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Effects of positive dispatcher encouragement on the maintenance of bystander cardiopulmonary resuscitation quality

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Abstract

Background : Implementation of dispatcher-assisted cardiopulmonary resuscitation (DACPR) has increased the likelihood of bystander CPR upon cardiac arrest. However, the quality of CPR has been found to be very low. In this study, we aimed to compare CPR quality between the current DACPR practices and the interventional instruction of adding verbal encouragement from the dispatcher.

Methods : In this randomized controlled trial, we recruited adult (age ≥18) laypersons who were non-health care providers and had never received any previous verified CPR training. They were randomly selected to perform DACPR using metronome sounds (mDACPR) as per the standard protocol, or DACPR with metronome sounds along with human encouragement (mheDACPR). The ratio of accurate compression rate, depth, and complete release for each CPR phase was examined.

Results: Sixty nine records (34, mDACPR; 35, mheDACPR) were taken. The median proportion of accurate chest compression rate was initially 29.5% with mDACPR, and significantly increased to 71% after 2 minutes of CPR administration ($P = .046$). However, the median ratio of accurate chest compression depth was 61.5% in the first phase, and significantly decreased to 0% in the last phase ($P < .001$). In contrast, for the mheDACPR group, a high accurate compression rate was maintained throughout the 2 minutes of CPR administration (91%, 100%, 100%, 100%).

Conclusion : To maintain the quality of CPR administered by bystanders, continuous feedback and repeated human encouragement should be provided during DACPR. Active dispatcher intervention reduces the time required to reach an appropriate CPR rate and allows for the maintenance of accurate compression rates.

Abbreviations: BLS = basic life support, BMI = Body mass index, CPR = cardiopulmonary resuscitation, DACPR = dispatcher-assisted cardiopulmonary resuscitation, OHCA = Out-of-hospital cardiac arrest, IQR = interquartile range, mDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome only, mheDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome and human encouragement.

Keywords: cardiac arrest, emergency ambulance systems, resuscitation

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The authors report no conflicts of interest.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major public health burden worldwide. Five million people experience OHCA every year, of whom only 7% survive.[1] Bystander cardiopulmonary resuscitation (CPR) is a key factor in the survival of patients with cardiac arrest.[2,3] However, the bystander CPR rate remains low.[4] To try to counteract this, dispatcher-assisted cardiopulmonary resuscitation (DACPR) programs have been implemented in many countries. The role of emergency medical dispatchers is not only to quickly recognize cardiac arrest, but also to guide bystanders to start CPR quickly and to achieve a high-quality CPR.[5] DACPR has successfully increased the likelihood of performing chest compressions on cardiac arrest.[6] However, the quality of CPR has been found to be very low when compared with that in the recommended guidelines.[7,8]

To improve the quality of CPR administered by bystanders, real-time guidance with audible prompt devices that administer metronome sounds have been used as a feedback method. Previous studies have demonstrated that guiding the metronome sounds in real time improves the compression rate.[9] However, using the metronome does not improve the depth of chest compressions.[10] In addition, it has not been confirmed that the quality of compression can be maintained for 2 minutes, which is the alternating CPR cycle recommended in the current guidelines.[10]

We hypothesised that if the dispatcher adds positive verbal encouragement to the current instruction protocol, this will improve and maintain the quality of bystander CPR. We aimed to compare the sustainability of the CPR quality between the current DACPR guidelines with the interventional instruction of adding dispatcher verbal encouragement.

2. Methods

2.1. Study design and participants

We performed a randomized controlled trial in a simulation setting using a manikin. This simulation trial was conducted at a simulation center that ran CPR training courses approved by the Korean Association of Cardiopulmonary Resuscitation and the American Heart Association. The participants were recruited from adult (aged ≥18) laypersons who attended the CPR training courses provided from January 2019 to January 2020 at the center. All participants were non-health care providers and had never received verified CPR training previously. Among the participants, those with physical or communication disabilities precluding CPR performances were excluded from this study.

