

Basic life support training programme in schools by school nurses

How long and how often to train?

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Abstract

Background: Cardiopulmonary resuscitation (CPR) training in schools, despite being legislated in Spain, is not established as such within the subjects that children are taught in schools.

Objective: to evaluate the acquisition of CPR skills by 11-year-old children after a brief theoretical-practical teaching programme taught by nurses at school.

Methods: 62 students were assessed in a quasi-experimental study on 2 cohorts (51.4% of the sample in control group [CG]). In total, 2 sessions were given, a theoretical one, and a practical training for skill development in children, in which the CG performed the CPR in 2-minute cycles and the intervention group in 1-minute cycles. The anthropometric variables recorded were weight and height, and the variables compression quality and ventilation quality were recorded using the Laerdal ResusciAnne manikin with Personal Computer/Wireless SkillReport.

Results: The assessment showed better results, in terms of BLS sequence performance and use of automated external defibrillator, in the CG and after training, except for the evaluation of the 10-second breathing assessment technique. The quality of chest compressions was better in the CG after training, as was the quality of the ventilations. There were no major differences in CPR quality after training and 4 months after the 1-minute and 2-minute training cycles.

Conclusions: 11-year-old children do not perform quality chest compressions or ventilations but, considering their age, they are able to perform a BLS sequence correctly.

Abbreviations: AED = automated external defibrillator, CG = control group, CPR = Cardiopulmonary Resuscitation, CPR-B = basic CPR, EMS = Emergency Medical Services, ERC = European Resuscitation Council, IG = intervention group.

Keywords: basic life support, cardiopulmonary resuscitation, children, school, school nursing

1. Introduction

BLS training is the key element to increase cardiopulmonary resuscitation (CPR) performed by bystanders. Following this

principle, BLS training for children in school age is one of the most important steps to increase the rate of CPR performed by bystanders and, in consequence, increase survival.^[1]

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SM-I and MG-S authors contributed equally to this work.

The authors have no conflicts of interest to disclose.

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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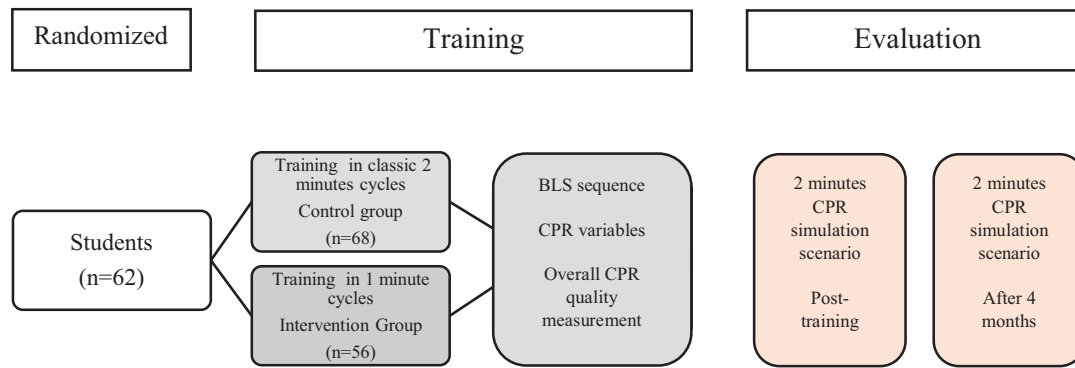


Figure 1. Flowchart of the study design.

Since 1992 the European Resuscitation Council (ERC) and the American Heart Association have committed to the inclusion of basic CPR teaching in the official school curriculum.^[2] The research “Kids Save Lives” showed that in 2015 only 5 countries had legislated the inclusion of the teaching of CPR in the school curriculum, and in 16 countries this was only a recommendation.^[3] In Spain, the implementation in the school curriculum was legislated in 2016 (Royal Decree 126/2014).^[4] In spite of this, the teaching of basic cardiopulmonary resuscitation techniques in our country is not standardised, although numerous projects have been developed with published results.^[5,6]

There are many unanswered questions, such as the age at which basic CPR (CPR-B) should be taught, the contents that should be explained considering the children’s age, how often this knowledge should be taught, and which methodology would be the most appropriate. Differences can be found in the literature regarding the type of training, the necessary support material, the instructors’ profile, the duration of the training, and the period of repetition of the training.^[7–11]

