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# 3 Comparison of instructor-led Automated External Defibrillation training and three alternative DVD-based training methods

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**Summary**

Background. Self-directed BLS-training, using a personal training manikin with video has been shown to be as effective as instructor-led training. This has not previously been investigated for AED-training.

Materials and methods. This prospective, randomized study with a non-inferiority design compared traditional instructor-led training with three DVD-based AED-training methods (2.5 minute DVD without practice; 4.5 minute DVD with manikin practice; 9 minute DVD with manikin practice and scenario training). After DVD BLS-training, 396 participants were assigned to one of the four AED-training methods by randomization stratified for age.

Participants were tested immediately after the training (post-test) and two months later (retention-test) using modified Cardiff criteria. The primary endpoint was the percentage of providers scoring 70% or higher on testing. The secondary endpoints were the mean scores and differences per item per age group.

Results. Comparison non-inferiority could not be accepted for the post-test or retention-test. Relative Risk (RR) and 95% Confidence Interval (CI) of passing for DVD without practice, with manikin practice and with manikin practice and scenario training compared to instructor-led training were 0.36 (0.25-0.53), 0.35 (0.24-0.51), 0.55 (0.38-0.79) respectively for the post-test, and 0.82 (0.68-0.97), 0.82 (0.68-0.97), and 0.84 (0.70-1.00) respectively for the retention-test. The performance of participants in all DVD-based training groups was significantly higher on the retention-test than on the post-test. Those receiving scenario training scored higher on the post-test compared to the other DVD training groups ($p<0.001$).

Conclusions. DVD-based AED-training without scenario is not recommended. Scenario training is a useful addition, but instructor-facilitated training remains the best method.

## Introduction

Every year thousands of people attend instructor-led Basic Life Support and Automated External Defibrillation (BLS/AED) courses lasting on average 3-4 hours.[1-3] As this large time investment leads to limited retention, newer training modalities have been proposed which may be more efficient in terms of time and cost [4-7]. Self-directed training, using a personal training kit containing a manikin and a DVD-video has been shown to be as effective as instructor-led training in BLS skills but with a smaller time-investment.[8-14] Video presentations have also been used in instructor-led training with manikin practice and for scenario training.[10,15]

DVD-video AED-training is also used, often following the BLS training.

However, it has not been established whether DVD-video-based self-directed methods are effective for AED-training. In this study we compared the effectiveness of traditional instructor-led AED-training with three DVD-based training methods as measured immediately after training and two months later. We used a non-inferiority methodology to test the hypothesis that the DVD-based training-methods are not inferior to instructor-based training. If so the shorter DVD-based training-methods would be more efficient as they could access a larger audience at lower cost than instructor-led training.

**Materials and methods**

We performed a prospective, randomized trial comparing acquisition and retention of AED-skills after instructor-led training, as a known effective standard training-method, and three DVD-based training-methods with and without manikin- and scenario-practice as described below. The study was approved by the ethics committee of the VU Medical Centre, Amsterdam, The Netherlands.

**Study participants**

Participants were volunteers recruited by advertising in local newspapers and sports-club magazines and by contacting scouting groups from different regions of the Netherlands. Volunteers who had followed CPR- or First Aid training within five years were excluded. Scouting groups were chosen as they are dispersed geographically and represent younger people from a range of social and educational backgrounds.[16]

Previous educational studies have shown that retention is related to age and can be a confounder in acquisition and retention studies.[17-21] Therefore participants were stratified into three age groups: 20 years or younger, 21 to 50 years and older than 50 years.[22,23]

Before giving their consent, respondents were told that the initial training would take up to 2 hours including the post-test, and that the retention-test would take 5-10 minutes, to be taken 2 months later.

Before the training, the following baseline data were collected: age, sex, education level, time since any previous training and time since participating in a real resuscitation event, if any.

