

## ORIGINAL ARTICLE

## Learning cardiopulmonary resuscitation theory with face-to-face versus audiovisual instruction for secondary school students: a randomized controlled trial

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**Objective.** To compare secondary students' learning of basic life support (BLS) theory and the use of an automatic external defibrillator (AED) through face-to-face classroom instruction versus educational video instruction.

**Methods.** A total of 2225 secondary students from 15 schools were randomly assigned to one of the following 5 instructional groups: 1) face-to-face instruction with no audiovisual support, 2) face-to-face instruction with audiovisual support, 3) audiovisual instruction without face-to-face instruction, 4) audiovisual instruction with face-to-face instruction, and 5) a control group that received no instruction. The students took a test of BLS and AED theory before instruction, immediately after instruction, and 2 months later.

**Results.** The median (interquartile range) scores overall were 2.33 (2.17) at baseline, 5.33 (4.66) immediately after instruction ( $P < .001$ ) and 6.00 (3.33) ( $P < .001$ ). All groups except the control group improved their scores. Scores immediately after instruction and 2 months later were statistically similar after all types of instruction.

**Conclusion.** No significant differences between face-to-face instruction and audiovisual instruction for learning BLS and AED theory were found in secondary school students either immediately after instruction or 2 months later.

**Keywords:** Basic life support. First aid. Video. Obligatory secondary education.

### *Ensayo clínico aleatorizado controlado que compara la formación presencial frente a la no presencial en el aprendizaje teórico de la reanimación cardiopulmonar entre los estudiantes de secundaria*

**Objetivo.** Comparar la formación presencial, mediante una clase teórica, frente a la formación no presencial, con un método audiovisual con y sin refuerzo posterior, en el aprendizaje teórico del soporte vital básico (SVB) y el desfibrilador externo automático (DEA) entre los estudiantes de secundaria.

**Método.** Se llevó a cabo un ensayo clínico aleatorizado que incluyó a 2.225 estudiantes de secundaria procedentes de 15 centros educativos que fueron asignados al azar a uno de los siguientes cinco grupos: 1) Grupo formación presencial sin refuerzo; 2) Grupo formación presencial con refuerzo; 3) Grupo formación audiovisual sin refuerzo; 4) Grupo formación audiovisual con refuerzo; 5) Grupo control. Se realizó un test sobre aspectos teóricos del SVB y DEA antes, después y a los 2 meses de la estrategia formativa.

**Resultados.** Los resultados mostraron diferencias estadísticamente significativas en todos los grupos, excepto el grupo control, entre la puntuación obtenida en el test basal 2,33 (RIC 2,17) y el test inmediato 5,33 (RIC 4,66) ( $p < 0,001$ ), y entre el test basal y el test final 6,00 (RIC 3,33) ( $p < 0,001$ ). No hubo diferencias en el aprendizaje inmediato y a los 2 meses entre los diferentes tipos de formaciones.

**Conclusión.** No se encontraron diferencias entre la formación presencial mediante charlas teóricas y la formación no presencial con método audiovisual en el aprendizaje teórico inmediato y a los dos meses en el aprendizaje teórico del SVB y el DEA entre los estudiantes de secundaria.

**Palabras clave:** Formación. Soporte vital básico. Primeros auxilios. Vídeo. Educación secundaria obligatoria.

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## Introduction

The annual incidence of out-of-hospital cardiopulmonary arrests (CPA) treated by emergency medical services (EMS) in Europe is 38 cases per 100,000 inhabitants<sup>1</sup>. Survival after a CPA can be three or four ti-

mes greater if an early cardiopulmonary resuscitation (CPR) is performed by citizens; It is also associated with a better prognosis of brain damage and a better quality of life<sup>2,3</sup>. Survival without neurological damage is estimated at 3-8% after a CPA. This result depends to a large extent on the speed of starting CPR and on

giving an electric shock<sup>4</sup>. Early defibrillation, in the first 3-5 minutes, significantly increases the survival rate, which reaches figures of 50-70%<sup>1,5,6</sup>, and even 90% if it occurs in the first minute after the CPA. It is a simple technique to learn where witnesses play an essential role, and therefore, these results are only achievable by putting the appropriate training in CPR and automatic external defibrillator (AED) in the hands of society<sup>7</sup>.

