

THE USE OF AUTOMATED REAL-TIME FEEDBACK DEVICES TO IMPROVE QUALITY DURING CPR TRAINING AND REAL CPR PERFORMANCE: A SYSTEMATIC REVIEW

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Abstract

High quality cardiopulmonary resuscitation (CPR) is imperative to improve patient outcome after a cardiac arrest. However, it has been demonstrated that CPR quality is normally of suboptimal quality in both real-life resuscitation attempts or simulated training. Automated real-time feedback (ARTF) devices have been considered a potential tool to improve the quality of CPR and maximise retention of the skills. Although previous studies have supported the usefulness of such devices during training, others have conflicting conclusions with regards to its efficacy during real-life CPR. This systematic review of the literature aims to assess the effectiveness of ARTF for improving CPR performance during simulated training and real-life resuscitation in the adult and paediatric population.

Following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [1], articles published between January 2010 and November 2019 were searched from 7 electronic databases (SCIELO, LILACS, BVS, PubMed, Web of Science, Embase, Cochrane, Cinahl, Google Scholar) and reviewed according to the pre-defined eligibility criteria. CPR performance quality was assessed based on guideline compliance for chest compression rate, chest compression depth and complete chest recoil.

871 studies were found, and 32 studies met inclusion criteria. 14 randomised controlled trials (RCTs), 08 randomised trials (RTs) and 10 randomised cross-over trials (RCOTs). Each study used ARTF devices during CPR training or real CPR to analyse the performance of healthcare professionals for paediatric or adult population. According to the studies, the use of ARTF devices enhances CPR performance in terms of achieving the recommended chest compression rate, depth and recoil.

Based on the results of the studies analysed in this review, the use of ARTF can significantly help improve CPR performance during training of healthcare professionals. Further research is needed to reach the same conclusion for real-life CPR.

Keywords: CPR quality, CPR training, automated real-time feedback.

1 INTRODUCTION

Cardiac arrest is a sudden cessation of cardiac activity and circulation due to an electrical malfunction of the heart. The occurrence and survival rates vary extensively around the world with an estimate of 400,000 cases per year in the US and 300,000 occurrences in Europe [2,3]. Survival to hospital discharge rates range between 2% and 18%, making cardiac arrest a worldwide health challenge with high rates of morbidity, mortality and associated costs [4,5].

Appropriate cardiopulmonary resuscitation (CPR) is imperative to the perfusion of vital organs during a cardiac arrest, improving patient outcome. This is achieved by reaching the following metrics, established by current resuscitation guidelines: (i) chest compression rate between 100-120cpm (compressions per minute); (ii) chest compression depth of 4cm for infants, 5cm for children and 5-6cm for adults, (iii) release of pressure on the chest after each compression, (iv) minimising interruption, and (v) rescue breaths between each cycle of chest compressions [6-9]. However, it has been demonstrated that CPR quality is normally of suboptimal quality in both real-life resuscitation attempts or simulated training, having a negative impact on survival and/or patient neurological outcome [5,10,11].

Automated real-time feedback (ARTF) devices have been considered a potential tool to improve the quality of CPR and maximise retention of the skills. A number of ARTF devices have been developed to assist during CPR training and real-life resuscitation. The devices range from metronome only to audio-visual feedback and are based on quality data collected and measured during performance. The data is processed according to resuscitation guidelines and result in visual information or voice messages. The devices provide feedback in real-time and inform the rescuer whether the CPR being delivered is effective [12,13].

Although previous studies have supported the usefulness of such devices during training, others have conflicting conclusions with regards to its efficacy during real-life CPR [14-17]. This systematic review of the literature aims to assess the effectiveness of ARTF for improving CPR performance during simulated training and real-life resuscitation in the adult and paediatric population.

2 METHODOLOGY

This review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

2.1 Eligibility criteria

Inclusion criteria: articles published between January 2010 and November 2019 in adult and paediatric CPR training, and adult and paediatric real-life CPR.

Exclusion criteria: animal studies, observational studies, smart devices.

2.2 PICOS strategy

We used PICOS (participants, intervention, comparison, outcomes, and study design) framework to identify potential studies that could fit our eligibility criteria.

P – healthcare providers

I – use of ARTF during CPR training and real-life CPR (adult and paediatric population)

C – no ARTF during CPR training and real-life CPR

O – quality of CPR based on chest compression rate, depth and recoil compliant with guidelines from the European Resuscitation Council (ERC) [6,7], American Heart Association (AHA) [8,9] and International Liaison Committee on Resuscitation (ILCOR) [6,7].