**Training methods**

All training and testing took place in sport halls. Before the AED-training, all participants were trained in BLS, using the commercially available Mini-Anne® personal training kit (Laerdal Medical AS, Stavanger, Norway). This kit also includes a 'mouse-pad' AED and a cardboard phone. For BLS-training,

participants were instructed to remove only the manikin and the cardboard phone from the package. They subsequently practised BLS guided by a 24 minute instructional DVD.
During the BLS-training, one instructor was available for every 24 participants who was permitted only to give assistance with psychomotor skills such as hand-positioning, but no verbal instruction or feedback. After BLS-training each participant was assigned to one of four AED-training-methods (groups A to D described below) by randomization stratified for age, using a web-based programme (http://www.randomizer.org/form.htm ) (Figure 1).

A. DVD demonstration without a manikin
Participants in group A returned the complete personal BLS training kit before watching a 2.5 minutes DVD demonstration of the use of an AED, in a single uninterrupted session, without hands-on practice. There was no instructor present, nor was scenario training given during the DVD demonstration. All three AED-training DVDs featured the same presenter using a similar style of presentation and demonstration. The content and presentation of the DVD demonstration resembled that developed by Roppolo et al. for airline personnel .[11]

B. DVD skill training using a personal manikin
Participants in group B practised AED-skills in a single uninterrupted session in groups of 12, watching a 4.5-min training DVD while using a personal manikin and 'mouse pad' AED. The DVD demonstrated the following aspects of using an AED: indications for use, switching on, attaching the electrodes, keeping a safe distance and delivering a shock. There was no instructor present and no scenario training was given.

C. DVD scenario training using a personal manikin
Participants in group C followed the same training as those in group B with the addition of working through two scenarios on the DVD which required them to practise AED-skills. The whole training lasted 9 minutes. In scenario 1 bystander-CPR was already in progress. Participants were expected to take over, connect the AED and deliver one shock. Scenario 2 was an unwitnessed arrest in which participants were warned by the victim by phone just before he collapsed. Participants had to check responsiveness, check for normal breathing, raise the alarm, turn on the AED, attach the electrodes (the AED initially advised 'no shock'), give CPR, allow the AED to give one shock and resume CPR. Participants in groups B and C returned the complete personal training kit after the AED-training, but before the post-test.

D. Instructor-led training

Participants in group D received the standard 90 minutes instructor-led AED-training-programme of the European Resuscitation Council, containing short demonstrations of patient assessment, attaching an AED and delivering one shock, first without, and subsequently with, verbal explanation from the instructor, a third demonstration by the instructor with commentary from the participants and hands-on training. Several scenarios of single shock success, no shock required, and shockable rhythm processing to non-shockable were used. [24]

Participants were trained in groups of 12 with two instructors, two Laerdal® Resusci-Anne™ Basic manikins (Laerdal Medical AS, Stavanger, Norway), and two Philips FRx Trainers (Philips Medical Systems, Seattle WA, USA). Participants in group D returned the complete personal BLS-training kit before starting the AED-training.

The personal training kit was returned to participants after the retention-test.

**Skills assessment**

Participants took a post-test immediately after the training to test skill acquisition, and an identical retention-test two months (+/- 5 days) later, to assess skill retention in the four groups. For the tests a Laerdal® Resusci-Anne™ full-body recording manikin with Skill-Reporting™ PC software 2.2.1 and a Philips AED-Trainer 2 were used. The AED-Trainer was programmed to a one shock scenario. Each testing-station had one assessor and one supervisor was present to ensure uniform evaluation of the skills. A convenience sample of 50% of the tests was recorded on DVD and evaluated by the main author to assess uniformity. For each test, the participant was asked to help a collapsed victim. A bystander (the assessor) was present but not able to help. No further instruction or feedback was given during or after the test. The test ended after the second AED rhythm-analysis or after two minutes of CPR if the AED was not used. After the test, participants were not allowed to confer with those waiting to be tested. Participants signed a written agreement not to talk to other participants, to follow additional resuscitation training or to search for information about resuscitation between the tests.

