Original Article

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Physiotherapy Section

Impact of Simulation-based Learning on the Performance of Cardiorespiratory Skills in Undergraduate Physiotherapy Students: A Stratified Randomised Controlled Trial

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ABSTRACT

Introduction: Simulation-based Learning (SBL) is widely recognised for bridging the gap between theoretical knowledge and clinical practice in health professional education. However, its systematic application in Indian physiotherapy education is limited, and its impact on developing essential cardiorespiratory clinical skills remains understudied.

Aim: To assess the effect of SBL in improving cardiorespiratory skills among Indian Physiotherapy students compared with traditional bedside training.

Materials and Methods: The present single-blinded, Stratified Randomised Controlled Trial (SRCT) was conducted at D.Y. Patil Deemed to be University, Navi Mumbai, Maharashtra, India from September 2022 to December 2022. Ninety IVth year Bachelor of Physiotherapy (BPT) students participated in a two-day theory session and were then allocated to two groups (n=45 per group). Over three weeks, the control group underwent only traditional bedside teaching, whereas the experimental group completed a 27-hour SBL module in addition to traditional bedside training. Both groups were assessed at baseline and after three weeks of basic cardiorespiratory skills training such as subjective evaluation, Blood Pressure (BP) measurement, auscultation, teaching breathing exercises, nebulisation techniques, and transfers using an adapted, validated checklist. Baseline and post-training scores were compared using Wilcoxon signed rank test and Mann-Whitney's U test with significance set at $p<0.05$.

Results: Both groups were demographically comparable, with similar mean age (21.04 years) and a female predominance consistent with Indian physiotherapy cohort. Within-group analysis indicated that experimental group (SBL+ traditional training) showed significant improvement in all skills ($p<0.05$), with large effect sizes (r=0.80-0.90). Control group (traditional training) also showed significant improvement in all skills ($p<0.05$) except in subjective evaluation and transfers. Between-group post-intervention comparison revealed significantly higher post-intervention scores in experimental group as compared to control group ($p<0.05$); however, teaching breathing exercises and huffing, although statistically significant, demonstrated a smaller effect size (r=0.29).

Conclusion: Participants receiving SBL with traditional training showed greater improvement across most cardiorespiratory skills compared to those trained solely through traditional bedside teaching. The smaller effect size for teaching breathing exercises and huffing suggests that efficacy of SBL's effectiveness may vary by skill type.

Keywords: Clinical competence, Education, Physical therapists, Simulation training

INTRODUCTION

India's healthcare system is a diverse and complex network of private and public-sector educational institutions and hospitals [1]. Rapid growth in science and technology has transformed healthcare delivery, demanding an evolution of education to meet the modern clinical demands. The traditional pedagogical approach relies on the apprenticeship model of practical training, which has numerous limitations. One issue is limited patient availability, making it difficult for students to gain experience. Chandra A highlights the ethical concerns further complicating this model, especially when students are required to perform assessments and treatment procedures [2], including potential lack of informed consent, patient discomfort, and the risk to patient safety. These challenges are intensified by the increasing number of students entering healthcare professions, particularly in urban institutions with poor student-patient ratio, making individualised teaching a challenge.

The SBL offers a promising solution to bridge the gap for traditional methods in terms of practical, educational, and ethical concerns. SBL facilitates clinical reasoning, self-efficacy, problem-solving and clinical competency among nursing students, allowing learners to practice skills in a secure, controlled environment, without compromising patient safety [3,4]. A systematic review found that SBL seems to offer a valuable opportunity to improve team functioning among healthcare professionals [5]. Few studies emphasise that SBL helps at different stages of students' training in their placements (patient learnings); prior to placement to equip students for the clinical setting, during placement to facilitate the intentional and repetitive practice of specific patient scenarios they have encountered or will experience, and post-placement to exhibit knowledge acquisition among colleagues [6-8]. SBL may serve as a remedial tool for underperforming students. Another study found that SBL improves critical thinking and skills for Physiotherapy and nursing students in acute illness management [9,10].

Cardiorespiratory Physiotherapy requires a high level of clinical expertise and decision-making. Integrating SBL into cardiorespiratory physiotherapy training can provide realistic hands-on experiences, bridging theory and practice. Korpi H et al., proposed that students' proficiency evolves in real work situations [11]. Studies have suggested that using any modality of simulation for practicing skills would help students develop their core cardiorespiratory treatment skills [12,13]. It also implies that generic communication skills may be transferable across areas [12].

