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Evaluating video-supported layperson CPR compared to a standard training course: A randomized controlled trial

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ABSTRACT

Background: While just-in-time (JIT) training is associated with time and cost savings, limited evidence directly compares layperson CPR performance using JIT videos to in-person CPR courses. We measured layperson CPR performance using a JIT video compared to an in-person course or no training.

Methods: Adult employees at a professional sports stadium were randomized to perform CPR in a simulated scenario a) after completing an AHA HeartSaver® course, b) using a JIT training video, or c) neither (control). CPR performance was assessed by trained evaluators and QCPR-enabled simulators. The primary outcome was the performance of pre-defined critical actions. Participants were blinded to study objectives and trained evaluators used standardized checklists.

Results: Of 230 eligible subjects, 221 were included in analysis, without significant differences in group characteristics. Correct CPR performance was low, though significantly higher in the AHA group (AHA: 40%, 95%CI 28–51; JIT: 15%, 95%CI 8–26; control 10%, 95%CI 4–19). Compression fraction was significantly greater in the AHA group (90%, IQR 69–98) compared to JIT (61%, IQR 29–89) or control (65%, IQR 33–93). An AED was requested more frequently in the AHA group (47%) than in the JIT (15%) or control (10%) groups.

Conclusions: While overall performance of correct CPR skills was best following a traditional CPR course, laypersons using real-time video training performed as well as those taking an AHA HeartSaver® course on several key measures including time to chest compressions and compression rate.

Trial Registration.

NCT05983640.

Introduction

Rapid identification, defibrillation, and initiation of high-quality cardiopulmonary resuscitation (CPR) mark the cornerstones of effective out-of-hospital cardiac arrest (OHCA) management.[1,2] Effective bystander CPR (B-CPR) is associated with a four-fold increase in survival to hospital discharge.[3] American Heart Association (AHA) guidelines outline three goals to improve bystander OHCA response: increasing rates of immediate B-CPR, increasing rates of automated external defibrillator (AED) use, and immediate activation of emergency medical services (EMS).[1]

Laypersons with CPR training are more likely to perform CPR than those without training.[4] Yet despite the clear importance of early bystander response to OHCA, rates of B-CPR remain low. A landmark systematic review and *meta*-analysis found that only one-third of OHCA patients receive B-CPR, notwithstanding the finding that a bystander witnessed the OHCA incident in more than one-half of cases.[2] In light of these findings, extensive work has been aimed at improving bystander response to OHCA, including studying and improving the implementation of training programs for laypersons.[5]

The AHA HeartSaver® CPR AED Training course is widely used to educate laypeople in OHCA emergency response. Unfortunately, the public perceives time, location, duration, and expense as barriers to in-person CPR classes.[6] Technology-enabled self-instruction, including

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just-in-time (JIT) videos, have been proposed as cost-effective alternatives to in-person training.[7–12] JIT videos provide real-time instruction to bystanders at the time of need. Our objective was to evaluate the effectiveness of a JIT video, as compared to the AHA HeartSaver® Course or no training, on layperson ability to perform CPR correctly in a simulated cardiac arrest.

Methods

Selection of Participants & Randomization

This was a randomized, three-arm, parallel-group controlled equivalence trial of employees ≥ 18 years at a professional sports venue from March to April 2023. Following informed consent and completion of a demographic survey, participants were randomized into one of three groups based on a predesignated block randomization sequence using sequentially numbered, sealed assignment packets. The study statistician and a designated research assistant prepared the randomization sequence and unblinded packet contents in advance. All other study staff and participants were blinded until allocation, and the statistician and designated research assistant had no other contact with study participants to further reduce potential for bias. This study was approved by the Mass General Brigham IRB (2023P000222) and registered on clinicaltrials.gov (NCT05983640) and follows the reporting guidelines for health care simulation research.[13]

Interventions

Participants were scheduled for a 4-hour training session. "Control Group" participants were individually evaluated on performance during a simulated scenario of a witnessed OHCA prior to any intervention. Participants entered a room with a Laerdal® QCPR-enabled patient simulator on the ground. An evaluator trained in the study-specific protocol was there to facilitate the simulation. Response actions and CPR performance were recorded using a standardized data collection form, with objective CPR quality metrics recorded electronically. Following the simulated scenario, each participant completed a post-scenario evaluation. The control "AHA Group" participated in an AHA HeartSaver® course before completing the same scenario and post-scenario evaluations.

