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Cardiopulmonary Resuscitation (CPR), Artificial Intelligence, Real-Time Feedback, Adolescents, Self-Efficacy, Practical Competency, Skill Retention, School-Based Training.

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Study on AI -based versus Conventional CPR Training: Effects on Adolescent competency and Self- efficacy

Abstract
Cardiopulmonary resuscitation (CPR) is the fundamental life-saving skill to save life during cardiac emergencies. This study aimed to compare the effectiveness of Traditional CPR Training and Artificial Intelligence (AI)-Based Real-Time Feedback CPR Training in the program with adolescents. A quantitative quasi-experimental pretest post-test design was used with 250 students, with half being assigned to the Traditional CPR Training group (n = 125) and the other half to the AI-Based CPR Training group (n = 125). Pte-intervention baseline assessment showed that both groups were comparable prior to the intervention. Structured questionnaire and CPR competency assessment tool were used to collect the data. The results showed that, both training methods showed significant increase in CPR knowledge, self-efficacy and practical competency ($p < 0.001$). The Traditional CPR Training group, however, performed much better on their post-test and long-term skill retention, compared to the AI group. The outcomes show the importance of hands-on experience, demonstrations and supervision in augmenting CPR learning outcomes. The study finds that Traditional CPR Training is a very effective method for enhancing the CPR competency and preparedness of adolescents.

INTRODUCTION

Cardiopulmonary resuscitation (CPR) is among the most critical life-saving skills and early intervention by bystanders can greatly enhance the likelihood of survival during sudden cardiac arrest events. In many of the out-of-hospital cardiac arrest cases, the first few minutes after cardiac arrest are critical, and having an educated lay responder present can make the difference in providing immediate chest compression's until medical help arrives. As such, CPR instruction is now slowly expanding its reach to community members, school youth, and young children. Adolescents are a very appropriate target group for CPR education because they can learn structured psycho motor skills; they can retain the procedural knowledge of CPR; and they can be future bystanders in the family, school, and public settings. School-based CPR training also provides a chance to establish a larger culture of emergency readiness from a young age [1].

Typical CPR training methods include demonstration, lecture, video presentation, and practicing on manikins with supervision. This approach is still significant as it allows for direct human contact and fundamental knowledge of cardiac arrest recognition, compression sequence, hand placement and activation of emergency response. But conventional training has its drawbacks, especially in the case of training large groups of students when the number of instructors is limited. In such situations, only an individual learner may not get the individual correction on the depth of compression, the rate of compression, the recoil, the hand position, and continuity of compressions. CPR is a psychomotor skill and its quality not only depends on the knowledge learned by the students, but also on multiple repetitions and correct feedback given during training. If not corrected, adolescents could be trained with poor technique and this could impact their confidence and performance in real life scenarios [2].

Skill sustainability is an important topic in CPR education. There have been a number of studies indicating that CPR skills can lose over time when they are not reinforced, refreshed or provided with feedback practice. The skill training and retention of CPR by high school students was discussed [2], noting that while adolescents can learn CPR, the retention of the skill needs to be evaluated beyond the post-training period. Likewise the need for CPR teaching techniques to be assessed for their short-term and long-term retention of CPR performance by schoolchildren. Thus, any CPR training model for the adolescent must be evaluated on competency in the short term, and sustainability in the long term [3].

Another significant CPR training outcome is self-efficacy, which is the knowledge needed to do CPR during an emergency; however, knowing a skill does not mean one will be willing or self-confident to do it. Adolescents might know CPR in theory but are hesitant to administer CPR if they are uncertain of their ability to administer compressions properly. CPR self-efficacy is the learner's self-perceived confidence to recognize cardiac arrest, call emergency services, start CPR and continue CPR until help has been called. Students who have the opportunity to practice a skill many times and to be corrected will benefit in both technical skill and confidence. CPR education in secondary schools and peer-based CPR training studies indicate that secondary school students are more likely to be confident and willing to perform CPR when they are actively practicing the technique, as opposed to merely listening to the instructors [1].

Common performance indicators for practical competency in CPR include successfully placing hands, compression depth, compression rate, complete chest recoil, minimal interruptions, and CPR quality. the importance of CPR quality assessment during schoolchildren training as the effectiveness of CPR education relies on the ability of the students to perform compressions according to recommendations. Practical competency is especially crucial in adolescent training, as students may have different physical abilities, coordination and experience with emergency education. CPR training using a method which allows objective performance measure may be helpful for identifying errors and helping to enhance the quality of CPR practice [4].

CPR training with the use of technology has recently gained attention as a means of achieving better learning outcomes for adolescents. Technology based approaches can involve using digital applications, video based teaching, virtual reality, simulation based platforms, feedback on manikins and, and real-time corrective systems. Studies show that digital and feedback-supported CPR education may augment traditional CPR education, as found that these technology-based training methods can enhance CPR-related knowledge and skills for adolescents [5]. Likewise, the increasing importance of the use of virtual reality techniques in CPR training, as immersive simulation can enhance learner interaction and create a more immersive learning space. The developments show that the CPR education is moving from the traditional teacher-centred learning to learner-centred and technology-driven CPR training models [6].

