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Research Article

Effectiveness of a CPR Training Program Using Medium and Low Fidelity Simulators in Primary School Students for the Acquisition of Learning Skills

Yrene Esperanza Urbina-Rojas[1], Angel López-González[2,3*], Maritza Asunciona Purizaga-Sorroza[4], Miriam Arredondo-Nontol[1], Jaime López-Tendero[5], Joseba Rabanales-Sotos[2,3], Zoila Esperanza Leitón-Espinoza[6]

[1]Health Sciences Faculty, National University of Tumbes (Universidad Nacional de Tumbes), Tumbes 24001, Perú.

[2]Department of Nursing, Physiotherapy and Occupational Therapy, Facultad de Enfermería de Albacete, University of Castilla-La Mancha (Universidad de Castilla-La Mancha/UCLM), Campus Universitario s/n, 02071 Albacete, Spain.

[3]Group of Preventive Activities in the University Health Sciences Setting, University of Castilla-La Mancha (Universidad de Castilla-La Mancha/UCLM), Campus Universitario s/n, 02071 Albacete, Spain.

[4]Social Sciences Faculty, National University of Tumbes (Universidad Nacional de Tumbes), Tumbes 24001, Perú.

[5]Castilla-La Mancha Health Service (Servicio de Salud de Castilla-La Mancha/SESCAM), University of Castilla-La Mancha (Universidad de Castilla-La Mancha/UCLM), 02071 Albacete, Spain.

[6]Nursing Faculty, National University of Trujillo (Universidad Nacional de Trujillo), Trujillo 13011, Perú.

[*]**Corresponding author:** Angel López González**,** Facultad de Enfermería de Albacete. Universidad de Castilla-La Mancha. Edificio Benjamín Palencia 02071 Albacete, Spain

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Abstract

The objective of this study was to determine the effectiveness of a cardiopulmonary resuscitation (CPR) training program using medium and low fidelity simulators in primary school students for the acquisition of learning skills. Quasi-experimental pre-post study, carried out at public Elementary school in Perú. **Results:** nine-two students from third-to-sixth grades included, participated in this study. Assessments of knowledge, attitudes and skills were carried out immediately after the training and at 30 days. 81% passed the knowledge test immediately after training and 87% after 30 days. With the three simulators and in both measurements, the majority passed the practical skills test, with the obtained result being better in the second measurement. After the training, 96.74% felt capable of facing CPR and all at 30 days post-training. Finally, the developed training program was shown to be effective regardless of the used simulator. **Conclusions:** Training in CPR must begin at an early age, with age-appropriate methodologies and materials, economic possibilities and accessibility to training spaces, with periodic recycling. A CPR training program aimed at boys and girls is shown to be effective in terms of the knowledge acquisition skills, and perception of positive attitudes towards its performance using medium and low fidelity simulators.

Keywords: Basic cardiac life support; Heart massage; First aid; Health knowledge; Attitudes; Practice

Introduction

Less than 10% of patients with Out-Of-Hospital Cardiac Arrest (OHCA) survive in good condition. This can be reversed by teaching basic Cardiopulmonary Resuscitation (CPR) to the entire population from an early age. All that is needed is two hands and proper teaching procedures [1-3].

Organizations such as American Heart Association (AHA) and the European Resuscitation Council (ERC) regulate for the simplification and universality of the basic RCP, and for that, implementing initiatives like "CPR Hands-Only™" [4,5]. Consequently, current guidelines recommend rapid application of chest compressions by anyone, until the arrival of Emergency Medical System (EMS) [6].

New methodologies and didactic materials have been proposed in the teaching of CPR to improve training and retention of what has been learned. However, it remains to be defined which is the best material and method for training each population group [7,8]. For this reason, new training strategies are being explored with more active, attractive and economically accessible materials and methods [9,10].

Improving the willingness of citizens to perform CPR, taking into account non-technical skills and the cognitive and emotional aspects that influence citizen behavior should be another objective to achieved [11,12]. The challenge is to know how to train the largest population group in the shortest possible time and with the optimal use of resources [13].

The declaration *Kids Save Lives* of the World Health Organization, recommends teaching CPR to a school-children from the age of 12 [14], although it is possible that it is not necessary to wait at that age to start teaching content related to basic life support (SVB). The teaching of CPR in early childhood, primary and secondary schools is a strategy for the future, valued positively by those responsible for Health and including it in curricular programming promoting "Health Schools", it would facilitate the teaching organization, being its teaching more efficient and effective when reaching a large group, that of school-children [15,16], that they are very receptive to learning CPR and that they will be teaching multipliers among their family and friends [14,17]. This conception of CPR teaching has doubled the number of OHCA´s attended by the population and tripled survival together with other improvements in care [17].

