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Low compliance with the 2 minutes of uninterrupted chest compressions recommended in the 2010 International Resuscitation Guidelines ☆

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ABSTRACT

Background: We aimed to analyze compliance with 2010 European guidelines' quality criteria for external chest compressions (ECC) during 2 minutes of uninterrupted cardiopulmonary resuscitation.
Methods: Seventy-two healthy nurses and physicians trained in advanced cardiopulmonary resuscitation performed 2 uninterrupted minutes of ECC on a training manikin (Resusci Anne Advanced SkillTrainer; Laerdal Medical AS, Stavanger, Norway) that enabled us to measure the depth and rate of ECC. When professionals agreed to participate in the study, we recorded their age, body mass index (BMI), smoking habit, and their own subjective estimation of their physical fitness. To measure fatigue, we analyzed participants' heart rates, percentage of maximum tolerated heart rate (MHR), and subjective perception of their fatigue on a visual analog scale.
Results: Nearly half (48.6%) the rescuers failed to achieve a minimum average ECC depth of 50 mm. Only 48.1% of ECCs fulfilled the 2010 guidelines' quality criteria; quality deteriorated mainly after the first minute. Poor ECC quality and deteriorating quality after the first minute were associated with BMI < 23 kg/m^2.
Rescuers with BMI ≥ 23 kg/m^2 fulfilled the quality criteria throughout the 2 minutes, whereas those with BMI < 23 kg/m^2 fulfilled them for 80% of ECCs during the first minute, but for only 30% at the end of the 2 minutes.
Conclusions: Compliance with the 2010 guidelines' quality criteria is often poor, mainly due to lack of proper depth. The greater depth recommended in the 2010 guidelines with respect to previous guidelines requires greater force, so BMI < 23 kg/m^2 could hinder compliance. Limiting each rescuer's uninterrupted time doing ECC to 1 minute could help ensure compliance.

1. Introduction

The first guidelines for cardiopulmonary resuscitation (CPR) were published in 1966 [1], and external chest compressions (ECCs) became a central component in emergency treatment of cardiac arrest [2,3]. The technique for delivering ECC is highly standardized based on international consensus statements updated every 5 years. The 2010 International Guidelines on Resuscitation [4,5] list the following quality criteria for ECC on adults: (*a*) rate, 100 to 120 compressions/min; (*b*) depth, at least 50 mm, but not exceeding 60 mm; and (*c*) technique, allowing the chest to recoil completely after each compression, taking approximately the same amount of time for compression as relaxation, and minimizing interruptions.

To prevent rescuer fatigue and its possible detrimental effects on the quality of ECC, the person delivering ECC should change every 2 minutes. Studies have found that rescuer fatigue can lead to decreased ECC depth 2 minutes after starting ECC [6]. Furthermore, the incidence of adverse effects (muscle strain, back symptoms, shortness of breath, hyperventilation) in rescuers performing ECC in 2-minute intervals is very low in both CPR training and actual performance [7].

The quality criteria for ECC are more demanding in the 2010 guidelines than in the 2005 guidelines [8,9], which called for an ECC depth of 38 to 51 mm vs a current greater than 50 mm; these changes could improve the quality of ECC but could also increase rescuer fatigue [6]. Recent publications conclude that rescuers' body weight and physical fitness can affect fatigue and the quality of ECC. Hasegawa et al [10] reported that ECC to a depth of at least 50 mm caused increased fatigue among light rescuers, leading to a gradual fall in quality; these authors concluded that light rescuers should be relieved after delivering ECC for 1 minute. Russo et al [11] showed that fatigue and the quality of the ECC can be predicted by body mass index (BMI) and physical fitness. Participants with a higher BMI (>25.4 kg/m^2) and better physical fitness performed better and showed less fatigue during ECC.

Abbreviations: ECCs, external chest compressions; CPR, cardiopulmonary resuscitation; BMI, body mass index; MHR, maximum heart rate.

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In the present study, we aimed to analyze the degree to which the 2010 guidelines' quality criteria for ECC were met in a well-trained population. We hypothesised that the fulfillment of the ECC quality criteria would be low among rescuers with low BMI.

2. Methods

After providing written informed consent, 72 volunteers (physicians and nurses with advanced training in CPR) performed 2 uninterrupted minutes of ECC in an experimental environment following the recommendations of 2010 international guidelines [4,5]: appropriate positioning of the hands; a rate of 100 to 120 compressions/min; and a depth of at least 50 mm, but not exceeding 60 mm; and allowing the chest to recoil completely after each compression and taking approximately the same amount of time for compression as relaxation.

Participants were instructed to achieve the best-quality ECC possible during an exercise on an intubated CPR training manikin without interruptions to synchronize ventilations (Resusci Anne Advanced SkillTrainer; Laerdal Medical AS, Stavanger, Norway). Associated software (Laerdal PC Skill Reporting System v.2.4.1; Laerdal Medical AS, Stavanger, Norway) measured the rate and quality of every compression for 2 uninterrupted minutes. Two trainers (S.Q. and B.S.) simultaneously evaluated the correctness of chest compressions. Deviations in the quality of ECC greater than 25% were verbally corrected during the exercise, and volunteers were highly motivated to do their best. We considered that the quality of ECC had definitively deteriorated if the resuscitator did not correct his or her technique within 5 seconds.