2.2. Ethics

Ethics approval was obtained from the Institutional Review Board at Hallym University to conduct a randomized controlled trial (Approval number: HDT 2018-12-010). Written informed consent was obtained from each participant. Participants were offered a gift certificate valued at $5 upon study completion.

2.3. Sample size

Referencing the data on CPR quality in prior studies, we assumed that 90% of the bystander group with metronome guidance would achieve an accurate compression rate with a 15% decrease in compression rate.[9,11] We also hypothesised that the compression quality of the intervention group could be maintained. To achieve an α error of 5% and a statistical power of 80% during 4 repeated measures conducted among the 2 groups, we estimated that a minimum sample size of 31 would be required in each group. Considering a 20% exclusion rate, we aimed to recruit a total of 78 subjects.

2.4. Study protocol

Before the study, we briefly explained the overview of DACPR to the subjects and introduced them to the simulation room. In the isolated space, we prepared the Resusci Anne Skill Reporter (Laerdal Medical Corporation, Stavanger, Norway) on the floor. The cellular phone (SM-G950N, Samsung, Seoul, Korea) was beside the manikin for administration of DACPR guidance.

The simulation scenario consisted of a witness of an OHCA, the activation of the emergency medical services (EMS) system with the prepared cellular phone, and the performance of bystander DACPR according to the instructions of the dispatcher. The participant entered the room alone, and the dispatcher communicated with the subjects only through the cellular phone.

Participants were randomly assigned into 2 parallel groups in a 1:1 ratio. Participants were randomly selected to perform DACPR using metronome sounds (mDACPR) as standard protocol or DACPR using metronome along with human encouragement (mheDACPR). The sequence of randomized assignments was generated by variable block randomization according to participant sex.

Following the standard protocol, audible guidance was given to the rescuer using the speaker function. After the posture, position, speed, and depth of the chest compression were guided, the metronome was activated. The metronome was set to 110 times per minute and hands-only CPR was conducted for 2 minutes. In addition, the mheDACPR group was encouraged by dispatchers every 30 seconds, with dispatchers saying: "You are doing well. Please cheer up a little bit more."

2.5. Outcome measures

A questionnaire was administered to participants by members of the study team. Information on age, sex, height, weight, exercise habit, underlying diseases, and history of prior CPR training was collected. Body mass index (BMI) was calculated from height and weight, as kg/m^2.

Each phase was divided into 4 analysis windows of 30 seconds in duration, starting with the first compression of the participants according to dispatcher instructions (phase 1: 0–30 seconds; phase 2: 30–60 seconds; phase 3: 60–90 seconds; phase 4: 90–120 seconds). The parameters assessed included compression rate, compression depth, and complete release of pressure between compressions for each phase. The average compression rate for each phase was defined as the number of compressions administered per minute. Based on the current guidelines, the accurate chest compression rate was defined as 100 to 120 compressions/minutes, while the accurate chest compression depth was set at 5 to 6 cm.[12,13] The outcome was the ratio of accurate compression rate, depth, and complete release for each phase depending on the instruction method for DACPR.

2.6. Statistical analysis

Categorical variables were compared using the Chi-Squared test. Nonparametric continuous variables were analyzed using the Mann–Whitney U test. In each group, the measurements for each phase were analyzed by the Friedman test to examine whether there was a change in the qualities of compression over time. The generalised estimating equation was used to evaluate the differences in quality change between the 2 groups. *P* values less than .05 were taken to be statistically significant. Statistical analyses were performed using SPSS, version 25.0 (IBM Corp., Armonk, NY, USA).

