisfaction and scores for the simulation methods were high, as determined by evaluation meetings with students and written comments.

Limitations: The study results can solely be generalized to students with the same characteristics as those in this sample group. None of the students included in the study had experience in any of the simulation methods used, and this might affect their anxiety levels. For this purpose, pre-briefing was provided prior to simulation training. Ultimately, the differences in practicing alone versus being observed might impact students' levels of anxiety, which would be another limitation of the study.

Conclusion: In this study, which is carried out to determine the effectiveness of computer-based and hybrid simulation methods for teaching the skill of intramuscular medication administration, the students in the CBS group experienced less anxiety about learning the skill and had higher scores for psychomotor skills.

Based on the results, the simulation methods used in nursing education should be integrated with different simulation types, and the effectiveness of simulation methods should be compared in clinical practices. There is a need for developing similar innovative and technological tools for the other skills of nursing, in line with student satisfaction. It is particularly essential that nursing teachers consider the 'anxiety' factor, which has the potential to affect the learning process, in their teaching and use techniques to mitigate the anxiety. In conclusion, it is suggested that similar, randomized, controlled and experimental studies be performed with practicing nurses as well.

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