The intervention "JIT Group" was evaluated using the same scenario with the addition of a tablet with a JIT CPR training video, and participants were able to have this JIT video playing concurrently while engaging in the resuscitation if they so chose. The video used for this study was developed and produced by the AHA as part of a hands-only CPR campaign.[14] This 90-s video provides guidance on the key components of hands-only CPR, including instruction to activate the 911 system and call for an AED, hand placement, and compression rate. A music soundtrack and metronome accompany the video to further guide compression rate. Instructions are provided twice during the video. The video was loaded on the provided tablet, and participants were instructed on how to start the video to view. Participants were not required to watch the video. A trained research assistant observed participants in the "JIT Group" to collect qualitative data on the participants' interactions and use of the video on the standard data collection form. While the video did not contain all the information provided in the full AHA HeartSaver® course, it did include all content necessary to successfully perform the simulated scenario.

All instructors and evaluators were trained, experienced AHA Instructors. After study procedures, the control and JIT groups completed the AHA HeartSaver® course.

Measurements

Objective measures included five critical actions: (1) activating the 9–1-1 system, (2) initiating chest compressions within one-minute, (3) correct hand placement during compressions, (4) compression depth of ≥ 2 in. or 5 cm, and (5) compression rate of 100–120 per minute.[1] Additional measurements included average compression depth and compression fraction (the percentage of time with active chest compressions). CPR quality metrics were assessed by trained evaluators using a standard data collection form, and objective metrics were assessed using QCPR-enabled simulators.

An 8-item knowledge assessment based on the AHA HeartSaver® curriculum was administered to participants immediately following the scenario.

Outcomes

The primary outcome was the performance of correct CPR, defined as the successful completion of all five critical actions. The secondary outcome was performance on the post-scenario knowledge assessment, ranging from 0 to 8 points.

Analysis

An *a priori* calculated sample size of 228 participants were needed to achieve 80% power for the primary outcome and a Bonferroni corrected alpha level for 3 pairwise comparisons. For the primary outcome of CPR performance, Fisher's Exact test was used with binomial confidence intervals. Three pairwise comparisons with Bonferroni correction were performed for the primary outcome only, with adjusted p-values for pairwise comparisons obtained using a Bonferroni step-down p-value.[15]

Standard descriptive analysis was used for other comparisons across the three arms, including Chi-square and Kruskal-Wallis tests, as appropriate. Multivariable logistic regression was used to assess for predictors of correct CPR, including covariates of age, sex, and prior medical knowledge. Collinearity was assessed using variance inflation factors. Linearity of continuous variables was confirmed with fractional polynomials. Model calibration was assessed using the Hosmer-Lemeshow goodness of fit test. All analyses were conducted on the individual level. All analyses were performed using Stata IC v 15.2 (StataCorp, College Station, TX).

Results

Of 230 eligible subjects, 228 were eligible for inclusion, 226 were randomized, and 221 completed the intervention and evaluation procedures (Fig. 1). Demographic characteristics were balanced across groups (Table 1).

Performance of correct CPR was significantly higher in the AHA group compared to the JIT or control groups (Table 2). Overall, 94% of participants performed compressions within 1 min, with significantly worse performance in the control group (87.7%) as compared to the AHA (97.4%) and JIT (95.8) groups. Compression rates of 100–120 were also significantly better in the AHA (51%) and JIT groups (47%) compared to controls (27%). An AED was called for more frequently in the AHA group (47%) than the JIT (15 %) or control (10%) groups. Compression fraction was significantly better in the AHA group (89%, IQR 77–99) compared to the JIT (75%, IQR 47–90) or control (49%, IQR 22–74) groups. The AHA group scored significantly better on the post-scenario knowledge test, with a median score of 8 (IQR 7–8) versus 4 (IQR 3–5) for the control group and 5 (IQR 4–6) for the JIT group.

Only 54 participants (75%) of participants in the JIT group played the video, with 48 (89%) of those watching the video completely (Table 3). Of those watching the video, 46 (85%) performed critical actions along with the video, 16 (30%) began responding before starting the video, 7 (13%) watched the entire video before responding, and 7 (13%) stopped providing chest compressions as soon as the video ended.