Consequently, this study aimed to determine the effectiveness of a training program for the acquisition of cognitive, attitudinal competencies and CPR skills, using medium and low fidelity simulators in students of a public Elementary School.

Materials and Methods

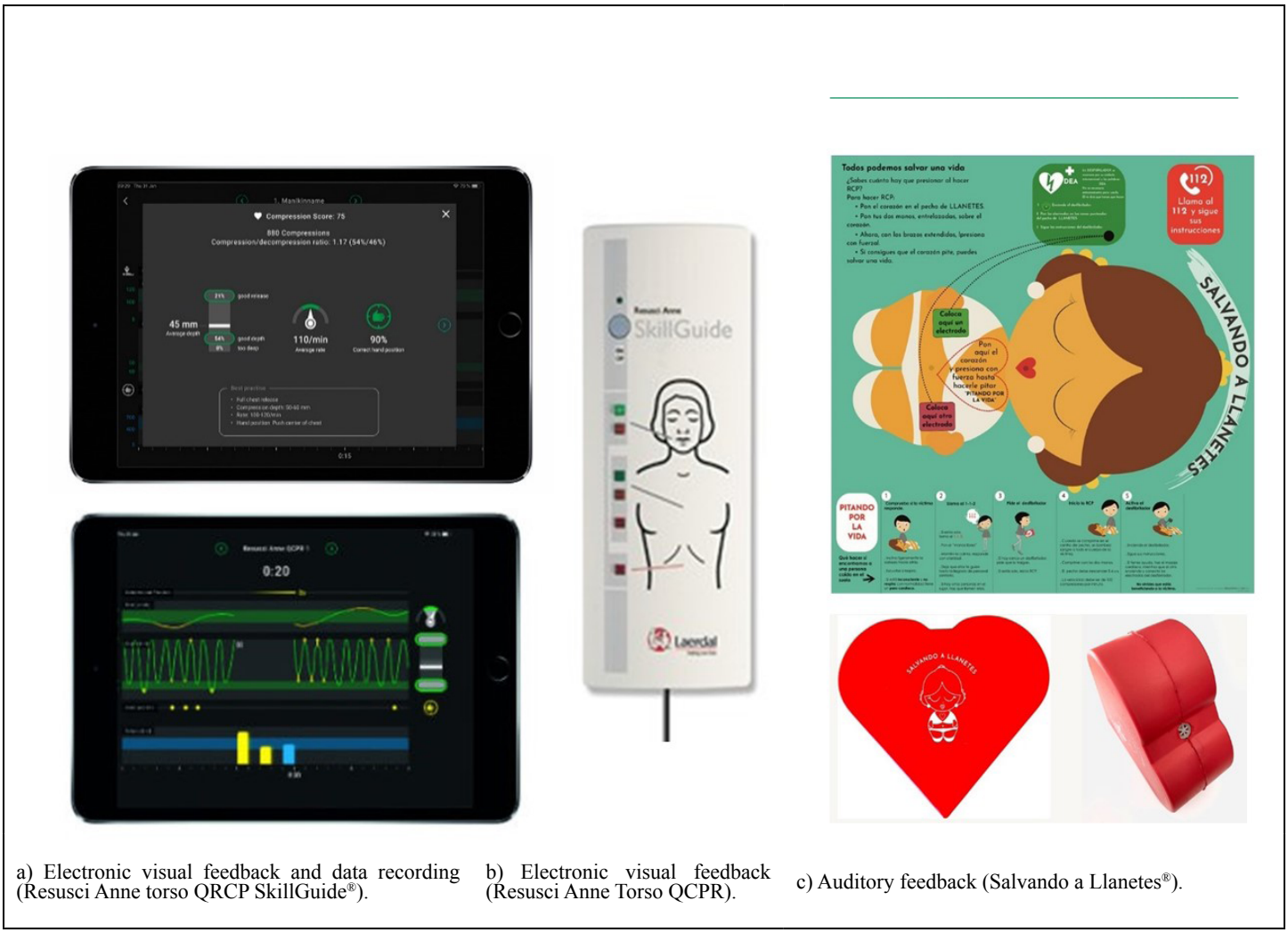
Materials

CPR simulators (Figure 1)

Device 1: Mannequin for CPR education purposes (Resusci Anne torso QRCP SkillGuide®; Laerdal Medical; Stavanger, Norway) with electronic visual feedback and data recording. This device records the data in its software and offers them in an excel file (Figure 1a). The necessary strength to perform the thorax compressions in this device was (according to product specifications) de 28.5-69 kp to compress 5 cm.