Many other questions are already being answered, such as that the age at which this training is started, the anthropometric characteristics and the physical condition of the performer are determining factors for the quality of compressions, establishing 50 kg and/or 12 years to 13 years as the barrier to perform high quality chest compressions.^[12] At 6 years of age, children can learn the basic CPR sequence and activate the survival chain.^[13]

There is no doubt regarding the fact that CPR-B training in schools will allow, in the future, that the vast majority of the population have knowledge on CPR-B which, complemented by telephone instructions from the Emergency Medical Services (EMS), will enhance the CPR performed by bystanders as well as its quality, and consequently, this will increase the survival rate of out-of-hospital cardiac arrest.

1.1. Objective

To compare 2 nurse-led training strategies (classic 2 minutes length training cycle VS 1-minute length training cycle) in terms of learning and acquisition of CPR skills in 11-year-old children at school.

2. Material and methods

2.1. Design

A quasi-experimental study on 2 cohorts was carried out with a convenience sample which was approved by the Ethics

Committee of the University of Leon. The students’ parents were informed and gave their consent.

The sample corresponds to 2 schools in the province of Leon (Spain), and the distribution in the control or intervention group was randomised for classes. The study design consists of 2 parts (Fig. 1).

In the first part, nurses trained the children for 2 sessions of 50 minutes each:

- (1) In the first session, the theoretical content was taught.
- (2) In the second session, the practical training was carried out with a manikin that had a quality real-time feedback system for chest compressions and an Automated External Defibrillator (AED). The manikin/student ratio was 1:5, and the teacher/student ratio 1:10.

Each student performed 6-minute compressions (Control Group [CG] in 2-minute CPR training cycles, and the Intervention Group “[IG],” in 1-minute CPR training cycles) in 3 sessions of 20 minutes each. The sessions were: continuous chest compressions on a manikin with real-time feedback, CPR sequence and chest compressions on a simple manikin, and execution of the complete sequence of basic CPR and AED on a simple manikin.

In the second part of the study, students were evaluated through 2 BLS simulation-based scenarios. Evaluations were performed just after training and 4 months later.

2.2. Inclusion criteria

The inclusion criteria were: children enrolled in the centre, parents who agreed to participate in the study, and the absence of physical or mental disability that prevented them from performing CPR correctly.

2.3. Exclusion criteria

Children who had incomplete data or did not attend one or more sessions.

2.4. Variables

The anthropometric variables recorded were weight and height, and the variables “quality compression” and “quality ventilation” were recorded using the Laerdal ResuscAnne manikin with personal computer/wireless skill report.

2.5. Training

The CG trained in 2-minute cycles and the IG in 1-minute. Evidence shows that children get tired during CPR and the quality of compressions decrease in the second minute.^[12]

2.6. BLS Variables

The recorded variables regarding compressions were: the average depth of compressions and the percentage of compressions at the correct depth (5–6 cm), the percentage of compressions with full re-expansion, the average rate and the percentage of compressions at the correct rhythm (100–120 com/min).

The variables of the registered ventilations were: the total number of ventilations, tidal volume due to insufflation in ml, the percentage of effective ventilations with visible chest elevation, and the percentage of ventilations with adequate volume, excessive, and inappropriate volume.

2.7. BLS Quality Variables

The quality values of the CPR-B are extracted from the registered parameters. The compression quality value was calculated using the formula (continuous compression percentage+ correct depth percentage+ correct rhythm compressions)/3, and the ventilation quality was established when reaching between 500 to 600 ml. The overall quality of the CPR formula (compression quality value + ventilation quality)/2 was used.

The quality standards proposed by the European Resuscitation Council (ERC) in its 2015 recommendations have been used,^[14] and the arbitrary value of 70% used in the literature has been applied to indicate the quality of the manoeuvres.^[15]

2.8. Perceived effort scale

After each evaluation, children have reported the perceived exertion using the modified 10-point Borg scale.^[16]

2.9. Randomization

It was done by cluster randomization. Cluster was defined as the school predefined classrooms. Randomization was done by Excel software RAND formula.

