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Website:
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DOI:
10.4103/jehp.jehp_565_24

Comparison of online content-based training with hands-on mannequin-based skill training on basic life support knowledge and skills among medical students

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Received: 27-03-2024
Accepted: 06-06-2024
Published: 28-02-2025

Abstract:

BACKGROUND: Sudden cardiac arrest remains a leading global cause of death. High-quality chest compressions during cardiopulmonary resuscitation (CPR) are crucial for patient outcomes. Basic life support (BLS) training must be adequately incorporated into undergraduate training. During the pandemic-regulated restrictions, our institute started the online CPR training course for medical undergraduates so that some training could be imparted to them if they needed to staff the clinical areas. This study compared online with traditional mannequin-based CPR training regarding skill acquisition and knowledge retention.

MATERIALS AND METHODS: This randomized cross-sectional study involved 108 medical undergraduates divided into two groups to receive online-based training (Group 1) and mannequin-based training (Group 2). Compression depth and rate were objectively measured using an AmbuMan CPR training mannequin. Knowledge assessment was conducted using relevant clinical vignettes, and participant performance was assessed using a skill-based checklist.

RESULTS: Both groups had comparable baseline knowledge. Group 2 exhibited significantly higher post intervention knowledge assessment and skill-based checklist scores. Mean compression depth [36.28 (13.84) vs 51.6 (8.7), $P < 0.001$] and median rate [110 (87.5 to 129.50) vs 123.0 (111.0 to 133.0), $P = 0.012$] were better in mannequin trained participants. Group 2 participants demonstrated superior skills across all checklist items, with notable differences in pre compression and compression steps. Scene safety checks (62%), compression rate (44%), and compression depth (48%) showed the most significant improvements, whereas steps involving Automated External Defibrillator (AED) usage had minimal enhancements.

CONCLUSION: The findings of this study are significant, demonstrating that hands-on mannequin-based training is significantly more effective than online training in teaching BLS skills to novice medical students, particularly in achieving correct chest compression depth and rate. The study's findings indicate that hands-on training is indispensable for effective skill acquisition despite the widespread adoption of online teaching.

Keywords:

Cardiac, cardiopulmonary resuscitation, checklist, cross-sectional study, death, manikins, medical, students, sudden

How to cite this article: Gupta N, Bansal B, Gupta A, Jindal D, Singhal M, Grewal A, *et al*. Comparison of online content-based training with hands-on mannequin-based skill training on basic life support knowledge and skills among medical students. J Edu Health Promot 2025;14:55.

Introduction

Sudden cardiac arrest is still one of the leading causes of death globally.[1] Therefore, Medical students at all training levels must possess basic knowledge of BLS to manage emergencies in such situations. Literature suggests a poor awareness of BLS skills among doctors, interns, and medical students.[2,3] High-quality chest compressions during cardiopulmonary resuscitation (CPR) are known to improve patient outcomes. Literature shows substandard CPR administration during in-hospital arrests due to ineffective depth and rate of chest compressions.[4,5]

The COVID-19 pandemic has immensely impacted medical education and skill training in recent years. During the COVID pandemic, there were restrictions on the hands-on training sessions, and at the same time, there was a massive need amongst our undergraduate students to get trained in BLS. This training program was thus started to ensure at least a minimum basic knowledge about BLS in medical students. The actual effectiveness of the program was, however, not formally evaluated. Although online teaching has been accepted as a reasonable alternative to physical teaching, skill-based programs such as BLS training are likely to be less effective in online mode than traditional methods. Online modes are increasingly used to impart skill-based learning to medical students. However, there needs to be more literature on the effectiveness of the online mode of teaching and training in essential BLS skills among medical students to make concrete recommendations.[6,7] The studies have yet to compare the two training modalities in a homogenous group with similar background knowledge. Hence, we have planned this study to quantitatively compare online-based CPR training with traditional mannequin-based training regarding skill (assessed through a skill checklist) and knowledge (assessed through relevant case vignettes). We hypothesized that the online-based CPR training format would be noninferior to the traditional program regarding CPR quality as assessed by measuring compression depth (primary objective).

