

Quality of continuous chest compressions performed for one or two minutes

Renan Gianotto-Oliveira,^{1*} Gustavo Gianotto-Oliveira,¹ Maria Margarita Gonzalez,¹ Ana Paula Quilici,¹ Felipe Passos Andrade,² Caio Brito Vianna,¹ Sergio Timerman²

¹Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo, Heart Institute, Sao Paulo/SP, Brazil. ²Medicine School of Anhembi Morumbi University – Laureate International Universities, Sao Paulo/SP, Brazil.

OBJECTIVES: This study was designed to assess cardiopulmonary resuscitation quality and rescuer fatigue when rescuers perform one or two minutes of continuous chest compressions.

METHODS: This prospective crossover study included 148 lay rescuers who were continuously trained in a cardiopulmonary resuscitation course. The subjects underwent a 120-min training program comprising continuous chest compressions. After the course, half of the volunteers performed one minute of continuous chest compressions, and the others performed two minutes, both on a manikin model. After 30 minutes, the volunteers who had previously performed one minute now performed two minutes on the same manikin and vice versa.

RESULTS: A comparison of continuous chest compressions performed for one and two minutes, respectively, showed that there were significant differences in the average rate of compressions per minute (121 vs. 124), the percentage of compressions of appropriate depth (76% vs. 54%), the average depth (53 vs. 47 mm), and the number of compressions with no errors (62 vs. 47%). No parameters were significantly different when comparing participants who performed regular physical activity with those who did not and participants who had a normal body mass index with overweight/obese participants.

CONCLUSION: The quality of continuous chest compressions by lay rescuers is superior when it is performed for one minute rather than for two minutes, independent of the body mass index or regular physical activity, even if they are continuously trained in cardiopulmonary resuscitation. It is beneficial to rotate rescuers every minute when performing continuous chest compressions to provide higher quality and to achieve greater success in assisting a victim of cardiac arrest.

KEYWORDS: Hands-Only CPR; Continuous Chest Compression; Cardiopulmonary Resuscitation; Fatigue; Basic Life Support.

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E-mail: rgo09@me.com

*corresponding author

INTRODUCTION

Continuous chest compressions in cardiopulmonary resuscitation (CCC-CPR, or hands-only CPR) has been advocated as an alternative to conventional CPR (30 compressions/two ventilations) (1-4). In the 2010 European Resuscitation Council (ERC) CPR guidelines for resuscitation (5), CCC-CPR was recommended as an alternative method and was encouraged for untrained rescuers. Animal (6-8) and clinical (9-11) investigations have shown that CCC-CPR is at least as effective as conventional CPR in terms of survival rates

and neurological outcomes. Because CCC-CPR does not include ventilation, it is easier to learn and remember than conventional CPR; thus, it is especially useful for lay people (1,12,13). In most cases, the fundamentals of a functional chain of survival are built by lay people (14); approximately 67% of sudden cardiac deaths are witnessed by bystanders, and the Emergency Medical Services response interval is eight minutes or longer (15). A flowchart with the current recommendations for cardiac support (16) is shown in Fig. 1.

Although the performance of hands-only CPR has some advantages, its quality (depth, rate, total number of compressions) decreases over time (17-19). This may be primarily due to rescuer fatigue. Current guidelines (16,20,21) recommend the rotation of rescuers every two minutes when performing conventional CPR or CCC-CPR. Because CCC-CPR may be more physically demanding than conventional CPR, the current rotation strategy recommended by the guidelines may be inappropriate for hands-only CPR (19,22,23).

