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Comparison of a newly established emotional stimulus approach to a classical assessment-driven approach in BLS training: a randomised controlled trial

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ABSTRACT

Objective The study objective was to implement two strategies (short emotional stimulus vs announced practical assessment) in the teaching of resuscitation skills in order to evaluate whether one led to superior outcomes.

Setting This study is an educational intervention provided in one German academic university hospital.

Participants First-yearmedical students (n=271) during the first3 weeks of their studies.

Interventions Participants were randomly assigned to one of two groups following a sequence of random numbers: the emotional stimulus group (EG) and the assessment group (AG). In the EG, the intervention included watching an emotionally stimulating video prior to the Basic Life Support (BLS) course. In the AG, a practical assessment of the BLS algorithm was announced and tested within a 2 min simulated cardiac arrest scenario. After the baseline testing, a standardised BLS course was provided. Evaluation points were defined 1 week and 6 months after.

Primary outcome measures Compression depth (CD) and compression rate (CR) were recorded as the primary endpoints for BLS quality.

Results Within the study, 137 participants were allocated to the EG and 134 to the AG. 104 participants from EG and 120 from AG were analysed1 week after the intervention, where they reached comparable chest-compression performance without significant differences (CR P=0.49; CD P=0.28). The chest-compression performance improved significantly for the EG (P<0.01) and the AG (P<0.01) while adhering to the current resuscitation guidelines criteria for CD and CR.

Conclusions There was no statistical difference between both groups' practical chest-compression-performance. Nevertheless, the 2 min video sequence used in the EG with its low production effort and costs, compared with the expensive assessment approach, provides broad opportunities for applicability in BLS training.

Strengths and limitations of this study

- One paramount strength of this study is the application of a newly developed cost-efficient emotional stimulus combined with a practical performance training method (eg, the emotional stimulus group).
- The measurement of practical performance defined as compression depth and compression rate on a reporting mannequin (Skillreporter Resusci Anne, Laerdal, Stavanger, Norway) with Laerdal PC-Skill Reporting Software (V.1.3.0, Laerdal, Stavanger, Norway) provides more objective data than the observation by an instructor or ratings of self-perception of participants.
- There is a high psychological impact associated with performing BLS on a real person that a simulated scenario cannot precisely reproduce.
- With a study sample consisting of 68% female participants aged 21 years on average, the study population is not representative of a normal cross-section of the general population all the while being consistent with a typical first-year medical class.
- The parameters chosen to evaluate the sufficiency of cardiopulmonary resuscitation performed by participants have not yet been validated scientifically, but they are identical to those proposed in recent European Resuscitation Council guidelines and comparable to those often reported by studies in various high impact journals.
- The emotional activation and its influence on the learning process is based on psychological research. The emotional stimulus intervention is based on theories and findings that are in accordance with this research. However, this study cannot provide an extensive overview of the influence of emotional activation on learning clinical skills. Further research is necessary to investigate the detailed psychological effects of emotional activation in this context.

INTRODUCTION

Background and importance

Cardiac arrest is one of the leading causes of death in Europe.[1] The survival rate relies heavily on the implementation of efficient cardiopulmonary resuscitation (CPR) and declines by 5.5% every minute that CPR is not provided.[2] Within CPR, external chest compressions (ECCs) are the key element, as they ensure forward blood flow and maintain heart and brain viability. ECCs are paramount to improving outcomes after in-hospital and out-of-hospital cardiac arrest. However, it is well known that the quality of ECCs is often insufficient, even when performed by professionals.[3] Therefore, teaching medical professionals and laypersons to perform efficient ECCs continues to be a challenge.[4 5] Teaching should lead to high BLS skills immediately after the training episode and for a long period thereafter. However, the current BLS training modalities are known to result in a rapid loss of BLS skills after training.[6] Which BLS teaching method results in the best short-term and long-term skills in laypersons and healthcare providers remains unknown. The 2010 and 2015 European Resuscitation Guidelines include using self-directed learning, a four-step training approach, feedback devices, frequent assessments and refresher courses.[7 8] There is no doubt that conducting assessments within training greatly supports the learning process.[9–12] At the same time, practical skills assessments can be very expensive and complex. Repeated testing is already widely applied to increase the retention of skills and knowledge.[13 14] Another promising approach to supporting the learning process is the use of emotional stimuli within BLS training. This training intervention has thus far been mostly unappreciated, despite the fact that there are several interesting indicators that suggest that emotional stimuli could amplify the effects of the learning process.[15–17] This goes back to neuroscientific research stating the modulating impact of emotions on attention and memory functions, especially if the stimulus refers to existing neuronal networks and implies social importance.[18–22] An important kind of memory triggered by emotional stimuli is the person's estimate of his or her ability to cope with an arising threat. This process is called secondary appraisal. It may reduce or heighten the emotional activation caused by the threat.[18]

We hypothesised that confronting medical students with a threatening situation—that is, the death of a same aged, outwardly healthy person—would impose said process. Students may conclude that their skills in dealing with such situations are insufficient, leading to heightened emotional activation. This arousal may prompt students to focus their attention on relevant features which can be modified in order to avoid the unpleasant outcome—that is, cardiac arrest—which could be achieved by sufficient BLS skills.

