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Kinect-based real-time audiovisual feedback device improves cardiopulmonary resuscitation quality of lower-body-weight rescuers☆

Jen-Chun Wang, M.D. [a], Shih-Hung Tsai, M.D., Ph.D. [a,*], Ying-Hsin Chen, M.D., Ph.D. [a], Yu-Long Chen, M.D. [b], Shi-Jye Chu, M.D. [c], Wen-I Liao, M.D. [a,*]

[a] Department of Emergency Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan
[b] Department of Emergency Medicine, Buddhist Tzu Chi General Hospital, Taipei Branch, Taipei, Taiwan
[c] Department of Internal Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan

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ABSTRACT

Background: Chest compression (CC) quality is associated with rescuer posture and body weight. We designed a Kinect module-based real-time audiovisual feedback (AVF) device to investigate the relationship between rescuer posture, body weight, and CC quality.
Methods: A total of 100 healthcare professionals were enrolled as participants in this randomized trial. A Kinect-based sensor system was used to monitor the depth and rate of CC and provide further real-time feedback. All participants were asked to perform continuous CC on a manikin with and without feedback for 2 min individually in either a kneeling or standing position.
Results: A kneeling posture can provide deeper CC than a standing posture can (6.37 ± 1.92 cm vs. 6.05 ± 1.87 cm, p value = 0.03). Real-time AVF feedback can provide a better compression depth, rate, and effective compression ratio (6.16 ± 1.88 cm vs. 5.54 ± 1.89 cm, p value = 0.02; 103.2 ± 21.0/min vs. 96.7 ± 25.8/min, p value = 0.03; 62.6 ± 28.0% vs. 51.0 ± 33.2%, p value = 0.004). Regardless of the effect of real-time feedback, the CC depth correlated to the rescuers' body weight. Rescuers who weighed below 71 kg benefited from the Kinect module-based real-time AVF device in terms of improved CC quality.
Conclusion: The Kinect-based AVF device can significantly improve CC quality in manikin training in rescuers with their body weight < 71 kg.

1. Introduction

Adequate compression rate and depth are emphasized by the 2015 American Heart Association and European Resuscitation Council guidelines [1-4]. The 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations also suggest the use of real-time audiovisual feedback and prompt devices during cardiopulmonary resuscitation (CPR) in clinical practice as part of a comprehensive system for care for cardiac arrest [5].

Several technologies have been used to provide real-time monitoring or feedback for CPR, including pressure sensors, accelerometers, force sensors, impedance signalling, and motion detectors [6,7]. Commercial audiovisual feedback (AVF) devices are usually not readily available or cost-effective. Kinect-based motion sensing devices are a newly developed technology for detecting and recording chest compression (CC) quality. Kinect is a motion-sensing input device manufactured by Microsoft for the Xbox 360 gaming console. Kinect provides three-dimensional motion capture of objects and recognition capabilities. A self-developed software is required for driving the Kinect camera. It is increasingly applied in medical fields such as balance training and rehabilitation tools [8]. Kinect-based AVF devices have been combined with self-developed software to improve the depth and rate of CC in CPR training [7,9]. However, previous studies regarding Kinect-assisted CC have only concerned standing posture use and single scenarios [7].

Several studies have demonstrated that rescuer posture and body weight can influence CC quality. A previous study demonstrated significant differences in compression rate and depth between CPR performed on manikins placed on the floor and those placed on a stretcher at rescuers' knee height [10]. When performing CC, rescuers developed fatigue more easily in the standing posture than they did in the kneeling posture [11]. When performing CC on a manikin on the

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* Corresponding authors at: Department of Emergency Medicine, Tri-Service General Hospital, National Defense Medical Center, No. 325, Sec. 2, Cheng-Kung Road, Taipei, Taiwan.
E-mail addresses: tsaishihung@mail.ndmctsgh.edu.tw (S.-H. Tsai), qqww0139@mail.ndmctsgh.edu.tw (W.-I. Liao).

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floor, rescuers with lower body weight tended to become fatigued, which resulted in gradually declining CC quality compared with those with higher body weight [12]. Rescuers with a body mass index (BMI) < 26 tended to perform CC with inadequate depth and finished CC faster than those with a BMI > 26 [13]. Although numerous feedback systems for CPR exist, studies investigating the effect of Kinect-based AVF on CPR quality are limited. In addition, no study has evaluated the effect of Kinect-based real-time AVF in terms of rescuer body weight and position.

The present study examined the effectiveness of Kinect-based real-time AVF devices and the association between the rescuer posture and body weight, CC quality, and real-time feedback. We hypothesized that CC quality might be influenced by the rescuer posture and body weight and that a Kinect-based real-time feedback device might produce improved CC quality. We concluded that healthcare providers with lower body weight tended to provide suboptimal quality CPR and would benefit from Kinect-based real-time AVF devices.