Materials and Methods

Study design and setting: Randomized cross-sectional study

Ethical consideration: This study was conducted following approval by the institutional ethics committee and prospective registeration in clinical trial registry. (CTRI/2023/01/048876)

Study participants and sampling

After approval by the institutional ethics committee and written informed consent, this was conducted on 108 consenting medical undergraduate students. Students with medical conditions that may restrict their training and those with prior exposure were excluded.

A knowledge assessment questionnaire based on relevant clinical vignettes was designed by experts in BLS training in line with the American Heart Association (AHA) guidelines and administered to all participants before planning any intervention.

After the baseline knowledge assessment, the participants ($n = 108$) were randomized either to Group 1 (Online videos and reading material) or Group 2 (Hands-on training). In Group 1, participants were given videos and reading material about the skills applicable to BLS. Participants in Group 2 were provided a four-hour hands-on mannequin-based training on BLS skills by AHA-certified trainers as per institutional protocol. The assessment of both groups involved a vignette-based knowledge evaluation and a checklist-based skill evaluation. The AmbuMan CPR training mannequin (Ambu A/s Baltropbhakken, Denmark) was used to assess real-time compression depth and compression rate to objectively assess the participants' skill in administering effective CPR. The participants were provided with a pre intervention questionnaire, which included a section asking for the participant's informed consent for enrolling in the study and gauged information about the participants' demographic background and prior experience. It also evaluated the participants' knowledge of BLS before the teaching intervention.

Data collection tool and technique

After completing this form, the enrolled participants in Group 1 were given a link to access videos and other readable resource material about the skill. These videos included experts performing BLS on mannequins and explaining their reasoning for each step. The participants had access to this content for a week before they were assessed, and they were actively encouraged to go through the content as many times as they wanted. All these participants were evaluated based on a checklist for skill assessment on the day of the program before any skill training. A concordant post intervention knowledge assessment was provided to the participants along with this skill assessment. After assessing skill and knowledge, group 1 participants were offered hands-on skill-based training to ensure equivalence in skills provided across both groups. No data were collected after the skill-based training in group 1.

The Group 2 participants were given a pre intervention questionnaire evaluating the participants' knowledge of the skill before the intervention; this form also served as informed consent for enrolling in the study and gauging information about the participants' demographic background and prior experience. After that, they were trained in BLS skills through a hands-on mannequin-based session by experts certified in training BLS. After the mannequin-based skill training, the participants' skill was assessed based on a checklist-based skill and a concordant post-intervention knowledge assessment.

Sample size

The compression depth is ideally assumed to be 6 cm. Assuming a noninferiority margin of 0.30 and a standard deviation of 0.60 for the traditional group, as per a study by Yu-Chien *et al*.,[8] level of significance (alpha) at 5%, power (beta) at 80%, we calculated a sample size of 49 participants per group. We included a sample of at least 100 (50 in each group) participants.

Statistical analysis

The data generated during the assessment was tabulated using Microsoft Excel and was analyzed through the statistical software Stata 14.0 (College Station, Texas, USA) and R-software version 4.1.3 (The R Foundation for Statistical Computing, Vienna, Austria). The statistical analysis was based on descriptive statistics of knowledge and skill scores across the two groups. Normality was checked using the Shapiro-Wilks test, and a student *t*-test was used to evaluate the significance of the mean difference of scores in the two groups for normally distributed variables. The Wilcoxon rank sum test and Hodges Lemann estimator were used for the median difference and the 95% confidence interval. A *P* value less than 0.05 was considered significant.

Results

One hundred twenty medical students were approached for enrolment in the study, and ten were excluded (did not consent = 8 and did not meet criteria = 2) [Figure 1]. Two students in the video-based training group did not take the test and were excluded. A total of 108 students (53 in the video-based training group and 55 in the online-based training group) pursuing MBBS in India were included, among whom 71.3% were 1st and 2nd -year students (45 in group 1 and 35 in group 2), 28.7% were 3rd and 4th-year students (8 in group 1 and 20 in group 2). The majority of participants were males in both groups [Table 1].