Device 2: Mannequin for CPR education purposes (Resusci Anne Torso QCPR; Laerdal Medical; Stavanger, Norway) with electronic visual feedback and not data recording (Figure 1b). The necessary force data is similar to the previous one. This device offers visual feedback in a signal box. The judges must record them in a checklist.

Device 3: Simulator (Salvando a Llanetes®; Cardioprotec&Health, Spain). Ultra-compact low-fidelity simulator in which a plastic heart (60 x 60 x 50 mm) is placed on a tapestry on which the figure of a doll is drawn, with auditory feedback that, when compressed perpendicularly and with sufficient force, emits a sound due to the movement of air contained in an interior cavity. The characteristics of hardness and the pressure with which the heart must be compressed are those necessary to reach the 50-60 mm described as the adequate depth for external chest compressions (ECC) in adults [10]. The judges must register in a checklist the ECC executed correctly according to their visual perception and the auditory feedback offered by the device (Figure 1c).



a) Electronic visual feedback and data recording (Resusci Anne torso QRCP SkillGuide®).

b) Electronic visual feedback (Resusci Anne Torso QCPR).

c) Auditory feedback (Salvando a Llanetes®).

Figure 1: Feedback system of the devices

Study Design and Participants

This study is part of the research entitled "Basic cardiopulmonary resuscitation training project in children and adolescents of a public educational institution. Tumbes, Perú, 2019".

For convenience, 92 students from the third, fourth, fifth and sixth year with ages between 8 and 13 years old of "8 de October" Primary Educational Institution, Tumbes, Perú were included, all of them with no previous knowledge in CPR.

The exclusion criteria were having received previous training in CPR, suffering from a disease that contraindicated or prevented CPR makeovers, not obtaining consent from their parents or guardians, as well as the refusal to participate in the study after knowing its objectives. No student met exclusion criteria.

The participants and their legal guardians were informed about the objectives and method of the study, as well as their personal contributions to it.

This study respected the ethical principles of the Helsinki Convention. To participate in the study, the adolescents had to agree and present the signed authorization of their parents and/or guardians. The research project was approved by the Research Ethics Committee of Tumbes National University with number 001-2021/ CEI-UNTUMBES.

Method

A quasi-experimental pre-post study was carried out between February and August 2022 at the Educational Institution "8 de October", Tumbes, Perú.

Six accredited nurses to train in basic CPR taught in each of the 4 grades, for a month, two theoretical sessions/week of two hours, which corresponded to the 2 weekly classes of the subject "Science and Technology". Theoretical contents were taught with materials adapted to their age with the method "CPR Hands-Only™" (flipchart, skits, songs) and guidelines ERC 2021 [18].

Practical training on the three described simulators was carried out for 2 weeks with a teacher/student ratio of 1:3. The mannequin/student ratio was 1:1 with the three devices. Each of the students performed 2 min of chest compressions on each device. The practical session was distributed in 3 stations: 1) basic CPR skills on the Device 1; 2) basic CPR skills on the Device 2; and 3) basic CPR skills on the Device 3.

At the end of the training and one month later, the participants responded to the surveys of knowledge and attitudes before a CPR. The CPR skills test was carried out on the three simulators at the end of the training and one month after it. Three nurses adequately informed and trained on the data collection process were responsible for the theoretical and practical evaluations. The flowchart of the study is shown in figure 2.