3. Results

3.1. Study population

Seventy eight participants were recruited, and 6 participants were excluded in this pilot study. The remaining 72 participants were then randomly divided into 2 study arms: 36 in the mDACPR group and 36 in the mheDACPR group. No crossover occurred between the 2 arms. One participant withdrew from the study in each group because of physical limitations, and 1 record from the mDACPR group was not stored because of a device error during simulation. A total of 69 records (34 in the mDACPR study arm and 35 in the mheDACPR study arm) were included for analysis (Fig. 1). Baseline characteristics, including sex, age, past medical

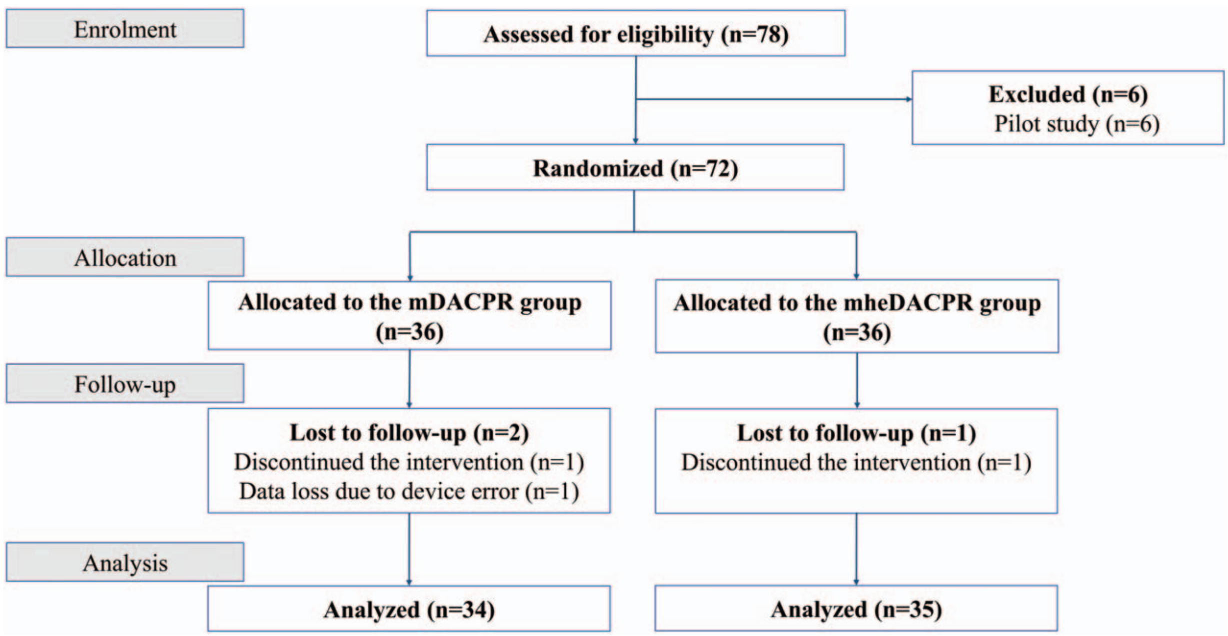


Figure 1. CONSORT flow diagram for the study.

history, height, weight, BMI, experience with CPR education within 1 year, and exercise sessions per week did not differ significantly between the groups (Table 1).

3.2. Rate and depth of chest compressions

In the mDACPR group, the median compression rate in phase 1 was lower than the setting value of 102 compressions per minute (IQR, 72–124) metronome 110. However, in phase 4, the compression rate tended to coincide with the setting value at 110 compressions per minute (IQR, 106–120). In mheDACPR group, the median rate was consistently maintained at 110 compressions per minute in phases 1 through 4. The IQR narrowed as the phase progressed in both groups (Fig. 2). In the mDACPR group, the median of compression depth during phases 1, 2, 3, and 4 became gradually shallower, with readings of 51 mm, 47 mm, 46 mm, and 43 mm, respectively. In contrast, the mheDACPR group-maintained compression depth constant values of 46 mm, 46 mm, 44 mm, and 46 mm (Fig. 3).