Participants in the AHA group had higher odds of performing correct CPR compared to control or JIT groups (aOR 6.76, 95% CI 2.65–17.27). Prior medical training was also significantly associated with increased

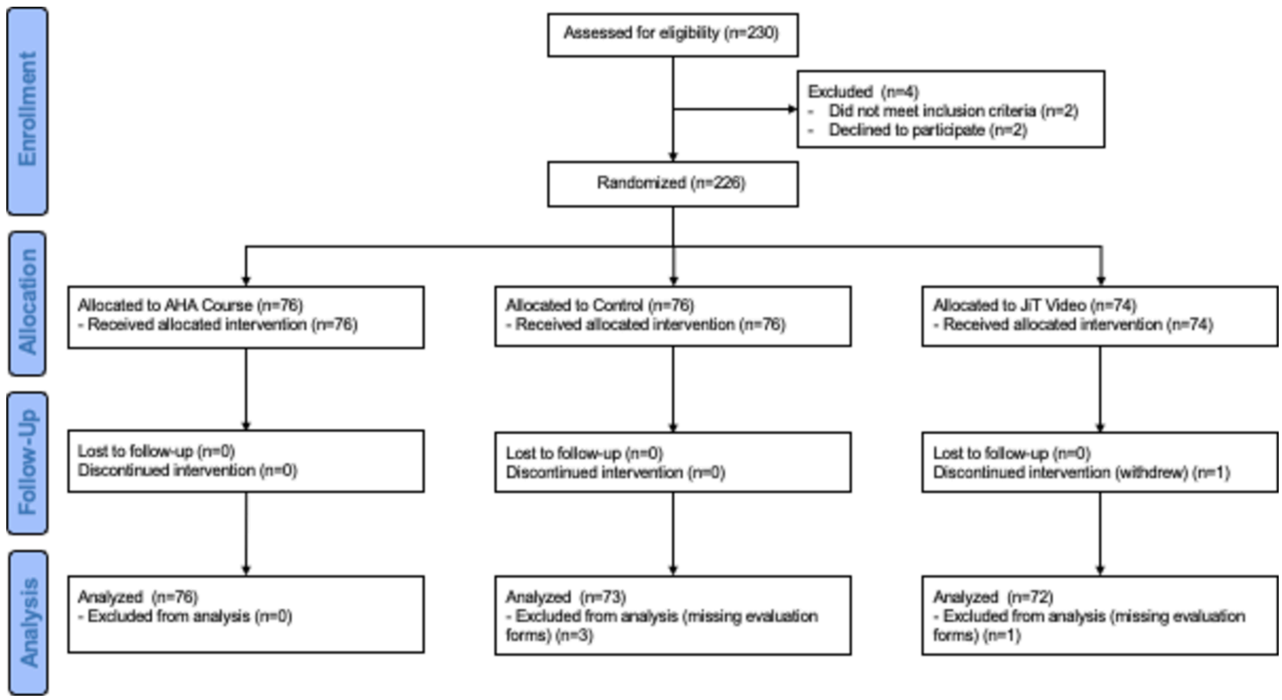

Fig. 1. CONSORT diagram. Abbreviations: AHA, American Heart Association; JIT, just-in-time.

Table 1
Demographic characteristics of participants, stratified by study arm.

	Overall (n = 221)	Control (n = 73)	AHA Group (n = 76)	JIT Group (n = 72)
Age in years, median (IQR)	36 (27–50)	37 (27–49)	35 (27–49)	37 (26–54)
Sex, n (%)				
Female	100 (45.3)	32 (43.8)	34 (44.7)	34 (47.2)
Male	121 (54.8)	41 (56.2)	42 (55.3)	38 (52.8)
Educational attainment, n (%)				
High school diploma	45 (20.4)	15 (20.6)	18 (23.7)	12 (16.7)
College degree	135 (61.1)	48 (65.8)	46 (60.5)	41 (56.9)
Graduate degree	41 (18.6)	10 (13.7)	12 (15.8)	19 (26.4)
Any prior medical training*, n (%)	143 (64.7)	45 (61.6)	50 (65.8)	48 (66.7)
Any prior simulated CPR training, n (%)	136 (61.5)	43 (58.9)	46 (60.5)	47 (65.3)
Simulated CPR training in past year, n (%)	8 (3.6)	2 (2.7)	2 (2.6)	4 (5.6)
Missing	1 (0.5)	0	0	1 (1.4)
Ever performed CPR, including in simulation or training, n (%)	22 (10.0)	7 (9.6)	7 (9.2)	8 (11.1)
Missing	1 (0.5)	0	0	1 (1.4)
Ever used AED, n (%)	21 (9.5)	7 (9.6)	7 (9.2)	7 (9.7)
Missing	1 (0.5)	0	1 (1.3)	0
Ever witnessed CPR in before, n (%)	77 (34.8)	26 (35.6)	25 (32.9)	26 (36.1)
Ever performed CPR in an emergency situation, n (%)	11 (5.1)	5 (7.1)	4 (5.2)	2 (2.9)
Missing	6 (2.7)	3 (4.1)	1 (1.3)	2 (2.8)