This focusing of attention caused by a strong affective reaction is accompanied by the rehearsal of the encoded version of this event in working memory. The reimagination of the events leading up to the emotional activation also enhances learning.[18] Students may thus analyse possible failures leading to the cardiac arrest, which would increase their motivation to learn coping strategies— in this case BLS skills.

We state that visual material depicting someone same aged suffering or even dying is to induce emotional activation,and connects to individual neuronal networks. Information on how to rescue someone in such a case is of vital significance. Introducing a person who did survive a life-threatening situation, for example, a sudden cardiac arrest, can also induce emotions of relief and empathy, which are important to social attachment. Providing an emotional stimulus through a media-based approach seems to be the most standardised method of implementing this type of intervention and has already been used in other educational studies.[17]

Goals of this investigation

The aim of this study was to evaluate the effects on the participants' CPR performance when implementing a video-based emotional stimulus versus announcing and conducting a practical assessment.

METHODS

Study design

This prospective interventional study was integrated into a two-part BLS training (figure 1). In a parallel group design, BLS performance (compression depth (CD) and compression rate (CR)) was tested prior to the training (baseline), shortly after completion (post) and voluntarily 6 months afterwards (follow-up).

Participants

All first-year medical students at the Medical School of Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen University in the winter term of 2012 during their first 3 weeks of studies were invited to participate in the study. We included all students regardless of previous medical knowledge of professional CPR.

Ethics approval, consent to participate and consent for publication

The participating students were informed that their performance and knowledge would be evaluated and used for scientific purposes as well as for publication and would not influence the evaluation of any of their medical studies. Written consent from each person was obtained prior to the baseline testing.

Intervention

After completing the individual precourse tests to measure the participants' CD and CR at baseline level, they received one of the following interventions (figure 1):

- Emotional stimulus group (EG): before the standardised training protocol was provided, a 2 min emotionally activating video sequence was shown to the participants. The video depicted the cardiac arrest and death of a professional football player aged 26 years who received insufficient measures taken by the first responder immediately after the incident. The second part of the video showed a 30 s interview with a survivor of cardiac arrest aged 22 years who received sufficient CPR, sharing personal thoughts and moments after being resuscitated successfully. The video did not contain any BLS training instruction.