Scientific societies, such as the American Heart Association (AHA) or the European Resuscitation Council (ERC), promote inclusion of the teaching of basic life support (BLS) in compulsory education<sup>1,8,9</sup>. In this sense, it seems logical to train society by introducing such teaching during the school stage<sup>10</sup>. Colquhoun et al, based on the evidence that existed in Germany, indicated that it was feasible to include CPR training at school ages, and that the school was the ideal place<sup>11</sup>. The consensus statement of the ERC on training in first aid in the school "Kids save lives" recommends the teaching of first aid and CPR from 12 years of age with a minimum duration of 2 hours per year<sup>5</sup>. Currently, 95% of people in Norway and 80% in Austria and Germany have received first aid training, while only 5% have received training in the United Kingdom. First aid education in schools is compulsory in 19% of European countries<sup>12</sup>. In Spain, training in BLS is not mandatory. The available literature on this subject indicates that there are no data in this regard and that the methodology of the training is heterogeneous<sup>13</sup>.

Training in first aid is necessary to save lives and is also considered profitable, since it reduces the costs of medical treatments by reducing the severity of injuries<sup>3</sup>. Kanstad et al. they highlighted the high motivation of Norwegian high school students in CPR training by contributing to the increase in survival rates<sup>14</sup>. In surveys conducted with UK teachers, most recognize that learning basic first aid and CPR would be very positive for school children and would even be willing to teach it as long as they were previously well trained<sup>15</sup>. The majority of educational centers are in favour of the realization of first aid training for teachers and students<sup>16</sup>.

New technologies, through demonstrative images or videos adapted to different ages, represent a novel way of transmitting knowledge to students, and there are numerous studies that use video systems to teach CPR<sup>17,18</sup>. The polimedia is a video where on the same screen we can see the teacher and the computer support that we choose with all the information regarding the subject that is explained<sup>19</sup>. The authors thought that the formation in BLS and AED, by means of the use of audio-visual systems, could obtain similar results to the face-to-face training, by means of classes, in the theoretical learning of the same of the students. This would help to promote a massive theoretical training of the students, without the presence of a sanitary being a *si-ne qua non* condition.

Therefore, the main objective of this study was to compare face-to-face training, with a traditional pedagogical method through a theoretical talk, versus non-

face-to-face training, with an audio-visual method through polimedia videos, in the theoretical learning in the CPR and the AED among students of Compulsory Secondary Education (CSE). The secondary objectives were to study the results of the training strategies based on the performance of a reminder intervention with polimedia per month, and if there were differences according to the age groups.

## Method

This is a randomized and controlled clinical trial that included CSE students from the educational centers of the Region of Murcia between the months of February and May 2016. This study followed the CONSORT<sup>20</sup> guidelines and was approved by the Ethics Committee of the Catholic University of Murcia (UCAM), by the direction of each of the centers where it was made and by the parents or guardians of the participants. All the students agreed to participate in the study.

Eligible students were between 12-16 years of age and were enrolled in CSE. An invitation was made to schools enrolled in the list of educational centers attached to the "Health Education in School Plan", of the Ministry of Health of the Region of Murcia, updated on December 1, 2015. They were received 17 requests for participation and, finally, 15 schools were included. Two centers were excluded by age criteria. Stratified random sampling was carried out according to the course of CSE. We excluded those students who did not agree to participate in the study, did not have the written consent of the parents or legal guardians, did not attend the training classes or did not complete all the evaluation questionnaires.

The students were randomly assigned to one of the five training groups: 1) face-to-face training group without reinforcement (FPSR); 2) face-to-face training group with reinforcement (FPCR); 3) audio-visual non-face-to-face training group without reinforcement (FNPSR); 4) audio-visual non-face-to-face training group with reinforcement (FNPCR); and 5) control group (CG). The face-to-face training (FP) consisted of lectures given by health professionals, instructors in BLS and AED accredited by the Spanish Society of Intensive and Critical Care Medicine and Units (SEMICYUC), using the same presentation of slides, made with the Power program. Point®, whose content followed the current guides of the ERC 2015. The audio-visual non-face-to-face training (FNP) consisted in the visualization in the classrooms of three polimedia on BLS, CPR and AED of 4, 6 and 4 minutes respectively. This polimedia system combines the projection of images and information while the instructor performs the explanation and demonstration. The instructor did not perform any type of intervention in this type of training. The polimedia were recorded by a researcher and included the same information (content, images and speech) as the one used for students who have received face-to-face training (FP). The reminder strategy consisted in the visual-