Feedback devices are particularly important in CPR training for the reasons that they offer immediate, objective and measurable information as to the performance of CPR. These devices can instruct learners on compression depth, compression rate, recoil, etc. while they are practicing. A number of CPR feedback devices have emerged that can enhance CPR quality by decreasing reliance on subjective assessment from an instructor, and provide immediate feedback to the learner to correct errors as they occur, as described [7].Furthermore, noted that corrective feedback devices have the potential to affect the acquisition and retention of CPR skills, making them relevant for research on competency and skill maintenance. In this particular setting, feedback-based training could be better than conventional training as it would enable adolescents to know exactly where their CPR delivery is right or wrong [8].

Feedback in real time is particularly useful, as CPR performance can be corrected while practicing. Real-time feedback was cited as an important strategy for CPR quality improvement is able to offer immediate feedback during CPR performance. This is very applicable to the adolescent student, as real-time correction could help them build up correct muscle memory and minimize opportunities for incorrect technique [9]. Also, compared the impact of feedback devices in CPR training and simulated cardiac arrest scenarios, suggesting that

feedback devices can have an impact on the quality of CPR and learner performance. These results provide a solid foundation for future research to compare the conventional training approach with CPR training using real-time feedback in adolescents [10].

CPR training using artificial intelligence is another step in the evolution of feedback-based teaching. This method involves using AI-powered systems to evaluate learner performance, identify mistakes, correct automatically, and offer personalized feedback during CPR practice. AI-based real-time feedback can deliver objective, standardized, and continuous assessment, as opposed to traditional training, which relies primarily on the feedback provided by the instructor. the role of AI in CPR training and emphasized the growing potential of using AI for enhanced simulation-based education, performance evaluation, and feedback provision. It may be especially valuable in school environments where there are multiple adolescents requiring training in a single organization [11].

Therefore, the comparison between traditional CPR training and real-time feedback CPR training utilizing AI is important not only for educational purposes but also for public health. Traditional training is still available, still familiar, and still applicable, but it can't always offer individual corrective training or measurable performance data. AI-powered real-time feedback training could overcome these drawbacks by providing real-time performance analysis, individualized correction, and objective CPR quality tracking. But the question remains of whether these technological benefits lead to the improvement of the durability of skills, self-confidence and skills in practice among adolescents.that CPR feedback devices in resuscitation training are essential, and the importance of studying CPR skill acquisition and retention effects of feedback-based training [9-12].

Despite the availability of several studies on CPR training within school children, adolescents and students, there is a need for specific comparative studies that directly compare the traditional CPR training to AI-based real-time feedback CPR training with multiple outcome measures. A lot of previous studies have centered on knowledge gain, immediate skill acquisition or the overall effectiveness of feedback devices. There is, however, a need to examine adolescent CPR education education in a broader way, considering the ability to sustain CPR over time, confidence in action in an emergency, and practical competency at CPR performance also suggested that the quality of basic life support training could be linked to the delivery of such training and trainer-related factors, thus highlighting the importance of investigating standardized technology-based training options [13].

Rational of the Study

Cardiopulmonary Resuscitation (CPR) is a life-saving technique which can make a difference in cardiac emergencies. Adolescents are an important population for CPR education as early education translates to greater community preparedness and emergency response capacity. While conventional CPR education enhances knowledge and skills, it may not provide immediate individualized feedback, potentially impacting the precision and retention of these skills. New innovations in Artificial Intelligence (AI) have enabled the development of real-time feedback systems, offering immediate corrective instruction while practicing CPR. There is limited evidence that AI-based CPR training is superior to traditional training methods in adolescents.The effectiveness of AI-based CPR training compared to traditional training methods in adolescents is limited. This study was designed to compare the Traditional CPR Training and the AI Based Real-Time Feedback CPR Training in terms of knowledge, self-efficacy, practical performance and long-term retention of CPR skills among adolescents. The results could inform school-based approaches to CPR training to be more effective.

Statement of the Problem

In cardiac emergencies, adolescents may lack knowledge of CPR, confidence and competency in performing CPR. While Traditional CPR Training is prevalent, AI-driven real-time feedback systems are an alternative to enhance CPR learning outcomes. But, there is limited evidence that compares the effectiveness of these two training methods among adolescents. For this reason, the present study was carried out to compare between Traditional CPR Training and AI-Based Real-Time Feedback CPR Training so as to gain better knowledge of CPR, self-efficacy, and practical competency skills, and also to learn about the retention of these CPR skills in adolescents.

Significance of the Study

The present study has an importance because it presents the evidence about the effectiveness of Traditional CPR Training and Artificial Intelligence-Based Real-time Feedback CPR Training among adolescents. The findings will enable educators, health care professionals, and policy makers to recognize which methods are effective in enhancing CPR knowledge, self-efficacy, practice and retention. The study also serves as a reminder of the future potential of innovative technologies to enhance school-based CPR education and emergency preparedness. In addition, the results could be used to develop effective CPR training programs to improve adolescents' competence and confidence in appropriate response during a cardiac emergency.