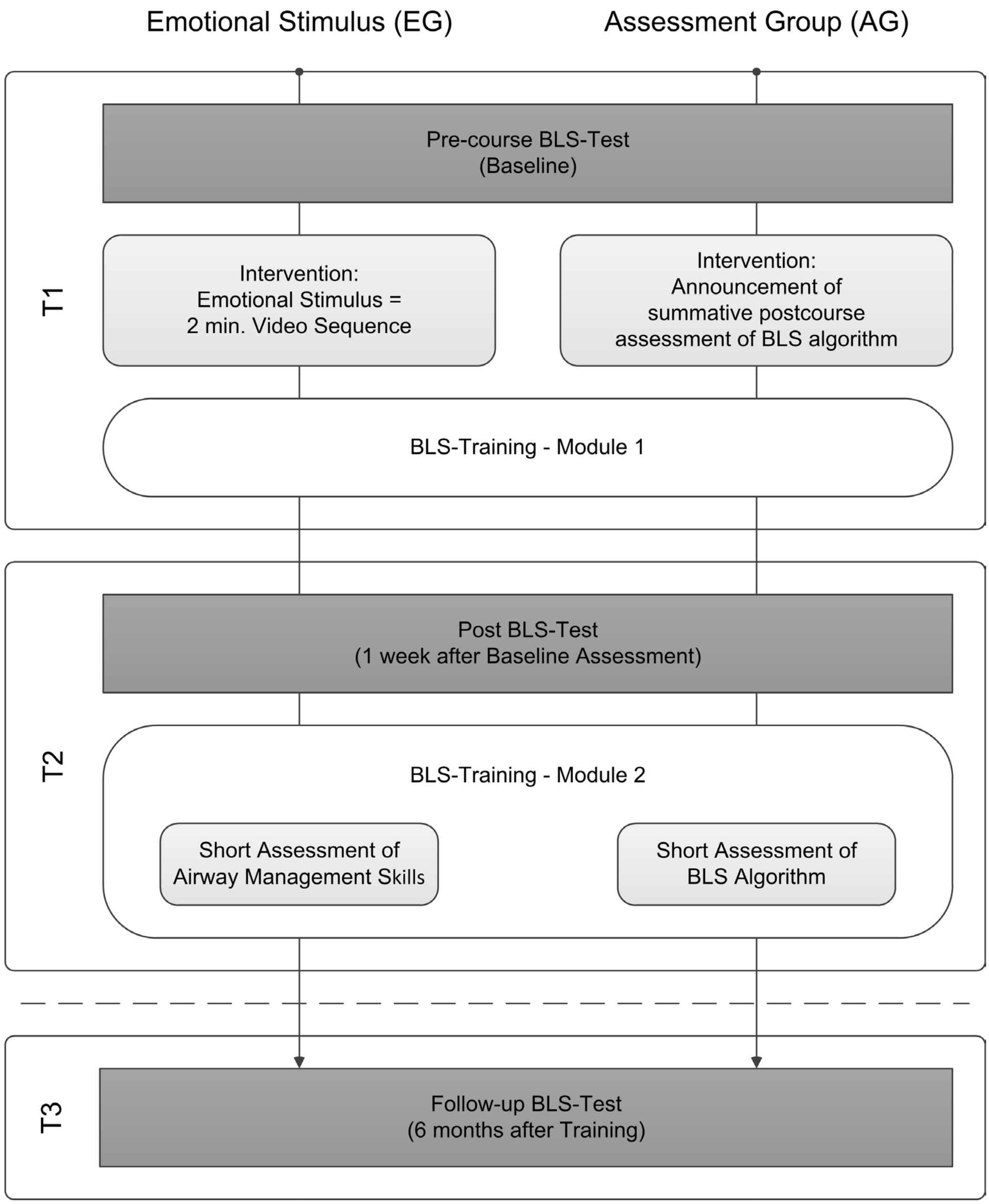

Figure 1 Study design of the study and the study protocol.

- Assessment group (AG): prior to their training, the course leader followed a standardised transcript to inform the participants about a practical assessment addressing the BLS algorithm within their second training module.

In terms of avoiding a Hawthorne effect, the EG was informed by the course schedule that the participants would be assessed in basic airway skills (eg, insertion of a laryngeal mask) or the application of basic rescue techniques (eg, safe management of the recovery position and splint devices), but not addressing the BLS algorithm. Both groups had their 'announced assessment' at the same time during their second training module.

Participants in both groups then worked through the same BLS training, for which they were gathered in groups of 10–12 students and taught by one instructor. To ensure identical instructions for all participants, a standardised and common teaching methodology called the '4-stage approach' (demonstration by instructor>explanation> instructor guided by learner>demonstration by learner/time to practice) was used in all groups.[23] Within these four steps, all students had the opportunity to learn BLS skills within the algorithm of the current European Resuscitation Council (ERC) guidelines. Throughout the course, emphasis was placed on the theory behind the standard algorithm, CPR techniques and assessments of the patient's airway. In addition to BLS theory and practical training, the principles of laryngeal mask-airway positioning and preparation for endotracheal intubation were provided, followed by practical training.

All participants received the same amount of time to train (course duration was 4 hours with adequate breaks), and equal support was provided by qualified tutors during the training. Tutors received a standardised training, including educational training, from an ERC-certified instructor. During the training and assessment sessions, three to four certified ERC instructors were present and supervised training and adherence to the study protocol. No feedback was given to the participants after the tests regarding each student's performance.

Outcomes

Precourse questionnaires

Prior to the intervention and training, all participants completed a questionnaire recording their demographic data and prior medical knowledge. Prior medical knowledge was defined as being qualified as a medical technician, paramedic or nurse (technician). Furthermore, they were asked about the personal significance of BLS, their motivation to provide BLS and confidence in their own skills in CPR in general and in the use of an automatic external defibrillator, and their responses were scored using a six-point Likert scale. As this study focuses on the performance outcomes, the latter questionnaire results are not reported.

Performance tests: outcome parameters compression depth and rate

Additionally, each student was individually tested before every BLS module following a testing protocol and unable to watch other participants' performances. Each procedure was conducted as a single-rescuer CPR scenario (ECCs combined with mouth-to-mouth ventilation) with a maximum duration of 180 s.

The test setup included a mannequin (Skillreporter Resusci Anne, Laerdal, Stavanger, Norway) laying supine on the floor, which was connected to Laerdal PC-Skill Reporting Software (V.1.3.0, Laerdal, Stavanger, Norway) for data acquisition. A certified ERC Advanced Life Support instructor supervised the performance and data recording.