Despite SBL's potential, research analysing its efficacy in addressing challenges compared to clinical bedside training in India is limited

[14-16]. SBL yet remains understudied in India, especially in Physiotherapy education. Therefore, the study hypothesised that integrating SBL with traditional bedside teaching will produce greater gains in cardiorespiratory clinical skills than bedside training alone. Evaluating this integration could provide evidence for SBL as a viable enhancement for clinical skills in the current educational setting.

MATERIALS AND METHODS

The present single-blinded stratified randomised controlled experimental study, with participants stratified by academic performance prior to randomisation. The study was conducted at D.Y. University, Nerul, Navi Mumbai, Maharashtra, India , from September 2022 -December 2022. The study received ethical approval from the Institutional Ethics Committee (IEC) for Biomedical and Health Research, D.Y. Patil School of Medicine, Navi-Mumbai (IEC Ref. No: DYP/IECBH/2020/074).

Inclusion and Exclusion criteria: The study invited all 92 fourth-year BPT (final-year) students to participate in the study. The inclusion criteria were: i) students currently studying in the IVth year of the BPT program; and ii) those who provided written informed consent. Exclusion criteria were: i) those who had physical or mental health conditions limiting their ability to participate at the time of procedure; ii) those who had subject arrears from previous academic years; and iii) those who failed to complete any of the assessments.

Sample size calculation: Sample size was estimated using strata 15.1 based on α=0.01, power=0.90.These parameters were informed by previous research by Wright A et al. evaluating SBL in healthcare education [17]. This yielded a sample size of 41 per group. The total number was inflated by 10%, resulting in a final target of 90 participants (45 per group), to account for potential dropouts or missing data.

A one-hour orientation session was held in the first term of the final year BPT to introduce students to the study. They were informed that their participation would be entirely voluntary and assured that they could quit the study at any time without impacting their academic standing or assessments for the course. Written informed consent was obtained.

Stratified randomisation was used to assign participants to the experimental and control groups within the academic curriculum setting. Participants were first stratified by their academic performance in the preceding year, i.e., 3rd-year BPT (>75%, 60%-75%, <60%). Within each academic stratum students were then randomly allocated to Group A (experimental group) and Group B (control group) using the lottery method. The two-step approach ensured balanced academic performance across groups while accommodating curricular logistics and minimising confounding factors.

Study Procedure

The three-week intervention period included traditional clinical placement for both groups. Additionally, Group A (experimental group) attended SBL sessions.

Preparatory theory sessions: Students in both groups participated in a two-day theory session, with four hours of instruction each day. These sessions reinforced core concepts in cardiorespiratory physiotherapy (e.g., respiratory assessment, oxygen therapy, airway clearance techniques, chest physiotherapy, etc.,) to consolidate knowledge prior to their clinical exposure. The students then commenced their clinical placements. All the students were then placed in cardiorespiratory wards for a period of three weeks. The students evaluated and treated patients under supervision, encountering patient case scenarios as they presented in the ward. The week-by-week description is as follows:

1st week: Clinical placement and baseline evaluation (both groups): Students from both groups developed and applied skills in real-time settings with support and guidance from the clinical teacher in the ward. They engaged in supervised cardiorespiratory assessments (observing breathing patterns, evaluation of chest expansion, auscultation, monitoring of oxygen saturation, and assessment of functional mobility) and treatment planning and execution (active cycle of breathing technique, breathing exercises, postural drainage, manual techniques, suctioning, postsurgical rehabilitation). Case discussions and presentations supported theory-practice integration and encouraged greater autonomy in patient care.