REVIEW OF LITERATURE

There is an increasing amount of research that demonstrates the need for successful adolescent and school CPR education. Typically, structured CPR instruction has been shown to enhance knowledge, confidence, skills, and emergency preparedness. The use of virtual reality (VR), augmented reality (AR), mobile learning apps, and real-time feedback systems have also revolutionized CPR education.In recent years, educational technology has additionally improved the study of CPR using virtual reality (VR) and augmented reality (AR) technologies, in addition to mobile learning apps and real-time feedback systems. Research shows that the use of technology-assisted training methods has been positively linked to learners' engagement, motivation, and procedural understanding in contrast to traditional instructional methods by Buttussi et al., 2020; Ricci et al., 2022 [14-15].

Results of several studies indicated that CPR training with feedback could significantly enhance the quality of compression, the accuracy of the procedure, and the overall CPR competency. Automated feedback devices,

audiovisual guidance systems, and videorecording-based feedback approaches have been found to be effective to provide immediate corrective information during practice sessions, which have been linked to improvements in learner performance, confidence, and skill acquisition by Gugelmin-Almeida et al., 2021; Lin et al., 2022; Sood et al., 2023 [16, 17-18] Likewise, mobile learning applications and digital educational systems have been proven to enhance CPR knowledge retention, student motivation, and emergency response self-confidence among adolescents by Arif et al., 2021 [19] .

Recent evidence also indicates the use of immersive technology (VR/AR) in CPR education. These methods simulate the real world and facilitate procedural learning, psychomotor coordination, learner satisfaction and retention of CPR skills (Artero et al., 2023; Castillo et al., 2023) [20-21]. Additionally, school-based CPR training programs have been shown to substantially enhance CPR knowledge, hands-on skills and emergency response skills in adolescents. Repeated practice, feedback supported learning, and technology-assisted instruction are important elements in maintaining CPR competency over time (Onbasilar et al., 2025) [22].

CPR education has also been shown to increase the confidence in CPR, willingness to perform CPR, and preparedness to respond to a cardiac emergency among adolescents. Fear, uncertainty, and hesitation are reduced and self-efficacy and emergency response behavior are increased through structured training programs (Hamednia et al., 2025). In general, the current literature demonstrates the importance of introducing innovative educational technologies and feedback-based learning strategies to CPR training programs [23]. Only a few studies have directly compared Traditional CPR Training and Artificial Intelligence-Based Real-Time Feedback CPR Training for adolescents in terms of knowledge, self-efficacy, practical competency and retention of skills.

Research Gap

Previous studies have demonstrated that CPR training increases knowledge and basic practical skills in adolescents, as well as the use of technology in CPR training, including virtual reality, mobile application, feedback device, and simulation-based learning, which can improve learner engagement and CPR performance (Buttussi et al., 2020; Lim et al., 2022; Castillo et al., 2023). The study of feedback devices also found that real-time correction of the chest compression quality and competency of CPR (Gugelmin-Almeida et al., 2021; Sood et al., 2023). Previous research was mainly on traditional CPR training or on each technology-assisted training technique individually, though. There are only a few studies that directly compared traditional CPR training with AI-based real-time feedback CPR training for adolescents. Furthermore, there has been a lack of research to look at baseline CPR knowledge, self-efficacy, skill competency, and the sustainability of the skills within one study design. Thus, it remains unclear whether AI-mediated real-time feedback CPR training can be more effective than conventional CPR training for long-term CPR skill retention, self-confidence and practical CPR competency for adolescents

Conceptual Framework

The Bandura's Self-Efficacy Theory (SCT) is used to guide this study, which focuses on the importance of an individual's self-efficacy (SE) beliefs in learning, performance, and skill retention (Bandura, 1977) [24]. The theory proposes that training builds confidence which leads to a higher motivation, capability and ability to perform well learnt skills. Developed this theory and applied it to CPR training:

- **Knowledge acquisition:** Adolescent's knowledge of CPR principles, emergency response and lifesaving techniques.
- **Self-efficacy:** Adolescents' self-assurance on their CPR performance in emergency situations.
- **Skill performance:** Effectively perform CPR procedures including chest compressions and rescue procedures.
- **Feedback and reinforcement:** Ongoing guidance and feedback that is provided throughout training, especially through AI-driven real-time feedback systems [11].
- **Behavioral competence:** Application of CPR knowledge and skills in simulated emergency situations with success.
- **Skill retention:** Capacity for adolescents to remember their CPR knowledge and skills over time [23].

The Self-Efficacy Theory is a comprehensive model that explains the effect of CPR training on knowledge, confidence, skill performance and retention in adolescents [25].

RESEARCH METHODOLOGY

This study was a comparative experimental research design for comparing the effectiveness of Traditional CPR Training with Artificial Intelligence-Based Real-Time Feedback CPR Training among adolescents. The study was designed to evaluate the effectiveness of both training methods on CPR knowledge, self-efficacy, CPR skills, and retention of CPR skills.

Research Design

A pre-test – post-test comparative experimental design was employed in the study. The participants were split into two groups: Traditional CPR Training Group and the AI-Based Real-Time Feedback CPR Training Group. The assessment of outcomes pre and post training intervention.