The practical end points were tailored to the current guidelines.[7] As the CPR mannequin's detection range was limited to 60 mm, we defined a compression depth from 50 to 59 mm as adequate to be able to detect any deep compressions exceeding 60 mm. To review the success of the training, the average CD and CR of each participant as well as of the complete study group were calculated and compared.[24]

The tests of practical BLS skills measuring CD and CR at the three time points throughout the study protocol were different to the announced assessment of the BLS algorithm (AG) and basic airway or rescue technique skills (EG) performed once at the end of the second BLS module. The announced assessment was performed by following an adopted Objective Structured Practical Examination (OSPE) checklist without collecting quantitative data (CR or CD) addressing the different topics for both study arms.

Costs of the training methods

The costs of a BLS training module are difficult to calculate. Various reasons such as a lack of defined financial parameters for personnel, training materials as well as teaching space might contribute to that. Conducting this study, we have tried to illustrate a few important cost aspects:

Instructor costs are equal in both groups, since both received the same training and the same learner-instructor ratio.

The assessment costs of the AG group mainly comprise personnel costs of four instructors who evaluated the practical performance of the participants of this group. The instructors were qualified physicians or paramedics with costs of approximately €40–€60 per working hour.

Per instructor:

2 hours for the practical assessment (OSPE);
1 hour for preparation time;
2 hours gathering, analysing and announcing the data.

In summary, 20 hours human resource cost a €50 equal €1000 for the whole AG.

In comparison, the production of the semi-professional video used in the emotional stimulus group was approximately €500. There were no licensing costs for the video sequence since free publicly available materials and a self-recorded interview with a volunteer were used.

Theoretically, the video could be used repeatedly as an emotional learning stimulus. In contrast, the costly assessment has to be financed every time when training is provided and assessment announced.

Sample size

The sample size was determined based on data collected from several pilot studies, using a power calculation with the same observed primary outcomes. Considering the observed differences in mean compression depth (0.9 vs 4.9 mm) and rate (1.2/min vs 31.7/min) and assuming a power of 80% and a significance level of 5%, a sample size of at least 99 persons per group was needed.

A total of n=271 students were invited to participate in the study. In the end, n=236 complete (baseline) datasets consisting of questionnaires, performance data and written consent were included in the study. Due to dropouts, missing or incomplete data collection during the study protocol, the number of datasets included in the several analyses of postassessment and follow-up assessment is lower. From the voluntary follow-up test, we could only collect 65 participants' performance data (figure 2).

Randomisation

Prior to study implementation, an independent administrative advisor, who was blind to the study, randomised the students into groups of 10–12 persons. Allocation was performed following a sequence of random numbers that was generated with the support of a statistician. The