2.10. Statistical analysis

The demographic and anthropometric variables of the sample (age, height, weight, body mass index [BMI]) were expressed by absolute and relative frequencies. Compression quality variables were expressed with measures of central tendency and dispersion [mean (Standard Deviation) (SD)]. The Pearson's chi-squared statistical test was used to study the association between categorical variables. However, the McNemar's statistical test was used to contrast the hypothesis of equal proportions of the "evaluation after training vs evaluation after 4 months" dichotomy. For the quantitative variables' assessment, normality was checked by using the Kolmogorov-Smirnov test. The independent averages comparison was carried out by means of the Student *t*-test or the Mann-Whitney *U* test, while the comparison of those related variables was carried out through the Student *t*-test or the Wilcoxon test. Regarding the quality of the resuscitation, an analysis of the variance was performed using repeated measures ANOVA.

This analysis integrated 2 factors: the first one, an inter-subject factor (1 minute versus 2 minutes of practical training); the second one, an intra-subject factor (immediate evaluation of the variables after training versus evaluation after 4 months). The data processing and analysis was carried out using the statistical package SPSS v.21.0. A significance level of $P < .05$ was established.

3. Results

The study sample was 62 school students, divided into a control and an intervention group (51.4% and 48.6%). 56.8% of them were girls, being the average age 11.86 (SD: 0.54) years, average height 149.60 (SD: 7.00) cm, average weight 45.00 (SD: 10.88) kg, and a BMI of 19.94 (SD: 3.79) kg / cm². The groups were homogeneous in terms of sex, age, weight, height, and BMI.

3.1. BLS & AED sequence

Table 1 and Figure 2 show the sequence data based on the practical skills training time (IG vs CG). Differences were observed when assessing the 10-second breathing assessment technique (61.1 vs 15.8%; $P < .000$), the way of pinching the nose (86.1 vs 100%; $P = .025$), and in the correct placement of AED patches (83.3 vs 100%; $P = .011$).

When comparing the sequence completion data after immediate training and after 4 months, a significant decrease in the percentage of students who secured the scene [95.9 vs 47.7%; $P < .001$], who checked for response [98.6 vs 49.9%; $P < .001$], who opened the airway [86.5 vs 43; $P < .001$], who checked breathing [94.6 vs 47%; $P < .001$], who called 112 [84.2 vs 40.9%; $P < .001$], and who initiated BLS (30:2) [58.1 vs 45.6; $P < .001$] was observed.

When analysing the different steps of the AED application sequence, after immediate training and after 4 months, differences were observed in the percentage of students who requested AED [83.2 vs 41.6; $P < .001$], who followed the instructions [95.3 vs 47.7%; $P < .001$], who placed the AED patches adequately [91.3 vs 45.6; $P < .001$], who performed chest compression while AED was charging [61.7 vs 30.9; $P < .001$], and who continued to perform chest compressions after the effective shock was delivered [95.3 vs 47.7%; $P < .001$].

3.2. Quality of the Chest compressions

Table 2 and Figure 3 show the results of the parameters that determine the quality of the chest compressions. Statistical differences were found in favour of the CG, as compared to the IG regarding the following variables: the average percentage of continuous chest compression [65.65% (SD: 12.22) vs 57.89% (SD: 16.34); $P = .024$], the mean depth [27.08% (SD: 7.89) vs 22.17% (SD: 7.65); $P = .009$], and the average percentage of correct chest compression [0.62% (SD: 2.03) vs 0.31% (SD: 1.83); $P = .012$].

When analysing the quality variables of compression after immediate training and after 4 months, an increase in the mean percentage of continuous chest compression and of the average percentage of chest compressions at the correct depth of the chest [0.52% (SD: 2.04) vs 2.75% (SD: 8.22); $P = .012$] were found.

3.3. Quality of the ventilation

Regarding the quality of the ventilations (Table 2 and Fig. 3), the results showed significant differences in favor of the CG vs the IG

Table 1
BLS sequence variables.