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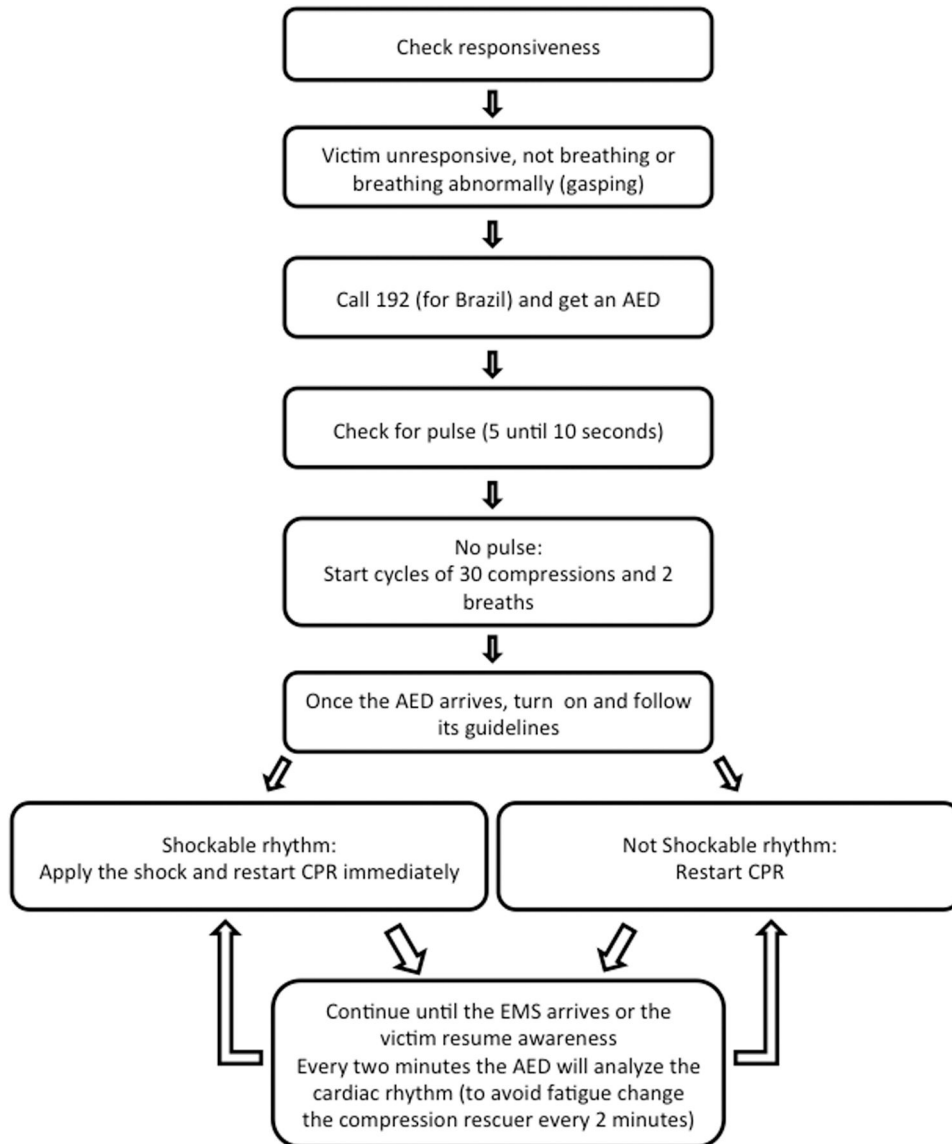


Figure 1 - Current recommendations for cardiac support (Basic Life Support).

Therefore, we hypothesized that the quality of CCC-CPR is better when performed for one minute than when performed for two minutes. This study aims to evaluate the quality of CCC-CPR performed on a manikin for one or two minutes by trained lay rescuers.

METHODS

Study Design

This study was a prospective, randomized crossover study. This design was chosen to identify differences in the performance of one or two minutes of CCC-CPR by each subject. The study protocol was approved by the Ethics Committee of the Foundation School of Medicine (registration number: 124.963).

Subjects and Materials

Lay rescuers who were continuously trained in the Heartsaver AED® course of the American Heart Association

were recruited between April 2012 and June 2012 to participate in this study, and 160 lay rescuers agreed to participate. These individuals worked as security guards for a company that has provided them with CPR courses since 2008. They complete the Heartsaver AED® course at least every two years, and most of them had participated in the care of cardiac arrest victims in their jobs.

Data collection included an identification questionnaire, the Laerdal Resusci Anne Skill Reporter manikin (Laerdal Medical, Stavanger, Norway), a body weight measure, a height scale, a tape measure, and a visual analogue scale (VAS) questionnaire.

Study Protocol

All lay rescuers underwent a 120-min training program in CCC-CPR based on the 2010 guidelines. After training, the participants were randomly distributed into two groups: the first group performed CCC-CPR for one minute (CCC-CPR 1 min), and the second group performed CCC-CPR for two



minutes (CCC-CPR 2 min). After 30 minutes of this session, the volunteers who had performed one minute of CCC-CPR subsequently performed two minutes, and vice versa. Immediately after each compression session, the volunteers answered the VAS questionnaire. A flowchart of the study is shown in Fig. 2.

The students were instructed to deliver only chest compressions without ventilation, initial rhythm assessment, or a pulse check. CPR was not performed using a metronome. One researcher monitored the Resusci Anne Skill Reporter manikin, which was positioned on the floor. None of the students received feedback, and they were told that they could stop if they were too tired to continue.

