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The effect of high- and low-fidelity simulators in learning heart and lung sounds by undergraduate nurses: a randomized controlled trial[†]

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Aim: To determine the effects of high- and low-fidelity simulators on student nurses' learning of heart and lung sounds.
Background: Simulation is an important part of nursing education because it helps to improve patient care and provides patient security.
Method: The sample consisted of 3rd and 4th year students who studied at a nursing faculty in Istanbul between April and June 2017. In this randomized controlled experimental study, students were randomly divided into 2 groups, the high-fidelity simulator group (HFS group, $n = 36$), and the low-fidelity simulator group (LFS group, $n = 35$).
Results: The auscultation skill levels of the HFS group were significantly higher post-training in comparison to the pre-training measurement ($P < .05$). There were no significant differences in the auscultation skill levels of the LFS group between the pretest and posttest measurements.
Conclusion: The use of high-fidelity simulators is more effective in the learning of heart and lung sounds by student nurses than low-fidelity simulators.

Keywords: heart sounds; lung sounds; student nurses; patient simulation

Background and introduction

Simulation is a method that has been frequently used in the education of students in the last few years (Alinier, Hunt, Gordon, & Harwood, 2006; Fanning & Gaba, 2007). Simulation interventions help students learn more effectively, and gain permanent knowledge and skills (Baxter, Akhtar-Danesh, Valaitis, Stanyon, & Sproul, 2009; Dreifuerst, 2012; Kelly, Berragan, Husebø, & Orr, 2016; Scherer, Foltz-Ramos, Fabry, & Chao, 2016). Therefore, nursing education has shifted from classrooms to laboratories where simulators are used (Nehring & Lashley, 2009; Rees, 2000). Current undergraduate education should prepare undergraduate student nurses for clinical practice and increase their professional skills using different methods (e.g. role-play, simulators) (Hayes, Power, Davidson, Daly, & Jackson, 2018). Students have less opportunity to practice in clinics because of the high number of students in nursing schools. Therefore, students perform many occupational practices on simulators in the laboratory (Mitchell, Henderson, Groves, Dalton, & Nulty, 2009; Nulty, Mitchell, Jeffrey, Henderson, & Groves, 2011). Moreover, the World Health Organization (WHO) (2009) and the National League for Nursing (NLN)

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(2005) recommend the use of simulators to support the learning and skill acquirement of student nurses (NLN, 2005; WHO, 2009). With the use of simulators in medical education, clinical practices are simulated in a way that is close to reality (Nehring & Lashley, 2009).

The more advanced the 'fidelity' features of simulation models are, the easier it becomes for students to learn (Alinier et al., 2006; Scherer et al., 2016). It is stated in the literature that nurses have difficulty in hearing patients' heart and lung sounds. For this reason, student nurses need to learn normal/abnormal heart and lung sounds safely and effectively with simulators before becoming professional nurses. Using simulators in practice can reduce risks to patients (Baykan, Baykan, & Naçar, 2012; Butter, McGaghie, Cohen, Kaye, & Wayne, 2010; Chen, Grierson, & Norman, 2015). Thus, student nurses may be more effective in the clinic with greater knowledge and skills (Linder & Pulsipher, 2008). In nursing education, different types simulators such as high-fidelity (interactive patient simulators), and low-fidelity simulators (computer and video) may be used (Şendir, 2013).

There is little scientific evidence proving that such simulators are better than more traditional techniques in the education of student nurses (Alinier et al., 2006). The aim of the present study was to determine the effects of high- and low-fidelity simulators on 3rd and 4th year student nurses' learning of heart and lung sounds.

Methods

Study participants

The inclusion criteria for the sampling groups were students being voluntary to participate in the study, having no visual and auditory problems that could affect the study, and having not received training about heart and lung sounds except in undergraduate lectures.