The mean (SD) of the baseline knowledge score was similar in the two groups [8.3 (2.0) vs 8.4 (2.7)] [Table 1]. Group 2 had a significantly higher post intervention mean knowledge assessment score (11.0 vs 12.8, $P < 0.001$) and median skill-based checklist score (9 vs 5.5, $P < 0.001$) than Group 1.

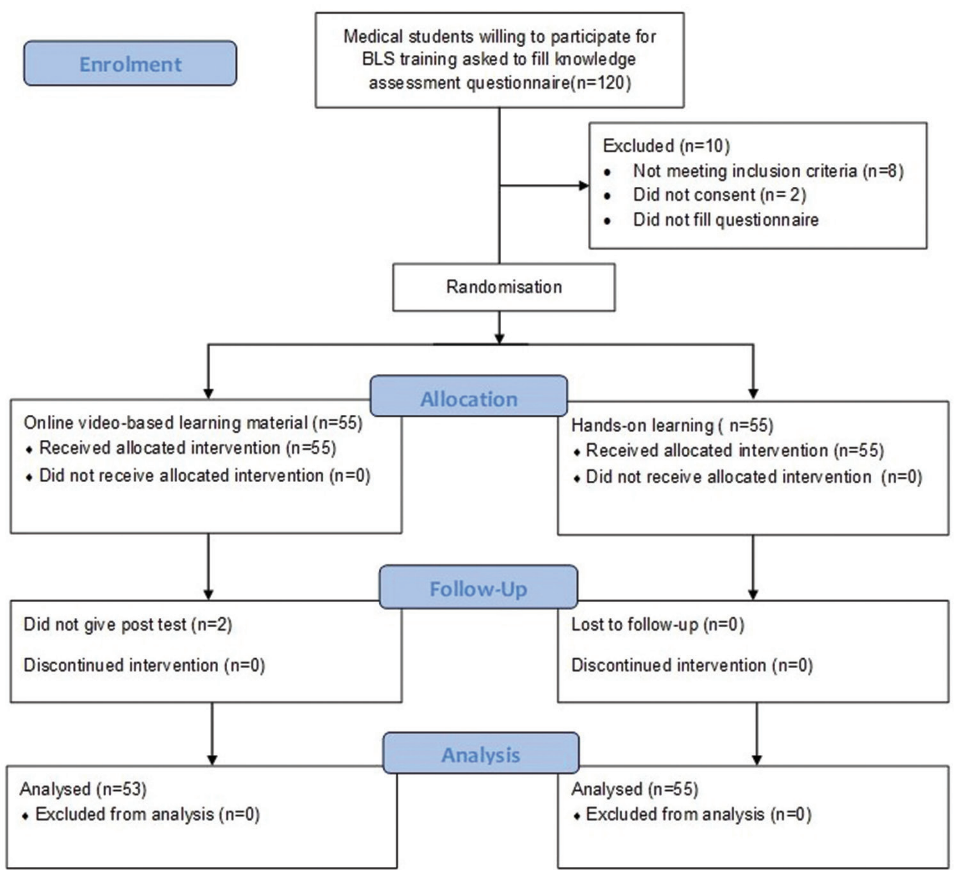

Figure 1: Consort flow diagram

The mean (SD) compression depth [36.28 mm (13.8) and 51.6mm (8.7), $P < 0.001$] and median (IQR) chest compression rates [110/min (88 to 129) and 123/min (111 to 132.5), $P = 0.012$] were significantly better in mannequin trained group [Table 1, Figures 2 and 3].

The participants from both groups were graded through a skill-based checklist in line with the American Heart Association guidelines. The participants in Group 2 performed better than their counterparts in Group 1 across all checklist items [Table 2] The differences are more marked in checklist items corresponding to pre compression and compression steps when compared with the steps involving the utilization of an automatic external defibrillator (AED). The most significant difference was found in the step recommending checking scene safety (62%) and adequate compression rate (44%) and depth (48%), which are relatively subtle components of good practices in basic life support. Switching on AED (9.6%) and correct placement of pads (6.5%) showed least improvement through mannequin-based training.