After a 2-3-day cooling-off period, baseline assessment of basic cardiorespiratory skills was conducted using an adapted clinical procedural checklist by two blinded evaluators (each focusing on different skill sets). The authors obtained permission from the publishers of Judith Wilkinson's Procedural Checklists for Fundamentals of Nursing [18], to adapt to meet the requirements of cardiorespiratory physiotherapy training. The adapted skill, along with author-developed items was combined into a modified checklist. Six skills were included, with varying performance items (subjective evaluation=13 items, blood pressure measurement=17, auscultation=20, breathing exercises=11, nebulisation=11, and patient transfer=13). Each item was scored on a 3-point scoring system (0=doesn't perform, 1=performs with errors, 2=performs correctly). Maximum possible scores were 26, 34, 40, 22, 22, and 26, for subjective evaluation, blood pressure measurement, auscultation, breathing exercises, nebulisation, and patient transfer respectively, with minimum score of 0 for all the skills. The checklist was then subjected to face validation by three field experts. No other psychometric testing was done for the adapted tool as the instrument was solely used for within cohort pre-post comparison rather than for diagnostic or predictive purposes. Students were aware of being assessed for their skills, but were unaware of the specific skills being scored, to ensure authentic performances rather than rehearsed behaviour.

2nd week: Group specific interventions

a. Group A (Experimental group): Participated in 27 hours of experiential learning through the prevalidated SBL module over three days, alongside traditional bedside teaching during the remainder of the week.

Simulation module (for Group A only): The authors developed a simulation module that underwent face validation by an expert panel comprising a consultant physician, two experienced physiotherapy faculties, and a healthcare simulation specialist, offering broad clinical, educational and simulation expertise. It was then piloted and qualitatively refined through participant interviews to enhance objectives clarity, scenario flow and feasibility before use in the current study. As the validation process focused on expert review and qualitative refinement, no formal statistical reliability testing was performed. The module was structured as per the International Nursing Association for Clinical Simulation and Learning (INACSL) Standards of Best Practice [19] and comprised four key phases: pre-briefing, briefing, simulation, and debriefing.

i) Pre-briefing phase: introduction to session objectives, roles, and duties, simulation environment and equipment; ii) Briefing phase: orientation to- manikins, task trainers, monitoring equipment and simulation set-up through interactive group tasks; iii) Simulation phase (elaborated below): students participated in 4-5 cardiorespiratory Physiotherapy scenarios per day, each performed by a small group of 4-5 students, focusing on assessment and treatment skills [Table/Fig-1]. Their peers observed, and performance was analysed through live video; iv) Debriefing phase: Reflection on scenario using video recordings, identification of challenges, and faculty feedback.

Simulation phase: (3 days for a total of 27 hours (9 hours each day) with each day focusing on specific skill sets and real-life patient scenarios (adult as well as paediatric). Daily activities were structured as follows:

[Table/Fig-1]: Simulation scenario.

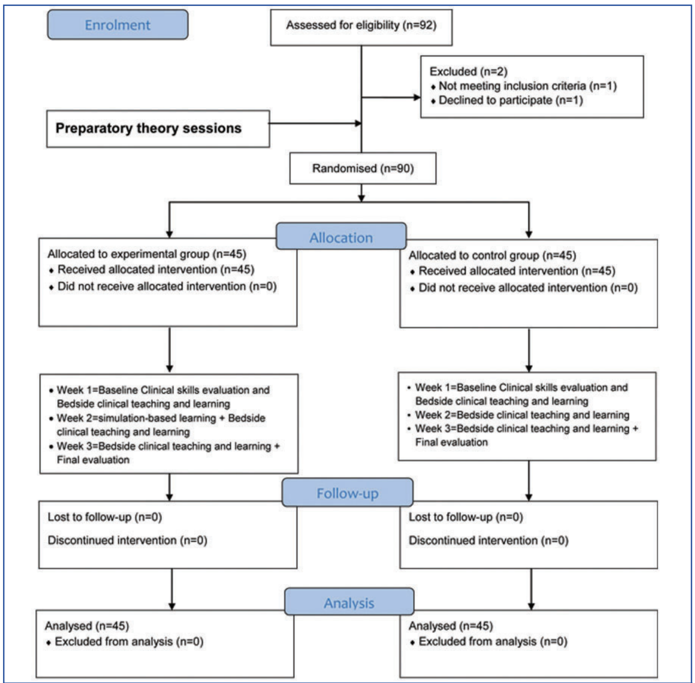
Day 1: Four assessment-based scenarios requiring subjective evaluation, BP measurement, auscultation skills, chest expansions, analysing investigation, etc.,

Day 2: Six cardiorespiratory intervention-based scenarios requiring teaching breathing exercises, positioning and nebulisation, and suctioning.