3.3. Sustainability of accurate chest compression

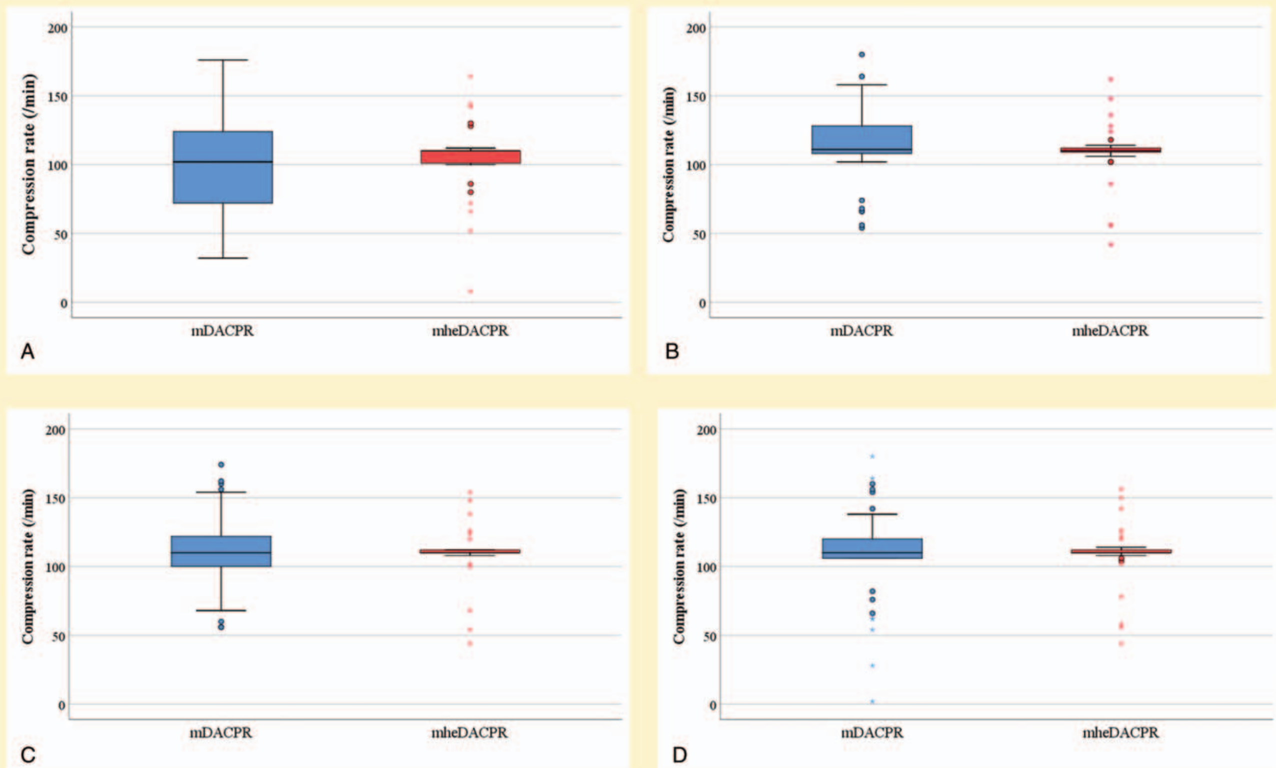
Table 2 shows changes in chest compression measures by phase in the mDACPR group and the mheDACPR group. The median ratio of the accurate chest compression rate by phase was initially 29.5% under the existing instruction (mDACPR), and significantly increased to 71% at 2 minutes ($P = .046$). However, the median ratio of the accurate chest compression depth was only 61.5% in the first phase and significantly decreased to 0% in the last phase ($P < .001$). In contrast, in the mheDACPR group, a high accurate compression rate was achieved starting from phase 1 and was maintained until the last phase. The accurate compression rate was also significantly maintained compared with that in the mDACPR group ($P = .004$). The median ratio of

Table 1

Comparison of baseline characteristics between the mDACPR and mheDACPR groups.

	mDACPR (n=34)	mheDACPR (n=35)	*P* value
Male, n (%)	12 (35.3)	16 (45.7)	.465
Age (years), median (IQR)	46.5 (26–61)	50 (29–60)	.728
Height (cm), median (IQR)	165 (157–169)	163 (158–170)	.687
Weight (kg), median (IQR)	60 (53–72)	62 (56–70)	.787
Body mass index (kg/m^2), median (IQR)	23.7 (20.9–25.9)	23.3 (21.0–25.9)	.924
Past medical history	9 (26.5)	3 (8.6)	.062
Experience of BLS practical education prior to recent 12 months, n (%)	2 (5.9)	5 (14.3)	.428
Exercise, n (%)			.935
None	14 (41.2)	14 (40.)	
1–2 times per week	8 (23.5)	9 (25.7)	
3–6 times per week	11 (32.4)	10 (28.6)	
Daily	1 (2.9)	2 (5.7)	

Data are presented as number (percentage); IQR = interquartile range; BLS = basic life support, mDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome only, mheDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome and human encouragement.