Study design

The population of the study consisted of 3rd and 4th year student nurses who studied at a Nursing Faculty in Istanbul between April and June 2017. In accordance with similar study samples, we calculated a sample size of a minimum of 34 students in each group with a power analysis (G*Power 3.1.9.2) (Alinier et al., 2006). Considering the possibility of participant dropout, 40 students were included in each group (HFS and LFS) who met the inclusion criteria for the study. To determine the groups of students, randomization was performed using a computer program on the total sample size ($N = 80$) (http://www.randomizer.org). Four students in the HFS group and five students in the LFS group were excluded because they did not want to participate in the study during the data collection period. Thus, the final numbers of students were 36 students in the HFS group and 35 students in the LFS group (Figure 1).

Ethical considerations

Before starting the study, ethical approval was obtained from Istanbul University Dentistry Faculty Clinical Research Ethics Committee (IRB No: 113781), and institutional approval was obtained from Istanbul University Florence Nightingale Nursing Faculty. The students were informed about the purpose, plan, and duration of the study, and their verbal and written consents were obtained.

Study instruments

Information Form: All students' age, sex, and academic years were recorded and whether they had received education about heart/lung sounds before on the information form.

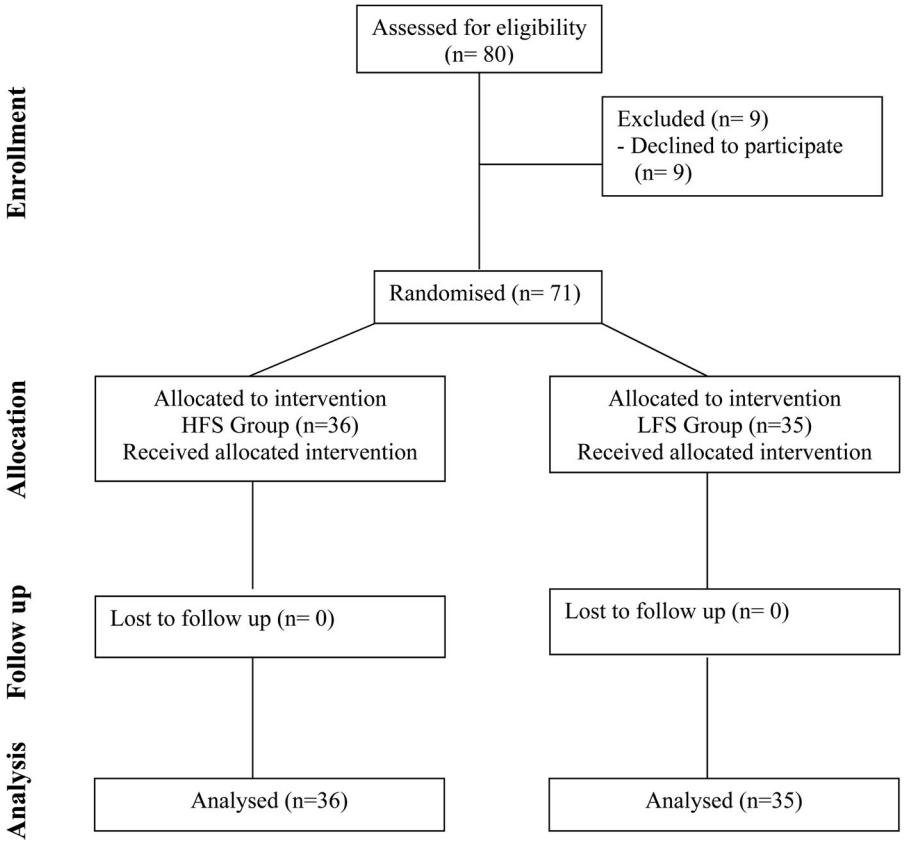


Figure 1. CONSORT diagram of this study.

Auscultation Skills Form: This form was used to mark recognition of four heart sounds (S1, S2, S3, S4) and four lung sounds (crackles, wheezing, stridor, rhonchi) by the students after listening to the sounds.

PowerPoint Presentation: The presentation, which was prepared by the researchers, was 17 pages long. The presentation was given to both groups by the same researcher, who has a PhD. Furthermore, the presenter has clinical experience and academic education about physical diagnostics. The four heart and four lung sounds selected for the research are important sounds that are frequently used for physical diagnosis in the clinic. The details of the sounds were explained by the researcher, giving the names of the sounds, aspects to focus on, and whether the sound was normal or abnormal.