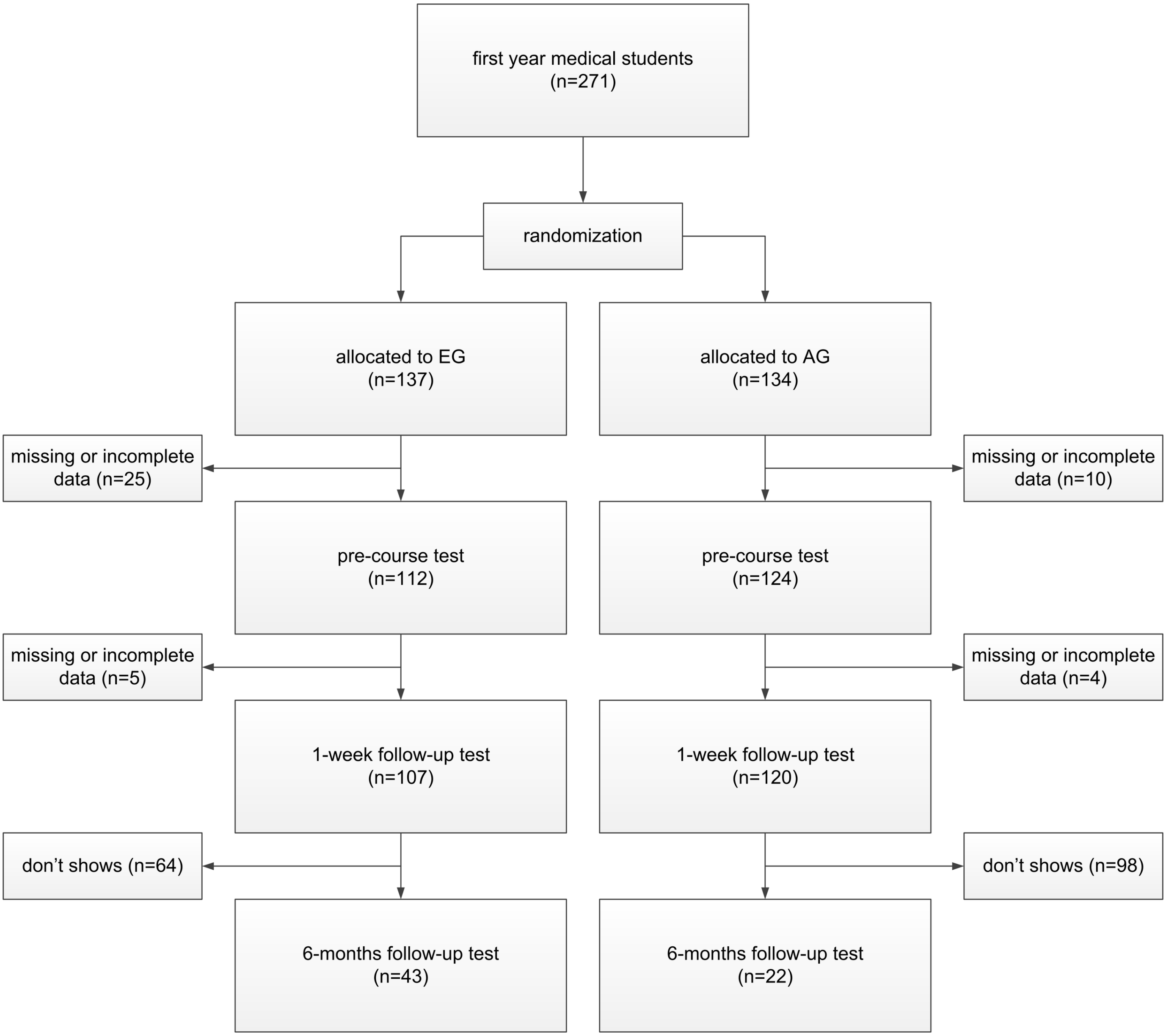

Figure 2 Flow diagram of how the study was performed and the participants were enrolled in the study protocol. AG, assessment group; EG, emotional group.

allocation was stratified by gender to ensure a homogenous ratio throughout all groups. The groups were allocated to the study arms using a balanced scheme taking the location (training room) and teacher into account.

Blinding

The participants were blinded to the two different interventions being used, and the individual evaluator was also blinded to the respective approach.

Statistical methods

In order to evaluate the baseline differences in the main end points, a univariate analysis of variance (ANOVA) was calculated. To account for the detected baseline differences, a repeated-measures ANOVA was performed for the postintervention main end points to investigate the effect of group (two levels: EG, AG), prior medical knowledge (two levels: with, without), time (three levels: baseline, after 1 week, after 6 months) and the resulting interactions. Appropriate contrasts were formulated and tested to compare the effects at a specific point of time within groups or between time points for one group. Chi-square tests were used to conduct group comparisons of dichotomous variables (eg, gender or sufficiency of CPR).

Continuous variables are summarised by the means and corresponding SD. Categorical data are presented as percentages. All tests were two-sided and were assessed at the 5% significance level. Due to the exploratory nature of the parallel study hypotheses, we did not adjust the significance level to account for multiple tests. The analyses were performed using IBM SPSS Statistics V.21 (IBM, Armonk, New York, USA).

Table 1 Demographic results: participants' characteristics derived from the precourse questionnaires regarding demographic data

Variable	EG (n=112)	AG (n=124)	P value
Age (years), mean±SD	21.0±4.1	21.1±4.2	0.95
Gender, n (%)			0.49
Male	39 (34.8)	37 (29.8)	
Female	73 (65.2)	87 (70.2)	
Prior medical knowledge, n (%)			0.47
With	15 (13.4)	21 (16.9)	
Without	97 (86.6)	103 (83.1)	

AG, assessment group; EG, emotional group.

RESULTS

Characteristics of study subjects

After excluding 35 subjects from the statistical analysis due to missing questionnaire data or written consent, 236 students were included (figure 2). The average age of both study groups was 21 years, and 160 (67.8%) were female. The groups did not differ significantly regarding gender, age distribution or prior medical knowledge (table 1).

Observed end points

Compression rate

There were no statistically significant differences between the two groups regarding CR and the baseline BLS test (P=0.33), with a mean CR of 104.8/min (±25.7) in the EG and a mean of 96.7/min (±28.0) in the AG. A subgroup analysis showed a significant difference (P<0.01, partial η^2=0.09) between participants with and without prior medical knowledge in the baseline BLS test. While the CR of participants considered to be laypersons was insufficient (M=97.1 ±26.7/min), participants with prior medical knowledge already met an average rate of 119.0/min (±22.5).

However, after further differentiation, only 9 (25.0%) participants with prior medical knowledge were within the range of 100–120/min, whereas 20 (55.6%) were above 120/min.

After the BLS training, both interventional groups showed significant improvements in CR, with an average value between 100 and 120/min on testing 1 week after the training (P>0.01). The EG now showed an average CR of 114.0/min (±16.0), while the AG had an average of 110.5/min (±15.2), not indicating a significant group difference (P=0.49) (table 2 and figure 3).