Abbreviations: AED, automated external defibrillator; AHA, American Heart Association; CPR, cardiopulmonary resuscitation; IQR, interquartile range (expressed as quartile 1-quartile 3); JIT, just-in-time.
*Including CPR training.

the odds of performing correct CPR (aOR 3.45, 95% CI 1.48–8.06), while increasing age was associated with lower odds per 5-year increment (aOR 0.86, 95% CI 0.75–0.99) (Table 4).

Discussion

This randomized controlled trial aimed to compare the effectiveness of B-CPR performed by laypersons using a 1-minute online CPR video from the AHA in real-time as compared to performance after completing the AHA HeartSaver® Course or performance during control conditions (i.e., no video or course). The results of our study contribute valuable insights into the relative efficacy of these two educational interventions and their potential implications for improving CPR skills in diverse populations. We demonstrated that a JIT video improved key metrics of CPR performance in laypeople as compared to controls. We found good usability, with two-thirds of participants in the JIT group performing CPR along with the video and over 75% of participants watching at least a portion of the video, consistent with previous studies utilizing video as modality to train CPR.[12,16] However, not all participants opted to use the JIT video, highlighting an opportunity to improve approachability and usability of this modality.

Laypersons currently use voice assistants or search engines to provide JIT instructions on virtually any topic, yet a recent analysis demonstrated that nearly half of voice assistant queries related to OHCA were answered with information unrelated to CPR.[17] Improved voice assistant responses coupled with video visuals may enhance JIT instruction in a real-time emergency, provided that such videos are determined to be effective for a comprehensive spectrum of laypeople with various levels of education, language, ethnicity, and social constructs. Several prior studies have explored videos as an alternative to in-person training in various formats ranging from ultra-brief videos (less than 60 s) to in-person training adjuncts.[18] However, to our knowledge no prior studies have examined a JIT approach in which a video was available to be viewed contemporaneously with resuscitation.

While literature exists on maximizing video efficiency for student learners in a formal educational context, little is known about layperson learners and online JIT videos.[5] Instructor-led training is still considered the gold standard in CPR education, with other approaches noted to be potentially less effective.[10,19] However, despite the proliferation of online CPR resources, we have a limited understanding of the efficacy of such course on real life outcomes. Private sector digital leaders and public health experts should have a shared goal of developing novel

Table 2
Objective performance, stratified by study arm.

	Control (n = 73)	AHA Group (n = 76)	JIT Group (n = 72)	p*
Correct CPR†, n (%)	7 (9.6)	30 (39.5)	11 (15.2)	<0.001
% (95 % CI)	9.6 (3.9–18.8)	39.5 (28.4–51.4)	15.2 (7.9–25.7)	
AHA vs. Control				<0.001‡
AHA vs. JIT				0.002‡
JIT vs. Control				0.33
Correct CPR† among those with no prior medical training (n = 78), n (%)	0/28 (0)	9/26 (34.6)	1/24 (4.2)	<0.001
% (95 % CI)	0 (0)	34.6 (17.2–55.7)	4.2 (0.1–21.2)	
AHA vs. Control				0.001‡
AHA vs. JIT				0.01‡
JIT vs. Control				0.46
Actions completed, n (%)				
Called for 9–1-1	47 (64.4)	64 (84.2)	45 (62.5)	0.004
Chest compressions within 1 min	64 (87.7)	74 (97.4)	69 (95.8)	0.045
Hand in correct position	51 (70.8)	65 (86.7)	53 (75.7)	0.06
Compression rate of 100–120	20 (27.4)	39 (51.3)	34 (47.2)	0.006
Compression depth of at least 2 in.	34 (46.6)	51 (67.1)	43 (59.7)	0.04
Called for AED	7 (9.6)	36 (47.4)	11 (15.3)	<0.001
Performed compression-only CPR**	31 (42.5)	51 (67.1)	48 (66.7)	0.003
Total actions completed, median (IQR)	4 (3–5)	5 (4–6)	4 (3–5)	<0.001
Time to first compression in seconds, median (IQR)	14.5 (10–24)	20 (14–24)	26 (13.5–38)	<0.001
Missing	7	2	0	
Compression performance from QCPR, median (IQR)				
Overall score (0–100)	0 (0–11)	49.5 (3–87.5)	4 (0–44.5)	<0.001
Compression score (0–100)	65 (33–93)	89.5 (68.5–98)	61 (29–89)	<0.001
Missing	10	4	5	
% with good release (0–100)	99 (35–100)	95 (36–100)	95.5 (49.5–100)	0.53
% with good depth (0–100)	86 (0–99)	99 (95.5–100)	81 (2–99)	<0.001
Average depth in mm	44 (37.5–52.5)	58 (53–60)	48 (36–53)	0.01
Missing	49	66	39	
Compression fraction (0–100)	49 (22–74)	88.5 (77–98.5)	75 (47–89.5)	<0.001
% with good rate (0–100)	28 (0–78)	33.5 (3–93.5)	25 (3–82)	0.21
Missing	12	4	6	
Average compression rate in compressions per minute	100 (69–114)	115 (107–125)	103 (84–113.5)	<0.001
Post-assessment knowledge test score (range 0–8), median (IQR)	4 (3–5)	8 (7–8)	5 (4–6)	<0.001
n (%) with all 8 correct	1 (1.4)	46 (60.5)	1 (1.4)	<0.001