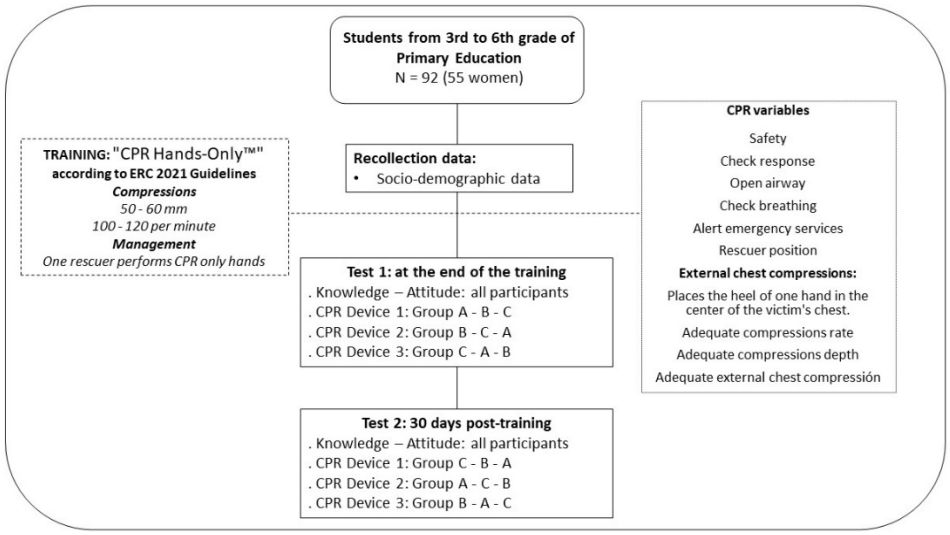


Figure 2: Study flow diagram.

Variables

In addition to socio-demographic variables (age, sex, education level), we recollected in all the subjects:

- For the knowledge evaluation in CPR, the questionnaire "Evaluation of knowledge about basic cardiopulmonary resuscitation in adolescents" (KBCPR_P21)" (19) was used. Questionnaire with 8 questions and four answer options, with only one correct. It was considered passed if correct answers ≥ 80%.
- To access attitudes towards CPR, the questionnaire was used: "Attitude Assessment Scale on Basic Cardiopulmonary Resuscitation in Adolescents (ABCPR_P21)" (19). With three options with the accumulation of scores, I feel very capable (33 to 23 points), I feel somewhat capable (22 to 12 points) and don't feel capable (11 to 1 point).
- The evaluation of practical skills in CPR was made using an "ad hoc" self-developed template for verification by direct observation of the judge and the reported data by the three devices (Table 1).

- During the test, ECC were considered adequate, according with the recommendations of the ERC [18], when: (a) rate of 100-120 ECC/min; (b) ECC in the centre of the victim´s chest; (c) the chest to recoil completely after each compression; (d) compressions depth ranging between 50 and 60 mm; and (e) taking approximately the same amount of time for compression as relaxation. The item was considered passed if ≥ 80% to that established by the ERC.

- The effectiveness of the training program was calculated as follows: KBCPR_P21 score (max 8 point) + ABCPR_P21 score (max 33 point) + skills score Device 1 + Device 2 + Device 3 (max 21 point). The program was considered effective if ≥45.

Data From Direct Observation By The Judge **Device 1, Device 2, Device 3**			
	Correct	Incorrect	
		Not Done	Bad Technique
Safety Of Place			
Check Response			
Open Airway			
Check Breathing (No More Than 10 S)			
Alert Emergency Services (Phone 116)			
Rescuer Position			
	Device 1. Data Reported By The Simulator System	Device 2 And Device 3. Data From Direct Observation By The Judge	
Compressions With Correct Location (%)			
Adequate Compressions Rate (%)			
Adequate Compressions Depth (%)			
Adequate Ecc (%)[*]			
[*] *Adequate Ecc (%):* [Adequate Ecc With Correct Location (%) + Adequate Depth Ecc (%) + Adequate Compression Rate (%) / 3] (20).			

Table 1: Verification list "checklist" direct and reported observation.

Statistical Analysis

All measurements were taken under standard conditions by the same researchers. The statistical normality of the variables was tested using graphical (normal probability plot). In addition, statistical (Kolmogorov-Smirnov test) procedures.

Differences by sex in demographic variables were verified using the Student's test. The Friedman test was used to analyze the obtained data by the same group of subjects at different moments in time, in order to assess not only the immediate effect of the intervention, but also its longer-term effect. The variables were described using measures of central tendency (mean) and dispersion (standard deviation). As criterion of bilateral statistical significance were used $p \leq 0.05$.

All the statistical analyses were performed with the IBM® SPSS® Statistics 24 software.

Results

Ninety-two students of both sexes participated in this study, where 59.78% were women, their ages ranged from 8 to 13 years old.

Table 2 shows the sociodemographic characteristics of the population studied, by sex. The predominant age group was 10 and 11 years old with 28.26% and 21.74% respectively. Regarding sex, there was a predominance of the female sex. Regarding the level of study, the predominant group in the entire population was the third grade.