A significant difference was found regarding CR increases between participants with and without prior medical knowledge (P<0.01, part. η^2=0.04). While participants without prior experience in professional CPR training had now attained an average CR of 110.8/min (±15.9), participants with prior medical knowledge mainly showed a reduced SD while still meeting the ERC guidelines, with an average CR of 119.1/min (±11.9). At this time point, 17 (48.6%) participants were within the ERC guidelines, and 16 (45.7%) were still compressing too quickly.

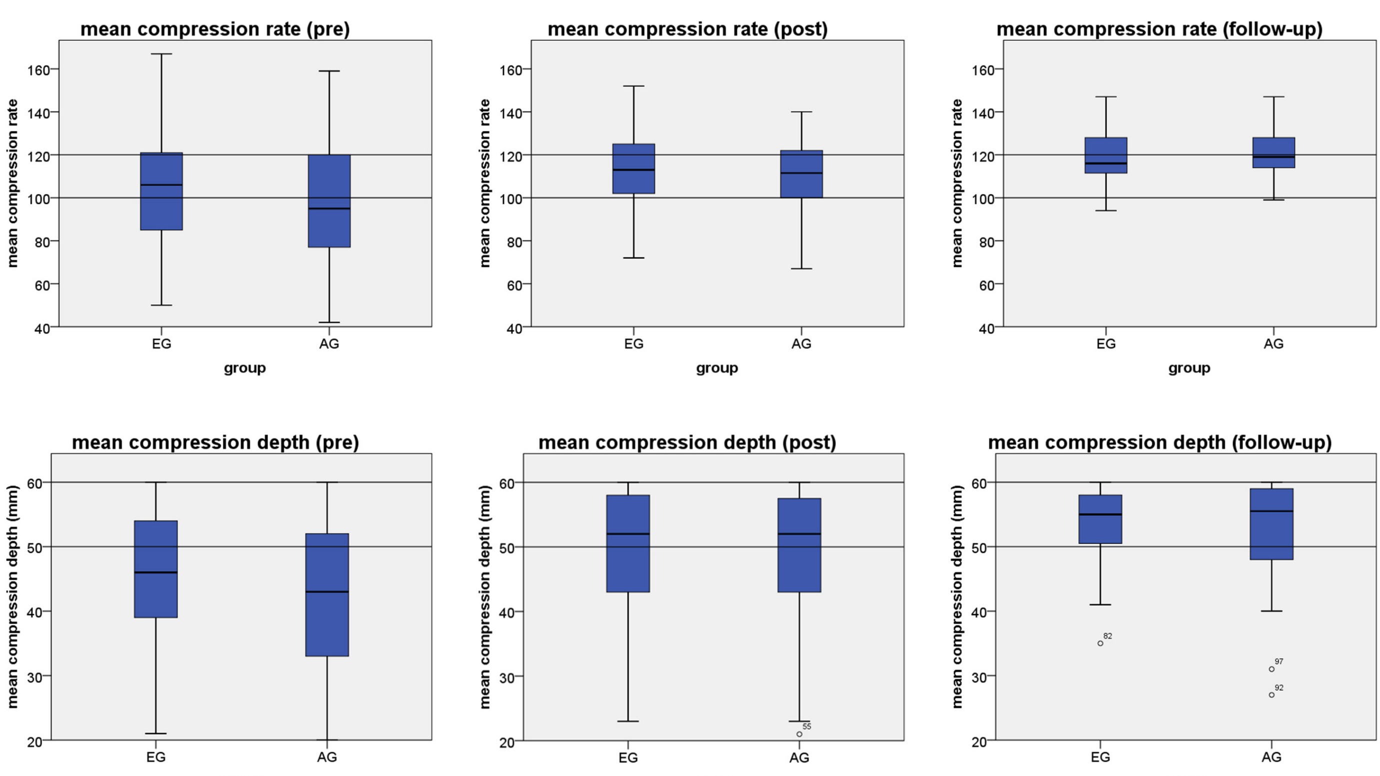

Figure 3 Box plots of the primary outcome parameters throughout the study protocol.