**Test measurements**

The Cardiff list, adapted to the ERC Guidelines 2005 was used to score the tests. [25, 26] All items were scored, but only the following items relating to the AED were used for analysis: switching on the AED; removing clothing; time from start assessment to switching on the AED; electrodes

attached correctly; location of wrongly placed electrodes; time from starting assessment to attaching electrodes; rescuer's position during analysis; pushing the shock button as directed; shock safety (stay clear); time from starting assessment to the first shock and restarting CPR. All AED-training devices used the same voice prompts and time intervals.
Overall test performance was represented by a score calculated as the results of all AED-skills scored divided by the maximum score of 22 points.

**Instructors**
Four ERC-certified instructors were available during the DVD BLS training and provided the instructor-led AED-training. Six other ERC-certified instructors, who were blinded to the training method, acted as assessors during the post- and retention-tests.

**Statistical analysis**
The primary end-point was the percentage of providers with an overall score above 0.7, based on the minimal necessary score for an acceptable level of AED execution. The secondary end-points were the mean total score per group and the mean scores and differences per item per age group. To assess the magnitude of differences we calculated Cohen's d, taking a score of greater than 0.2 absolute to be relevant.[27]
The trial was designed to determine whether the DVD-training methods are as effective as (e.g. non-inferior to) conventional instructor-based scenario training for the primary outcome measure: the percentage of participants who passed the test. The null hypothesis ($H_0$) was that any DVD-based training is inferior to instructor-led training. To reject the $H_0$ and demonstrate non-inferiority, a relative risk margin of less than 0.2 was accepted, thus, the lower bound of the two-sided 95% confidence interval for the relative risk of passing the test with a DVD-based training compared to the instructor-based training needed to fall above 0.8.[28] If $H_0$ could not be rejected, conventional p-values were reported for two-sided comparisons of the training methods (ANOVA/Duncan's test).
We assumed a pass-rate of 0.8 for the instructor-led training. Selecting an alpha-value of 0.05, a beta-value of 0.2 and a power of 0.8, we calculated that 78 participants would be necessary per group. Anticipating drop-out, we increased this by 25% and a total of 396 participants were recruited.
Item-analysis between groups was done with the Kruskal-Wallis test, statistical significance was accepted when $p \leq 0.05$. All statistics were performed using SPSS® 16.0.1 for Windows (SPSS Inc. Chicago, USA). Cohen's Kappa was used to assess uniformity of assessment.

**Results**

Cohen's kappa for the evaluation of uniformity of the assessments recorded on DVD was between 0.92 and 1 for each item.

Figure 1 shows the distribution of participants over the groups. Individual characteristics did not differ significantly between the groups. Forty-three participants did not take the retention-test for various reasons (Figure 1).