The bivariate analysis showed statistically significant differences in the comparison of sex with age (p=0.008) and educational level (p=0.008). The same was true between men and women in the group of 12 years old children (p=0.045) and with those in 6th grade (p=0.045).

	Total (n=92)	**Men** (n=37)	**Women** (n=55)	**P**
Age (years)				
8	23 (25%)	14 (37.84%)	9 (16.36%)	0.008
9	13 (14.13%)	3 (8.11%)	10 (18.18%)	0.008
10	26 (28.26%)	7 (18.92%)	19 (34.54%)	0.008
11	20 (21.74%)	7 (18.92%)	13 (23.64%)	0.008
12	9 (9.78%)	5 (13.51%)	4 (7.27%)	0.045
13	1 (1.09%)	1 (2.70%)	-	
Grade				
3º	29 (31.52%)	14 (37.84%)	15 (27.27%)	0.008
4º	21 (22.82%)	5 (13.51%)	16 (29.09%)	0.008
5º	27 (29.35%)	11 (29.73%)	16 (29.09%)	0.008
6º	15 (16.30%)	7 (18.92%)	8 (14.44%)	0.045

Table 2: Socio-demographic variables of study population, by sex.

Table 3 shows the percentage of participants who passed the knowledge test, being significantly lower in the immediate post-training period when analyzing by gender. Regarding age, the associations are statistically significant.

	Post-training	30 days post-training	p
Total (n=92)	81 (88.04%)	87 (94.57%)	
Men	31 (83.78%)	36 (97.30%)	0.001
Women	50 (90.91%)	51 (92.73%)	0.001
Age (years)			
8	17 (18.48%)	23 (25%)	0.005
9	12 (13.04%)	12 (13.04%)	0.005
10	24 (26.09%)	23 (25%)	0.005
11	18 (19.57%)	19 (20.65%)	0.005
12	9 (9.78%)	9 (9.78%)	0.005
13	1 (1.09%)	1 (1.09%)	0.005

Table 3: Participants knowledge in a CPR training program for students of a public Educational Institution, by sex and age.

Table 4 indicates that, with the three simulators, both immediately post-training and at 30 days, the participants passed the CPR practical skills test, regardless of the simulator used and age, obtained better results in the three simulators, electronic control simulators (Device 1 and 2) than in Device 3.

	DEVICE 1			DEVICE 2			DEVICE 3		
	Post-training	**30 days post-training**		**Post-training**	**30 days post-training**		**Post-training**	**30 days post-training**	
Total (n=92)	89 (96.74%)	91 (98.91%)	**p**	74 (80.43%)	88 (95.65%)	**p**	73 (79.35%)	83 (90.22%)	**P**
Sex									
Men	37 (40.22%)	37 (40.22%)	0.000	29 (31.52%)	35 (38.04%)	0.000	27 (29.35%)	35 (38.04%)	<0.001
Women	52 (56.52%)	54 (58.70%)	0.000	45 (48.91%)	53 (57.61%)	0.000	46 (50.00%)	48 (52.17%)	<0.001
Age (years)									
8	22 (23.91%)	23 (25%)	<0.001	17 (18.48%)	23 (25%)	<0.001	17 (18.48%)	16 (17.395%)	<0.001
9	12 (13.04%)	12 (13.04%)	<0.001	10 (10.87%)	11 (11.96%)	<0.001	10 (10.87%)	11 (11.96%)	<0.001
10	25 (27.17%)	26 (28.26%)	<0.001	24 (26.09%)	25 (27.17%)	<0.001	23 (25.00%)	26 (28.267%)	<0.001
11	20 (21.74%)	20 (21.74%)	<0.001	16 (17.39%)	19 (20.65%)	<0.001	15 (16.30%)	20 (21.74%)	<0.001
12	9 (9.78%)	9 (9.78%)	<0.001	6 (6.52%)	9 (9.78%)	<0.001	7 (7.61%)	9 (9.78%)	<0.001
13	1 (1.09%)	1 (1.09%)	<0.001	1 (1.09%)	1 (1.09%)	<0.001	1 (1.09%)	1 (1.09%)	<0.001

Table 4: Participants who have passed the CPR practical skills test using various simulators, by sex and age.