**Table 1.** Demographic characterization of the sample included in the study

| Course Group (%) | 1 <sup>st</sup> CSE |                  | 2 <sup>nd</sup> CSE |                   | 3 <sup>rd</sup> CSE |                   | 4 <sup>th</sup> CSE |                   | Total             |                     |
|------------------|---------------------|------------------|---------------------|-------------------|---------------------|-------------------|---------------------|-------------------|-------------------|---------------------|
|                  | M n (%)             | F n (%)          | M n (%)             | F n (%)           | M n (%)             | F n (%)           | M n (%)             | F n (%)           | M n (%)           | F n (%)             |
| FPSR             | 38 (1.9)            | 40 (1.9)         | 48 (2.4)            | 51 (2.5)          | 63 (3.1)            | 67 (3.3)          | 49 (2.4)            | 52 (2.6)          | 198 (9.8)         | 210 (10.4)          |
| FPCR             | 40 (1.9)            | 43 (2.1)         | 51 (2.5)            | 54 (2.7)          | 67 (3.3)            | 71 (3.5)          | 51 (2.5)            | 56 (2.7)          | 209 (10.3)        | 224 (11.1)          |
| FNPSR            | 39 (1.9)            | 42 (2.1)         | 50 (2.4)            | 53 (2.6)          | 65 (3.2)            | 70 (3.5)          | 51 (2.5)            | 54 (2.6)          | 205 (10.1)        | 219 (10.8)          |
| FNPCR            | 36 (1.8)            | 38 (1.9)         | 46 (2.2)            | 49 (2.4)          | 60 (3)              | 65 (3.2)          | 46 (2.2)            | 50 (2.4)          | 188 (9.3)         | 202 (10)            |
| GC               | 33 (1.6)            | 36 (1.8)         | 43 (2.1)            | 46 (2.3)          | 57 (2.8)            | 60 (3)            | 43 (2.1)            | 47 (2.3)          | 176 (8.7)         | 189 (9.8)           |
| <b>Total</b>     | <b>186 (9.2)</b>    | <b>199 (9.1)</b> | <b>238 (11.8)</b>   | <b>253 (12.5)</b> | <b>312 (15.5)</b>   | <b>330 (16.5)</b> | <b>240 (11.7)</b>   | <b>257 (12.7)</b> | <b>976 (48.3)</b> | <b>1.044 (51.6)</b> |

Percentages calculated on the total sample.

CSE: Compulsory Secondary Education; M: male; F: Female; FPSR: face-to-face formation group without reinforcement; FPCR: face-to-face training group with reinforcement; FNPSR: non-face-to-face audiovisual training group without reinforcement; FNPCR: non-face-to-face audiovisual training group with reinforcement; CG: control group.