Each participant completed a brief questionnaire comprising demographic information (age, gender, body weight, height, performance of regular physical activity) as well as the participant's prior number of CPR training courses and the number of CPR procedures he or she had performed on the job.

Performance Data and Skill Assessment

Observations of the resuscitation simulations were recorded by the Resusci Anne manikin Skill Reporter. The parameters that were considered correct were based on the 2010 ERC guidelines for adults: a rate of at least 100 compressions per minute with a compression depth of at least 5 cm at the lower third of the sternum.

A compression with adequate depth was defined as ≥ 5 cm, as registered by the skill-report system, in accordance with the 2010 guidelines. A mean compression depth of greater than 38 mm is associated with better outcomes in ventricular fibrillation cardiac arrest based on clinical evidence (24) and current guidelines (20,21); the compression depth was also evaluated.

Body mass index (BMI) was calculated from the subject's height and weight, and the subjects were classified as

obese/overweight (BMI ≥ 25.00), normal (BMI 18.50–24.99), or underweight (BMI < 18.50), according to the World Health Organization's international category guidance (25).

Regular physical activity was considered aerobic activity performed at least 30 minutes per day at least three times per week. We also correlated the results with whether the subjects practiced regular physical activity and with the participants' BMI. For this analysis, we considered the following parameters: average rate, percentage of compressions with adequate depth, percentage of compressions with a depth greater than 38 mm, and correct hand positioning.

A VAS questionnaire (26,27) was administered immediately after each compression session to obtain the degree of fatigue on a scale from 1 (no fatigue) to 10 (extreme fatigue).

Statistical Methods

Quantitative values are presented as the mean \pm standard deviation (SD) and were compared using two-sided paired or unpaired Student *t* tests or Wilcoxon signed rank or Mann-Whitney U tests for non-Gaussian distributions. Categorical variables were analyzed by chi-square or Fisher's exact test. SPSS statistics software (version 19.0, Armonk, NY, IBM Corp) was used for all statistical analyses. The sample size was not planned. A *p* value < 0.05 was considered statistically significant.

RESULTS

General Characteristics

Seven subjects of the 160 volunteers were excluded because of insufficient data (four did not provide a VAS score, one did not perform CCC-CPR for one minute, and two did not perform CCC-CPR for two minutes). Two of the remaining 153 participants did not complete the 120-min training program for CCC-CPR, and three were underweight and were therefore excluded. As a result, 148 lay

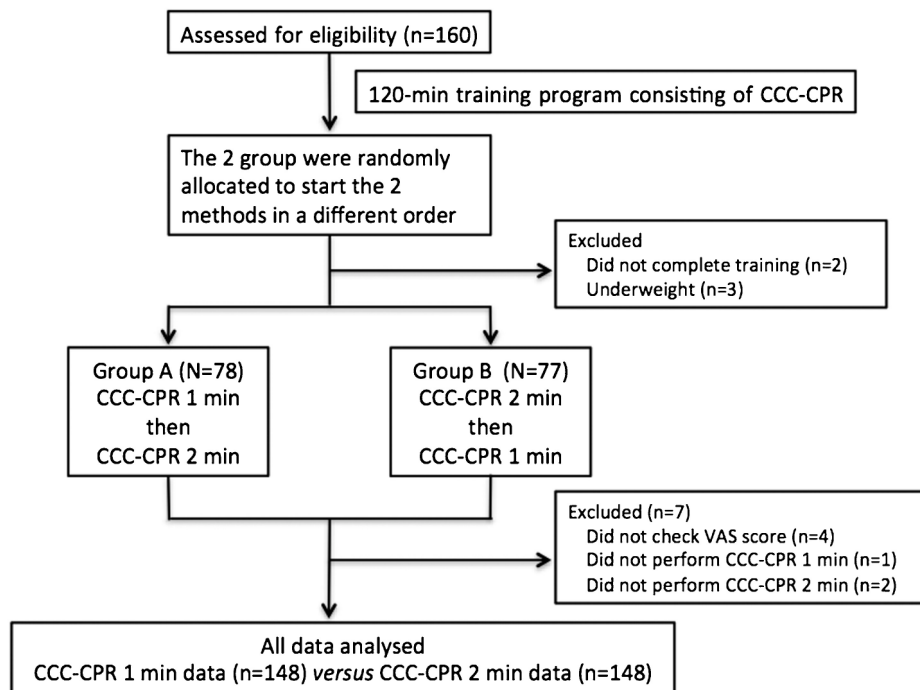


Figure 2 - Flow diagram of the study.



Table 1 - Baseline data for the study participants.