Day 3: Scenarios related to transfers and mobilisation techniques in cardiorespiratory inpatients, concluding with two integrated sessions combining all learnt skills.

b. Group B received traditional bedside teaching covering the same set of skills as the experimental group, delivered by the same investigator to maintain consistency in content and instruction.

3rd week: Consolidation and post-intervention assessment (Both groups): Students from both groups continued with their clinical bedside learning to consolidate the learning. To measure skill acquisition, post-intervention evaluation was conducted by the same blinded evaluators using the same checklist as at baseline. [Table/Fig-2] shows the CONSORT flow chart.



[Table/Fig-2]: CONSORT flow chart.

STATISTICAL ANALYSIS

Data were compiled using Microsoft Excel and analysed using Statistical Package for the Social Sciences software version 22.0 (SPSS Inc., Chicago, IL). Nonparametric tests were used due to the ordinal characteristics of the data and the existence of non-normal distributions. Results were presented as median and Interquartile Range (IQR) values. Within-group (pre vs post) differences were tested using the Wilcoxon signed-rank test, and between-group (Group A vs B) differences using the Mann-Whitney U test. Effect sizes were calculated as $r=Z/\sqrt{N}$, where Z is the test statistic and N the overall sample size. All tests were two-tailed, with level of significance set at $p<0.05$.

RESULTS

The study evaluated the impact of SBL on the clinical cardiorespiratory skills of the IVth year BPT students. The demographic data of the 90 participants of Group A and Group B are provided in [Table/Fig-3]. The gender distribution reflected the pattern of BPT students in Indian institutions, with more female students than males.

Characteristic	Group A	Group B
Gender, n (%)		
Female	42 (93.33)	38 (84.44)
Male	3 (6.67)	7 (15.56)
Age, Mean (SD) (Years)	21.04 (0.20)	21.04 (0.20)

[Table/Fig-3]: Participants' demographic information.

As seen in [Table/Fig-4], at baseline, the scores for all the clinical skills were comparable between groups ($p>0.05$). Group A (SBL+traditional training) demonstrated statistically significant improvement in all the tested skills post intervention ($p<0.05$)- accompanied by a large effect size, ranging from r=0.8-0.9, denoting a strong impact of the intervention. Group B (traditional training only) showed a similar statistical improvement in all the skills post-intervention except in subjective evaluation and transfers, though with variable and much smaller effect sizes (ranging between 0.3 and 0.5).

As shown in [Table/Fig-5] the post-test median scores for all measured parameters were statistically higher in Group A than Group B. Group A achieved significant improvement in all skill metrics, with large effect sizes, indicating the intervention's efficacy. Although post-intervention scores of teaching breathing exercises and Huffing were statistically significant, the effect size was found to be small (r=0.29).

DISCUSSION

This study investigated the impact of integrating SBL into traditional bedside teaching on cardiorespiratory skills among undergraduate physiotherapy students. The gender distribution of the participants mirrored demographic profile of physiotherapy education in Indian, with predominance of female students [20]. The pre-intervention scores of the skills demonstrated no statistically significant differences between experimental and control groups ($p>0.05$), indicating comparable baseline competencies prior to the intervention. Findings demonstrated that integrated of SBL with traditional bedside teaching resulted in significantly enhanced scores across all the skills ($p<0.05$; r=0.80-0.90). Whereas the control group showed improvement in most skills, no statistically significant gain were observed in subjective evaluation and transfers (p=0.78 and p=0.79). The experimental group showed improvement in higher order skills like subjective evaluation and transfer scores ($p<0.001$ for both), which require adaption to varied clinical presentations. These skills involve higher cognitive and psychomotor load, requiring integration of knowledge, decision-making, and physical execution making them challenging to address solely through traditional bedside teaching. SBL addresses this by segmenting complex tasks, reducing extraneous cognitive load and allowing