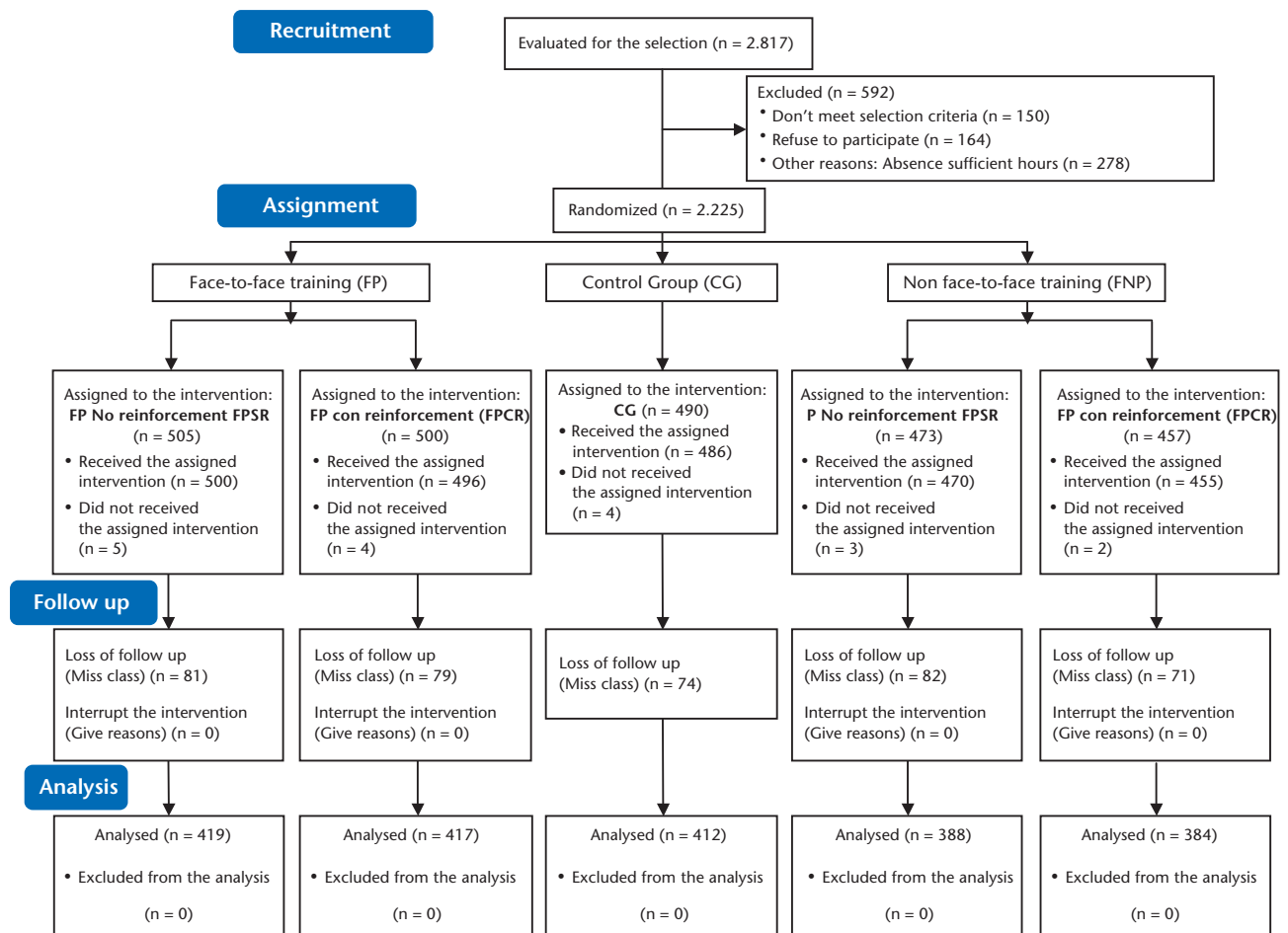
lization of the same polimedia of the FNP 30 days after the first training.

The main variable of the study was the grade obtained in the test. A test was performed on aspects of BLS and AED before (baseline test, BT), then (immediate post-test, IT) and after 2 months (final test, FT) of the training strategy. The questionnaires were formed by 20 multiple-choice questions with 4 possible response options, in which only one answer was correct. Each wrong question penalized 1/3 of a correct question. Fi-

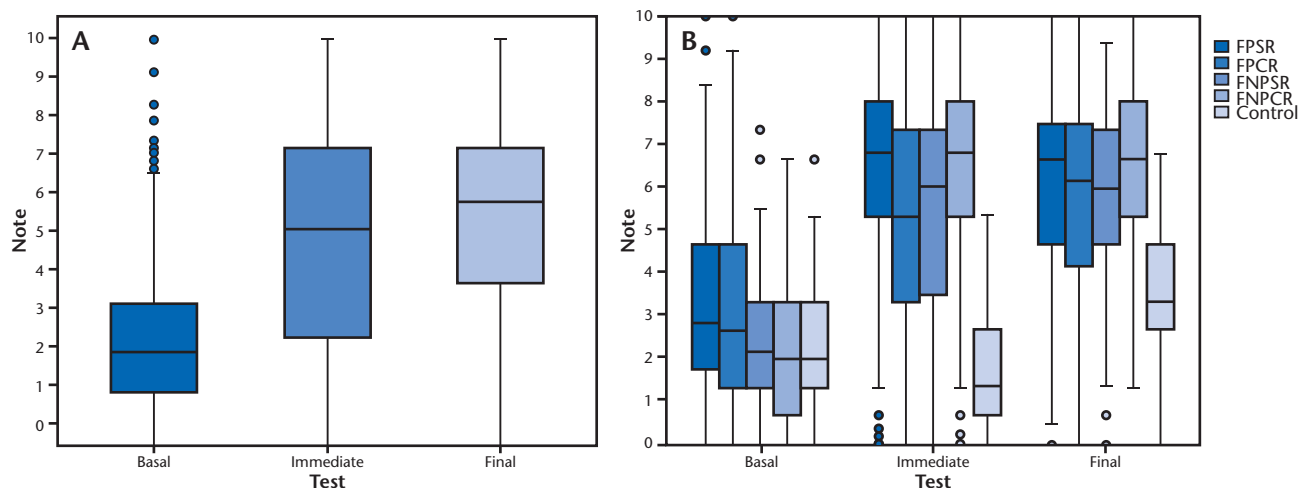
nally, a weighting was done to obtain a score calculated on a scale of 0 to 10 points.