High-fidelity Simulator [Nasco Smartscope Simulator (NSS)]: The students in the HFS group listened to the heart and lung sounds on the NSS in the laboratory. On the front of the NSS there are six normal/abnormal heart sounds and five normal/abnormal lung sounds, and on the back of the NSS there are fourteen normal/abnormal lung sounds. The NSS can be arranged by the researcher for sounds. The students and the researcher can listen to the eight sounds (S1, S2, S3, S4, crackles, wheezing, stridor, rhonchi) simultaneously via the double-headset set up of the stethoscope.

Low-fidelity Simulator (computer-based): The students in the LFS group listened to the same four heart and four lung sounds via a computer, which was synched with the NSS in the laboratory. Due to the inadequate number of headphones, the eight sounds were played through loudspeakers.

Data collection

Before the intervention, all students' ages, sexes, and academic years were recorded on the information form.

LFS group interventions

Before the LFS group training, students listened to all the heart and lung sounds via a computer that was synched with the NSS. The students wrote down what they thought sounds were on the auscultation skills form. Then, the sounds training was given to the students by the researcher via a PowerPoint presentation. Each sound was played from the computer for one minute for the students to recognize again to strengthen the training after the presentation. The training was completed in approximately 45 min for the LFS group.

Three weeks after the training, the students listened to all the heart and lung sounds via a computer for one minute again. The students wrote down what they thought the sounds were on a different auscultation skills form. The order in which the sounds were played was different than in the previous training. This post-training intervention for the LFS group was completed in approximately 15 min.

HFS group interventions

Before the HFS group training, the students listened to all the heart and lung sounds from an NSS via the double-headset of the stethoscope under the supervision of the researcher for one minute. After listening, the students wrote down what they thought the sounds were on the auscultation skills form. Then, sounds training was given to the students by the researcher via the same PowerPoint presentation. After the training, each sound was replayed from the NSS for a minute. Each sound was played from the NSS for one minute such that the students would recognize it again to strengthen the training after the presentation. The training was completed in approximately 6 h for the HFS group.

Three weeks after the training, the students listened to the sounds again from the NSS via the double-headset of the stethoscope for one minute. The students wrote down what they thought the sounds were on a different auscultation skills form. The order of the sounds was different to that in the previous training. This post-training intervention for the HFS group was completed in approximately 2.5 h.

Data analysis

For statistical analysis, the IBM SPSS Statistics for Windows Version 21.0 (IBM Corp., Armonk, NY, USA) software was used. To assess the data, descriptive statistics (frequency, percentage, mean and standard deviation) were used. The independent-samples *t*-test and the Yates's adjusted Chi-squared test were used to evaluate the normality of distribution of the descriptive characteristics. The Wilcoxon signed-rank test was used to evaluate the difference between the pretest and posttest mean scores of each group, and the Mann–Whitney U test was used to compare the pretest and posttest mean scores between the groups. The normality of distribution of numerical variables was evaluated using Skewness and Kurtosis values and the Kolmogorov–Smirnov test. Significance was evaluated at the level of $P < .05$.

Results

It was determined that most students in both groups were female (HFS: 91.7%, LFS: 77.1%) and in their third year of study (HFS: 63.9, LFS: 77.1). The mean age in the HFS group was

21.53 ± 0.70 years, and that in the LFS group was 21.74 ± 1.12 years. There was no statistically significant difference between the HFS and LFS groups in terms of their descriptive characteristics ($P > .05$) (Table 1).

When the HFS and LFS groups were compared before the training, there was no statistically significant difference between the mean heart sounds knowledge scores (HFS: 38.89 ± 26.35, LFS: 42.14 ± 31.95), mean lung sounds knowledge scores (HFS: 45.83 ± 38.03, LFS: 43.57 ± 28.66) or mean total sounds knowledge scores (HFS: 42.36 ± 21.19, LFS: 42.86 ± 22.34) ($P > .05$) (Table 2).