Discussion

In this study, we have compared the effect of online-based BLS training with traditional hands-on training on chest compression rate and depth and have shown that hands-on training resulted in better CPR quality [Figure 4]. The core principles of BLS, such as the chain of survival, effective CPR, airway management, and early utilization of automated external defibrillators (AEDs), are essential for better outcomes. However, medical education in India currently falls short in incorporating BLS training into the compulsory curriculum, often resulting in suboptimal nonformal training within colleges. We included only preclinical students to ensure a homogenous group and avoid differences in the level of training, which may affect BLS readiness. A previous study also shown similar levels of compression depth [50 (7.7)] and rate [11.2 (9.4)] in preclinical MBBS students after hands-on BLS training.[9]

The COVID-19 pandemic has brought about significant transformations in education across various disciplines and has led to broader adoption of online platforms.[10] The delivery of medical education, which heavily relies on practical knowledge, has faced criticism because of this shift. However, medical schools have been compelled to explore video lecture-based learning of medical skills to meet the demand for skilled healthcare professionals while mitigating the risks associated with face-to-face lectures and practical classes for large cohorts. This article examines the degrees of success in implementing online training in BLS skills, considering its potential as an appealing alternative. We found that the physical mode was much more effective than the online mode

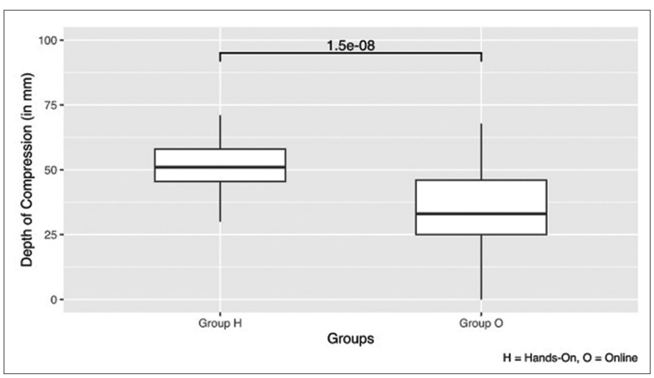

Figure 2: Box-and-whisker plots illustrate the two groups' depth compression (mm). The inner horizontal line within the box represents the median, and the outer horizontal lines represent the 25th and 75th quartiles. The horizontal lines of the whiskers represent the 95% confidence intervals

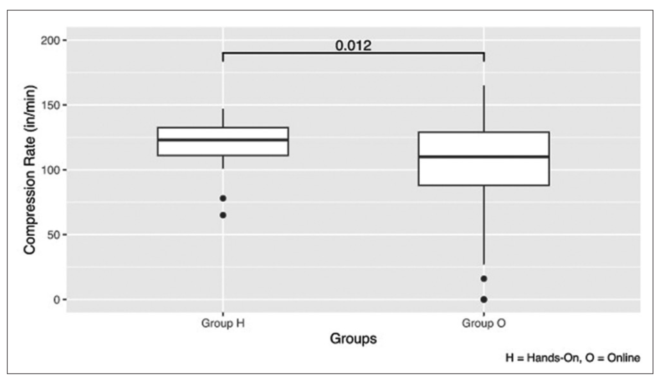

Figure 3: Box-and-whisker plots illustrating the two groups' compression rate (min) comparison. The inner horizontal line within the box represents the median, and the outer horizontal lines represent the 25th and 75th quartiles. The horizontal lines of the whiskers represent the 95% confidence intervals

Table 1: Demographic characteristics and CPR performance parameters in medical students of two groups