Table 5 shows the attitudes of the participants about CPR, by sex and age. It is evident that after the training the participants, mostly and significantly, felt capable of performing a CPR, significantly increasing this self-perception at 30 days.

	Post-training				30 days post-training			
	Very capable	Somewhat capable	Unable	P	Very capable	Somewhat capable	Unable	p
Sex								
Men	34 (36.96%)	0 (0%)	3 (8.11%)	0.001	36 (39.13%)	1 (1.09%)	0 (0%)	0.003
Women	48 (52.17%)	7 (7.61%)	0 (0%)	0.001	55 (59.78%)	0 (0%)	0 (0%)	0.003
Age (years)								
8	23 (25%)	0 (0%)	0 (0%)	0.003	23 (25%)	0 (0%)	0 (0%)	0.001
9	7 (7.61%)	6 (6.5%)	0 (0%)	0.003	12 (13.04%)	1 (1.09%)	0 (0%)	0.001
10	25 (27.17%)	1 (1.1%)	0 (0%)	0.003	26 (28.26%)	0 (0%)	0 (0%)	0.001
11	17 (18.48%)	0 (0%)	3 (3.26%)	0.003	20 (21.74%)	0 (0%)	0 (0%)	0.001
12	9 (9.78%)	0 (0%)	0 (0%)	0.003	9 (9.78%)	0 (0%)	0 (0%)	<0.001
13	1 (1.09%)	0 (0%)	0 (0%)	0.003	1 (1.09%)	0 (0%)	0 (0%)	<0.001
TOTAL	82 (89.13%)	7 (7.61%)	3 (8.11%)		91 (98.91%)	1 (1.09%)	0 (0%)	

Table 5: Attitudes of participants about CPR, by sex and age.

Table 6 shows that the training program was significantly effective when analyzed by gender, regardless of simulator used (Device 1: 97.83%, Device 2: 97.82%, Device 3: 98.91%). When analyzing the results 30 days after training, with the three simulators the number of participants in whom the training program was effective regardless of simulator and gender increased to 100%.

Post-training	**DEVICE 1**	**DEVICE 2**	**DEVICE 3**	**p**
Total (n=92)	90 (97.83%)	90 (97.82%)	91 (98.91%)	0.003
Men	36 (39.13%)	36 (39.13%)	36 (39.13%)	0.003
Women	54 (58.70%)	54 (58.,69%)	55 (59.78%)	0.003
30 days post-training	**DEVICE 1**	**DEVICE 2**	**DEVICE 3**	**p**
Total (n=92)	92 (100%)	92 (100%)	92 (100%)	0.003
Men	37 (40.22%)	37 (40.22%)	37 (40.22%)	0.003
Women	55 (59.78%)	55 (59.78%)	55 (59.78%)	0.003

Table 6: Effectiveness of a CPR training program in students of a public Educational Institution, by simulator and sex.

Table 7 shows that, analyzing by age, the training program was significantly effective with the three simulators (Device 1: 97.83%, Device 2: 98.92%, Device 3: 98.91%). At 30 days post-training, with the three simulators, the effectiveness of the training program was maintained at all ages, except for the 11 years-old which increased.

Post-training	DEVICE 1	DEVICE 2	DEVICE 3	p
8	23 (25%)	23 (25%)	23 (25%)	p<0.001
9	13 (14.13%)	13 (14.13%)	13 (14.13%)	p<0.001
10	26 (28.26%)	26 (28.26%)	26 (28.26%)	p<0.001
11	18 (19.57%)	18 (19.57%)	19 (20.65%)	p<0.001
12	9 (9.78%)	9 (9.78%)	9 (9.78%)	p<0.001
13	1 (1.09%)	1 (1.09%)	1 (1.09%)	p<0.001
30 days post-training	**DEVICE 1**	**DEVICE 2**	**DEVICE 3**	**P**
8	23 (25%)	23 (25%)	23 (25%)	p<0.001
9	13 (14.13%)	13 (14.13%)	13 (14.13%)	p<0.001
10	26 (28.26%)	26 (28.26%)	26 (28.26%)	p<0.001
11	20 (21.74%)	20 (21.74%)	20 (21.74%)	p<0.001
12	9 (9.78%)	9 (9.78%)	9 (9.78%)	p<0.001
13	1 (1.09%)	1 (1.09%)	1 (1.09%)	p<0.001

Table 7: Effectiveness of a CPR training program in students of a public Educational Institution, by simulator and age.