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Table 2 Main results of the study with the primary outcomes over the three time points. They are distributed following the study design

		Within-subjects contrasts				Group comparison						Prior medical knowledge comparison					
						EG		AG				With		Without			
		M (±SD)	N	P value	Part. η^2	M (±SD)	N	M (±SD)	N	P value	Part. η^2	M (±SD)	N	M (±SD)	N	P value	Part. η^2
Compression rate	Pre*	100.0 (±26.9)	221			104.8 (±25.7)	109	96.7 (±28.0)	121	0.33	–	119.0 (±22.5)	36	97.1 (±26.7)	194	<0.01†	0.09
	Post‡	112.1 (±15.6)	221	<0.01†	0.06	114.0 (±16.0)	104	110.5 (±15.2)	117	0.49	–	119.1 (±11.9)	35	110.8 (±15.9)	186	<0.01†	0.04
	Follow-up‡					119.0 (±12.3)	43	121.5 (±11.6)	22	0.47	–	123.7 (±14.9)	9	119.2 (±11.6)	56	0.48	–
Compression depth	Pre*	43.5 (±11.6)	222			45.4 (±10.9)	109	42.0 (±12.1)	122	0.17	–	48.4 (±8.5)	36	42.7 (±12.0)	195	<0.01†	0.03
	Post‡	50.0 (±8.8)	222	<0.01†	0.08	50.2 (±8.6)	104	49.8 (±9.1)	118	0.28	–	50.1 (±7.9)	35	50.0 (±9.0)	187	0.01†	0.03
	Follow-up‡					53.4 (±5.9)	43	52.2 (±9.4)	22	0.14	–	52.6 (±6.5)	9	53.0 (±7.4)	56	0.29	–

*Univariate ANOVA.
†Statistical significance at α-level 0.05.
‡Repeated measures ANOVA, prepost within-subjects contrast resp. interaction between time (within-subject factor) and group or prior medical knowledge (between-subject factors).
ANOVA, analysis of variance.

After 6 months, the volunteering participants from the EG showed an adequate mean CR according to the ERC criteria (119.0/min ±12.3), while participants from the AG performed slightly over the ERC recommendations on average (121.5/min ±11.6), however revealing no statistically significant difference (P=0.47).

Compression depth

In the baseline BLS test, most participants showed an insufficient performance (figure 3) with no significant differences between the two groups (P=0.17) (table 2). The mean CD was 45.4 mm (±10.9) in the EG and 42.0 mm (±12.1) in the AG. In the EG, 39 participants (34.8%) attained adequate depth versus only 31 (25.0%) in the AG.

Participants with and without prior medical knowledge differed significantly in CD (P<0.01, part. η^2=0.03), with both groups not meeting the ERC recommendations (with: 48.4 mm±8.5 vs without: 42.7 mm±12.0).

After completing the standardised BLS training, the average CD of both study arms met the ERC guidelines, which is a significant improvement (P<0.01). While there is no significant difference between the two groups (EG: 50.21 mm±8.6; AG: 49.8 mm±9.1; P=0.28), at this point, 52 participants (48.1%) in the EG and 56 (46.7%) in the AG met the required mean CD according to the ERC guidelines. There was a differential increase in CD from before to after the BLS training between participants with and without a prior medical knowledge, with both groups now meeting the actual ERC guidelines (with: 50.1 mm±7.9 vs without: 49.9 mm±8.9, P=0.009, part. η^2=0.03).

Six months after the training, the average CD of the volunteering participants in the two study arms still met the ERC guidelines without a significant group difference (EG: 53.4 mm±5.9; AG: 52.2 mm±9.4; P=0.14) (table 2). At this time point, 30 participants (69.8%) in the EG and 11 (50.0%) in the AG met the ERC guidelines with their mean CD.

DISCUSSION

The findings of this study confirm that both teaching approaches significantly improved the performance of CD and CR and led to comparable results in terms of the learners' ECC skills 1 week after the course. This result is of particular interest because of the superior cost-benefit ratio of the emotional stimulus, which included a low cost, time-efficient and simple video production. Compared with these advantages, the assessment group required a time-consuming and people-intensive design and enforcement to announce the practical assessment and implement individual testing after the training.

Although assessments are widely acknowledged to boost participants' performance in practical as well as cognitive outcomes, emotional stimuli are rarely used, and their effects remain mostly unknown. Former qualitative interview studies have shown that students place a greater learning emphasis on topics that will be tested later.[25] There is scientific consensus regarding the applicability of retesting as an adequate tool to enhance learning success.[13 14 26–28] While most publications address leading cognitive learning settings, there is emerging evidence that transferring the findings to the training of practical skills is possible.[9]

In this study, participants in the AG were able to meet recent guideline recommendations in terms of CR and CD 1 week and 6 months after the training. There are several theories explaining the 'testing effect'[10] regarding the 'assessment drives learning' phenomenon.[11] Announced assessments seem to create a greater ability to focus on the target of interest and to generate a directive character of themselves.[11 25] Larsen *et al* emphasised the positive influence of repetitive exposure to the newly acquired skill under assessment conditions.[12] The initial evidence regarding the usability of assessments related to BLS courses for students was provided by Kromann *et al* in 2009.[10] However, the positive effects of testing as an implementation tool that were shown in the intervention group immediately after completion of the course were no longer detectable 6 months after the course.[29] We were able to include a study population that was three times the size of the one investigated in the study mentioned above as well as to show that an announced assessment was helpful in the 6-month retention of CPR skills. A preferably small amount of time between the course and the actual testing seems to be fundamental for long-term outcomes[30]; this brief period was provided in this study, with only a week between the standardised training and the administration of the assessments.

