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Effects of metronome use on cardiopulmonary resuscitation quality

Dikmen Çalışkan¹, Fikret Bildik^{2*}, Mehmet Ali Aslaner², İsa Kılıçaslan², Ayfer Keleş², Ahmet Demircan²

¹Emergency Service, Antalya Kepez State Hospital, Antalya, ²Department of Emergency, Gazi University School of Medicine, Ankara, Turkey

*Corresponding author

Abstract:

OBJECTIVE: Whether the use of metronome affects the quality of cardiopulmonary resuscitation (CPR) remains unclear. In this study, we investigated the effect of metronome use on CPR quality.

METHODS: This was a prospective, simulation-based CPR manikin study. There were two phases: without and with metronome use. Chest compression was performed for 2 min, and three CPR quality criteria including chest compression depth, recoil, and rate were recorded with TrueCPR Feedback Device in both phases.

RESULTS: In all, 102 resident physicians were included. The achievement of optimal chest compression depth and complete recoil was better with metronome use than without (83% and 77% vs. 78% and 39%, $P \leq 0.001$, respectively). Optimal chest compression rate was also reached with metronome use because the range of the compression rate was closer to the normal limits than those without metronome use (110 [interquartile range (IQR) 109–113] vs. 120 [IQR 109–129], $P \leq 0.001$). Of all the participants, 70.6% stated that metronome use had a positive effect on their performance during the CPR application and 66.7% stated that they wished to use the metronome in their daily practice.

CONCLUSION: Using a metronome during simulation-based CPR improved the compression depth and recoil by fixing chest compression rate. We suggested that metronome should be used in CPR trainings of health-care professionals.

Keywords:

Cardiopulmonary resuscitation, chest compression, high-quality cardiopulmonary resuscitation criteria, metronome

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ORCID:

DÇ: 0000-0002-9015-5983

FB: 0000-0003-2464-0232

MAA: 0000-0002-7851-7881

İK: 0000-0002-0330-2595

AK: 0000-0003-4429-3100

AD: 0000-0002-7993-8098

Address for correspondence:

Dr. Fikret Bildik,
Department of Emergency,
Gazi University School of
Medicine, Ankara, Turkey.
E-mail: fbildik@gazi.edu.tr

Introduction

High-quality cardiopulmonary resuscitation (CPR) is essential to improve the survival rates. Therefore, guidelines try to set clear and simple criteria for high-quality CPR, and adequate application of these criteria is attempted in all CPR trainings. Despite all the efforts, a standard CPR application is generally not possible because resuscitation providers are different groups and have different personal

approaches and experiences. Moreover, even among health-care professionals, these criteria can be achieved at different rates.^[1]

Many resuscitation assisting devices have been described in literature, of which some are currently in use.^[2] The most well known of these are mechanical CPR devices. Although these devices can apply standard compression in every application, they are not available in every health-care facility. The use of metronome is a simple and economic guidance method for health-care professionals in manual CPR.^[3] The metronome that produces an audible

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Box-ED

What is already known on the study topic?

High-quality cardiopulmonary resuscitation (CPR) is essential to improve the survival rates

The use of metronome is a simple and economic guidance method for health-care professionals in manual CPR.

What does this study tell us?

Usage of a metronome device improved the quality of compression depth, and chest recoil by fixing chest compression rate

Two-thirds of the participants stated that the use of metronome had a positive effect on their performance and they wanted to use the metronome in their routine CPR practices.

beat at regular intervals has become popular to acquire a stable rhythm (tempo) and increases the quality of chest compressions during CPR.^[4] Some defibrillation devices that include a metronome guidance have been manufactured, but their use is negligible. Different studies have reported different results regarding metronome-guided CPR quality because they differ in their methods and study group characteristics.^[5-7]

We hypothesized that usage of a metronome will positively affect the three high-quality criteria of CPR (adequate chest compression depth, rate, and full chest recoil) according to the European Resuscitation Council Guidelines for Resuscitation 2015,^[8] which are applied by intensive care and emergency medicine resident physicians who frequently perform CPR in their daily practice in tertiary care hospitals.