		Phase			
		Phase 1 (A)	Phase 2 (B)	Phase 3 (C)	Phase 4 (D)
Rate of chest compression (/min)	mDACPR	102 (72–124)	111 (108–128)	110 (100–122)	110 (106–120)
	mheDACPR	110 (101–110)	110 (109–112)	110 (110–112)	110 (110–112)

Figure 2. Rate of chest compression in (A) phase 1; (B) phase 2; (C) phase 3; (D) phase 4.

accurate compression depth was only 17.3% in phase 1 and remained low until phase 4 ($P=.654$). The ratio of complete release remained constant throughout 2 minutes in both groups ($P=.623$, $P=.204$).

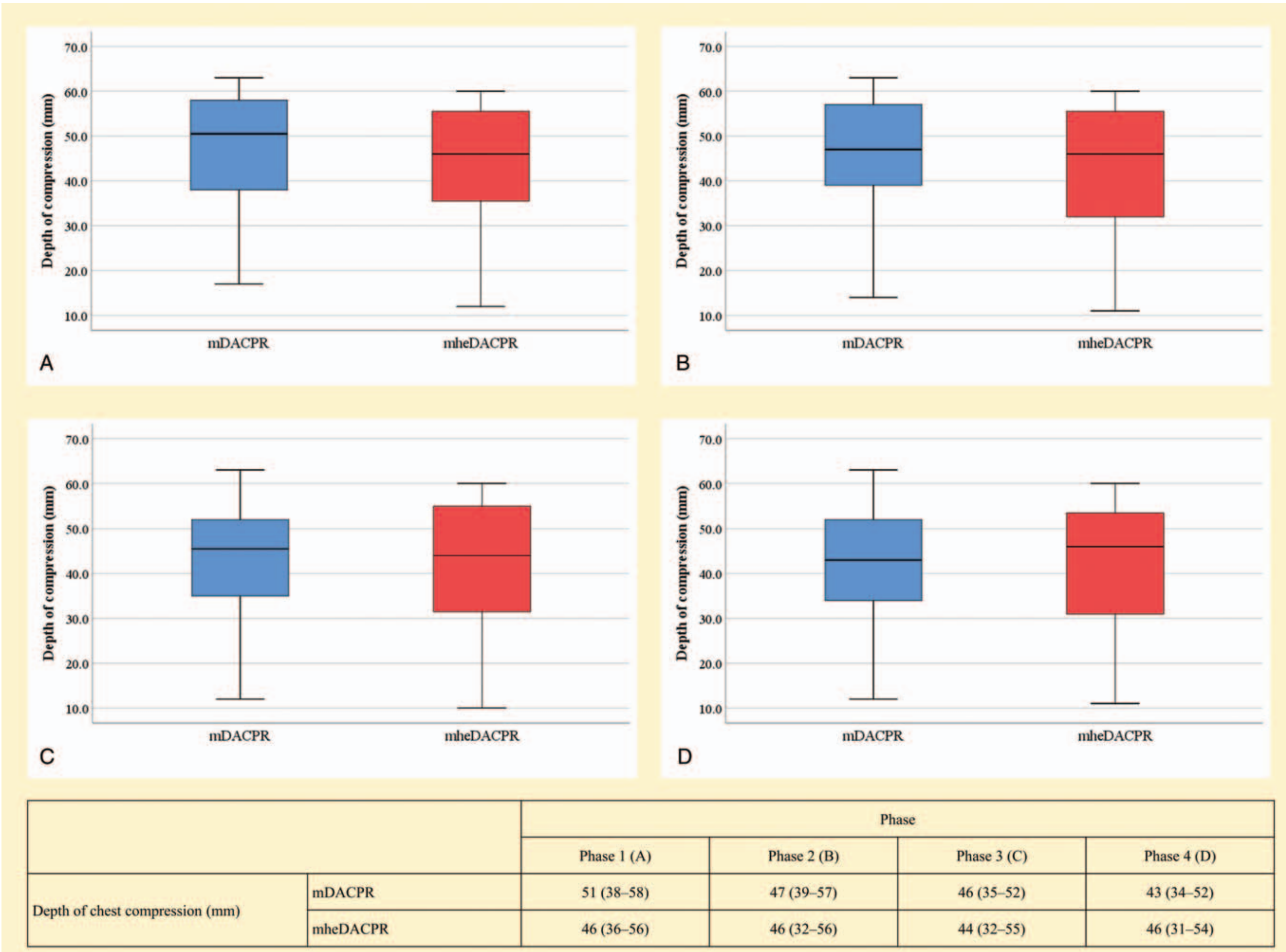
4. Discussion

In our study, we found that when a dispatcher provided verbal encouragement in addition to the standard metronome protocol for bystander-administered CPR, the compression rate of the bystander could be maintained more accurately and consistently. However, there was no improvement in the quality of compression depth.

Bystander CPR for the treatment of pre-hospital cardiac arrest increases survival but is frequently not performed because of fear of causing injury and a lack of knowledge by those without medical training.[14] To overcome this, in Korea, delivery of CPR training throughout the population was expanded in accordance with global guidelines and DACPR has been introduced since 2012.[15] Therefore, although the bystander CPR performance rate was very low at 2.1% in 2006,[4] this rate greatly increased to 58.7% in 2017.[8] However, although the implementation of DACPR has led to greatly increased CPR initiation of the bystander, only 6.0% of bystanders are found to perform high-quality CPR when evaluated by paramedics arriving at the scene.[8]