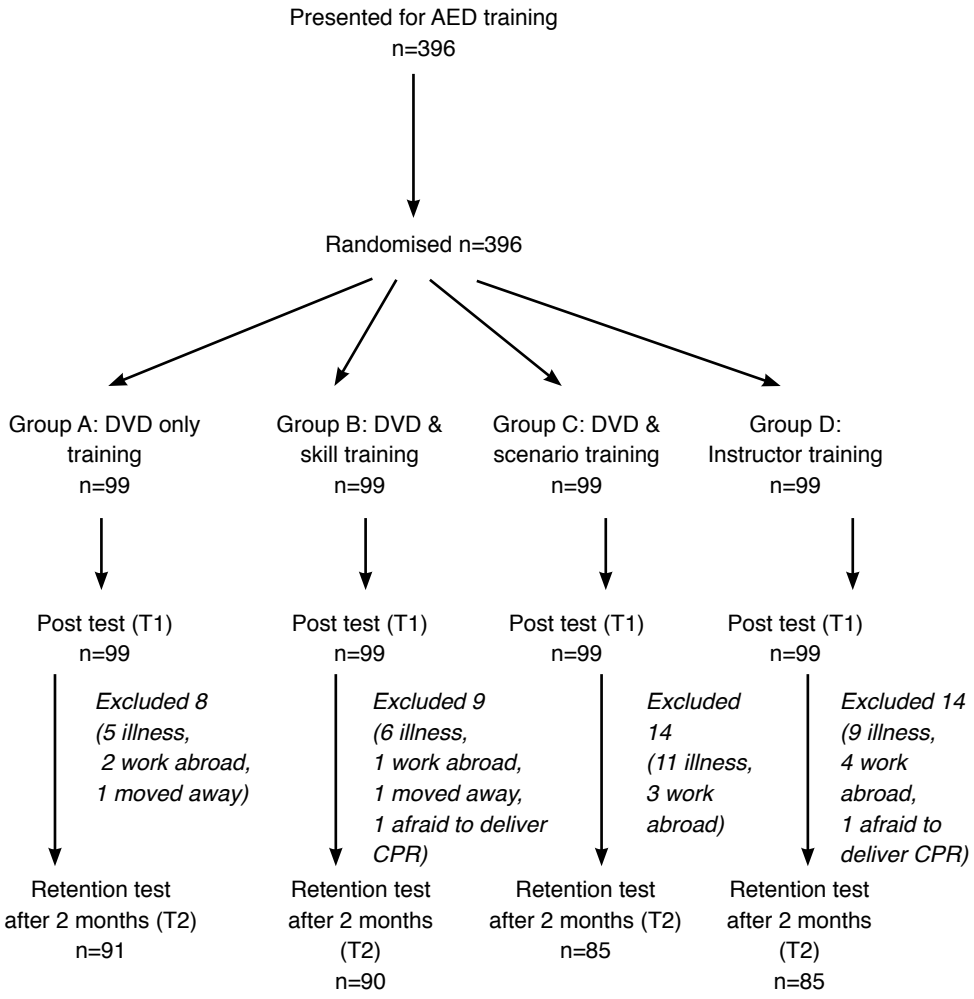



*Figure 1.*

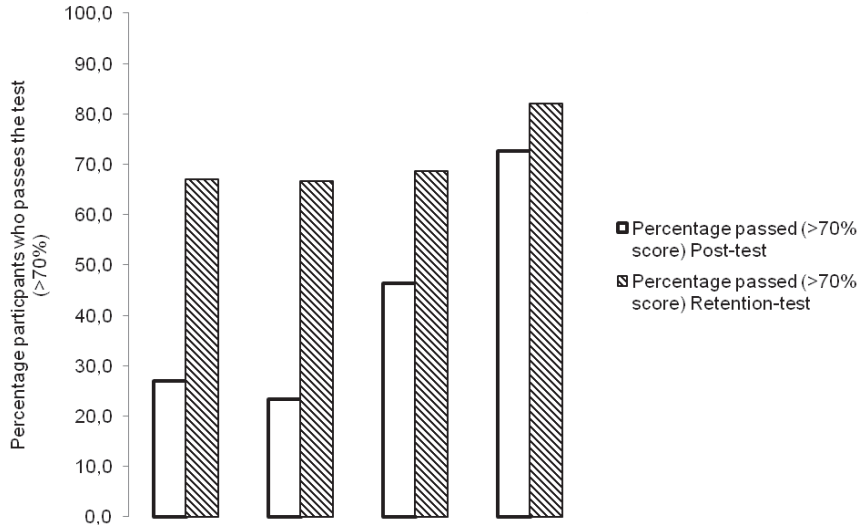
***Consort participant flow diagram.***

Two participants dropped out as they were afraid to deliver CPR. The post-test performance of participants who did not take the retention-test, did not differ significantly from those who did ($p > 0.37$), nor did their personal data ($p > 0.19$), except that those not taking the retention-test had more previous experience with a manikin (27% vs. 16%; $p=0.03$).
In the post-test comparison the confidence intervals of all three DVD training methods were lower than the margin of non-inferiority to the instructor-led training, meaning that the hypothesis of inferiority to instructor-based training could not be rejected. Moreover, each of the three DVD-based training methods was inferior to instructor-led training, according to classical hypothesis testing (ANOVA/Duncan). Significantly more participants in the DVD-only training group, and the DVD and manikin skill-training group failed to use the AED during the post-test compared to the other groups ($p < 0.001$).
For the retention-test the confidence interval of the relative risk of passing was lower than the margin of non-inferiority, meaning that the hypothesis of inferiority could not be rejected for all three DVD-based methods (Table 1).