When the HFS and LFS groups were compared after the training, the mean heart (56.25 ± 36.04) and mean lung (67.36 ± 33.71) sounds knowledge scores in the HFS group were higher in comparison with the LFS group (42.86 ± 38.62 and 52.14 ± 34.50, respectively), but there was no statistically significant difference ($P > .05$). However, the mean total sounds knowledge score in the HFS group (61.81 ± 23.89) was significantly higher in comparison with the LFS group (47.50 ± 22.65) ($P < .001$) (Table 2).

The HFS group's pre-training mean heart sounds knowledge score was 38.89 ± 26.35, and its post-training mean score increased to 56.25 ± 36.04, and the difference was statistically significant ($P < .05$) (Table 2). Although the LFS group's pre-training mean heart sounds knowledge score was 42.14 ± 31.95 and its post-training mean score increased to 42.86 ± 38.62, the difference was not statistically significant ($P > .05$) (Table 2).

The HFS group's pre-training mean lung sounds knowledge score was 45.83 ± 38.03, and its post-training mean score increased to 67.36 ± 33.71; the difference was statistically significant ($P < .01$) (Table 2). For the LFS group, it was found that the pre-training mean heart sounds knowledge score was 43.57 ± 28.66, and the post-training mean score increased to 52.14 ± 34.50, but the difference was not statistically significant ($P > .05$) (Table 2).

The pre-training mean total knowledge score in the HFS group was 42.36 ± 21.19, and the post-training mean total knowledge score increased to 61.81 ± 23.89, which was statistically significant ($P < .001$) (Table 2). For the LFS group, it was found that the pre-training mean total knowledge score was 42.86 ± 22.34, and the post-training score increased to 47.50 ± 22.65; however, the difference was not statistically significant ($P > .05$) (Table 2).

Table 1. Comparison of descriptive characteristics of groups ($N = 71$).

	HFS Group (n: 36)		LFS Group (n: 35)			
	S	%	S	%	χ^2	*p*
Gender						
Female	33	91.7	27	77.1	1.857[y] (df: 1)	.173
Male	3	8.3	8	22.9		
Undergraduate class						
3rd year	23	63.9	27	77.1	.928[y] (df: 1)	.335
4th year	13	36.1	8	22.9		
	$\bar{x} \pm$ **SS**		$\bar{x} \pm$ **SS**		T	*p*
Mean age	21.53 ± 0.70		21.74 ± 1.12		.968	.337

t: Independent-samples *t*-test, df: 69; χ^2: Pearson chi-squared analysis; y: Yates-adjusted chi-squared analysis.

Table 2. Comparison of pre-training and post-training total knowledge scores of students in the HFS and LFS groups ($N = 71$).

Knowledge subject	Groups	Pre-training $\bar{x} \pm SD$	Post-Training $\bar{x} \pm SD$	Z	*P*
Heart sounds	HFS group	38.89 ± 26.35	*56.25 ± 36.04*	2.183	.029
	LFS group	42.14 ± 31.95	*42.86 ± 38.62*	.187	.852
	Test	*U:620.0 p: .903*	*U: 496.5 p: .113*		
Lung sounds	HFS group	45.83 ± 38.03	*67.36 ± 33.71*	2.712	.007
	LFS group	43.57 ± 28.66	*52.14 ± 34.50*	1.355	.176
	Test	*U:622.5 p: .929*	*U: 470.5 p: .054*		
Total knowledge score	HFS group	42.36 ± 21.19	*61.81 ± 23.89*	4.527	<0.001
	LFS group	42.86 ± 22.34	*47.50 ± 22.65*	1.203	.229
	Test	*U: 619.0 p: .898*	*U:413.0 p: .011*		

U: Mann Whitney U test; Z: Wilcoxon Signed-Rank test.

Discussion

It is important for nurses to correctly identify and evaluate normal and abnormal parameters related to heart and lung sounds for planning patient care accordingly (Humbrecht & Van, 1982). Different teaching methods are used in order to provide students with professional skills. However, the teaching methods appropriate to the desired skill should be preferred (Hayes et al., 2018). During university education, different types of simulators, which are training materials, may be used to improve student nurses clinical skills. We preferred high and low fidelity simulators in our study because we focused on teaching heart and lung sounds more easily (Jeffries, 2005; Şendir & Doğan, 2015).