Setting of the Study

The study was carried out on the selected educational institutions among the adolescents. Training sessions took place in an artificial learning environment with standardized procedures and equipment for CPR training.

Population and Sample

The target population was adolescents who are eligible to participate in CPR training programs. Twenty-five (250) adolescents were involved in the study, with 125 subjects randomly assigned to the Traditional CPR Training Group and 125 to the AI-Based Real-Time Feedback CPR Training Group.

Sampling Technique

The participants were selected by purposive sampling technique considering the inclusion criteria and the willingness of the participants in the study.

Criteria for Sample Selection

Inclusion Criteria

- Adolescents willing to participate in the study.
- Adolescents who were available during the data collection.
- Adolescents who gave informed consent/assent.

Exclusion Criteria

- Adolescents who had advanced CPR certification.
- Adolescents unwilling to participate in the study.

Data Collection Instruments

CPR knowledge, CPR self-efficacy and practical competency were measured using a structured assessment tool. Practical skills and competency were evaluated in a training session using standardized CPR performance evaluation criteria.

Reliability and Validity

Content validity was achieved through the work of the CPR training and emergency care experts. The instrument was then tested for its reliability by calculating the Cronbach's alpha coefficient, with a value greater than 0.80 was considered as good internal consistency which made the instrument suitable for this study.

Ethical Considerations

Ethical clearance was given before data collection was done. The involvement of the subjects was voluntary and informed consent was obtained. The information from the participants was kept confidential and anonymous throughout the study.

Data Collection Procedure

A baseline assessment of knowledge, self-efficacy and practical competency in CPR was performed prior to training. The participants were then randomly assigned to either Traditional CPR Training or the AI-Based Real-Time Feedback CPR Training group. The post-test assessments and the skill retention were carried out as per the study protocol.

Data Analysis Plan

Descriptive and inferential statistics were used for analysing the collected data. Descriptive analysis was presented in terms of frequency, percentage, mean and standard deviation. Differences within group and between groups were compared using Independent t-test and paired t-test. A p value < 0.05 was regarded as statistically significant.

RESULT AND FINDINGS

Table 1: Demographic Profile of the Respondents

S.No.	Demographic Variable	Category	Frequency (n)	Percentage (%)
1	Age	13–14 years	72	28.8
		15–16 years	108	43.2
		17–18 years	70	28
2	Gender	Male	128	51.2
		Female	122	48.8
3	Educational Level	Secondary School	118	47.2
		Higher Secondary School	132	52.8
4	Previous CPR Training	Yes	64	25.6
		No	186	74.4
5	Source of CPR Knowledge	School	82	32.8
		Internet	58	23.2
		Healthcare Professional	34	13.6
		Family	29	11.6
		No Previous Knowledge	47	18.8
6	Participation in Emergency or First Aid Programs	Yes	91	36.4
		No	159	63.6
7	Familiarity with Technology-Based Learning	Very Familiar	52	20.8
		Familiar	88	35.2
		Neutral	47	18.8
		Unfamiliar	39	15.6
		Very Unfamiliar	24	9.6
8	Availability of Smartphone or Digital Device	Yes	214	85.6
		No	36	14.4
9	Willingness to Perform CPR During Emergency	Strongly Willing	69	27.6
		Willing	96	38.4
		Neutral	43	17.2
		Unwilling	28	11.2
		Strongly Unwilling	14	5.6
	Total		250	100

The demographic profile analysis of the 250 adolescents revealed that the majority of adolescents were aged 15 to 16 years (43.2%), 13 to 14 years (28.8%) and 17 to 18 years (28%). Gender distribution shows a balance of almost 50:50 with male respondents making up 51.2% and female respondents 48.8%. Education wise, 52.8% of

the respondents are from higher secondary school and 47.2% are from secondary school. Limited prior exposure to formal CPR education indicated by the majority of participants who have never received CPR training (74.4%). The internet (23.2%) was the second most important source of CPR knowledge with school being identified as the primary source (32.8%) and 18.8% indicating they had no prior knowledge of CPR. It was also found that prior to this study, 63.6% of the respondents had no prior participation in any emergency or first aid programs. Regarding technology-based learning, most respondents were familiar (35.2%) or very familiar with (20.8%) digital learning systems. The vast majority (85.6%) of participants had a smartphone or digital device. Further, a significant number of respondents indicated that they would be willing to give CPR assistance in an emergency situation, 38.4% and 27.6% respectively would be willing and strongly willing to assist with CPR.

1.1 Baseline Comparison Between Study Groups

Table 2: Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Knowledge_Total_Pre	1.00	125	24.2880	5.57474	.49862
	2.00	125	24.3680	5.60031	.50091
SelfEfficacy_Total_Pre	1.00	125	23.7840	4.99772	.44701
	2.00	125	23.7680	4.99376	.44666
Practical_Total_Pre	1.00	125	24.4160	4.95005	.44275
	2.00	125	24.1040	4.80394	.42968

Before the training intervention, the mean scores of the two groups (Traditional and AI) were very similar, as shown by the Group Statistics results. The mean knowledge scores for the Traditional and AI groups were 24.29 and 24.37, respectively, with the mean self-efficacy scores for the Traditional and AI groups being 23.78 and 23.77, respectively, and the mean practical competency scores for the Traditional and AI group being 24.42 and 24.10, respectively. The results indicated that the knowledge, confidence and competency in CPR between the two groups were nearly equal at the beginning of the study.