		After training			After 4 mo		P
		1 min	2 min	P	Total (mean)	Total (mean)	
1	Safe approach	97.4	94.7	.521	95.9	47.7	.000
2	Checks consciousness	100	97.4	.514	98.6	49.9	.000
	<i>Asks and shouts</i>	100	92.1	.130	95.9	47.7	.000
	<i>Shakes it</i>	97.2	92.1	.328	94.6	47	.000
3	Opens airway	86.1	86.8	.597	86.5	43	.000
	<i>Head tilt/chin lift</i>	80.6	78.9	.547	79.7	39.6	.000
4	Checks breathing	97.2	92.1	.328	94.6	47	.000
	<i>Holds head tilt/chin lift</i>	83.3	77.8	.383	78.4	38.9	.000
	<i>See-Hear-Feel</i>	97.2	89.5	.196	93.2	46.3	.000
	<i>Assesses in 10 seconds</i>	61.1	15.8	.000	37.4	18.8	.000
5	Calls 112	86.1	78.9	.308	84.2	40.9	.000
	<i>Asks for AED</i>	77.8	89.5	.147	83.8	41.6	.000
6	Performs 30:2	88.9	94.7	.311	58.1	45.6	.000
	<i>Opens airway</i>	80.6	84.2	.457	82.4	48.9	.000
	<i>Clamps nose</i>	86.1	100	.025	91.9	45.6	.000
	<i>Insufflates 1 second</i>	100	97.4	.514	98.6	49.0	.000
7	Turns AED on	94.4	100	.233	97.3	48.3	.000
	<i>Follows Instructions</i>	97.2	94.7	.521	95.4	47.7	.000
	<i>Place pads</i>	83.3	100	.011	91.9	45.6	.000
	<i>Chest compressions while charging</i>	52.8	71.1	.084	62.2	45.6	.000
	<i>Effective discharge</i>	100	100	1	100	100	1
8	Continue CPR	100	92.1	.130	95.9	47.7	.000

AED=automated external defibrillator, BLS=basic life support, CPR=cardiopulmonary resuscitation.

regarding both the immediate evaluation after training and the evaluation after 4 months as for the average percentage of ventilations that did not reach the appropriate volume (62.91% [SD: 39.53] vs 28.51% [SD: 38.29]; $P < .001$) and (47.47% [SD: 40.76] vs 21.07% [SD: 32.03]; $P = .006$) respectively.

3.4. CPR quality

The different ways of measuring the overall quality of CPR (Table 3) did not show significant differences regarding the

quality of compressions after the immediate evaluation, as compared to the evaluation after 4 months [42.23% (SD: 14.49) vs 41.60% (SD: 12.19); $P = .152$], when only one student performed quality compressions.

3.5. Perceived exertion

The perceived exertion after the immediate post-training evaluation and after 4 months did not show significant differences

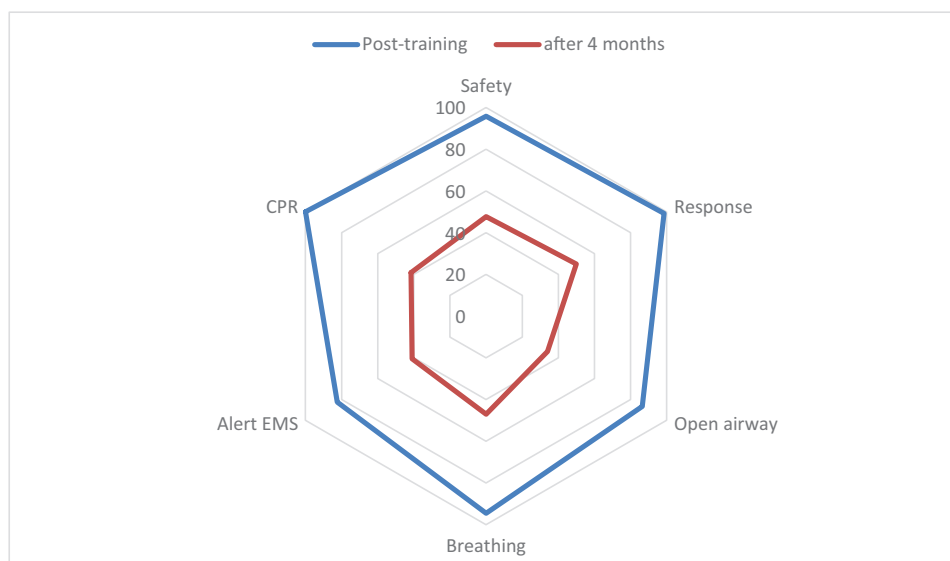


Figure 2. Percentages of sequence performance according to the moment of evaluation.