Characteristics	Data
Gender (n)	148
Male	125
Female	23
Average age (years)	40.81 ± 10.38
Average height (cm)	174 ± 8
Average weight (kg)	81.59 ± 14.26
Average BMI (kg/m ²)	26.80 ± 3.99
Average number of CPR training sessions attended before the study	2.89 ± 1.26
Average number of real resuscitation attempts before the study	0.72 ± 0.85

rescuers were included as subjects in this study. The general characteristics of the participants are shown in Table 1.

Continuous Chest Compression Quality for One or Two Minutes

Comparing the continuous chest compressions performed for one or two minutes, the average rate (compressions/minute), the mean percentage of compressions with adequate depth, the average depth (mm), the mean percentage of compressions with insufficient depth, and the mean percentage of compressions with no errors showed significant differences ($p < 0.05$). There were no significant differences in the mean percentages of the duty cycle, compressions > 38 mm and compressions with correct hand positioning (see Table 2).

Fatigue Analysis

We used a VAS scored immediately after each performance to evaluate fatigue. The VAS was 1.99 ± 1.09 for one minute of CCC-CPR and 4.56 ± 1.68 for two minutes of CCC-CPR ($p < 0.001$).

Other Analyses of the Quality of Continuous Chest Compressions

Among the participants, 57 (39%) practiced regular physical activity, and 91 (61%) did not. An analysis of the correlation of the compression data with the regular practice of physical activity is presented in Table 3.

Among the participants, a group of 56 (38%) had a normal BMI. The other group was composed of 65 (44%) participants who were overweight, 20 (13%) who had class I obesity, and 7 (5%) who had class II obesity, for a total of 92 (62%) of the lay rescuers. An analysis of the compression data correlated with the BMI is shown in Table 4.

Table 2 - Chest compression continuously performed for one and two minutes.

Compression characteristics	CCC-CPR 1 min	CCC-CPR 2 min	P value
Average rate (compressions/min)	121.0 ± 13.01	124.09 ± 11.71	0.003
Adequate depth (%)	76.21 ± 35.31	54.34 ± 40.05	< 0.001
Average depth (mm)	53.59 ± 7.48	47.70 ± 7.68	< 0.001
Depth > 38 mm (%)	95.27 ± 21.30	89.86 ± 30.28	0.119
No error (%)	62.04 ± 38.54	47.79 ± 39.10	< 0.001
Average duty cycle (%)	44.93 ± 5.58	45.66 ± 5.97	0.061
Correct hand position (%)	87.08 ± 30.57	91.06 ± 23.91	0.140

DISCUSSION

The quality of CPR plays a crucial role in reducing patient mortality rates (16,20,21). Fewer pauses and better chest compression quality are thought to improve overall survival following cardiac arrest (21,28). However, rescuer fatigue can degrade the quality of compressions (19,22,29), particularly when performing hands-only CPR (23). CCC-CPR by lay bystanders has been recommended by several studies (30-33) and by the American Heart Association (AHA) (21) and the European Resuscitation Council (ERC) (20) to increase bystander CPR rates. Based on these factors, we evaluated the effects of one or two minutes of CCC-CPR performed by periodically trained lay rescuers.

In the present study, a substantial effect of the compression rate or correct hand placement was not shown for either CCC-CPR group. We observed that the two-minute CCC-CPR group performed compressions at a higher frequency than the one-minute CCC-CPR group. This may have occurred to compensate for the decrease in depth to avoid deteriorating the quality of compressions. Comparing the depth parameters of the compressions, one minute of CCC-CPR was more effective than two minutes of CCC-CPR, similarly to the findings of previous studies (18,19,22,23,34,35). Unlike other

Table 3 - Quality of chest compressions performed for one and two minutes in relation to the practice of regular physical activity.

Compression characteristics	1 min	2 min	p-value ^b
Average rate			
Practicing	118.70 ± 11.3	122.82 ± 11.5	0.009
Not practicing	122.63 ± 13.8	124.88 ± 11.7	0.111
p-value ^a	0.062	0.299	
Adequate depth (%)			
Practicing	77.64 ± 33.8	55.63 ± 42.4	< 0.001
Not practicing	75.89 ± 36.1	53.54 ± 38.6	< 0.001
p-value ^a	0.766	0.763	
Depth > 38 mm (%)			
Practicing	96.49 ± 18.5	91.23 ± 28.5	0.182
Not practicing	94.51 ± 22.9	89.01 ± 31.4	0.095
p-value ^a	0.577	0.659	
Correct hand position (%)			
Practicing	87.91 ± 30.0	87.38 ± 29.0	0.894
Not practicing	86.56 ± 31.0	93.36 ± 19.9	0.057
p-value ^a	0.792	0.174	
VAS (points)			
Practicing	1.98 ± 0.93	7.19 ± 1.6	< 0.001
Not practicing	2.0 ± 0.8	7.40 ± 1.4	< 0.001
p-value ^a	0.908	0.417	

^aDifferences between subjects who practice regular physical activity and those who do not.