Methods

Study design

This study was a prospective, simulation-based, single-blind, pre-post phase study conducted between June 1 and July 31, 2017, in a tertiary care hospital. The study was approved by Gazi University's Ethics Committee (Approval date: 31.06.2017, Approval number: 06). Written informed consent was obtained from each participant before the study.

Participants

The study participants were resident physicians working in the emergency department and adult intensive care units where they perform CPR in their routine practice. The departments of residents included emergency medicine, cardiology, anesthesiology and reanimation, internal medicine, chest diseases, neurology, cardiovascular surgery, general surgery, and thoracic surgery. Exclusion criteria were refusal to participate in the study, pregnancy, orthopedic problems, and not being able to attend the second phase of the study.

Equipment

A Prestan professional adult CPR training manikin (Mayfield Village, OH, USA) was used and placed on an AneticAid QA3 wheeled bed (Baildon, West Yorkshire, UK) in the study. The participants were free to use a step booster to assume the appropriate position. To standardize chest compressions to 2 min, a digital stopwatch was used by the researcher in both phases.

TrueCPR Coaching Device (Physio-Control, Redmond, WA, USA), a feedback device, was used to measure CPR quality criteria throughout the study, and the audible metronome feature of the device was used only in the second phase according to the study methodology. This device consists of two different parts connected to each other via a cable. One part is placed on the back of the patient's shoulder. The other part is placed on the sternum, and the device is designed for chest compression on this part. The device uses three-dimensional magnetic fields to measure the distance between two objects (the chest pad and the back pad); thus, it accurately computes chest compression depth, rate, and full chest recoil.^[9] The optimal chest compression depth for the device is 5–6 cm, and the appropriate compression depth applied during the procedure was given as percentage. Similarly, full chest recoil is considered optimal, and the device gives a percentage of recoil quality during CPR. In addition, the device gives average compression rate/min. During CPR, in both phases, the screen of the device was completely closed, and all feedback features were blocked for all participants.

Procedure

The study was planned as two phases consisting of 2-min chest compressions. The participants were taken to the room alone where the application was set up and were asked to perform 2-min continuous chest compression. After all participants completed the first phase without the metronome, the second phase was commenced. The time duration between participants' first and second CPR applications was 1 month. In the second phase, the participants were asked to apply chest compressions with the help of the metronome sound set to 110 beats/min. In addition, the participants were not informed about which parameters were measured until the all the study phases were completed. During the study, the tasks of manikin and device placement, stopwatch use, and data collection were performed by a single researcher.

At the end of the second phase, the participants were asked two questions about the effects of the metronome on CPR application performance and whether they would use it in CPR applications; their responses were based on a 3-point Likert scale (disagree, neutral, and agree). Finally, the following data were noted for each participant: CPR

application more than once a month, CPR training in the past year, length of residency, and body mass index.

Data analysis

Statistical analyses were performed using IBM SPSS statistical package for Windows version 15 (IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov and Shapiro–Wilk tests were used to determine whether the continuous variables fit the normal distribution. Categorical variables were expressed as percentage, and continuous variables were expressed as median and interquartile range (IQR). Because the CPR performance data obtained in the first and second phases did not show normal distribution, Wilcoxon and sign tests were used for intergroup comparisons.

Results

In total, 102 of 119 resident physicians were included in the study. The median age was 28 (IQR 26–29) years, and 61.8% were male. The median residency length was 2 years (IQR 1–3). Among them, 86.2% performed CPR more than once a month and 29.4% received CPR training in the last year. The three most common departments of residents were internal medicine (30.4%), emergency medicine (20.6%), and anesthesiology and reanimation (14.7%). The characteristics of the participants are presented in Table 1.

Adequate chest compression depth was applied during the CPR more frequently with metronome than without metronome (83% [IQR 77–90] vs. 78% [IQR 60–97], $P < 0.001$). The percentage of full chest recoil instances during CPR was significantly higher with metronome use (77 [IQR 63–85]) than without (39 [IQR 10–70], $P < 0.001$). The optimal compression rate during CPR was achieved with metronome use (110 [IQR 109–113]) compared with without metronome (120 [IQR 109–129], $P < 0.001$) [Figure 1].