The calculation of the sample size was made based on an infinite population, assuming an error of 5%, a confidence level of 95%, a distribution level of responses of 50% and fixing an error of ± 1. finally, a sample of 97 students was determined. Based on a forecast of a 20% dropout rate from the study, it was determined that each of the groups was composed of at least 117 volunteers.

The data were expressed by means and interquartile



**Figure 1.** Flow chart based on the CONSORT diagram. FPSR: face-to-face formation group without reinforcement; FPCR: face-to-face training group with reinforcement; FNPSR: non-face-to-face audiovisual training group without reinforcement; FNPCR: non-face-to-face audiovisual training group with reinforcement; CG: control group.



**Figure 2.** Results of the baseline, immediate and final test: overall results (A) and results by groups (B). Comparisons for the Figure 2A: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.085$ ). Comparisons for Figure 2B: FPSR: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.001$ ); FPCR: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.001$ ); FNPSR: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.041$ ); FNPCR: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.989$ ); Control: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.001$ ).

FPSR: face-to-face formation group without reinforcement; FPCR: face-to-face training group with reinforcement; FNPSR: audiovisual training group without reinforcement; FNPCR: audiovisual training group with reinforcement; CG: control group.

range. For the comparison of the results between study groups, nonparametric tests were used, after checking that the normality principles were not met, the Mann-Whitney U test and the Kruskal-Wallis test for independent samples, to make the comparisons between two groups and between more than two groups respectively. The results were considered statistically significant when the  $p$ -value was less than 0.05. For the processing and analysis of the data, the statistical package IBM SPSS® (New Castle, New York, USA) for Windows version 22.0 was used.

## Results

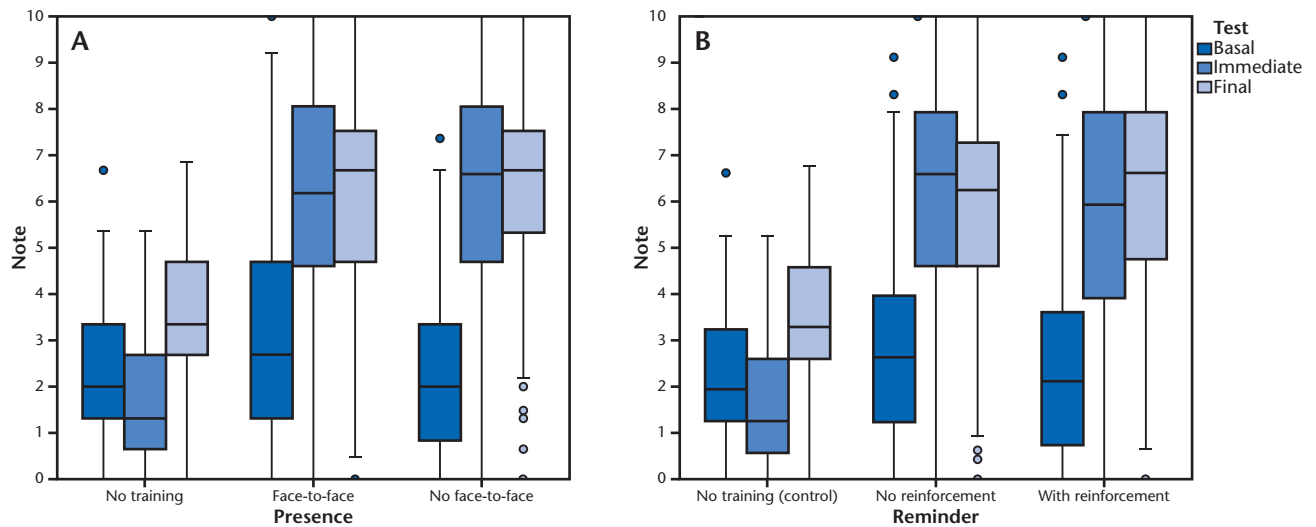
The results for the main variable of the study were median BT score 2.33 (RIC 2.17), IT 5.33 (RIC 4.66) and FT 6.00 (RIC 3.33). There was a significant increase in the level of knowledge in both IT ( $p < 0.001$ ) and FT ( $p < 0.001$ ), with respect to BT. Overall, there were no statistically significant differences between the results of IT and FT ( $p = 0.085$ ) (Figure 2A).