Parameters	Group	Pre Median (IQR)	Post Median (IQR)	Difference (Pre-post)	Test Statistic (Z)	p-value (Wilcoxon signed rank test)	Effect Size (r)
Subjective evaluation	A	18 (4)	24 (4)	6	5.1	< 0.001	0.8
	B	18 (6)	18 (4)	0	0.3	0.78	-0.04
Blood pressure measurement	A	18 (6)	29 (3)	11	5.7	< 0.001*	0.9
	B	18 (6)	22 (7)	4	3.6	< 0.001*	0.5
Auscultation	A	14 (9)	24 (5)	10	5.7	< 0.001*	0.9
	B	13 (7)	16 (6)	3	3	0.002*	0.5
Teaching breathing exercises and huffing	A	9 (2)	10 (5)	1	3.8	< 0.001*	0.6
	B	8 (3)	8 (2)	0	2.1	0.04*	0.3
Nebulisation	A	3 (2)	8 (4)	5	5.4	< 0.001*	0.8
	B	4 (4)	6 (4)	2	2.1	0.032*	0.3
Transfers	A	7 (6)	11 (4)	4	5	< 0.001*	0.8
	B	7 (3)	8 (7)	1	0.3	0.794	0.04

[Table/Fig-4]: Pre vs Post skills score analysis within each group using Wilcoxon signed rank test. Values are expressed as Median (Interquartile range).
(*) indicate statistically significant difference at p<0.05

Parameters	Timepoint	Group A Median (IQR)	Group B Median (IQR)	Difference (between group)	Test statistic (Z)	p-value (Mann-Whitney U test)	Effect size (r)
Subjective evaluation	Pre	18 (4)	18 (6)	0	0.9852	0.324	0.1
	Post	24 (4)	18 (4)	+6	5.8818	<0.001*	0.62
Blood pressure measurement	Pre	18(6)	18 (6)	0	0.6917	0.489	0.073
	Post	29 (3)	22 (7)	+7	6.917	<0.001*	0.72
Auscultation	Pre	14 (9)	13(7)	+1	0.4813	0.63	0.051
	Post	24 (5)	16 (6)	+8	5.942	<0.001*	0.63
Teaching breathing exercises and huffing	Pre	9 (2)	8 (3)	+1	1.580	0.114	0.17
	Post	10 (5)	8 (2)	+2	2.769	0.006*	0.29
Nebulisation	Pre	3 (2)	4 (4)	-1	1.608	0.108	0.17
	Post	8 (4)	6 (4)	+2	3.987	<0.001*	0.42
Transfers	Pre	7 (6)	7 (3)	0	0.518	0.604	0.05
	Post	11 (4)	8(7)	+3	4.3567	<0.001*	0.46

[Table/Fig-5]: Between-group comparison (Group A vs B) using Mann-Whitney U test.
(*) indicate statistically significant difference at p<0.05

repeated practice at suitable levels [21]. A meta-analysis by Lapierre A et al., indicated that repetitive practice, structured feedback, and controlled task progression during simulation optimised cognitive load for novices [22]. Additionally, SBL facilitates incremental mastery of complex tasks and builds confidence [4,23]. Conversely, Andersen SA et al., reported that poorly aligned segmentation in simulation resulted in higher cognitive load (52% vs 41%, p=0.02) compared to regular simulation session, reinforcing importance of structuring SBL carefully [24].

Between group post-intervention comparisons demonstrated that the experimental group outperformed the control group across all assessed skills (p<0.05 for all comparisons), with moderate to large effect sizes, indicating practical significance of integrating SBL. These findings are consistent with Dairo YM et al., who emphasised development of profession-specific subjective and objective skills through SBL [8]. Walker CA et al, demonstrated significantly higher post-intervention median scores for most cardiorespiratory skills, except medical and physical interviewing skills, following use of Standardised Patients (SP) (p=0.07 and p=0.69). The authors attributed these to skills not being focus of the simulation session [12]. But, present study demonstrates significant gains in subjective evaluation (p<0.001), likely due to deliberate incorporation of structured subjective assessment within high fidelity simulation.

An exception was observed in teaching of breathing exercises and huffing, where although post-assessment differences were statistically significant (p=0.006), the magnitude of change was small reflected by effect size of 0.29. SBL was effective in improving procedural skills (like auscultation, transfer skills, etc.), through structured practice, repetition, and immediate feedback- a feature critical for motor skills [25,26]. Subjective evaluation further benefitted from manikin-based voice interaction simulating patient-therapist dialogue. However, teaching breathing exercises remained challenging because high-fidelity simulation, while advanced, was unable to replicate the nuanced, multisensory, and interactive nature of human physiology and responses (e.g., facial expressions, hand placement feedback, overuse of accessory neck and shoulder muscles in breathing patterns). Evidence suggests that SP could enhance the use of psychomotor skills, kinaesthetic feedback and patient communication [27-29]. While SP could have addressed some of the study limitations, their use was precluded by the need to maintain authentic and consistent pathological presentations, like auscultation or chest palpation, required for clinical reasoning and decision-making for teaching breathing exercises and huffing. Similarly, Wendling AL et al reported superior diagnostic recognition using simulation compared to SP encounter (84.6% vs 23.8%), supporting the advantage of simulation in consistently reproducing pathological signs that are difficult with use of SPs [30].