Abbreviations: AED, automated external defibrillator; AHA, American Heart Association; CPR, cardiopulmonary resuscitation; IQR, interquartile range; JIT, just-in-time.
*Unless otherwise specified (i.e., for primary outcome), p-values from Kruskal-Wallis or Fisher's exact test, depending on nature of variable, testing differences across study arms.
†Correct CPR included completing actions 1–5 correctly.
‡P-values from Fisher's exact test. Statistically significant using the Holm-Bonferroni step-down method to control for multiple comparisons. For this method, the alpha levels for each comparison were: 1) AHA vs Control, α=0.017; 2) AHA vs. JIT, α=0.025; and 3) JIT vs. Control, α=0.05.
**Participant provided chest compressions only and did not attempt rescue breaths or airway manipulation.

Table 3
Participant in intervention (JIT) group interaction with video.

	n (%)
Participants in JIT group (n = 72) who played video at any point during scenario	54 (75.0 %)
For participants in JIT who played video at any point during scenario (n = 54):	
Watched entire video	48 (88.9 %)
Performed critical actions along with video	46 (85.2 %)
Responded before starting video	16 (29.6 %)
Watched entire video before responding	7 (13.0 %)
Watched video while responding	44 (81.5 %)
Stopped compressions when video stopped	7 (13.0 %)

Table 4
Associations between participant characteristics and correctly performing compression-only CPR.

	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
Study arm		
AHA Course	1.00 (referent)	1.00 (referent)
Control	0.16 (0.07–0.40)	0.15 (0.06–0.38)
JIT Video	0.28 (0.13–0.61)	0.26 (0.11–0.59)
Age, per 5-year increase	0.92 (0.82–1.03)	0.86 (0.75–0.99)
Sex		
Female	1.00 (referent)	1.00 (referent)
Male	1.50 (0.78–2.89)	1.86 (0.90–3.87)
Prior medical training		
No	1.00 (referent)	1.00 (referent)
Yes	2.46 (1.15–5.26)	3.45 (1.48–8.06)
Educational attainment		
High school	1.00 (referent)	1.00 (referent)
College	0.85 (0.38–1.87)	0.90 (0.37–2.18)
Graduate school	0.75 (0.27–2.10)	0.96 (0.31–3.04)

Abbreviations: AHA, American Heart Association; CI, confidence interval; JIT, just-in-time; OR, odds ratio.

measurement and evaluation tools to improve understanding of true impact and efficacy of JIT digital education tools. CPR is an ideal domain to begin these efforts which could expand to other layperson empowerment initiatives including AED use, naloxone, hemorrhage control, and others. It is important to note that in our study, while an instructor-led course was superior on several key metrics, access to a JIT video did improve CPR performance in several domains, such as compression fraction, compared to controls. JIT training benefits from ease of implementation and broad reach, making it attractive for individuals and communities with poor access to training and low rates of bystander CPR.[20] In certain contexts, a concise instructional video may serve as a viable alternative for disseminating CPR knowledge, especially when considering the time constraints and accessibility issues seen in other training modalities. Coupled with increasingly ubiquitous voice assistants and easy access to multiple search engines and online video platforms, JIT videos may prove a valuable tool in assisting real-time CPR and resuscitation.

