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Original Contribution

Rescuer factors predict high-quality CPR—a manikin-based study of health care providers☆,☆☆

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ABSTRACT

Background: In the provision of high-quality cardiopulmonary resuscitation (CPR) by health care providers, factors associated with high-quality CPR should be explored.
Methods: This is a post hoc analysis using data from a manikin-based survey of CPR quality among volunteer emergency medical technicians (EMTs) from 2 county fire departments in northern Taiwan.
Results: Among the 95 enrolled EMTs, 36 (37.9%) performed high-quality CPR on a manikin. The baseline characteristics that differed significantly between groups were board-certified EMT levels ($P = .010$), body mass index (BMI, $P = .029$), average exercise frequency ($P = .001$), and average exercise duration ($P = .005$). Average total exercise time per week, which uses frequency times exercise duration, was independently associated with high-quality CPR performance after adjusting for variables via logistic regression analysis (odds ratio, 1.004; $P = .044$). An index was developed (BMI × ExeTime) based on the product of BMI and average total exercise time per week. A comparison of the area under curve for the different indices showed that BMI × ExeTime was a significant predictor of high-quality CPR, with an area under curve of 0.718 (95% confidence interval, 0.613-0.824; $P < .001$; Fig. 2) and a cutoff value of 4136.7 kg·min/m^2 (sensitivity, 0.722; specificity, 0.678).
Conclusions: This study identified factors associated with the performance by health care providers of high-quality CPR, including BMI and exercise habits. To optimize CPR quality, a program of exercise frequency and duration adjusted according to individual's BMI should be considered in such populations.

1. Introduction

Guidelines for basic life support have increasingly focused on the importance of high-quality chest compressions during cardiopulmonary resuscitation (CPR) [1,2], including a rate of 100 to 120 compressions per minute [3,4], a compression depth of at least 5 cm [5,6], a fully recoiled chest after each compression [7,8], and minimization of the frequency and duration of interruptions [9,10]. Therefore, factors associated with the rescuer's ability to perform high-quality chest compressions are of major concern. Previous studies have identified several factors associated with CPR quality, including the rescuer's body weight, body height, physical fitness, and muscle strength [11–13]. Hasegawa et al [11] showed that increased fatigue led to falling quality of chest compressions in a lighter body weight group among 18 nurses. Hansen et al [12] observed 15 health care professionals in a 15-minute hands-on CPR session on a manikin and demonstrated significant correlations between chest compression quality and body height in addition to physical fitness and muscle strength. In contrast, Ock et al [13] found that muscle strength was the only factor affecting CPR quality among 47 participants. In short, factors associated with high-quality CPR remain uncertain and may vary in different populations. Given the absence of clear evidence regarding the role of previously identified factors in the provision of high-quality CPR by health care providers, associated factors should be explored in this population.

1.1. Goals of this investigation

We aimed to identify factors associated with the performance of high-quality CPR by health care providers using a manikin-based method.

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2. Methods

2.1. Study design and setting

This study is a post hoc analysis of data from a prior study that examined the effects of self-debriefing with additional biomechanical directions on emergency medical technician's (EMT's) performance of CPR on manikins. That study was conducted at 7 county-based fire departments in northern Taiwan. The study was approved by the ethics committee of Chang Gung Memorial Hospital, Linko, Taiwan, and the requirement to obtain informed consent was waived.

2.2. Participant selection

Emergency medical technicians are often first responders and are therefore involved in the resuscitation of most cases of out-of-hospital cardiac arrests. Board-certificated EMT-1s, who joined the 45th EMT-2 training course session in Taiwan, were enrolled at the Taoyuan County fire department. Emergency medical technicians from 6 fire stations near the central fire department in Hsinchu County, Taiwan, participated in this study. Participating EMTs were classified in Taiwan as EMT-1 (EMT-basic in the United States). Other EMT levels include EMT-2 (EMT-intermediate in the United States), and EMT-paramedic (EMT-P in the United States). Emergency medical technician–1, EMT-2, and EMT-P personnel receive 40, 280, and 1280 hours of training, respectively, before certification, and they receive continuing education for 24, 72, and 96 hours, respectively, every 3 years. Enrollees who were unwilling to participate, were lost follow-up, or had incomplete data were excluded.

2.3. Study protocol

Participants were blind to the study purpose. Background characteristics of all participants were collected by study assistants using a standardized template. A pretest comprising 2 minutes of hands-only CPR in a kneeling position on a manikin (Resusci-Anne with QCPR; Laerdal Medical Corporation, Wappinger Falls, NY) was performed by all participants. In the present post hoc analysis, the pretest results of enrolled participants were extracted. The first author performed a review of the records and data abstraction for further analysis.