Figure 2B shows the results of the BT, IT and FT scoring medians for each of the groups: FPSR group [BT 2.8 (RIC 3.0), IT 6.8 (RIC 2.7) and FT 6.7 (RIC 2.8)], FPCR [BT 2.7 (RIC 3.3), IT 5.3 (RIC 4.0) and FT 6.2 (RIC 3.3)], FNPSR [BT 2.2 (RIC 2.0), IT 6.0 (RIC 3.8) and FT 6 (RIC 2.7)], FNPCR [BT 2.0 (RIC 2.7), IT 6, 8 (RIC 2.7) and FT 6.7 (RIC 2.7)] and CG [BT 2.0 (RIC 2.0), IT 1.3 (RIC 2.0) and FT 3.3 (RIC 2.0)]. When comparing BT and IT, segmented according to the 5 groups, a significant increase ( $p < 0.001$ ) in the median score of the tests was found for all groups, with the exception of CG. When comparing IT and FT, we found values of the median of FT equal to or greater than 6 in all cases,

with the exception of the CG that was 3.3, and different behaviours according to the study group. A significant decrease was documented for FPSR ( $p < 0.001$ ), a significant increase for FPCR ( $p < 0.001$ ) and FNPSR ( $p = 0.041$ ), and very little variation of FNPCR ( $p = 0.989$ ). In the IT we found statistically significant differences ( $p < 0.001$ ) between the FNPCR group with the FNPSR group and between the FPCR group with the FPSR group. In the FT we found a statistically significant difference ( $p < 0.001$ ) between the FNPCR group and the FNPSR group, while no significant differences were found ( $p = 0.136$ ) between the FPCR and FPSR group. The analysis according to the type of training, the results of the median of the tests for FP were 2.7 (RIC 3.3) for BT, 6.2 (RIC 3.5) for IT and 6.7 (RIC 2.8) for FT; and for FNP 2.0 (RIC 2.5) for BT, 6.6 (RIC 3.3) for IT and 6.7 (RIC 2.2) for FT. Both types of training achieved a significant increase in the level of training (BT vs IT  $p < 0.001$  and BT vs FT  $p < 0.001$ ). When comparing the IT and the FT, no significant differences were obtained neither for the FP ( $p = 0.746$ ) nor for the FNP ( $p = 0.182$ ) (Figure 3A).

There were also no statistically significant differences with respect to the IT ( $p = 0.536$ ) or the FT ( $p = 0.102$ ) of both types of formations.

The analysis based on the performance of the reinforcement, the results of the median of the tests for the groups without reinforcement were 2.7 (RIC 2.7) for BT, 6.7 (RIC 3.3) for IT and 6.3 (RIC 2.7) for FT; and for groups with reinforcement were 2.2 (RIC 2.9) for BT, 6.0 (RIC 4.0) for IT and 6.7 (RIC 3.2) for FT. When comparing IT and FT, significant differences were documented for reinforcement training ( $p = 0.004$ ) but not for those who did not receive reinforcement ( $p = 0.187$ ) (Figure 3B). There were no statistically signifi-



**Figure 3.** Results by groups of the basal, immediate and final test: according to the type of training (A) and depending on the use of reminders (B). Comparisons for Figure 3A: Face-to-face training: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.746$ ); non-face-to-face training: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.182$ ). Comparisons for Figure 3B: formation without reinforcement: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.187$ ); training with reinforcement: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.004$ ).

cant differences with respect to the FT of both types of reinforcement ( $p = 0.058$ ). Figure 4 shows the comparisons of the tests in the different courses (1st to 4th CSE). Statistically significant differences were found between BT and IT ( $p < 0.001$ ), and BT and FT ( $p < 0.001$ ) in all courses. There were no statistically significant differences ( $p = 0.334$ ) between the medians of the FT for the different courses.