Our findings suggested some key themes that are critical to future video design to facilitate user efficacy. While all subjects in the JIT group did have the video available, only 75% of subjects played the video. While 85% of those who watched the video used the video to guide CPR in real time, 11% of those participants did not watch the entire video, further suggesting that the video may not have adequate usability for all individuals. Further, 13% watched the entire video prior to providing CPR, representing a potentially unnecessary delay in care, while an additional 13% of participants stopped chest compressions once the video ended. Future iterations of a JIT video might stress the importance of following along with the instructions provided in the video in real time, or might highlight the importance of continuing high-quality compressions, even after the video ends, until emergency personnel arrive.

Previous studies have demonstrated a degradation in CPR performance when transitioning from the classroom to real-world situations, and we saw similar in our study. Notably, in the AHA group only 39% of participants effectively performed all 5 critical actions of CPR after completion of the AHA HeartSaver® Course. Though the AHA course does not certify people to perform CPR and only assesses satisfactory learning of skills, our data suggest there is a clear disjoint between trained skills and performance during simulated or real-life experiences. Previous studies have similarly shown wide variation in CPR quality despite robust training, even among trained healthcare providers.[21–26] The need to enhance CPR training at the course level is critical and further studies are needed to identify mechanisms to enhance learner-centered approaches that enhance intention to act and high-quality performance.[5]

While not addressed in this study, JIT videos may also play a role in skill retention. Several studies have demonstrated that CPR specific skills and knowledge deteriorate within 3 to 6 months after initial training.[9,27,28] Recognizing that skill retention after a course declines significantly, various modalities to improve retention that rely on low dose, high-frequency principles have been explored.[27–29] However, this concept relies on serial interactions with videos, mannequins, simulators, or instructors, which can be logistically unfeasible for the public. Shifting the paradigm of CPR education from the classroom to digital, readily accessible modalities has the potential to mitigate the need for retention if the design provides highly effective JIT results in the hands of the public.

Limitations

Our study had several limitations. This sample of stadium employees may not be generalizable to the population at large, and while our a priori power calculation called for a sample size of 228 subjects, final enrollment after exclusions was 221, though it is unlikely that this small variance affected study results. Overall CPR performance quality was low in all groups, including the AHA group, though this likely represents real-life performance. Further, we did not objectively quantify individual instructors' level of performance, though variability of instructor assessments has been demonstrated previously in advanced life support courses.[30] We were unable to capture an upper limit of compression depth due to limitations of the recording device. We considered a measured compression depth of $\geq$ 2 in. or 5 cm correct though guidelines recommend an upper limit of 2.4 in. or 6 cm, and it is possible that some individuals marked as correct may have exceeded this upper threshold.

Importantly, overall CPR performance in our group was poorer than expected, regardless of intervention group, with just 22% of the total cohort achieving all critical actions, highlighting the need of widespread, high-quality CPR education amongst the lay public. Although the JIT video used in our study was designed by the AHA as a public service and is readily available and easily accessible, it was not specifically designed as a JIT video for contemporaneous use during CPR. Further, our study used the video as both a teaching intervention as well as a cognitive aid, potentially diluting its utility as a JIT training video. Future iterations of this video may yield improved performance. Furthermore, while CPR performance was most effective in the AHA arm, our assessment occurred immediately after the course and may not fully capture the long-term retention and application of CPR skills. Our study was conducted in a simulated patient care environment, and generalizability to patient-based outcomes is unclear. Follow-up studies with extended observation periods could provide a more comprehensive understanding of the sustained impact of these educational interventions. Finally, the study was conducted in a controlled setting, and the transferability of these findings to real-world scenarios warrants further investigation.

Conclusion

While overall performance of correct CPR skills was best following an AHA HeartSaver course, laypersons using a real-time training video performed as well as those taking an AHA HeartSaver® course on several key measures such as rapid chest compression and compression rate.

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CRediT authorship contribution statement

S.A. Goldberg: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **R.E. Cash:** Writing – review & editing, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **G.A. Peters:** Writing – review & editing, Methodology, Data curation, Conceptualization. **D. Jiang:** Writing – review & editing, Project administration, Data curation. **C. O'Brien:** Writing – review & editing, Project administration, Data curation. **M.A. Hasdianda:** Writing – review & editing, Project administration, Data curation. **E,M. Eberl:** Writing – review & editing, Data curation. **K.J. Salerno:** Data curation. **J. Lees:** Data curation. **J. Kaithamattam:** Writing – review & editing, Data curation. **J. Tom:** . **A.R. Panchal:** Writing – review & editing, Methodology. **E. Goralnick:** Writing – review & editing, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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