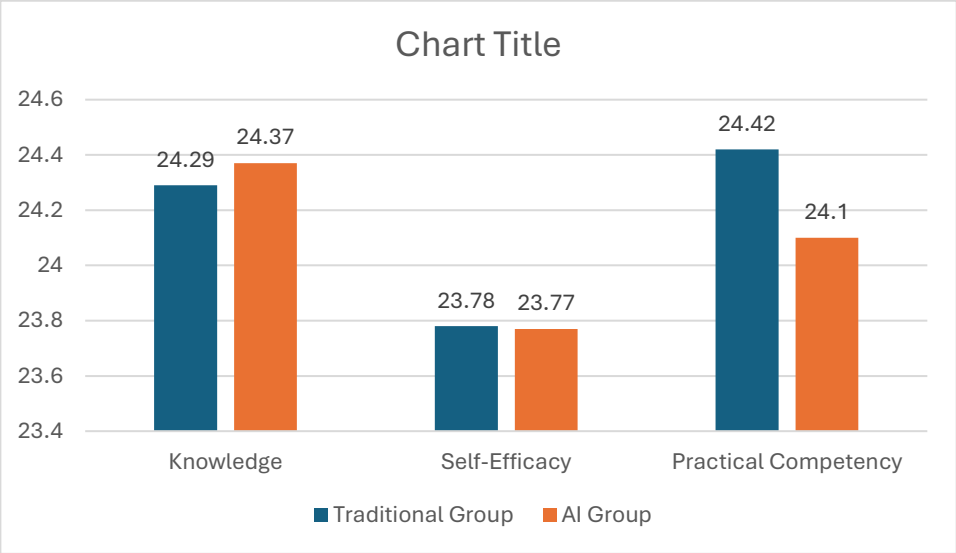

Figure 1. Baseline Comparison of Traditional and AI Groups Before CPR Training

To confirm that there were no significant differences between the two groups in terms of baseline characteristics, the mean scores of CPR knowledge, self-efficacy and practical competency before training are compared and presented at the end of each scoring sheet in figure 1.

Table 3: Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper

Knowledge_Total_Pre	Equal variances assumed	.125	.723	-.113	248	.910	-.08000	.70677	-1.47204	1.31204
	Equal variances not assumed			-.113	247.995	.910	-.08000	.70677	-1.47204	1.31204
SelfEfficacy_Total_Pre	Equal variances assumed	.049	.824	.025	248	.980	.01600	.63192	-1.22861	1.26061
	Equal variances not assumed			.025	248.000	.980	.01600	.63192	-1.22861	1.26061
Practical_Total_Pre	Equal variances assumed	.225	.635	.506	248	.614	.31200	.61697	-.90316	1.52716
	Equal variances not assumed			.506	247.778	.614	.31200	.61697	-.90317	1.52717

For baseline scores, there were no statistically significant differences between the Traditional and AI groups for knowledge (p = 0.910), self-efficacy (p = 0.980), and practical competency (p = 0.614) found using the Independent Samples T-Test. All the p values were larger than the set value of 0.05, so H_{01} was accepted. Thus, both groups were similar in baseline levels and a valid comparison could be made between the effectiveness of the two CPR training methods.

1.2 Outcomes of Conventional CPR Training

Table 4: Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Knowledge_Total_Pre	24.2880	125	5.57474	.49862
	Knowledge_Total_Post	32.1600	125	1.31615	.11772
Pair 2	SelfEfficacy_Total_Pre	23.7840	125	4.99772	.44701
	SelfEfficacy_Total_Post	31.3840	125	1.28128	.11460
Pair 3	Practical_Total_Pre	24.4160	125	4.95005	.44275
	Practical_Total_Post	31.3520	125	1.25246	.11202

The results of the Paired Samples Statistics indicate a significant increase in the mean scores following Traditional CPR Training. Before training, the mean knowledge score was 24.29; and after training, it was 32.16. Likewise, the self-efficacy of students was increased from 23.78 to 31.38 and practical competency of students was increased from 24.42 to 31.35. The results showed that Traditional CPR Training lead to significant changes in CPR related knowledge, confidence, and skills among adolescents.