Various DACPR methods have been proposed to improve the quality of CPR. These interventions include adding instructions with speakerphone activation, continuous instruction during CPR,[16] simplified compressions-only CPR instructions,[17,18] instruction to "push as hard as you can,"[19] video-assisted DACPR,[20] and administration of metronome sounds to the rescuer.[10] Based on several studies, the standard protocol for untrained persons in Korea includes compressions-only CPR with speakerphone and metronome sounds until EMS arrive.

Another factor related to the quality of CPR is the fatigue of the rescuers. Ochoa et al[21] reported that a decrease in compressions quality after the first minute of CPR is observed regardless of the rescuers sex, age, weight, height, or profession. They found a reduction of 79.7% in correct compression performance after the first minute of CPR. Other studies also showed that the number of satisfactory chest compressions performed decreases progressively during resuscitation.[22] Hence, it is recommended to use feedback equipment because it is difficult to maintain consistency in CPR administration, not only among the general public but also in hospital arrest patients.[23] Since bystanders do not have access to such compression feedback equipment, this study



		Phase			
		Phase 1 (A)	Phase 2 (B)	Phase 3 (C)	Phase 4 (D)
Depth of chest compression (mm)	mDACPR	51 (38–58)	47 (39–57)	46 (35–52)	43 (34–52)
	mheDACPR	46 (36–56)	46 (32–56)	44 (32–55)	46 (31–54)

Figure 3. Depth of chest compression in (A) phase 1; (B) phase 2; (C) phase 3; (D) phase 4.

attempted an interventional periodic encouragement from dispatchers in addition to the existing metronome protocol.