Table 2
Analysis for the CPR variables.

	Training duration	Evaluation								
		After training (E1)			After 4 mo (E2)			E1 vs E2		E1 vs E2 Repeated measurement
		Minute	Mean (SD)	<i>P</i>	Overage Mean (DE)	Mean (SD)	<i>P</i>	Overage Mean (DE)	<i>P</i>	<i>P</i>
Chest Compression										
CCP	2	65.65 (12.22)	.024	62.45 (15.11)	67.47 (9.08)	.771	67.45 (9.50)	.038	.165	
	1	57.89 (16.34)			66.82 (8.24)					
HP	2	96.73 (15.41)	.224	97.98 (11.70)	97.00 (9.47)	.229	94.34 (18.94)	.224	.173	
	1	99.72 (1.3)			90.50 (26.69)					
MD	2	27.08 (7.89)	.009	25.15 (8.24)	28.76 (10.05)	.106	26.80 (9.15)	.138	.832	
	1	22.17 (7.65)			24.93 (7.92)					
CDcP	2	82.41 (27.06)	.829	87.83 (21.45)	87.38 (20.67)	.079	89.65 (17.62)	.829	.894	
	1	93.33 (15.58)			94.21 (7.25)					
CDP	2	0.62 (2.03)	.012	0.52 (2.04)	4.12 (10.58)	.177	2.75 (8.22)	.012	.086	
	1	0.31 (1.83)			1.39 (4.27)					
CRC	2	42.97 (34.52)	.318	39.44 (32.90)	32.03 (30.98)	.897	30.55 (30.15)	.204	.479	
	1	35.47 (28.94)			31.00 (30.54)					
RM	2	114 (12.96)	.402	113.56 (15.79)	113.76 (18.52)	.922	114.08 (19.23)	.996	.699	
	1	111.31 (17.87)			114.26 (20.58)					
Ventilation										
MV	2	409.91 (190.56)	.722	431.56 (279.187)	400.79 (221.87)	.124	453.27 (281.58)	.532	.359	
	1	433.69 (344.68)			517.21 (337.92)					
VEV	2	18.67 (27.00)	.287	23.11 (33.82)	19.12 (29.24)	.014	29.41 (36.75)	.152	.129	
	1	27.03 (37.55)			42.86 (41.30)					
AVV	2	13.06 (15.43)	.566	14.92 (21.49)	21.59 (26.80)	.285	18.89 (25.89)	.487	.235	
	1	16.00 (25.87)			14.50 (24.43)					
NAVY	2	62.91 (39.53)	.000	46.27 (42.43)	47.47 (40.76)	.006	35.78 (38.82)	.091	.555	
	1	28.51 (38.29)			21.07 (32.03)					

AVV=appropriate volume ventilations, CCP=continuous compression percentage, CDcP=correct decompression percentage, CDP=correct depth percentage, CRC=correct rhythm compressions, HP=hands position, MD=mean depth, MV=mean volume applied, NAVV=non appropriate volume ventilations, RM=rhythm of compressions per minute, VEV=ventilations exceeding the maximum volume.

(3.60 [SD: 1.61] vs 3.43 [SD: 1.37]; $P=.503$). Neither when the training time of practical skills (CG vs. IG) was compared regarding the immediate post-training evaluation (3.88 [SD: 1.66] vs 3.25 [SD: 1.51]; $P=.165$), and the evaluation after 4 months (3.52 [SD: 1.48] vs 3.32 [SD: 1.25]; $P=.587$).

4. Discussion

Our study shows that children who have followed a short training programme and have been taught by nurses learn the basic life support sequence, with a success rate similar to the one recorded on adults, as well as CPR skills according to their age. It is observed that, over time, the sequence steps cease to be performed and the compression and ventilation skills are maintained.