| | Post-test | | | Retention-test | | |
|---|---|---|---|---|---|---|
| | Video only | Video skill | Video scenario | Video only | Video skill | Video scenario |
| Relative risk of passing compared to instructor-led training | 0.36 | 0.35 | 0.55 | 0.82 | 0.82 | 0.84 |
| 95% CI | 0.25 – 0.53 | 0.24 – 0.51 | 0.38 – 0.79 | 0.68 – 0.97 | 0.68 – 0.97 | 0.70 – 1.00 |
| Non-inferiority testing | $H_0$ of inferiority not rejected | $H_0$ of inferiority not rejected | $H_0$ of inferiority not rejected | $H_0$ of inferiority not rejected | $H_0$ of inferiority not rejected | $H_0$ of inferiority not rejected |
| Inferiority testing of video-based training | P<0.001 | P<0.001 | P=0.001 | P=0.02 | P=0.02 | P=0.05 |
| Mean score (SD) | 0.34 (0.34) | 0.36 (0.35) | 0.53 (0.33) | 0.63 (0.31) | 0.63 (0.30) | 0.68 (0.26) |
| Cohen's d compared to instructor-led training | -1.38 | -1.32 | -0.76 | -0.50 | -0.50 | -0.35 |

*Table 1.*
***Non-inferiority analysis.***

The percentage of participants passing the test in all DVD-based training groups was significantly higher on the retention-test than the post-test (Figure 2).




| | *DVD Demonstration only* | *DVD Skill* | *DVD Scenario* | *Instructor-led* |
|---|---|---|---|---|
| *Number of participants that passed the post-test* | *27/99* | *23/99* | *46/99* | *72/99* |
| *Number of participants that passed the retention-test* | *61/91* | *60/90* | *58/85* | *69/85* |

*Figure 2.*
***Results per method.***

Scores for most items improved or remained the same on the retention-test compared to the post-test, but the number of participants attaching the electrodes outside the correct area and not baring the chest both increased. The most common fault was that the right electrode was placed too caudally and the left electrode too medially.
All three time-intervals measured were significantly longer for participants older than 50 year ($p < 0.03$; Cohen's d against the other two groups between 0.27 and 0.65). There was no significant difference in the number of participants tested by each assessor in each group or in the scoring per assessor. There was no indication of non-adherence to the test protocol from the DVD recordings of the testing.

**4. Discussion**

Our results suggest that 2.5, 4.5 or 9 minutes of DVD-training is insufficient to teach the use of AED, when compared to a 90 minutes instructor led AED course. The addition of scenario-training improves the effectiveness of DVD-training, but this remains inferior to instructor-led training.
We hypothesize that both practising scenarios and that the presence of an instructor to guide the training and give personal feedback is important for successful acquisition and retention of AED-skills, However, two other factors might have contributed to our findings. Firstly, the longer duration of instructor-led training - 90 minutes as opposed to a maximum of 9 minutes for the DVD-based training methods. The DVDs were identical in respect of content and style of presentation, the only difference being the addition of hands-on manikin practice and scenario training. Therefore the DVDs were of different durations, with the scenario DVD lasting the longest and therefore the duration of training differed between the groups. Standardizing this between the four training methods might reduce the difference in outcomes between the methods.
Secondly, the instructor-led training used the four-step approach to skills-teaching with feedback, which is considered to be a highly effective method, while the DVD-based training methods used only two or three steps without feedback.[29,30] We are unable to quantify the relative contribution of these elements on our study results.
We studied AED-related skills only and cannot comment on the effectiveness of the four methods in respect of BLS-training. It is well recognised that BLS-skills deteriorate within months of acquisition whereas skills in the use of an AED are better retained.[4-6,31,32] This might be due to the fact that the use of an AED is a less complex task than BLS and because the rescuer is aided by voice prompts.
Retention is influenced by the time-interval between training and the