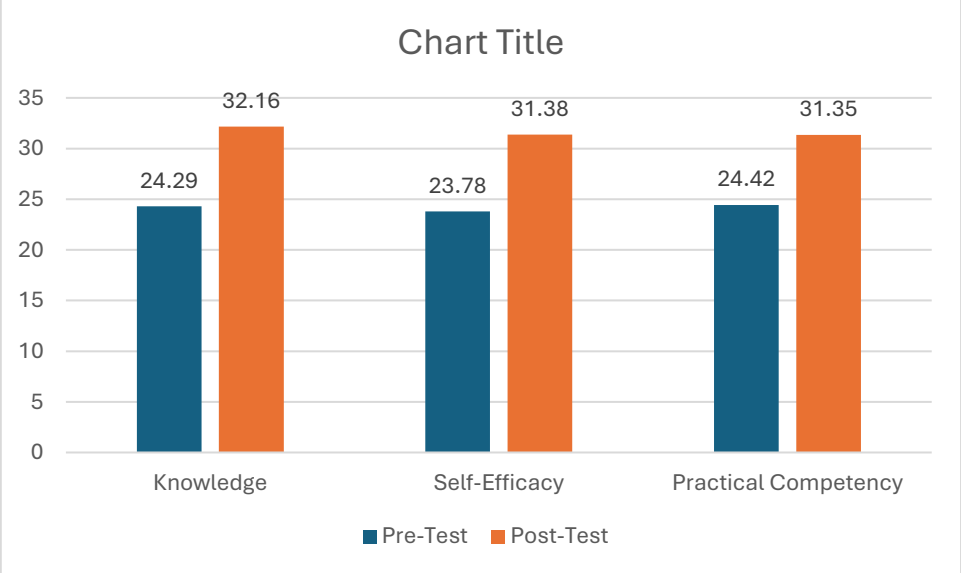

Figure 2. Pre-Test and Post-Test Comparison of Knowledge, Self-Efficacy, and Practical Competency Following Traditional CPR Training.

After Traditional CPR Training, there was a significant improvement in CPR knowledge, self-efficacy, and practical competency as seen in Figure 2. All post-test scores were significantly higher than the pre-test scores, suggesting that Traditional CPR Training can positively impact the CPR knowledge, confidence, and ability of adolescents.

Table 5: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Knowledge_Total_Pre - Knowledge_Total_Post	-7.87200	5.65111	.50545	-8.87243	-6.87157	-15.574	124	.000
Pair 2	SelfEfficacy_Total_Pre - SelfEfficacy_Total_Post	-7.60000	5.14625	.46029	-8.51105	-6.68895	-16.511	124	.000
Pair 3	Practical_Total_Pre - Practical_Total_Post	-6.93600	5.09703	.45589	-7.83834	-6.03366	-15.214	124	.000

Overall, the Paired Samples T-Test showed that all assessed domains were significantly better after Traditional CPR Training. There was a significant increase in the scores of knowledge, self-efficacy, and practical competency ($t = -15.574$; $p < 0.001$, $t = -16.511$; $p < 0.001$, $t = -15.214$; $p < 0.001$, respectively). Hence, the null hypothesis was rejected suggesting that the Traditional CPR Training had a significant positive impact on the CPR knowledge, self-efficacy and practical competency of adolescents.

1.3 Outcomes of AI-Based Real-Time Feedback CPR Training

Table 6: Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Knowledge_Total_Pre	24.3680	125	5.60031	.50091
	Knowledge_Total_Post	27.9760	125	1.53173	.13700
Pair 2	SelfEfficacy_Total_Pre	23.7680	125	4.99376	.44666
	SelfEfficacy_Total_Post	27.7760	125	1.91288	.17109
Pair 3	Practical_Total_Pre	24.1040	125	4.80394	.42968
	Practical_Total_Post	27.9760	125	1.73421	.15511

The Paired Samples Statistics results revealed an improvement in all areas of measurement after the intervention for the AI-Based Real-Time Feedback CPR Training group. The mean knowledge score was 24.37, which rose to 27.98, and the mean self-efficacy score was 23.77, which rose to 27.78, and the mean practical competency score was 24.10, which rose to 27.98. The results indicate that the overall application of AI in CPR training proved beneficial, improving participants' knowledge, confidence, and ability in CPR.

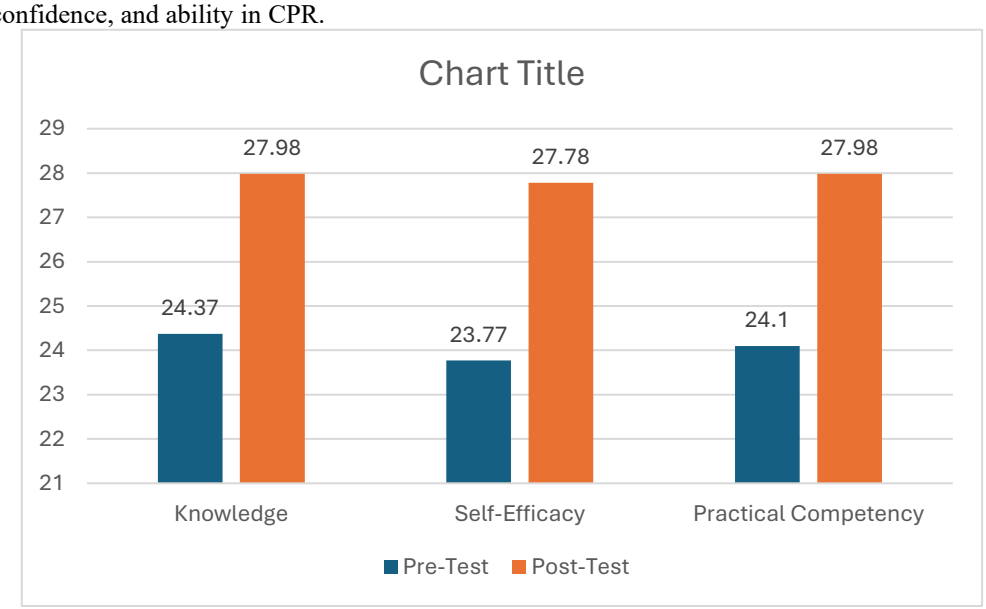

Figure 3. Pre-Test and Post-Test Comparison of Knowledge, Self-Efficacy, and Practical Competency Following AI-Based Real-Time Feedback CPR Training

