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Review

Effectiveness of digital resuscitation training in improving knowledge and skills: A systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Aim: This review aims to evaluate the effectiveness of digital resuscitation training in improving knowledge and skill compared with standard resuscitation training.

Methods: We searched through the CINAHL, Cochrane Library, EMBASE, ERIC, ProQuest Dissertations and Thesis, PsycINFO, PubMed and Scopus from inception of our review until 5 March 2018. The quality of individual and overall evidence was evaluated according to the risk of bias, Medical Education Research Study Quality Instrument (MERSQI) and Grade of Recommendation, Assessment, Development and Evaluation (GRADE) system, respectively. Meta-analyses were performed with the Review Manger software. *Z*-statistics were used to evaluate the overall effect of training, and I^2 test was used to assess heterogeneity. Sensitivity and subgroup analyses were used for additional meta-analyses.

Results: Amongst the 15,528 studies retrieved, 20 randomised controlled trials (RCTs) were selected from 13 countries across different ethnicities. More than half (52%) of the trials had a low risk of bias, and MERSQI scores ranged from 13.5 to 15.5. The overall quality of evidence was very low according to GRADE criteria. Meta-analyses revealed that trainees in digital resuscitation training had better knowledge scores but poorer chest compression rates than that of trainees in standard resuscitation training. Digital resuscitation trainings were non-inferior to standard resuscitation trainings in skill performance scores. Subgroup analyses suggested that digital resuscitation training might consider using blended learning approach with virtual patient, computer-screen based, learning theories and video-recorded assessment, especially for basic life support trainings amongst health professionals.

Conclusion: Despite the wide variation in digital resuscitation trainings, evidence suggesting the use of digital resuscitation training for improving knowledge and skills is inadequate. Well-designed non-inferiority RCTs in multiple settings with follow-up data and large sample size are needed to ensure the robustness of the evidence.

Introduction

Resuscitation training uses multimodal delivery methods to equip trainees with essential knowledge and performance skills to effectively help patients in cardiac arrest. Notwithstanding, digital technology innovation is currently advancing at an unprecedented pace in education and is expected to add value especially in resuscitation training. To improve the flexibility and mobility of training, digital resuscitation approach is used as an alternative to the standard face-to-face training [1,2]. Digital resuscitation training refers to the training that is facilitated by digital technology, including blended, online games, computer support and mobile or virtual learning [3]. Trainers engaged in digital learning activities using a combination of synchronous and asynchronous affordances, resulting in high clarity and effectiveness [4]. Evidently, digital resuscitation training demonstrates equivalence in overall pass rate, autonomy enhancement, manpower reduction and cost-effectiveness [1,2,5] compared with the standard resuscitation training. However, the extent of digital resuscitation training's effectiveness with regard to knowledge and correct compression rate remains unknown.

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According to behavioural and cognitive learning theories, digital resuscitation training is designed from the initial skill level, in which trainees gradually perform a task along the path to mastery [3]. Trainees may build a goal-oriented and self-regulated process through control, self-monitoring, revised techniques, cognitive task analysis procedure and cognitive strategies [6]. Digital resuscitation training helps trainees control their training by using a digital ecosystem of media and tools [7]. The dissemination of training content provides great accessibility because trainees can access the content anywhere at any time. Importantly, no differences are found between digital and non-digital learning on metacognitive process [8]. Trainees can make instructional decisions on content to be covered, select the estimated optimal level of difficulty, sequence a learning path and regulate the speed [9].

Notably, technological advances in the form of ubiquitous digitalization have altered the training format in last few decades. In parallel, a growing number of systematic reviews have supported the effectiveness of trainings with multimodal delivery formats [10–13]. These systematic reviews compare the effect of self-instruction [12], use of high-fidelity manikins [11] or audiovisual feedback devices [10] with standard resuscitation training. However, these reviews are restricted on the combination of various research designs [13], use of few databases [11], combination of human and manikin studies [10] and narrative synthesis only [12]. A few reviews compare the effectiveness of digital resuscitation training and standard resuscitation training in randomised controlled trials (RCTs) only. In this light, the current review aims to synthesise the best evidence for evaluating the effectiveness of digital resuscitation training in improving knowledge and skills compared with SRT by using a meta-analytic approach. Results are crucial for recommending the digital resuscitation training as a possible alternative to the standard resuscitation training.