## Discussion

The overall results of the study show a learning between the basal and immediate test, and between the basal and final test. The training given and the evaluation have been only theoretical, so the results indicate that the students have improved their theoretical knowledge about CPR and AED, but without being able to affirm that they have increased their practical skills. The main objective was to compare face-to-face and non-face-to-face training. The results allow to affirm that the students did not learn in a different way depending on the method. Liberman et al. observed that some groups obtained better results with video training than with traditional training<sup>21</sup>. Marchiori et al. they found results of 8 out of 10 in students trained by an expert and 7 out of 10 in students trained with a video game<sup>22</sup>. Cristina Jorge-Soto et al. carried out a quasi-experimental study in children aged between 10 and 13 years where they found similar results in the ability to manage the AED after a brief training through a 60-second video<sup>23</sup>. The results of the PROCES<sup>24</sup> program obtained increases in knowledge similar to those of the present study, with an average score of 2.5 points in the initial test and 7.9 points in the final test after training.

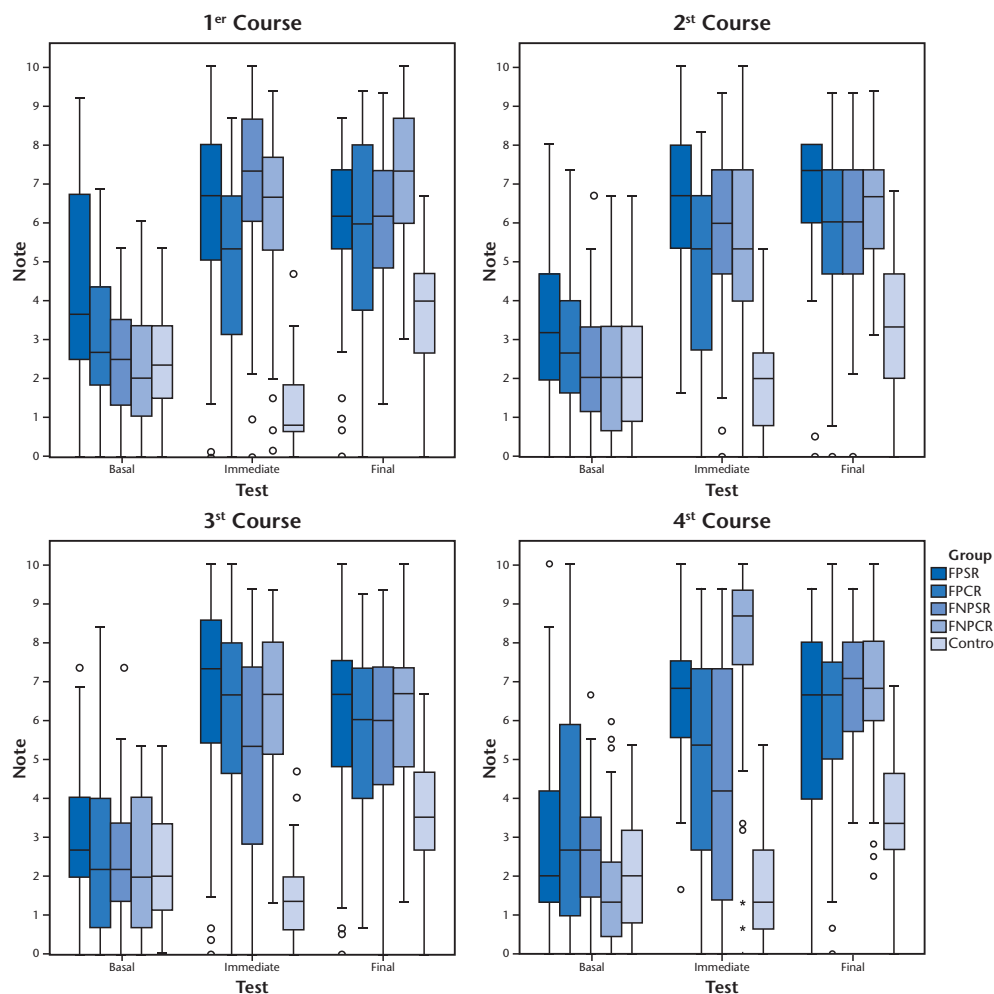
On the other hand, this study has managed to train

a population of 2,225 in a single school year and the inclusion of a control group to consolidate the reliability of the study. They trained 5.6% of teachers and 26.2% of students belonging to children and primary education<sup>25</sup>, and the PROCES<sup>24</sup> program for 3,000 students for 10 years.