Discussion

Our study aimed to determine the effectiveness of a CPR training program using medium and low fidelity simulators in children of a Primary public educational institution. In general, the data show that CPR performed reached adequate quality values and similar to those previously reported with other high/medium fidelity simulators and much higher cost.

Learning CPR implies a learned ability and skill, however, this learning requires prior knowledge, in such a way that it must be acquired through the teaching-learning process. There are studies that coincide with the results obtained by the present investigation that evaluated basic knowledge of CPR in students, before and after the training. They demonstrated a statistically significant improvement in students 'CPR knowledge [21,22]. Also, Martínez-Isasi et al. [23], to evaluate the theoretical knowledge of the CPR, they found that it increased between the pre and post questionnaire in all the courses and that it was greater in the students of higher courses.

CPR learning in childhood and adolescence allows the acquisition of knowledge progressively according to the age and maturation of the student, but taking into account that these characteristics are not axiomatic and are subject to the particularities of each child and the sociocultural environment that surrounds them, that is, their emotional, social, motor and cognitive development must be taken into account [24-26]. Our results, probably due to the simplicity of the asked questions, do not confirm the above, something similar happens with the acquisition of skills. In our case, the acquisition of knowledge and skills does not increase with age, which demonstrates the effectiveness of the recommendation to simplify the concepts and skills to be taught in training to citizens [11].

There are CPR training studies that increase the readiness of people in a life-threatening situation, and it is considered that at an earlier age they have a positive attitude to learn resuscitation if necessary [26], results which coincide with those obtained in this study and that show the predisposition of the students to help people with vital risk so has strengthened their solidarity attitude after each training. These results are different from what was found by Peiro, et al. [27], regarding the attitudes assumed by young people at the end of the workshops, where 20% of them were incapable, while our results show that 99% of the participating children felt capable of performing CPR. Students, regardless of their age or sex, showed a greater attitude towards providing help in a life-threatening situation. This difference could be justified by the differences in the teaching method used, the teacher/student relationship and the student/simulator relationship. From the analysis it is also deduced that with respect to the stages of life, children are more supportive, participatory and are more recipients of the indications that people give them in the teaching-learning process [34,36], these last data coincide with our findings.

Our results show that low fidelity devices are useful for Teaching "CPR Hands-OnlyTM" to the population, which coincides with other studies in which other more sophisticated devices were used [8,28-37]. In our study, the % correct ECC performed on Device 3 reached values that can be considered adequate for the initial training of the population, although it did not reach the reached values in high/medium fidelity simulators reported by others [8,28-33].

Improving OHCA survival involves early initiation of CPR by the population until the arrival of the EMS once cardiac arrest has occurred [17]. The strategies go through teaching the lay public, from children, with the appropriate materials and methods, the techniques of SVB. Our study shows that even low-fidelity devices are adequate to achieve this [10,36].

Strengths and Limitations

Our study has some limitations, including the fact that a single training method has been used in which the simulation conditions are difficult to extrapolate to real cases, since the psychological variables that influence a real situation cannot be reproduced in simulation. Finally, the students belonged to only one school, a factor that could also influence the results.

Conclusions

Teaching to improve school-age children's knowledge and attitudes to respond to a life-threatening emergency is just as important as teaching CPR skills, as they increase the survival rate from cardiac arrest.

CPR training should begin at an early age, with age-appropriate methodologies and materials, economic possibilities, and accessibility to training spaces, with periodic recycling that includes recognition of cardiac arrest, requesting help from EMS, and introduction sequence of more Complex actions with increasing age and height. However, the best training system remains unclear.

The importance of a low economic cost and small dimensions of the simulators used are important factors to bring CPR training to the largest possible amount of the population. We can affirm that low-fidelity simulators are useful for training population groups with limited economic resources and with difficulties in accessing other more complex systems. Low fidelity simulators contribute to the teaching of CPR to children and other groups, in addition to their low economic cost, a friendly appearance that allows "gamification" teaching "CPR Hands-OnlyTM" and facilitating other logistical aspects that should not be forgotten, such as ease of transport and storage.

We can affirm that a CPR training program aimed at boys and girls is effective in terms of the acquisition of knowledge, skills and perception of positive attitudes towards its performance using medium and low fidelity simulators.

Conflict of Interest Statement

Authors of the manuscript entitled "Effectiveness of a CPR training program using medium and low fidelity simulators in primary school students for the acquisition of learning skills" disclose none has any conflict of interest. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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