The study contributes to the broader literature on improving cardiorespiratory skills by including SBL, specifically addressing its impact on cardiorespiratory skills among undergraduate physiotherapy students [12,31]. The study is unique in its stratified randomised controlled design, which allows integration of SBL into the existing academic curriculum and provides practical insights into its integration in real-world educational settings. Another distinctive aspect of the study is its focus on a diverse but basic set of cardiorespiratory skills, ranging from subjective evaluation to procedural skills.

Implications: In the Indian physiotherapy education context, SBL can help standardise skill training despite variable clinical exposure. The study supports incorporating SBL as a systematic component of physiotherapy education, particularly for complex cardiorespiratory skills. Regulatory bodies and educational programs may consider a blended model that uses SBL to standardise competencies while maintaining bedside training for patient interaction-dependent skills.

Limitation(s)

The stratified randomised controlled design, though pragmatic, may introduce confounding variables like skill variation. Gender-related learning differences in SBL couldn't be examined due to the skewed gender ratio within the cohort and the broader physiotherapy profession in India. The adapted tool used to compare skills was not subjected to psychometric analysis beyond face validity, limiting generalisability. Conducting the study in two batches to accommodate lab capacity and manage effective teacher-student ratio could introduce minor inter-batch variability despite standardise content and delivery. Finally, a single-institution setting may limit generalisability.

Future scope: Further research could examine the long-term impact of SBL on students' clinical competencies and patient outcomes.

CONCLUSION(S)

The SBL group achieved greater improvement in most cardiorespiratory skills than those trained solely through traditional bedside teaching. This justifies SBL as a valuable tool to supplement traditional clinical training in cardiorespiratory skills, whereas the significance of bedside teaching for patient interaction-dependent skills remains today.