In this study, we observed that the chest compression rate was getting closer to the metronomes setting value and the accurate compression rate increased regardless of verbal encouragement. Similar findings were reported in a previous study regarding metronome use with regard to accurate compression rates.[10] However, in the group that underwent CPR under the standard protocol, cases that were considered outliers, such as those in which the compression rate increased to > 150 beats/minutes or decreased to < 50 beats/minutes, increased over time. It is thought that rescuer fatigue increases as compressions are repeated, and rescuer concentration likewise decreases with repeated metronome administration. In the mheDACPR group, rescuers who were outliers from the start of the first compression were found to maintain an inaccurate compression rate without being affected by the metronome or verbal encouragement over time. This reveals the limitations of DACPR improving bystander CPR. Such findings are thought to be due to the influence of other factors, such as the age, sex, BMI, and previous education of bystander, as reported in previous studies.[8,24]

Table 2

Ratio of accurate compression rate, depth, and complete release according to phase.

	mDACPR (n = 34)					mheDACPR (n = 35)					
	Phase 1	Phase 2	Phase 3	Phase 4	*P* value*	Phase 1	Phase 2	Phase 3	Phase 4	*P* value*	*P* value**
Accurate compression rate, % (IQR)	29.5 (0–92)	59.5 (0–95)	52.0 (0–95)	71.0 (0–100)	.046	91 (64.5–100)	100 (49–100)	100 (71–100)	100 (68.5–100)	.013	.004
Accurate compression depth, % (IQR)	61.5 (0–100)	21.0 (0–98.8)	13.2 (0–78.6)	0 (0–85.5)	< .001	17.3 (0–94.3)	18.2 (0–96.3)	0 (0–100)	1.8 (0–97.3)	.654	.829
Complete release, % (IQR)	98.2 (76.4–100)	98.4 (54.2–100)	96.4 (67.8–100)	97.2 (67.1–100)	.623	100 (95.8–100)	100 (97.7–100)	100 (100–100)	100 (96.4–100)	.204	.061

* *P* values calculated using the Friedman test.

** *P* values calculated using the generalised estimating equation.

IQR = interquartile range, mDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome only, mheDACPR = dispatcher-assisted cardiopulmonary resuscitation using a metronome and human encouragement.

The reported depth of chest compressions was below the recommended guideline over the entire study period. Similarly, many previous intervention studies on DACPR have failed to reach an accurate depth.[10,16] In contrast, Rodriguez et al[25] reported a meaningful adequate depth when instructions to "push as hard as you can" was given in a pediatric CPR setting. Therefore, we assumed that repetitive verbal instructions could also improve depth in our study. However, we found that the accurate compression depth to be very low, as in other studies, although the median compression depth could be maintained at the same level over time.

Our study had several limitations. First, it was conducted at a single training center. The center is in the city center and may not reflect the characteristics of participants in rural areas that are difficult to access geographically. Second, we evaluated the intervention for only 1 scenario. However, we evaluated the most frequently occurring bystander situation (cardiac arrest and a single rescuer). Finally, this study is not a true out-of-hospital CPR study but was rather conducted in a simulated situation. Therefore, through the pilot simulations of the first 6 times, the simulation environment was adjusted to reflect the reality.

A strength of our study is the inclusion of participants representative of typical bystanders. This was achieved by excluding participants who had previously received verified CPR training and by excluding first responders. Therefore, the participants average age was higher than that in other simulation studies, and the actual CPR query results are also expected to be more like what would occur in an out-of-hospital setting.

5. Conclusions

To maintain the quality of bystander CPR, it is necessary to provide continuous feedback and repeated human encouragement during DACPR. Although it is difficult to improve the compression depth, active dispatcher intervention reduces the time to reach an appropriate CPR rate and allows an accurate compression rate to be maintained.

Author contributions

Conceptualization: Ju Ok Park, Choung Ah LEE.
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Formal analysis: Bo Na Hwang, Eun Hae Lee, Hang A Park, Ju Ok Park, Choung Ah LEE.
Funding acquisition: Choung Ah LEE.
Investigation: Eun Hae Lee.
Methodology: Eun Hae Lee, Ju Ok Park.
Resources: Hang A Park, Ju Ok Park.
Supervision: Choung Ah LEE.
Validation: Hang A Park.
Writing – original draft: Bo Na Hwang.
Writing – review & editing: Choung Ah LEE.

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