Of all the participants, 70.6% stated that metronome use had a positive effect on their performance during the CPR application and 66.7% stated that they wished to use the metronome in their daily practice [Table 2].

Discussion

This is the first study to demonstrate that metronome use during CPR by resident physicians who routinely perform CPR significantly improved the three adult CPR quality criteria specified in the 2015 CPR guidelines – correct chest compression depth, complete chest recoil, and optimal chest compression rate.

Kern *et al.* showed that metronome is efficacious in achieving accurate chest compression and ventilation rates

both in bag/valve/mask ventilation and endotracheal intubation in firefighter/emergency medical technicians according to the 2005 guidelines.^[3] Zimmerman *et al.* stated that metronome use optimized chest compression rates in their study on pediatric mannequins.^[10] Another study found that metronome use facilitated appropriate chest compression rate, as per 2005 American Heart Association guidelines, and improved participants' technical skills and confidence in performing CPR.^[4] Scott *et al.* reported that a software-based metronome tool is effective in getting layperson-callers to improve the target compression depth and compression rate in CPR scenarios.^[11] Paal *et al.* found a higher overall score and better chest compression rate with a mobile phone metronome application in lay rescuers.^[12] Gündüz *et al.*

Table 1: Characteristics of the study participants (n=102)

Parameters	
Age, median (IQR)	28 (26- 29)
Male sex, n (%)	63 (61.8)
Length of residency (year), median (IQR)	2 (1- 3)
Height (cm), median (IQR)	172 (168- 178)
Weight (kg), median (IQR)	74 (63- 83)
BMI (kg/m ²), median (IQR)	24 (22- 26)
BMI classification (kg/m ²), n (%)	
Underweight (<18.5)	1 (1)
Normal weight (18.5- 24.9)	56 (54.9)
Preobesity (25- 29.9)	40 (39.2)
Obesity (≥30)	5 (4.9)
Specialties, n (%)	
Internal medicine	31 (30.4)
Emergency medicine	21 (20.6)
Anesthesiology and reanimation	15 (14.7)
General surgery	10 (9.8)
Cardiology	6 (5.9)
Chest diseases	6 (5.9)
Neurology	5 (4.9)
Cardiovascular surgery	4 (3.9)
Thoracic surgery	4 (3.9)
CPR application ≥ 1 (month), n (%)	88 (86.2)
CPR training in the last year, n (%)	30 (29.4)

BMI=Body mass index, CPR=Cardiopulmonary resuscitation, IQR=Interquartile range

Table 2: Participants' thoughts about the metronome

	n (%)
Do you think the use of the metronome has a positive effect on your CPR performance?	
Agree	72 (70.6)
Neutral	24 (23.5)
Disagree	6 (5.9)
Would you like to use the metronome in your routine CPR practice?	
Agree	68 (66.7)
Neutral	31 (30.4)
Disagree	3 (2.9)

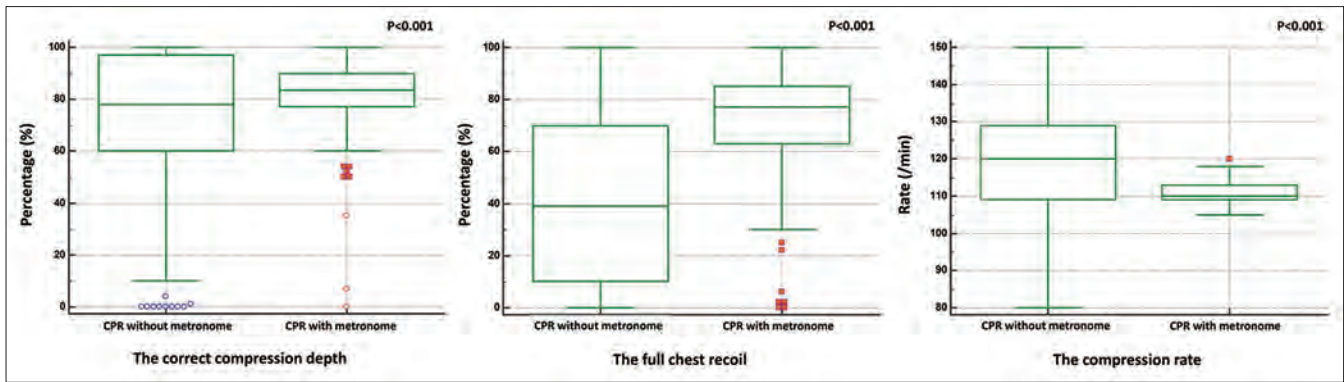


Figure 1: Effects of using metronome on the three cardiopulmonary resuscitation quality criteria