2. Methods

2.1. Data collection

This study is a randomized trial with 100 participants who are employees of Tri-Service General Hospital and ambulance service, including doctors, nurses, and emergency medical technicians. All had received CPR training and certification within 2 years of the study. This prospective collection of CC data was approved by the Institutional Review Board of the Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan.

2.2. Study protocol

All participants underwent full BLS or ACLS training programs according to the 2010 International Liaison Committee on Resuscitation guidelines within 2 years of the start of this study. CPR was administered in one-rescuer and compression-only mode to focus the efficiency of chest compressions. Participants were divided into two randomized groups: those kneeling beside the manikin on the floor and those standing beside the manikin lying on a bed with a hard backboard (bed height = 60 cm). Participants performed continuous CCs on a manikin without feedback for 2 min and shifted to with feedback groups (Fig. 1). All participants had at least a 1-h rest period between two CPR settings.

A self-developed software was paired with the Kinect (Microsoft, Redmond, WA, USA) motion-sensing module to monitor the number and depth of CCs and provide real-time AVF (Fig. 2). The horizontal field of the Kinect sensor was approximately 50–70 cm, and the vertical field was 70 cm, resulting in a resolution of slightly >0.6 mm per pixel. The participants attached a hand marker (4 × 4 cm) made of paper to the top surface of their left hand. Kinect sensors detect and record the position and motion of participants' hands every 1/20 s. The feedback group performed CC with real-time AVF during the entire 2-min test. Participants could adjust their CCs according to the information presented on the monitor, including the depth and rate of compressions. The non-feedback group performed CC without any feedback and the Kinect device was used to record only the depth and rate.

2.3. Data analysis

The CC quality was analysed according to the CC rate and depth and the effective compression ratio (compressions with depth > 5 cm/total

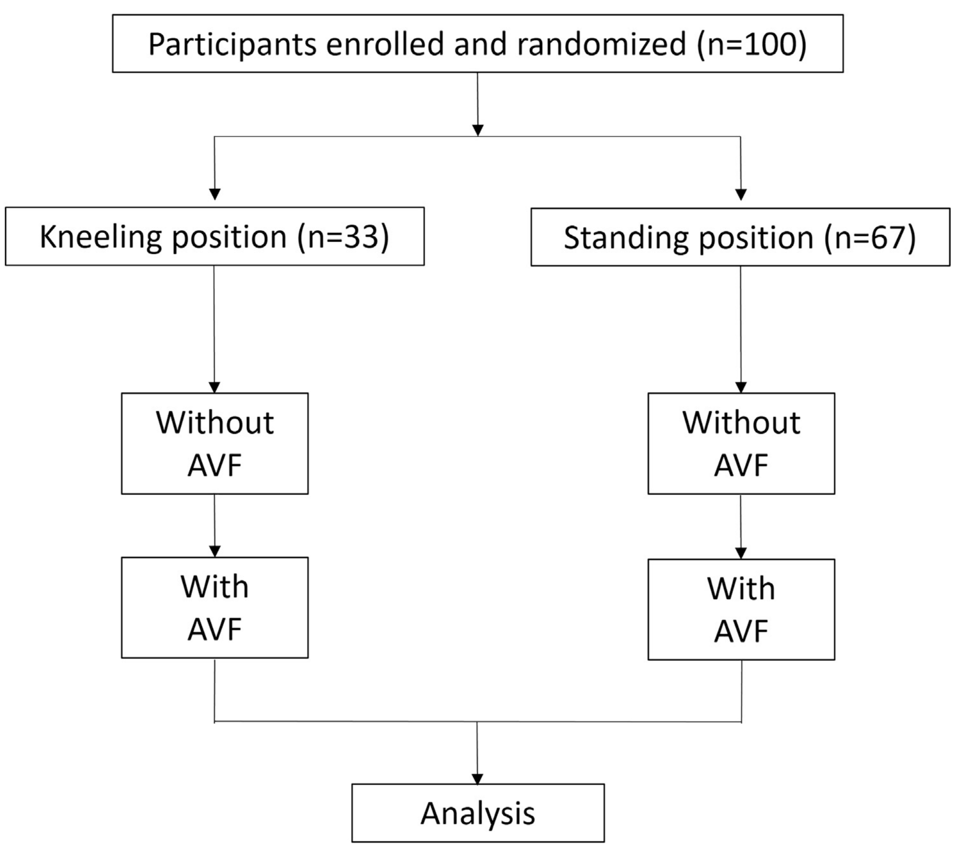

Fig. 1. Study flow chart. Participants performed continuous CCs on a manikin without feedback for 2 min and shifted to with feedback groups. All participants had at least a 1-h rest period between two CPR settings.

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