2.1. Data collection

We recorded the following data: profession, age, sex, BMI (using the standard formula [weight (kg)/height $(m)^2$]), smoking habit, and volunteers' subjective estimation of their physical fitness.

We measured volunteers' heart rate and continuous oxygen saturation at baseline and at the end of 2 minutes of ECC, using a pulse oximeter (N-550; Nellcor Puritan Bennett Inc, Pleasanton, Calif). We calculated the MHR using the formula used in stress tests (MHR = 220 − age in years).

Finally, volunteers rated their subjective perception of fatigue on a visual analog scale (VAS) from 0 to 10.

2.2. Statistical analysis

Qualitative variables are expressed as percentages and were compared using the χ^2 test; quantitative variables are expressed as mean ± SD or ranges and were compared using Student *t* test.

We used receiver operating characteristic curves to determine the BMI cutoff for deterioration of ECC quality.

We used the Kaplan-Meier estimator to determine the deterioration of ECC quality during 2 minutes of CPR.

To calculate the sample size, we assumed that at least 80% of the participants would show good tolerance, so a sample of 72 subjects would guarantee that the confidence interval of the proportion would not exceed 10%.

Significance was set at $P < .05$.

We used SPSS V.13 17 (SPSS Inc, Chicago, Ill) for all statistical analyses.

3. Results

All 72 participants (52 [72%] women; 62 [86.1%] physicians; 11 [15.3%] smokers; mean age, 28.6 ± 4.6 years; mean BMI, 22.3 ± 2.3 kg/m^2) had completed advanced CPR training, and 56.9% considered themselves physically fit.

Participants' heart rate was 94.5 ± 16.5 beats/min at baseline and 125.2 ± 19.4 beats/min after 2 minutes of uninterrupted ECC. At the end of CPR, rescuers' heart rate was 65.4% ± 9.8% of MHR, and none reached more than 80% of MHR during the test. Participants' rated their fatigue 6.4 ± 1.6 on the VAS. No significant decline in oxygen saturation was observed.

Less than 50% of the ECC fulfilled all the quality criteria: only 51.4% of participants achieved an average depth of ECC ≥ 50 mm, but hand positioning and ECC frequency were correct in all cases. Compliance with quality criteria for ECC deteriorated over time: in the first minute, 86.1% of the ECC fulfilled the criteria, whereas after the first minute, only 52.8% did.

Table 1 shows the characteristics of rescuers who achieved adequate depth of ECC and of those who did not. The 2 groups differ in sex and BMI. The MHR at the end of 2 minutes of ECC was similar in the 2 groups, but rescuers who did not achieve adequate depth rated their sensation of fatigue higher than those who fulfilled the depth of ECC criterion.

In a receiver operating characteristic analysis of the relationship between BMI and the quality of ECC (considering that a participant fulfilled the ECC quality criteria if at least 80% of compressions achieved all the quality criteria), a BMI cutoff of 23 kg/m^2 yielded an area under the curve of 0.75 with a sensitivity of 75% and specificity of 75% for deterioration of quality of ECC. We found a statistically significant relationship between the cutoff BMI < 23 kg/m^2 and greater physical fatigue as reflected in both objective and subjective measures, poor quality chest compressions, and a deterioration in the quality of ECC after the first minute (Table 2).

Finally, we used Kaplan-Meier curves to analyze the quality of ECC over time in the groups of rescuers above and below the BMI cutoff. In the group with BMI ≥ 23 kg/m^2, throughout the 2-minute period, more than 90% of ECCs achieved adequate compliance with quality criteria. In the group with BMI < 23 kg/m^2, however, only 70% of ECCs fulfilled the quality criteria at 60 seconds; the percentage decreased to

Table 1
Characteristics of rescuers according to the depth of ECC

	ECC depth ≥50 mm (n = 37)	ECC depth <50 mm (n = 35)	*P*
Female (%)	48.1	97.1	<0.001
Age (y), mean ± SD	29.7 ± 5.0	27.5 ± 4.7	0.6
BMI (kg/m^2)	23.3 ± 2.5	21.2 ± 1.4	<0.001
Baseline heart rate (beats/min), mean ± SD	91.4 ± 17.7	97.7 ± 14.8	0.1
Heart rate (beats/min) after 2-min ECC, mean ± SD	123.6 ± 21.2	127.1 ± 17.3	0.4
% of ECC with depth ≥50 mm	85.2 ± 14.7	20.3 ± 15.6	<0.001
% of rescuers who did ECC with depth < 50 mm within the first minute	0	20	<0.001
% of rescuers who did ECC with depth < 50 mm after the first minute	16	91.4	<0.001
% MHR after 2-min ECC	63.9 ± 10.7	66.8 ± 8.9	0.25
Subjective perception of fatigue (VAS), mean ± SD	5.6 ± 1.5	7.2 ± 1.2	0.015
% of rescuers with BMI < 23 kg/m^2	45.6	94.3	<0.001