2.4. Data collection and outcome measures

Two study assistants collected data using the standardized template. Data obtained for each participant included sex, age, body weight, body height, body mass index (BMI) (body weight [kg]/body height [m]^2 [14]), arm length (from great tubercle to the tip of middle finger of the right arm), leg length (anterior superior iliac spine to the heel of the right leg), exercise habits (average number of times per week, average duration of each exercise period in minutes, and average total exercise time per week), and whether they had taken a CPR training course in the past 3 months. Parameters for the quality of CPR, which included correct position of hands (%), average compression depth (cm), average rate (compressions per minute), fully recoiled chest (%), and hands-on time (%), were generated by the manikin (Resusci-Anne with QCPR; Laerdal Medical Corporation, Wappinger Falls, NY).

2.5. Primary data analysis

High-quality CPR was defined as a compression rate of at least 100 per minute and an average compressions depth of at least 5 cm. The EMTs were grouped by whether they had performed high-quality CPR in the pretest (group 1) or not (group 2). Factors associated with different groups were identified, and a prediction model was developed and validated.

2.6. Statistical tests

Data were analyzed using SPSS 13.0 for Windows (SPSS, Chicago, IL). Categorical variables, presented here as numbers and percentages, were compared using the χ^2 or Fisher exact test, as appropriate. Continuous variables are presented as the median and interquartile range (IQR). The Mann-Whitney *U* test was used for nonnormally distributed continuous variables. Logistic regression analysis was applied to examine the independent associations of the factors with CPR quality. The areas under the receiver operating characteristic curve (AUC) for the various indices were compared. In all analyses, a *P* value $<.05$ indicated statistical significance.

3. Results

Fig. 1 shows the characteristics of participants enrolled. Among 96 participants, one was excluded because of withdrawal from the trial. Among the remaining 95 enrolled EMTs, 36 were assigned to group 1 based on high-quality CPR in the pretest. All others were assigned to group 2. The baseline characteristics that differed significantly between groups were board-certified EMT levels ($P = .010$), BMI ($P = .029$), average exercise frequency ($P = .001$), and average exercise duration ($P = .005$, Table 1). Average total exercise time per week, which uses frequency times exercise duration, was independently associated with high-quality CPR performance after adjusting for variables via logistic regression analysis (odds ratio, 1.004; $P = .044$; Table 2). An index was developed (BMI × ExeTime) based on the product of BMI and average total exercise time per week. A comparison of the AUC for the different indices, including BMI, average total exercise time per week, and BMI × ExeTime, was used to predict high-quality CPR (Fig. 2). The results showed that BMI × ExeTime was a significant predictor of high-quality CPR, with an AUC of 0.718 (95% confidence interval, 0.613-0.824; $P < .001$) and a cutoff value of 4136.7 kg·min/m^2 (sensitivity, 0.722; specificity, 0.678).

4. Discussion

This is a post hoc analysis using data from a manikin-based survey of CPR quality among volunteer EMTs from 2 county fire departments in northern Taiwan. Among the participants in this study, 37.9% performed high-quality CPR on a manikin. The study identified several factors associated with high-quality CPR in this population, including the BMI and average exercise time per week. An index termed *BMI × ExeTime*, which combined both BMI and exercise, was shown to be a significant predictor of high-quality CPR performance.

Several aspects of our results should be mentioned. First, our results echo previous reports that the rescuer's BMI significantly affects the quality of chest compressions. Hasegawa et al [11] examined the relationship between the decay of CPR performance on manikins with participants' heart rate, oxygen uptake, and perceived exertion between lighter and heavier groups among 18 registered nurses. The lighter group easily became fatigued, with CPR quality declining during the 5-minute test.

A chest compression is a piston-like move to transfer perpendicular force to the patients' chest wall, which changes the intrathoracic and ventricular volume and pressure, resulting in blood flow in and out of the chest [15,16]. From a biomechanical point of view, one should press using upper body weight to increase the force of the compression. A rescuer leans forward and shifts the center of gravity of his or her torso over the area of compression while performing CPR [17]. In addition, guidelines for basic life support emphasize the importance of a compression depth of at least 5 cm [1,2]. Therefore, the BMI of the rescuer is correlated with the likelihood of high-quality CPR among experienced health care providers who know how to perform effective chest compressions. Another study of CPR quality with manikins conducted by Hansen et al [12] demonstrated significant correlations of chest