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REFERENCES

[1] Kumar A. The transformation of the Indian healthcare system. Cureus. 2023;15(5):e39079.
[2] Chandra A. Ethical issues and proposed solutions in conducting practical assessment of medical students involving patients. Indian J Med Ethics. 2024;9:217-22.
[3] Seo YH, Eom MR. The effect of simulation nursing education using the outcome-present state-test model on clinical reasoning, the problem-solving process, self-efficacy, and clinical competency in Korean nursing students. Healthcare (Basel). 2021;9(3):243. MDPI.
[4] Elendu C, Amaechi DC, Okatta AU, Amaechi EC, Elendu TC, Ezeh CP, et al. The impact of simulation-based training in medical education: A review. Medicine (Baltimore). 2024;103(27):e38813.
[5] Buljac-Samardzic M, Doekhie KD, van Wijngaarden JD. Interventions to improve team effectiveness within health care: A systematic review of the past decade. Human Resour Health. 2020;18(1):2.
[6] O'Shea O, Mulhall C, Condron C, McDonough S, Larkin J, Eppich W. A qualitative study of physiotherapy educators' views and experience of practice education and simulation-based learning. International Journal of Healthcare Simulation. 2023;2023.
[7] Koukourikos K, Tsaloglidou A, Kourkouta L, Papathanasiou IV, Iliadis C, Fratzana A, et al. Simulation in clinical nursing education. Acta Inform Med. 2021;29(1):15.
[8] Dairo YM, Hunter K, Ishaku T. The impact of simulation-based learning on the knowledge, attitude and performance of physiotherapy students on practice placement. BMC Med Educ. 2024;24(1):786.
[9] LaMartina K, Ward-Smith P. Developing critical thinking skills in undergraduate nursing students: The potential for strategic management simulations. Journal of Nursing Education and Practice. 2014;4(9):155-62.
[10] Stenseth HV, Steindal SA, Solberg MT, Ølnes MA, Mohallem A, Sørensen AL, et al. Simulation-based learning supported by technology to enhance critical thinking in nursing students: Protocol for a scoping review. JMIR Res Protoc. 2022;11(4):e36725.
[11] Korpi H, Peltokallio L, Piirainen A. The story models of physiotherapy students' professional development. Narrative research. The Eur J Physiother. 2014;16(4):219-29.
[12] Walker CA, Roberts FE. Impact of simulated patients on Physiotherapy Students' Skill performance in cardiorespiratory practice classes: A pilot study. Physiother Can. 2020;72(3):314-22.
[13] Molloy MA, Holt J, Charnetski M, Rossler K. Healthcare simulation standards of best practiceTM simulation glossary. Clin Simul Nurs. 2021;58:57-65.
[14] Pai DR. Current status of simulation-based medical education in India and the way forward. International Journal of Healthcare Simulation. 2021;1(1):41-44.
[15] Kundra P, Cherian A. Simulation based learning: Indian perspective. Journal of Anaesthesiol Clin Pharmacol. 2014;30(4):457-58.
[16] Mishra SS, Palekar T, Panhale V. Investigating the effects of simulation-based teaching on learning domains designed for physiotherapy students. Journal of Modern Rehabilitation (JMR). 2024;18(1):70-75.
[17] Wright A, Moss P, Dennis DM, Harrold M, Levy S, Furness AL, et al. The influence of a full-time, immersive simulation-based clinical placement on physiotherapy student confidence during the transition to clinical practice. Adv Simul (Lond). 2018;3(1):3.
[18] Wilkinson JM, Treas LS, Barnett KL, Smith MH. Procedure checklists for fundamentals of nursing. FA Davis; 2019 Oct 23.
[19] Sittner BJ, Aebersold ML, Paige JB, Graham LL, Schram AP, Decker SI, et al. INACSL standards of best practice for simulation: Past, present, and future. Nurs Education Perspect. 2015;36(5):294-98.
[20] Chhabra C, Hamdard J, Kaur H. Gender perspective in the field of physiotherapy: An opportunity for gender neutrality. In: Gender justice in India: Contemporary issues and challenges. New Delhi: Bharti Publications; 2023. p.107-16.
[21] Reedy GB. Using cognitive load theory to inform simulation design and practice. Clin Simul Nurs. 2015;11(8):355-60.
[22] Lapierre A, Arbour C, Maheu-Cadotte MA, Vinette B, Fontaine G, Lavoie P. Association between clinical simulation design features and novice healthcare professionals' cognitive load: A systematic review and meta-analysis. Simul Gaming. 2022;53(5):538-63.
[23] Cooper JB, Taqueti V. A brief history of the development of mannequin simulators for clinical education and training. Postgrad Med J. 2008;84(997):563-70.
[24] Andersen SA, Mikkelsen PT, Konge L, Cayé-Thomasen P, Sørensen MS. The effect of implementing cognitive load theory-based design principles in virtual reality simulation training of surgical skills: A randomized controlled trial. Adv Simul (Lond). 2016;1(1):20.
[25] Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of instructional design features in simulation-based education: Systematic review and meta-analysis. Med Teach. 2013;35(1):e867-e898.
[26] McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. Med Educ. 2010;44(1):50-63.
[27] McGaghie WC, Siddall VJ, Mazmanian PE, Myers J. Lessons for continuing medical education from simulation research in undergraduate and graduate medical education: Effectiveness of continuing medical education: American College of Chest Physicians Evidence-Based Educational Guidelines. Chest. 2009;135(3):62S-8S.
[28] Flanagan OL, Cummings KM, Cummings K. Standardized patients in medical education: A review of the literature. Cureus. 2023;15(7):e42027.
[29] Kneebone R, Nestel D, Wetzel C, Black S, Jacklin R, Aggarwal R, et al. The human face of simulation: Patient-focused simulation training. Acad Med. 2006;81(10):919-24.
[30] Wendling AL, Halan S, Tighe P, Le L, Euliano T, Lok B. Virtual humans versus standardized patients: Which lead residents to more correct diagnoses?. Acad Med. 2011;86(3):384-88.
[31] Blackstock FC, Watson KM, Morris NR, Jones A, Wright A, McMeeken JM, et al. Simulation can contribute a part of cardiorespiratory physiotherapy clinical education: Two randomized trials. Simul Healthc. 2013;8(1):32-42.

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