^bDifferences between one and two minutes of CCC-CPR.



Table 4 - Quality of chest compressions performed for one and two minutes in relation to the body mass index of the participants.

Compression characteristics	1 min	2 min	p-value ^b
Average rate			
Normal	121.18 ± 12.8	123.73 ± 11.6	0.246
Overweight/obese	121.08 ± 13.2	124.30 ± 11.8	0.022
p-value ^a	0.962	0.773	
Adequate depth (%)			
Normal	74.81 ± 36.7	51.85 ± 40.2	0.001
Overweight/obese	77.63 ± 34.3	55.86 ± 40.0	< 0.001
p-value ^a	0.643	0.557	
Depth > 38 mm (%)			
Normal	91.07 ± 28.7	91.07 ± 28.7	> 0.999
Overweight/obese	97.83 ± 14.6	89.13 ± 32.6	0.020
p-value ^a	0.107	0.701	
Correct hand position (%)			
Normal	93.47 ± 22.4	89.45 ± 27.3	0.421
Overweight/obese	83.19 ± 34.1	92.03 ± 21.6	0.023
p-value ^a	0.028	0.599	
VAS (points)			
Normal	1.98 ± 0.93	7.21 ± 1.6	< 0.001
Overweight/obese	2.0 ± 0.8	7.39 ± 1.4	< 0.001
p-value ^a	0.908	0.501	

^aDifferences between subjects who practice regular physical activity and those who do not.

^bDifferences between one and two minutes of CCC-CPR.

studies, this protocol considered compressions with adequate depth to be those of at least 5 cm, as proposed by current guidelines. Thus, although the one-minute CCC-CPR group performed better on this parameter, only 75.23% achieved compressions with adequate depth, indicating that this is difficult to achieve even among continuously trained participants. When considering compressions deeper than 38 cm, we observed that 95% of the participants were able to achieve this parameter for one minute, maintaining quality compressions for nearly the entire one-minute cycle. This finding reinforces that continuous CPR training provides good quality chest compressions.

Fatigue, as measured by the VAS, was very low in the one-minute CCC-CPR group, and a significant difference was observed compared with the two-minute CCC-CPR group. Therefore, one minute of CCC-CPR appears to reduce rescuer fatigue and to increase CPR quality. Regardless of whether individuals practiced regular physical activity, the depth performance was the same during one or two minutes. To the best of our knowledge, no previous study has compared the quality of CCC performed by lay rescuers who practice regular physical activity. However, highly fit rescuers are known to perform good-quality CPR, as noted in a study of rescuer lifeguards (36).

Hong (34) and Sayee (37), found significant differences in the parameters of quality chest compressions when comparing individuals with normal BMI with overweight/obese individuals. However, in our study, individuals with differing BMIs performed compressions of better depth for one minute than for two minutes.

The present study has some limitations. First, this study used a manikin. A compression graded “adequate” by Resusci Anne may not correlate with a clinically effective compression, and the rescuer’s attitude during a simulated situation may differ from an actual cardiac arrest. Second, most of the participants were male; thus, they may have been more physically fit and had greater strength than the

average bystander or spouse at home. These differences may have affected the results. Most importantly, although further clinical and animal studies are needed to clarify some points, this study showed better results for CCC-CPR performed for one minute than CCC-CPR performed for two minutes.

The quality of CCC-CPR is superior when performed by lay rescuers for one minute rather than for two minutes; this result is independent of BMI or regular physical activity, even if the rescuers are continuously trained in CPR. Thus, it is beneficial to rotate rescuers every minute when performing CCC-CPR to provide higher quality and to achieve greater success in assisting victims of cardiac arrest. The main parameter that requires improvement is the depth of compressions, reinforcing the need for devices that measure the depth of chest compressions during CPR maneuvers.

■ AUTHOR CONTRIBUTIONS

Gianotto-Oliveira R and Gianotto-Oliveira G wrote the project, performed the data collection and wrote the manuscript. Gonzalez MM assisted in the writing of the project, as well as in the discussion and conclusion. Quilici AP assisted in the discussion and conclusion. Andrade FP performed the data collection and assisted in the discussion and conclusion. Vianna CB performed the statistical analysis. Timerman S helped in the discussion and performed the final revision of the manuscript.

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