Type of intervention	Outcome variable	Group 1 (*n*=53)	Group 2 (*n*=55)	MD[95% confidence interval]	*P*
	Gender (M/F), *n*	34/19	26/29	NA	__
Knowledge assessment	Mean (SD) baseline knowledge score (out of 20)	8.2 (3.0)	8.4 (2.7)	-0.25[-1.33-0.83]	0.65#
	Post intervention knowledge score (out of 20)	11.0 (2.7)	12.8 (2.4)	-1.80[-2.79--0.82]	<0.001***&
Skill assessment	Depth of compression (in mm), mean (SD)	36.28 (13.84)	51.6 (8.7)	-15.34 [-19.74--10.95]	<0.001***#
	Rate of compression (/min), median (IQR)	110 [87.5-129.50]	123.0 [111.0-133.0]	-12.0[-21.0--2.0]	0.012*&
	Skill checklist score (out of 10)	5.50[4.0-7.0]	9.0[8.0-9.50]	-3.50[-4.0--2.50]	<0.001***#

Mean (Standard deviation), Median [25th-75th percentile,] MD=mean difference and median difference, and Mann Whitney *U* test, #Unpaired student *t*-test. Hodges Lehmann method was applied for median difference, and its 95% confidence interval

Table 2: Participant performance of individual components of CPR skills as per the AHA checklist

Variable	Overall, *n*=108	Group 1, *n*=53	Group 2, *n*=55	Difference[1]	*P*[1]
Checks scene safety, *n* (%)	69 (64%)	17 (32%)	52 (95%)	-62%	<0.001
Checks responsiveness, *n* (%)	85 (79%)	34 (64%)	51 (93%)	-29%	0.001
Calls for help, *n* (%)	72 (67%)	26 (49%)	46 (84%)	-35%	<0.001
Checks breathing and pulse, *n* (%)	90 (83%)	40 (75%)	50 (91%)	-15%	0.10
Identifies the correct site for chest compressions, *n* (%)	88 (81%)	35 (66%)	53 (96%)	-30%	<0.001
Compressions at appropriate rate, *n* (%)	59 (55%)	17 (32%)	42 (76%)	-44%	<0.001
Compressions at appropriate depth, *n* (%)	59 (55%)	16 (30%)	43 (78%)	-48%	<0.001
Allows chest recoil before new compression, *n* (%)	81 (75%)	30 (57%)	51 (93%)	-36%	<0.001
Minimizes interruptions, *n* (%)	83 (77%)	35 (66%)	48 (87%)	-21%	0.033
Switches on AED, *n* (%)	97 (90%)	45 (85%)	52 (95%)	-9.6%	0.25
Correct placement of pads, *n* (%)	81 (75%)	38 (72%)	43 (78%)	-6.5%	0.74
Ensures safety of victim while using AED, *n* (%)	92 (85%)	41 (77%)	51 (93%)	-15%	0.080
Delivers Shock while using AED, *n* (%)	98 (91%)	45 (85%)	53 (96%)	-11%	0.12
Resumes CPR immediately after AED, *n* (%)	89 (82%)	38 (72%)	51 (93%)	-21%	0.016

[1]3-sample test for equality of proportions without continuity correction

for training BLS skills regarding correct depth and rate of compression in medical students.

Studies have suggested online training in BLS as an alternative to hands-on training, but most studies show that hands-on training can only incorporate adequate motor skills (chest compression depth and rates) with hands-on training.[7,11,12] Studies have also shown that hands-on training was better than other training modalities regarding chest compression depth and rates.[13-15] Most studies compared various BLS training methods, such as giving online instructions followed by hands-on practice on a mannequin without an instructor and completely offline instructor-led training methods.[7,11-15] Our results are similar to those of previous literature and suggest that hands-on training resulted in better knowledge and psychomotor skills, as indicated by better chest compression depth and rate in this group. Chang *et al*.[16] also compared traditional face-to-face learning, hybrid learning (with a hands-on approach), and learning via virtual reality (without hands-on mannequin practice), as CPR teaching methods to laypersons- and depth and compression rate remained inferior in the virtual reality training as compared to the former two. Ali *et al*.[17] analyzed outcomes of the depth of chest compressions and their rate among laypersons in India after the administration of CPR training via a video-based demonstration versus an instructor-led demonstration and showed comparative results. However, in their study, none of the training methods included participant hands-on practice on mannequins after the instructions, unlike our study. So, our study results are different from their research, both in terms of study population and outcomes. Our study reiterates the fact that hands-on, skill-based training is essential for the development of psychomotor skills.