Methods

This systematic review and meta-analysis is reported in accordance to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [14]. Our review protocol was registered in PROSPERO (registration number: CRD42018091982).

Eligibility criteria

RCTs were considered eligible if they (1) are health and non-health professionals; (2) underwent DRT by using blended, online learning, technology based, video, game or virtual reality; (3) compared the counterparts that underwent standard resuscitation training and (4) are reported to have (at least) one of the skill performance and knowledge. The full inclusion and exclusion criteria for the systematic review are described in Appendix A.

Data sources and search strategy

We searched the Cochrane Databases of Systematic Review, PubMed Clinical Queries, the Centre for Review and Dissemination and the Joanne Briggs Institute to prevent duplication of systematic reviews. To optimise the search, we included published or unpublished trials in English without time limitation. All searches were conducted from inception until 5 March 2018. We collaborated closely with a senior librarian to develop a three-step extensive search strategy according to the recommendations of the Cochrane Handbook for Systematic Review [15]. Firstly, we searched through eight databases, namely, the CINAHL, Cochrane Library, EMBASE, ERIC, ProQuest Dissertations and Thesis, PsycINFO, PubMed and Scopus. Index terms and keywords are documented in Appendix B. We explored and truncated the index and key terms according to different syntax rules of individual database. Secondly, we searched for the ongoing and unpublished trials from various clinical trial registries. Thirdly, we optimised potential trials by handsearching on the reference lists of selected trials and relevant systematic reviews.

The study selection involved four phases by using the PRISMA flow diagram [13]. In the first phase of identification, all records from the respective database were collated in ENDNOTE software version X8 (Thomson Reuters, New York, USA), and duplicates were removed. In the second phase of screening, two reviewers (YL and RN) independently screened the title and abstract to remove irrelevant trials. In the third phase, the reviewers independently assessed the full-text articles for eligibility. In the fourth phase, the two reviewers met to compare their findings and verify if any article was overlooked. They resolved any disagreement through discussion or by inviting a third reviewer (STL).

Quality assessment

The Cochrane collaboration's tool [16] was used to assess the quality of individual trials. Allocation, blinding and outcome were used to assess the risk of performance, detection, attrition and reporting biases [16]. Considering that the selected trials were medical education research, we added the Medical Education Research Study Quality Instrument (MERSQI) [17]. The maximum score for the six domains is 3 and the total scores range from 5 to 18. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system (GRADE pro 3.6) was used to assess the overall strength of evidence [18]. We rated the quality of evidence as high, moderate, low and very low on the basis of the five domains of evidence, namely, methodological limitations, inconsistency, indirectness, imprecision and publication bias [18]. We also investigated the attrition rate [19], intention-to-treat (ITT) analysis [20], missing data management [21], protocol, trial registration and grant support [22] to ensure the robustness of trials [23]. We used a kappa statistic to the assess agreement between reviewers.

Data extraction

The two reviewers (YL and RN) extracted the data independently from the included trials by using standardised data extraction form [15]. Information extracted from eligible trials included authors, year, setting, country, design, subjects, sample size, intervention, comparator, outcomes, measures, attrition rate, ITT, protocol, trial registration and grant support (Table 1). Information extracted for digital resuscitation training included the type of training, learning theory, digital component, training material, interactivity, functionality, provider, examiner, evaluation method and follow-up. The authors were contacted if information was missing or insufficient. After the extraction of all the data, YL and RN met to verify data outcomes. When inconsistencies existed amongst the extracted data, a third reviewer (STL) reviewed full-text articles for verification.

Statistical analysis

The Review Manager Software (Version 5.3, The Nordic Cochrane Centre, Copenhagen) was used to synthesise the outcomes of meta-analyses. *Z*-statistics were used to evaluate the overall effect of the intervention. Effect size, which measures the magnitude of training effect, was expressed as Cohen *d* or standardised mean difference (SMD), where *d* (0.1) = very small, *d* (0.2) = small, *d* (0.5) = medium, *d* (0.8) = large, *d* (1.2) = very large and *d* (2.0) = huge [24]. The SMD expresses the size of the intervention effect in each trial relative to the variability observed in that trial [15]. The SMD was calculated as the mean difference between digital and standard resuscitation training groups divided by the standard deviation of outcome for all participants pooled across both groups [25].

The effect of heterogeneity was calculated as the percentage of total variation across trials using I^2 statistics [26]. The value of I^2 was