The ERC recommends to start teaching BLS at 12 years or even earlier.^[17] Although they are not able to perform quality chest compressions due to their anthropometric characteristics,^[12] they have the cognitive ability to learn, retain knowledge and reproduce learned manoeuvres.^[18] We have selected this age group for being the group immediately below the recommendations stated in the guidelines. The subjects of our study correspond to the 86.4% percentile of weight and height for their age.

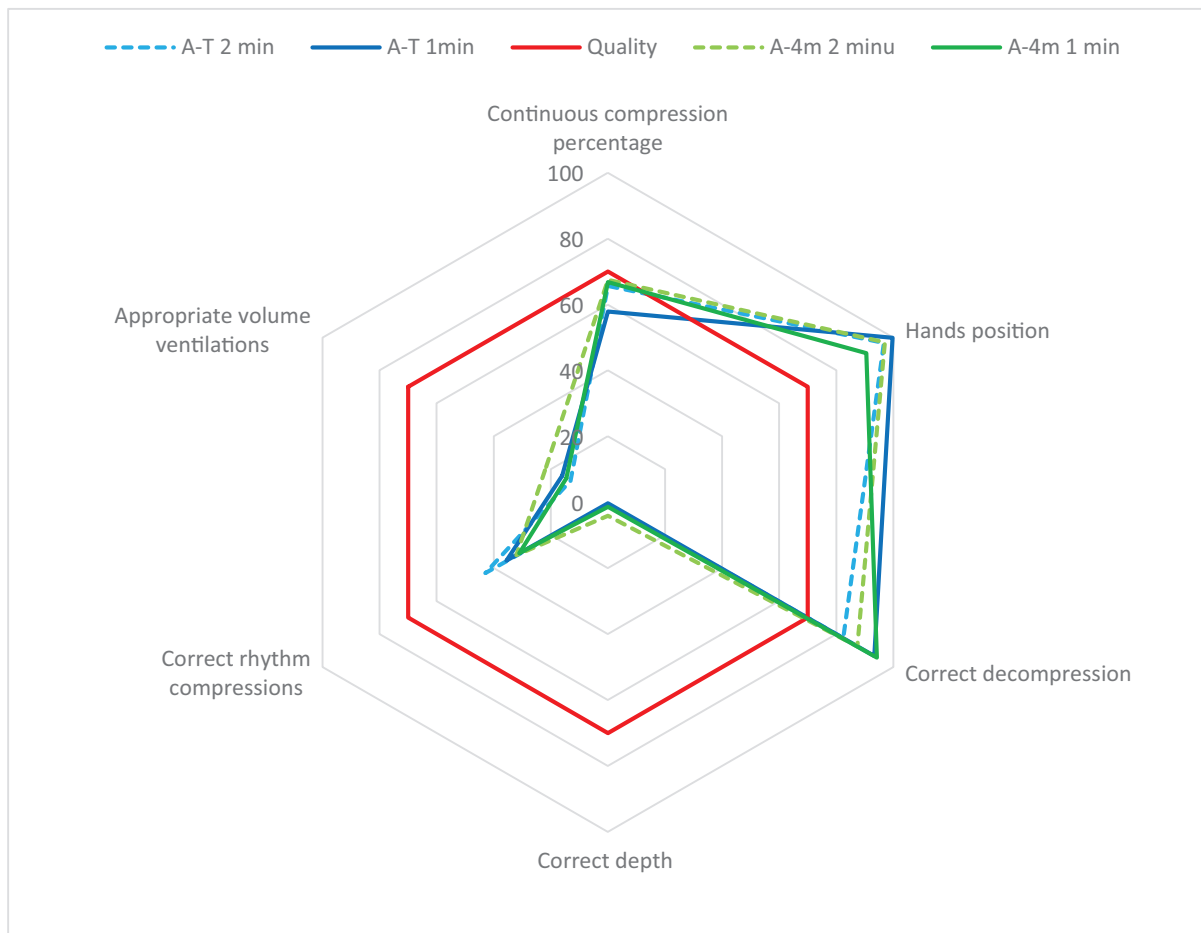
The trainers in our research are nurses with BLS knowledge who have previously demonstrated CPR knowledge and performance skills. The reason why the nursing staff was selected as trainers was for their presence in schools and primary care,

being education and health promotion functions attributed to this group of workers.