S - interventional studies including randomised controlled trials (RCTs), randomised trials (RTs) and randomised cross-over trials (RCOTs)

2.3 Search strategy and appraisal

A comprehensive search of the published and unpublished literature was performed with the use of 8 electronic databases: SCIELO; LILACS; BVS; PubMed; Web of Science; Embase; Cochrane and Cinahl. Titles and abstracts from each source were reviewed by 3 researchers independently (DA, TP, LT) according to our predefined eligibility criteria.

Initial sources that met eligibility criteria via title and abstract were subsequently analysed by the researchers. We searched for all interventional studies, including randomized trials assessing the use of ARTF during CPR training and real-life CPR (adult and paediatric population) in which chest compression rate, chest compression depth and/or chest recoil were an explicit outcome.

In order to facilitate the record and analysis of eligible sources, each study was added to a spreadsheet according to the following: title, author, year of publication, country, type of study, number of participants, intervention, outcomes and results.

PRISMA statement was followed to create a four-phase flow diagram.

3 RESULTS

After the initial search, a total of 871 studies were found. 6 additional records were identified through other sources. Following removal of 196 duplicates, 681 sources were screened via titles and abstracts, resulting in 201 possible relevant studies. Upon full text analysis, 32 studies met inclusion criteria and were included in our review including 14 randomised controlled trials (RCTs) [14,17,18,20,23,24,29,32,33,38,40,42,44,45], 08 randomised trials (RTs) [25-28,31,36,37,41] and 10 randomised cross-over trials (RCOTs) [15,16,19,21,22,30,34,35,39,46]. The flow chart of the search and selection process is presented in Fig. 1.

Each study used ARTF devices during CPR training or real CPR to analyse the performance of healthcare professionals for paediatric or adult population.