Studies comparing hands-on training versus entirely online training in BLS for medical students in India need to be included in the literature. Li *et al*.[18] compared the effect of video-assisted debriefing (VAD) with trainees' errors with simulated errors on skill learning among medical students.[18] They showed that though both were similar regarding knowledge and skill of BLS skills, trainees preferred simulated mistakes as a teaching method. A recent study suggested that BLS knowledge was low in medical students, necessitating a better system for training.[19] Our study divided novice medical students with no baseline exposure and understanding of AHA-based BLS into mannequin-based and online content-based training groups. Students who underwent mannequin-based training, as opposed to video-based training, demonstrated improved performance in clinical vignettes and skill checklists as per AHA recommendations.

Limitations and recommendation

This study adds an objective evaluation of adequate chest compression depth and rate, which provides an objective and most relevant parameter to assess the readiness of students to deliver effective CPR in emergencies. Further investigations are required to assess the potential cost-effectiveness of online training for many providers in this crucial skill. In addition, it is worth exploring the effectiveness of integrating online content with mannequin-based training, preceding or after the latter.

A nonsignificant baseline difference in knowledge score and an inexperienced homogenous study group make the groups broadly identical, ensuring the study's internal validity. However, the study was conducted at a single center, and the results may not entirely represent the population. The online learning mode needs constant access to the internet and good-quality content. These things are cost-intensive and need upfront investment for infrastructure.

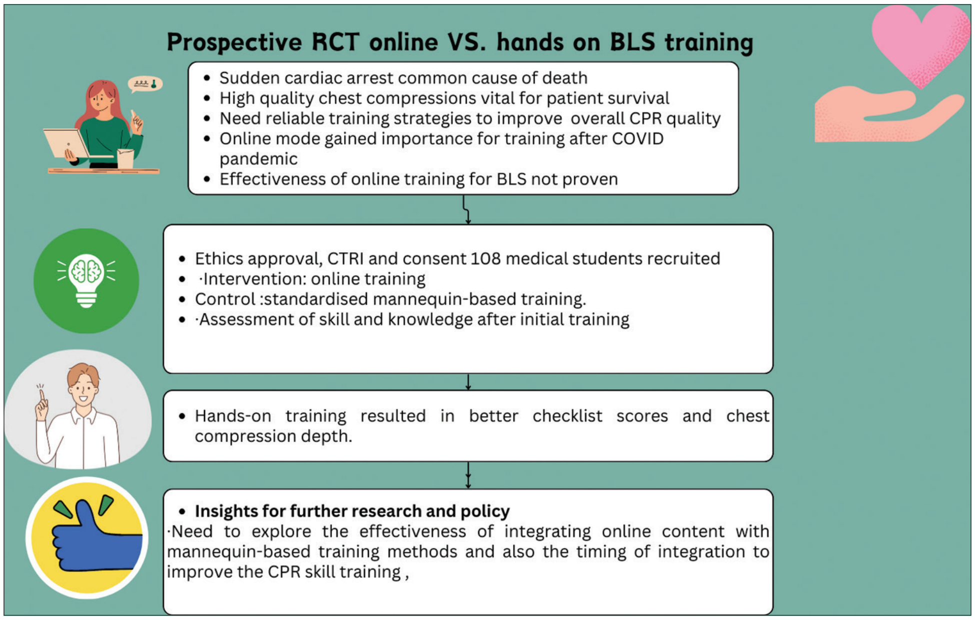

Figure 4: Study infographic

Conclusion

The findings of this study are significant, demonstrating that hands-on mannequin-based training is significantly more effective than online training in teaching BLS skills to novice medical students, particularly in achieving correct chest compression depth and rate. In the post COVID era, physical teaching is gradually being replaced by online platform-based teaching. This information is crucial for medical educators and students, underscoring the importance of practical, hands-on, skill-based training in BLS.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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