The methodology used in our study was adjusted to the teaching schedules, not exceeding 2 hours of training, and was both theoretical and practical, as suggested by the ERC.^[17] Feedback devices were used as a teaching aid, with proven useful benefits, and as a system for measuring the quality of compressions and ventilations.^[19,20]

Our study shows that, with a brief theoretical-practical training, 11-year-old students are able to learn the steps needed for the basic life support sequence and how to activate the survival chain with results similar to previous studies.^[18,21,22] The percentage of children who perform the different steps of the sequence in our study drops after 4 months, a fact observed in another study.^[23] In both studies, about 50% of the children made the call to the EMS correctly after 4 months, which was very important since the telephone operator was able to guide the children and remind them of the different sequence steps in order to perform them correctly. Therefore, it is very important to place particular emphasis on the importance of calling the EMS during the training.

A relevant fact found during the study corresponds to the differences found in certain steps of the sequence depending on the type of training. Although this appears to have no influence on the sequence itself and the trainers are the same in the different sessions, it may be thought that students attach more importance to some steps than others. Therefore, the trainer must effectively highlight the most relevant steps.



A-T: After training; A-4T: after 4 months

Figure 3. Percentages of training-related quality CPR variables.

The compression quality results found in our study show that children are not able to compress the chest to the recommended depth, as compared to other studies performed with the same age range.^[12,21,23,24] However, they do place their hands in the right place and decompress the chest correctly, coinciding with a previous study.^[25] In addition, in the correct decompression of the chest and the average rhythm, the study of He et al^[24] presents very similar data.

Although the ERC suggests that children only do chest compressions, our study, as do similar ones,^[21,24–26] shows that

the mean insufflated volume is lower when performed by children. In our study, the percentage of insufflations with adequate volume is greater at 4 months after training, and this causes an increase in the overall results regarding quality of compressions.

In our study, it was also observed that CPR skills do not deteriorate over time, although it is true that many of the analysed variables do not reach the random figure of 70% accepted by the scientific community to determine quality. Regarding the variables in which children reach quality, such as correct hand

Table 3

Overall CPR quality measurement.

Training duration	Evaluation after training (E1)			Evaluation after 4 mo (E2)			E1 vs E2 Repeated measurement	
	Mean (SD)	P	Overall mean (SD)	P	Overall mean (SD)	P	P	
QCC	2	42.45 ± 16.27	.897	42.23 (14.49)	41.09 (13.48)	.726	41.60 (12.19)	.697
	1	41.96 ± 12.27			42.20 (10.67)			
QCPR	2	27.95 (9.64)	.606	28.70 (12.49)	49.84 (15.44)	.163	46.75 (19.12)	.067
	1	29.61 (15.41)			43.00 (22.54)			
E-QCPR	2	49.84 (15.44)	.163	46.75 (19.12)	42.64 (16.77)	.846	43.04 (17.15)	.163
	1	43.00 (22.54)			43.50 (17.90)			

E-QCPR=Effective Cardiopulmonary Resuscitation, QCC=Chest Compression Quality, QCPR=Global CPR quality.

position, percentage of continuous compressions and complete decompression of the chest, they are still correctly performed after 4 months.

The type of training in cycles of 1 or 2 minutes does not show any real improvement in CPR quality after immediate training or after 4 months, and there is no observed relation when looking at students' effort.

The main limitations of our study are that, so far, very few studies have used the same chest compression assessment tools, and few studies have analysed the quality of the ventilations, thus making it difficult to compare results.

The trainers and assessors were the same during the whole process. In addition, in order to minimise observation bias, assessment of the different sequence steps and of the used technique was carried out by following a standardised template which included the agreed criteria beforehand.

Randomization was done by clusters to reduce information bias. This way, the risk of children in the same class receiving different training was avoided.

Other limitation is the sample size, is small and the generalization is not possible.

5. Conclusion

It can be concluded that CPR training in cycles of 1 or 2 minutes has no influence on its quality in the short or medium term, nor does the feeling of perceived effort vary, being qualified by the children as "soft."

11-year-old children do not perform quality chest compressions or ventilations but, considering their age, they are able to perform a BLS sequence correctly. In addition, we conclude that re-training and/or re-assessment should be performed in periods shorter than the 4 months originally established.

Author contributions

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