AI-Based Real-Time Feedback CPR Training resulted in higher mean scores for CPR knowledge, self-efficacy, and CPR competency in practical skills as seen in Figure 3. The result demonstrated that the post-test scores in all the domains were higher than the pre-test scores, suggesting that the AI-based training was effective in developing adolescent CPR knowledge and confidence levels, as well as practical skills.

Table 7: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Knowledge_Total_Pre - Knowledge_Total_Post	-3.60800	5.79056	.51792	-4.63312	-2.58288	-6.966	124	.000
Pair 2	SelfEfficacy_Total_Pre - SelfEfficacy_Total_Post	-4.00800	5.19537	.46469	-4.92775	-3.08825	-8.625	124	.000
Pair 3	Practical_Total_Pre - Practical_Total_Post	-3.87200	4.97409	.44490	-4.75257	-2.99143	-8.703	124	.000

AI-Based Real-Time Feedback CPR Training was found to have statistically significant improvements in knowledge ($t = -6.966$, $p < 0.001$), self-efficacy ($t = -8.625$, $p < 0.001$), and practical competency ($t = -8.703$, $p < 0.001$) after the training. Hence, AI-based CPR training was determined to have a significant positive effect on CPR knowledge, self-efficacy, and skill among the adolescents, which led to the rejection of H_{03}.

1.4 Between-Group Comparison of Training Outcomes and Skill Retention

Table 8: Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Knowledge_Total_Post	Trad	125	32.1600	1.31615	.11772
	AI	125	27.9760	1.53173	.13700
SelfEfficacy_Total_Post	Trad	125	31.3840	1.28128	.11460
	AI	125	27.7760	1.91288	.17109
Practical_Total_Post	Trad	125	31.3520	1.25246	.11202
	AI	125	27.9760	1.73421	.15511
Retention_Total	Trad	125	31.4080	1.32650	.11865
	AI	125	27.6160	1.85257	.16570

The Group Statistics results show the mean scores for each group were higher than the other group in all outcome measures for the Traditional CPR Training group. The Traditional group reported higher knowledge (32.16 vs. 27.98), self-efficacy (31.38 vs. 27.78), practical competency (31.35 vs. 27.98), and skill retention (31.41 vs. 27.62) scores. The results indicate that Traditional CPR Training was more effective in terms of overall learning outcome and retention in the long term among adolescents.

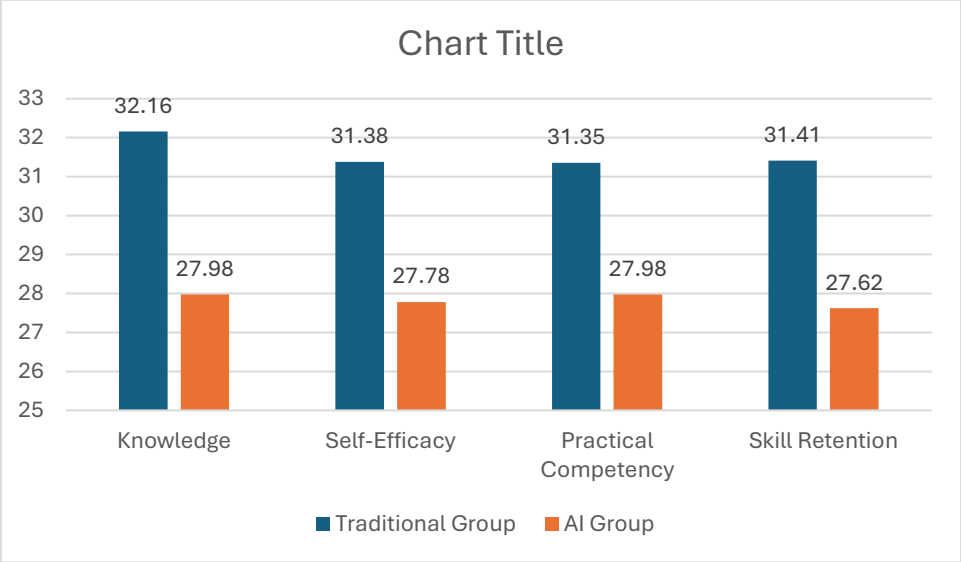

Figure 4. Comparison of Knowledge, Self-Efficacy, Practical Competency, and Skill Retention Between Traditional and AI-Based CPR Training Groups

The mean scores of the Traditional CPR Training group were higher than the AI-Based Real-Time Feedback CPR Training group in all four components of the study: knowledge, self-efficacy, practical competency, and skill retention (see Figure

4). This suggests that the overall CPR learning outcomes of adolescents were better improved with Traditional CPR Training.