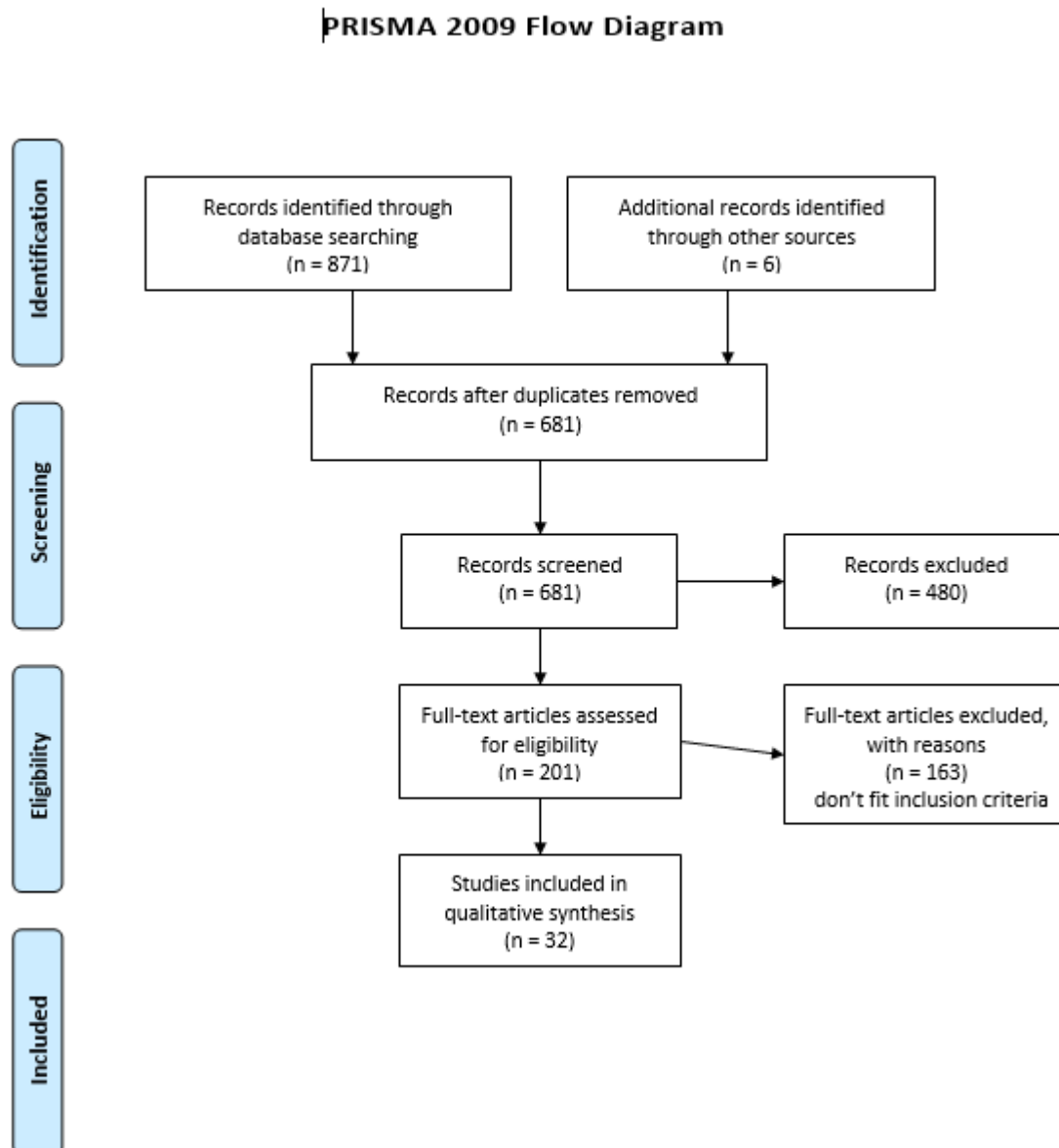


Fig.1. PRISMA diagram (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

3.1 Analysis of individual studies

Due to the different elements included in this systematic review, the researchers classified the studies into three distinct groups: (1) the use of ARTF during paediatric CPR training, (2) the use of ARTF during adult CPR training and (3) the use of ARTF during real adult CPR performance, as demonstrated in Tables 1, 2 and 3. The researchers have not found any study about the use of ARTF during real paediatric CPR performance.

Table 1. The use of ARTF during paediatric CPR training

Author	Year	Country	Type	Intervention	Outcomes
Austin et al.	2017	USA	RCT	simulated paediatric CPR: metronome X visual X none	rate, depth, recoil
Calvete et al.	2017	Spain	RT	ARTF visual X none during simulated paediatric CPR	rate, depth recoil
Cheng et al.	2015	Canada, USA, UK	RCT	ARTF visual X none during simulated paediatric CPR and ARTF X none during training before simulated CPR	rate, depth
Gregson et al.	2016	UK	RCOT	CPR with and without ARTF	rate
Kandasamy et al.	2018	UK	RCT	ARTF X none during simulated infant CPR	rate, depth, recoil
Lin et al.	2018	Canada	RCT	distributed training + ARTF X normal training with no ARTF for paediatric CPR	rate, depth, recoil
Martin et al.	2013	UK	RCT	ARTF X none during simulated infant CPR	rate, depth recoil
Sutton et al.	2011	EUA	RT	instructor-only X ARTF only X instructor combined with ARTF during simulated infant CPR	rate, depth,

Table 2. The use of ARTF during adult CPR training

Author	Year	Country	Type	Intervention	Outcomes
Aguilar et al.	2018	USA	RT	ARTF X none during simulated adult CPR	rate
Allan et al.	2013	Canada	RT	previous training X CPR with/without ARTF	depth
Buleón et al.	2016	France	RCOT	ARTF X none during simulated adult CPR	rate
Cheng et al.	2015	Canada, USA, UK	RCT	ARTF training before simulated CPR X ARTF during simulated CPR	rate, depth
Havel et al.	2010	Austria	RCOT	standard manual CPR X CPR with ARTF	rate, depth