In the literature, there are experimental studies to determine the effect of different types of simulators used in the training of medical students and student nurses (Alinier et al., 2006; Baykan et al., 2012; Butter et al., 2010; Franklin & Lee, 2014; Gürol, Akpınar, & Apay, 2016). In a meta-analysis study, the results of procedures in a pretest-posttest design revealed that the use of simulators in education was effective in increasing the competence levels of nurses (Franklin & Lee, 2014). In our study, there was a statistically significant difference between the HFS and LFS groups in terms of their total knowledge scores, and the mean total knowledge score of the HFS group was higher in the post-training measurements, which was consistent with the results reported by other studies (Table 2). Alinier et al. (2006) performed routine clinical training with one group of nurses, while another group also received simulation training, and it was found that the total knowledge scores with intermediate-fidelity simulation training increased more. In the study by Baykan et al. (2012), one group of medical students had theory lessons on heart sounds and another group had both theory lessons and simulation training; it was determined that the students who practiced on the simulator described the heart sounds better. Butter et al. (2010) found that the cardiac auscultation skills of 3rd year medical students who were given simulation training were significantly better than those of 4th year students who received theoretical training only. Gürol et al. (2016) examined the effect of simulation on parenteral medications and arterial blood pressure measurements and found that the parenteral medication skills were better in the experimental group compared with those in the control group. The use of advanced simulator technology also has great potential in continuing professional education in student nurses. In our study, the students from both groups may have gained some clinical skills with the simulation training in addition to their normal undergraduate program.

Different types of simulators such as low- or high-fidelity simulators may be used in the education of nursing students to enable them to learn clinical skills (Jeffries, 2005). Using high-

fidelity simulators is more effective in nursing education, and depending on clinical skills, has advantages over other types of simulators (Cant & Cooper, 2010). De Giovanni, Roberts, and Norman (2009) played heart sounds from a high-fidelity heart sound simulator to one group and from a CD to the other group, and no statistically significant difference was found between the two groups in terms of identifying the sounds. Chen et al. (2015) found no statistically significant difference in auscultation skills regarding heart and lung sounds among the low- and high-fidelity simulation groups and reported that the low-fidelity simulation group performed better in recognizing the sounds (Chen et al., 2015). In our study, there was no statistically significant difference between the mean post-training knowledge scores of the HFS and LFS groups. This was similar to the results of previous studies (Chen et al., 2015; De Giovanni et al., 2009) with post-training group comparisons. However, when the groups were compared within themselves in terms of their pretest- posttest scores, it was seen that, the mean knowledge scores of both heart and lung sounds in the HFS group were higher after training in comparison with pre-training. This result is consistent with the results of previous studies (Alinier et al., 2006; Baykan et al., 2012; Franklin & Lee, 2014; Gürol et al., 2016) that evaluated the efficacy of simulation and compared pretest-posttest scores.

Study limitations

In present study, we measured the ability of student nurses to auscultate heart and lung sounds while performing physical diagnostics on the simulator in the laboratory, but we did not assess their skills in patients or in the clinic. The study was conducted only on nursing faculty students. The study could have compared nursing students from different universities and even with medical students. The large number of participants is a strength of the study.

Impact statement

High-fidelity simulation is a relatively new field in nursing education that uses high technology simulation monitors and computers. Continued study of outcomes from the use of high-fidelity simulators as a strategy in nurses for safe hearing of cardiac and pulmonary sounds may further confirm the transfer of learning and proficiency from simulation experiences to the clinical environment.

Conclusion

Nursing students have difficulty in hearing cardiac and pulmonary sounds in the clinic. Therefore, they need to learn heart and lung sounds effectively and correctly before being stationed in clinics. The use of high fidelity simulators was found to be more effective in teaching heart and lung sounds to student nurses. Students' ability to listen to sounds effectively will reduce the risk of mistakes when they start working in the clinic. The findings from this study suggest that using high-fidelity simulators for teaching these skills in training should be recommended.

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