Table 9: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Knowledge_Total_Post	Equal variances assumed	.444	.506	23.163	248	.000	4.18400	.18063	3.82823	4.53977
	Equal variances not assumed			23.163	242.505	.000	4.18400	.18063	3.82819	4.53981
SelfEfficacy_Total_Post	Equal variances assumed	14.717	.000	17.521	248	.000	3.60800	.20593	3.20241	4.01359
	Equal variances not assumed			17.521	216.623	.000	3.60800	.20593	3.20212	4.01388
Practical_Total_Post	Equal variances assumed	6.314	.013	17.644	248	.000	3.37600	.19133	2.99915	3.75285
	Equal variances not assumed			17.644	225.688	.000	3.37600	.19133	2.99897	3.75303
Retention_Total	Equal variances assumed	16.872	.000	18.607	248	.000	3.79200	.20380	3.39061	4.19339
	Equal variances not assumed			18.607	224.685	.000	3.79200	.20380	3.39040	4.19360

The Independent Samples T-Test showed significant differences between the Traditional and AI-Based CPR training groups for knowledge ($t = 23.163$, $p < 0.001$), self-efficacy ($t = 17.521$, $p < 0.001$), practical competency ($t = 17.644$, $p < 0.001$), and skill retention ($t = 18.607$, $p < 0.001$). All p-values were <0.05 so H_{04} was rejected. Thus, Traditional CPR Training was shown to be significantly more effective than AI-Based Real-Time Feedback CPR Training in the areas of CPR knowledge, self-confidence, competency, and retention of CPR skills among adolescents.

DISCUSSION

The results of this study show that the Traditional CPR Training and the AI Based Real-Time Feedback CPR Training were effective in improving CPR knowledge, self-efficacy, and skills among adolescents. Both groups were found to be statistically equivalent at baseline assessment, which equalizes the groups and allows for comparison of the effectiveness of training. After the training program, marked improvement was seen in both groups, demonstrating the effectiveness of CPR education in improving participants' understanding, confidence, and performance. The Traditional CPR Training group improved more on all outcome measures. Instructor-led training resulted in higher scores in CPR knowledge, self-efficacy, practical competency, and long-term retention of skills. It seems that direct demonstration, supervised practice, and immediate feedback from the instructor have helped to improve learning experiences and retention of CPR procedures. Human interaction also facilitated the participants to better understand their doubts and gain confidence and skills to use them practically. The results of AI Based Real-Time Feedback CPR Training were comparable and showed positive changes with automated feedback, but were less than the Traditional Training group. The overall findings highlight the ongoing need for teaching CPR to teenagers by an instructor. Traditional CPR Training provided a comprehensive learning environment that facilitated improved understanding, confidence, competency and sustainability of CPR skills.

CONCLUSION

In the current study, the effectiveness of Traditional CPR Training and Artificial Intelligence Based Real-Time Feedback CPR Training were compared amongst adolescents. The results showed that both training methods effectively enhanced participants' knowledge, self-efficacy, practical skills, and retention of CPR skills. But the Traditional CPR Training group performed well in all outcome scores that were significantly higher than the AI-based Training group. The findings indicate that, instructor-led demonstration, supervised practice, and direct feedback are significant factors in improving the learning, confidence and retention of CPR skills over time. AI-based real-time feedback systems showed promise in learning outcomes and skill development, but were less effective in maintaining overall CPR competencies compared to traditional training approaches. Thus, Traditional CPR Training is the better way to prepare adolescents to be able to do CPR. The research highlights the need for the structured CPR training programs to be integrated into the educational landscape of schools and other educational institutions to enhance emergency response capabilities and foster life-saving skills among young people.

Implications

The results of this research showed that CPR training has a positive effect on increasing adolescents' knowledge, self-efficacy, competency, and skill retention. The findings justify the inclusion of CPR training programs in schools and educational facilities. This study also emphasizes the need for demonstrations, supervised practice, and feedback to improve the CPR learning outcomes of adolescents.

RECOMMENDATION

- CPR training should be a regular health education activity in schools and educational institutions.
- Long-term skill retention can be increased by running periodic refresher training sessions.
- Schools should be encouraged by healthcare professionals to be involved in CPR awareness and training.
- The use of AI-based feedback technologies can be considered as an additional tool to improve CPR practice and engagement in learning.

LIMITATIONS

- The study was carried out in selected educational institutions, so the results from the study may be limited in generalizability.
- The study was based on the CPR training outcomes during a study period.
- Self-efficacy was determined by self-reported response, which can be subject to participant perceptions.

SUGGESTIONS FOR FUTURE RESEARCH

- Larger and more diverse populations from geographical regions other than those studied could be included in future studies.
- Longitudinal studies could be performed to measure the long-term retention of CPR skills over longer time periods.
- Future studies can explore the differences between various technology-assisted CPR training methods, including virtual reality, augmented reality, and AI-driven systems.
- Other research could include other factors related to adolescents willingness to perform CPR in actual emergencies.

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