In contrast to the elaborate setting needed to conduct an assessment following the course, an emotional stimulus in the form of a short video sequence is a cost-efficient and time-efficient alternative to improve participants' learning effects. Although there is scientific consensus regarding a better reproduction of emotionally occupied knowledge and skills[31 32] and a strong influence of emotions on information uptake and processing,[16] an emotional stimulus as a supportive learning method has hardly been examined. Several authors have highlighted a greater interest and intrinsic motivation for solving problems when individuals are emotionally activated.[33–35] Although the use of video and audio sequences to create greater personal involvement among participants is slowly increasing in some first-aid courses in Germany,[36] our study represents the first observation of this type of approach in BLS training and demonstrates that the described setting is a capable alternative for promoting students' practical performance in a time-efficient and cost-efficient manner.

A similar approach was described by Beckers *et al*,[15] who used an emotional stimulus by asking the participants to imagine that the mannequin was someone emotionally related to them combined with feedback following the performance.[15] The effects of emotional activation created in this study persisted even without the additional feedback and still created satisfying results in terms of

CD and CR 6 months after the intervention. This finding seems to be due to the higher and repetitive cognitive management of the topic.[37]

Overall, this study showed that both interventions were capable of supporting the acquisition of practical CPR skills and probably could help to improve long-term retention. The use of an emotional stimulus, with only a short 2 min video sequence, has provided convincing short-term results and offers a new time-efficient and cost-efficient way to improve future BLS teaching. These videos may draw greater attention to the fundamental importance of adequate ECC in rescuing people experiencing sudden cardiac arrest. Our findings indicate that this may also be valid for long-term results, but due to the high drop-out rate in the 6 months follow-up, this needs further investigation. As discussed above, emotional activation promotes learning by directing attention to the preceeding or accompanying events and to stimuli that are judged to be significant or predictive of the unpleasant outcome, that is, cardiac arrest.[18] It would thus be interesting to investigate whether the video-based stimulation leads to repeated reimagination of the events, thereby enhancing long-term memory of the event itself and possibly the acquired BLS skills.

The emotional stimulus method is very easily implemented in comparison to the assessment method because of the significantly lower effort and the simplicity of integrating this method into existing or newly created training approaches. Therefore, emotional stimuli offer the potential of being widely applied and could play a substantial role in increasing first-responder rates in regions with continuously low rates and an urgent need for cost-efficient training, for example, Germany.[38] Furthermore, as both participants with and without prior medical knowledge benefited from the BLS training combined with an emotional stimulus, this type of stimulus presents broad opportunities for the training of laypersons as well as of medical professionals.

In summary, this study indicates that both interventions are capable of supporting the acquisition of practical CPR skills and suggests their ability to achieve long-term skill retention. Emotional stimuli with short video sequences could be used exceedingly, and they offer an efficient method of improving BLS teaching and establishing a greater focus on the fundamental importance of ECC in rescuing people experiencing sudden cardiac arrest. In particular, the video sequence used in the emotional stimulus group with its excellent cost-benefit ratio provides broad opportunities for applicability in layperson BLS training as well as in professional refresher courses.

CONCLUSIONS

In summary, the results of this study underline the capability of both interventions to support the acquisition of practical CPR skills and to help gain long-term retention. The emotional stimulus approach offers efficient ways to improve BLS teaching in the future and to establish a greater attention for the fundamental importance of adequate external chest compression in the rescue of people being struck by sudden cardiac arrest. In particular, the video sequence used in this study with its excellent cost-benefit ratio opens wide possibilities of applicability in laypersons' BLS training as well as in professional refresher courses.

Contributors All authors have made contributions to the manuscript. KK contributed substantially to the acquisition, analysis and interpretation of the data and has written the manuscript. He is first author of this manuscript and thus all other authors agreed to his first authorship. RR, SKB and HS contributed substantially to the interpretation of the data and have critically revised the manuscript for important intellectual content. LS contributed substantially to the designing of this study, the statistical analysis and interpretation of the data. SS made substantial contributions to the planning and designing the study protocol, analysis and interpretation of the data, assisted to the writing of the manuscript as well revised it critically for important intellectual content.

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Patient consent Obtained.

Ethics approval The trial was approved by the ethics commission of the medical faculty of RWTH Aachen University (Chair: Professor Dr med. Günther Schmalzing) with the registration number: EK 249/12.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Extra data can be accessed via the Dryad data repository at http://datadryad.org/ with the doi: 10.5061/dryad.g8d74.

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