<i>Heard et al.</i>	2019	USA	RCT	standard manual CPR X CPR with ARTF X video based	rate, depth
<i>Iskrzycki et al.</i>	2018	Poland	RCOT	ARTF X none during simulated adult CPR	rate, depth, recoil
<i>Kornegay et al.</i>	2018	USA	RCT	ARTF X none during simulated adult CPR	rate, depth
<i>Kurowski et al.</i>	2015	Poland	RT	ARTF (2 different) during simulated adult CPR	rate, depth
<i>Lee et al.</i>	2015	USA	RCOT	ARTF X none during simulated adult CPR	rate, depth
<i>Lin et al.*</i>	2018	Canada	RCT	distributed training + ARTF X normal training with no ARTF for adult CPR	rate, depth, recoil
<i>Lu et al.</i>	2019	China	RCT	ARTF X none during simulated adult CPR	rate, depth
<i>Pavo et al.</i>	2016	Austria	RCT	standard BLS (no feedback) X ARTF X instructor only feedback	depth
<i>Segal et al.</i>	2011	France	RCOT	metronome based X ARTF for CPR on floor and dentist chair	depth
<i>Skorning et al.</i>	2010	Germany	RCOT	ARTF X none during simulated adult CPR	rate, depth
<i>Skorning et al.</i>	2011	Germany	RCOT	ARTF X none during simulated adult CPR	rate, depth
<i>Tanaka et al.</i>	2017	USA	RCOT	previous training X ARTF with/without football shoulder pads	rate, depth
<i>Tanaka et al.</i>	2019	Japan	RCT	standard CPR training X CPR training with ARTF	rate, depth, recoil
<i>Truszcwski et al.</i>	2016	Poland	RCOT	ARTF (3 different) X none during simulated adult CPR	rate, depth, recoil
<i>Wang et al.</i>	2018	China	RCT	ARTF X none during simulated adult CPR standing and kneeling	rate, depth
<i>Wutzler et al.</i>	2015	Germany	RT	ARTF X none during simulated adult CPR	rate, depth
<i>Yeung et al.</i>	2014	UK	RCT	ARTF (3 different) X none during simulated adult CPR	rate, depth

* *Lin et al.* 2018 – compared adult and paediatric CPR training and was included in both tables

Table 3. The use of ARTF during real adult CPR performance

Author	Year	Country	Type	Intervention	Outcomes
Bohn et al.	2011	Germany	RT	ARTF (audio) and ARTF (visual) on real adult CPR	rate, depth
Hostler et al.	2011	Canada, USA	RT	ARTF (audio) and ARTF (visual) on real adult CPR	depth, recoil
Vahedian-Azimi et al.	2016	IRAN	RCT	standard manual CPR or CPR with ARTF	rate

3.1.1 Discussion

ARTF devices have been developed to improve the quality of CPR performance during resuscitation attempts or to improve acquisition and retention of CPR skills during training. However, there are a great variety of ARTF devices available and the differences between them result in dissimilar outcomes [12,15,22,24]. Some feedback devices offer information about performance, so that rescuers can make real time adjustments to their CPR attempt [38]. Others, such as metronomes, only provide prompts for the rescuer to perform chest compressions at a predetermined measurement, rate for example, but cannot assess the quality of the performance [24,45].

The use of ARTF devices has been examined in each study included in this review and it has been demonstrated that all feedback and/or prompt devices may not have the same impact on performance. Generally, CPR training utilising ARTF results in improved acquisition of CPR skills, longer retention and subsequent enhanced performance when compared to baseline or control groups [16-19,20,23,32,39,44,45]. Metrics such as chest compression rate, chest compression depth, recoil, hand-off time, fatigue reduction and general quality of CPR, significantly improved as a result of the use of ARTF during training in those studies. Conversely, few studies have demonstrated mixed effects with some results showing only modest improvements in CPR skill acquisition but not clinically significant to be considered true change [14,33,46] or no improvement at all [21] and others finding improved CPR measures with the use of ARTF but those results being no better or no worse than those associated with feedback from a trained human instructor [42].

Although the effect of ARTF during CPR training has mostly positive results regarding skill acquisition, retention and simulated performance, the impact of this improvement on clinical outcomes is less clear. Most studies could not demonstrate significant improvement in cardiac arrest survival associated with the use of a feedback device during real CPR performance in comparison to a standard resuscitation attempt [28,36]. Nevertheless, the study published by Vahedian-Azimi et al. (2016) established an improved adherence to current CPR guidelines and CPR quality, as well as increased rates of return of spontaneous circulation and a decrease in rib fractures [29].

Whilst it may be intuitive to assume that the use of ARTF will lead to improvements in cardiac arrest outcomes, none of the studies conducted to date provide definitive evidence of improved survival. However, because ARTF devices appear to enhance CPR quality during training and simulated management of cardiac arrest, the 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care recommends the use of feedback devices as an adjunct to CPR training [43].

4 CONCLUSIONS

This review provides good evidence supporting the use of ARTF devices during CPR training in both adult and paediatric population as a strategy to improve CPR skill acquisition and retention, and reducing fatigue during performance, which increases the chance of a successful outcome when CPR is performed. The evidence may also suggest that the use of ARTF devices in clinical practice, as part of

an overall strategy to improve the quality of CPR, could likewise be beneficial. Further studies are required to assess if the improvements in quality of CPR related to the use of ARTF devices translate into real life cardiac arrest outcomes.

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