showed that basic life support application under the guidance of metronome standardized compression rate and decreased provider fatigue among physicians, emergency medical technicians, and paramedics. On the other hand, metronome use decreased the compression depth but still met the requirements of the 2015 guidelines.^[13]

By contrast, studies have indicated that metronome reduces or has no effect on chest compression, causes delay in the onset of chest compression, and/or requires more compression rate than recommended in the guidelines to achieve better compression depth. Jäntti *et al.* reported that metronome guidance corrected chest compression rates but did not affect chest compression quality or rescuer fatigue among nurses.^[14] Chung *et al.* reported that metronome guidance was associated with lower chest compression depth of the first five cycles and shorter ventilation count in a simulated one-person basic life support model performed by medical students. In addition, they found that metronome did not affect rescuer fatigue.^[5] Oh *et al.* reported that audio tone guidance provides better ventilation and chest compression rate but this does not mean better CPR quality.^[15] However, most of the above-mentioned studies performed evaluation according to the 2005 guidelines.

When looking at studies investigating the relationship between compression rate and depth and/or recoil, a significant interaction between chest compression depth and rate was found during simulated resuscitation in a study performed in Japan.^[16] Lee *et al.* reported that the number of high-quality CPR compressions was the highest at a compression rate of 120 min, and the rate of incomplete chest recoil was lower at compression rates of 100 and 120 min among emergency medical technicians and paramedics, respectively.^[17] In another study, it was found that significantly deeper chest compression depths were noted at rates over 120/min but there were significantly more incomplete chest

recoils at the rate of over 120/min among high school students.^[18] We believe that metronome improves compression depth and recoil by optimizing the heart compression rate along with preventing fluctuations in compression rate during CPR.

In real life, results could be different. In an out-of-hospital arrest case, the female rescuer applied metronome-assisted chest compressions to her husband at 100/min for 5 min, as per the instruction of the emergency medical services during her 9-1-1 call. The patient was then taken to the hospital and discharged as neurologically intact.^[19] However, Botelho *et al.* conducted a case-control study regarding metronome use during CPR for real cardiac arrest patients in the emergency department of a university hospital in Brazil. They did not find any differences between groups with and without metronome use related to the rates of return of spontaneous circulation and death.^[6] However, they did not investigate the effect of quality criteria on survival between the two groups.

Study limitations

The feedback device evaluating the CPR quality criteria and the manikin used were different from those of other studies. Different feedback devices are available, and we used the TrueCPR manikin, which is stated to be more effective than other manikin models in CPR studies.^[20] Nevertheless, different results can be obtained depending on the manikin model and feedback devices.

There are many parameters that determine the quality of CPR. We assessed only compression depth, chest recoil, and compression rate, and the effects of these parameters on real patients are unknown. In our study, CPR was applied for 2 min without interruption as suggested in advanced cardiac life support. The effect of metronome use on ventilation was not investigated. In addition, because the duration was limited to 2 min, the effect of the metronome on the development of fatigue in prolonged CPR was not investigated.

Conclusion

Using a metronome device during simulation-based CPR improved the quality of compression depth, and chest recoil by fixing chest compression rate. Therefore, we recommend using a metronome device during CPR trainings of health-care professionals. Furthermore, two-thirds of the participants stated that the use of metronome had a positive effect on their performance and they wanted to use the metronome in their routine practice.

Author contribution statement

D.Ç., F.B., and A.D. contributed to the conception and data collection and manuscript writing. M.A.A., İ.K., and A.K., contributed in statistical analysis and manuscript checking.

Conflicts of interest

None Declared.

Ethical approval

The study was approved by Gazi University Ethics Committee (Approval date: 31.06.2017, Approval number: 06). Written informed consent was obtained from each participant before the study.

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