As for the reminder, the comparative results at the end of the study showed that for the FP group there were no significant differences between having received a reminder and not having received it. On the contrary, in the FNP group there were statistically significant differences in favour of the group that received the reminder. These data are of interest, since it could be deduced that in the audio-visual method the forgetting effect appears before. Pavon Prieto et al. conducted a study in 253 students under 13 years of age who received practical training in the use of the AED, and observed a loss of learning at 6 months despite obtaining good results. This work showed the need for a reminder within that time<sup>26</sup>. On the other hand, Cristina et al. They determined that months after the formation there was no forgetting curve<sup>23</sup>. Despite this, some authors affirm that knowledge must be provided during the school stage and be repeated and updated every year to avoid forgetting<sup>27</sup>. This would possibly allow us to get closer to the CPR statistics obtained by other countries in our European environment<sup>14</sup>.

The analysis by courses shows that all students learn in a similar way, with a median higher than 5 in all cases in which they have received training. Victor Fradeja et al. They showed that children, from 13 years old, are able to learn as fast as an adult<sup>28</sup>. The results obtained support the "Kids Save Lives"<sup>15</sup> indications to start training at age 12, since no significant differences in learning were found between the different CSE courses.

The results of this work represent an important advance, since the theoretical training of BLS and AED in



**Figure 4.** Baseline, immediate and final results for each of the groups and courses of the study. Comparisons for the 1st course: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.034$ ). Comparisons for the 2nd course: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p < 0.001$ ). Comparisons for the 3rd course: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.889$ ). Comparisons for the 4th course: BT-IT ( $p < 0.001$ ), BT-FT ( $p < 0.001$ ) and IT-FT ( $p = 0.011$ ).

FPSR: face-to-face formation group without reinforcement; FPCR: face-to-face training group with reinforcement; FNPSR: non-face-to-face audiovisual training group without reinforcement; FNPCR: non-face-to-face audiovisual training group with reinforcement; CG: control group.

schoolchildren could be carried out through the audiovisual multimedia system<sup>29</sup>. This method could be easily adapted to the school calendar without the need for personnel with specific training<sup>28</sup>. The authors defend this type of programs, as do Cerdà Vila M et al., Who criticize societies that do not implement the teaching of basic CPR in schools<sup>12</sup>, since in addition to learning at a pedagogical level it is matured in several areas and they represent a great advantage in the community in which they are implanted. With this formative intervention all the groups that received some type of training increased their theoretical knowledge in an important way.

Among the limitations of our study we found that we cannot generalize these results outside the setting of the age groups and selected centers of the Region of Murcia. In addition, the evaluation was only theoretical and not practical. This was due to the limited time

available in the school calendar and the size of the sample. On the other hand, we have observed that students have difficulties to adapt to the method of evaluation type test.

In conclusion, the polimedia could be considered an effective tool for the formation of CSE students, since no differences were found between face-to-face training with theoretical and audio-visual talks with polimedia videos in the immediate theoretical learning and two months after the BLS and AED among high school students. It would be advisable that these theoretical training programs be complemented with practical sessions given by accredited professionals. Therefore, future lines of work should be aimed at including parents and teachers in the training of various pedagogical resources: virtual reality glasses, video games and computer applications.

## Conflicting interests

The authors declare no conflict of interest in relation to this article.

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The authors declare the non-existence of external financing of this article.

## Ethical Responsibilities

The study was approved by the Ethics Committee of the Catholic University of Murcia (UCAM), by the management of each of the centers where it was conducted and by the parents and/or guardians of the participants. All students gave their consent to participate in the study.

All authors have confirmed the maintenance of confidentiality and respect for patients' rights in the author's responsibilities document, publication agreement and assignment of rights to EMERGENCIAS.

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