retention-test and attrition of resuscitation skills has been demonstrated to increase progressively between one to three months following training.[6,33,34] Therefore it was an unexpected finding that participants in all DVD-based training methods showed increased skills on the retention-test. We consider the most plausible explanation for this to be an effect of the post-test itself. This gave all participants additional hands-on experience with the AED.[35] We speculate that performance on the retention-test would have been worse if participants had not taken the post-test, however, the post-test was methodologically necessary to demonstrate the level of initial skill-acquisition. We would expect the effect of additional practice during the test to be greatest for the shortest and most simple training methods, as we observed. This mechanism would presumably also be true in the instructor-based training group, however, this group did not show an increase between the post-test and the retention-test. However, as this group had a significantly better test result than the other groups, a ceiling-effect might have been operating, whereby near optimal learning was achieved during training which could not be improved further with more practice.

Rappolo et al. found that a short demonstration by an instructor, similar to the one used in the DVD demonstration-only method, can be effective for learning AED-skills.[11] Our inability to repeat this may be due to methodological differences between our study and that of Rappolo et al: we used a simple MiniAnne® manikin without clothes instead a more sophisticated, clothed one; and Rappolo et al. used an AED with voice prompts whereas our participants received the voice prompts from the DVD. The instructor-led group in our study was thus more familiar with manikin used in the test than the other groups leading to less difficulty with transferring their new knowledge to the test. However, Einspruch et al. found that those trained in BLS, using a MiniAnne® manikin actually performed better in testing on a full-sized manikin than those trained using a full size manikin.[14] Rappolo et al. did not measure time-intervals but did prompt the use of the AED during the test. We choose not to prompt participants in order to improve the validity of the test as fetching the AED in a real cardiac arrest depends on the rescuer's own initiative. As a consequence we observed that during the post- and retention-tests an appreciable number of the participants did not use the AED. This has not be found in other studies in various settings, where prompting was used.[11,36-38]

We found in our participants that delay in applying the AED was a major cause of failing the test and we believe that this is critical important for the use of an AED during a real resuscitation effort.

Limitations

All participants in our study were volunteers who make up the largest group of BLS- and AED-learners but are known to perform better than others, probably due to stronger internal motivation.[39] Therefore our conclusions might not be relevant to the training of non-volunteers.

Drop-out might have biased our assessment of retention. Chamberlain et al. found in their study that the less a participant learns during training the greater their motivation to return.[5] It might be that this trend is comparable to what happened during our retention-test, but we found no evidence of this. The post-test performance of participants who did not take the retention-test, did not differ significantly from those who did ($p > 0.37$).

Finally, the successful completion of an AED course is an indicator, but no guarantee of good performance during a real resuscitation and the differences in performance we found might not correspond to performance during a true cardiac arrest.[40]

## 5. Conclusions

Our results suggest that 2.5, 4.5 and 9 minutes DVD-training using a simple personal manikin and a 'mouse pad' AED is insufficient to teach the use of AED, when compared to a 90 minutes instructor led AED course. Scenario training improves the learning effect, but instructor-led training involving feedback and personal contact remains the best method. DVD-based training without scenario training cannot be recommended as an alternative training method for AED-skills.

## Conflict of interest

WdV is an employee of Doczero, a company which develops and sells digital skills-training. He is free to perform research, and his employer was not involved in designing the study, analysing data or writing the manuscript. The remaining authors have no conflict of interest to declare.

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