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The effect of rescuers' body mass index on chest compression performance during simulation training in Hong Kong

Annemarie Hor Wan Cheung

MNurs, RN
Lecturer, School of Nursing, Caritas Medical Centre, Hong Kong.

Vico Chung Lim Chiang

PhD, RN, FHKAN
Assistant Professor, School of Nursing, The Hong Kong Polytechnic University, Hong Kong

Esther Suk Bing Mok

PhD, RN, FHKAN
Assistant Professor, School of Nursing, The Hong Kong Polytechnic University, Hong Kong

ABSTRACT

Background: High quality cardiopulmonary resuscitation (CPR) is crucial in out-of-hospital or in-hospital cardiac arrests, but the quality of chest compressions varies in different rescuers. Body mass index (BMI) had an effect on chest compression performance, especially the compression depth.

Objectives: To evaluate the effect of BMI on chest compression performance through simulation training among student nurses in Hong Kong.

Methods: A longitudinal observational study with repeated measures of an equivalent group of 99 student nurses was performed, with the pre-test performed immediately before the adult basic life support provider course, followed by an immediate post-test, and a retention-test four weeks later. Chest compression performance was assessed and evaluated between the three consecutive simulated skills tests.

Results: Body mass index was found to have significant effects on the overall mean chest compression depth that the overweight participants compressed better than other BMI groups for the three time points of evaluation. However, being overweight did not warrant sufficient chest compression depth, nor complete chest recoil.

Conclusions: The higher the BMI was, the deeper the chest compressions were. However, with the higher the BMI, higher incidence of incomplete chest recoil was noted. Despite the above, BMI had no clear effect on other CPR quality. Most participants had difficulty in achieving the recommended compression depth even after training. Simulation training of CPR for high quality chest compression should continue to focus on the practice of chest compression depth and complete chest recoil.

Keywords: Cardiopulmonary resuscitation, Body mass index, Simulation training

Corresponding Author: Vico Chung Lim CHIANG
School of Nursing, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong.
Tel: 61-2-4349-4535, Fax: 61-2-4349-4538, E-mail: vico.chiang@polyu.edu.hk

BACKGROUND

High quality chest compressions demand adequate chest compression rate and depth, minimal interruptions between compressions and full chest recoil (Meaney et al., 2013). This can facilitate cardiac output, which increases survival rate and decreases permanent neurological damages, thereby improving survivors' prognosis (Rajab, Pozner, Corad, Cohn & Schmitto, 2011). Manual chest compressions consume energy and body weight has an effect on chest compression depth (Roh & Lim, 2013). Underweight rescuers were found to have difficulty in attaining an optimal chest compression depth, and easily got fatigue (Krikscionaitiene et al., 2013). On the contrary, individuals who were overweight might be able to perform better in cardiopulmonary resuscitation (CPR) (Roh & Lim, 2013). Nevertheless, there was also evidence that body weight did not have an effect on compression depth (Krasteva, Jekova & Didon, 2011), which reveals the need for further scientific investigation.

According to the World Health Organization (WHO, 2000), BMI cut-offs for underweight is <18.5, normal weight is 18.5-22.9, and overweight is ≥23 in Asians. Apart from chest compression depth, no similar studies were carried out to assess other compression properties, like chest compression rate and chest recoil. With the inconsistent results of chest compression depth and other outcomes in respect to body weight and BMI (Roh & Lim, 2013; Krikscionaitiene et al., 2013; Krasteva, Jekova, & Didon, 2011), this study aimed to explore the effect of body mass index on chest compression quality in Hong Kong before, immediately after, and at 4-week after simulation training. This may provide insights for improvement in CPR practice and training.

METHOD

Design

A longitudinal quasi-experimental study with repeated measures of an equivalent group was performed, with a pre-test performed immediately before CPR simulation training (T0), followed by an immediate post-test (T1), and a retention-test 4 weeks later (T2). Chest compression performance was assessed and evaluated between the three consecutive simulated skills tests.

Participants

A convenience sample with a total of 99 student nurses was recruited voluntarily to the study in November 2012. All the participants were junior student nurses of a nurse training institute in Hong Kong, who had no prior training or experience of CPR, and were free from any physical factors that hindered them from performing CPR. The study was granted ethics clearance by the institution review board (IRB) of the related area health service which governed the training institute.

Procedure

Data for the independent variable BMI (by underweight, normal, and over-weight) were collected from the participating students after informed consent was obtained. A 1-minute compressions-only CPR was carried out as the baseline skill test (T0) on a sensored manikin Resusci® Anne full-body SkillReporter connected to a computer with Laerdal PC SkillReporting System version 2.4.1, after a 30-minute lecture on the basic theory of CPR. The dependent variables were chest compression rate, depth, correct percentage in compressions, and percentage in incomplete hand release (incomplete chest recoil). After the 1-minute baseline skill test, all participants then completed a typical 4.5-hour instructor-led and stimulated CPR course in groups of 6-7, with intensive hands-on experience to perform the chest compressions with the use of sensored manikin Resusci® Anne manikins. Immediately after the CPR training (T1), all participants performed an immediate post-test of 1-minute compressions-only CPR. All participants were then asked to practice CPR at least once every week, and performed the retention skills test four weeks later (T2).

Data Analysis

Data were entered into the SPSS Statistics Desktop version 20.0 for analysis. Estimated effects were evaluated a 95% confidence interval, where appropriate. Unless otherwise specified, a 5% level of significance was used. Descriptive statistics were used to describe the demographic data. The comparison of means like compression rate and depth between three time points was performed by repeated measures analysis of variance (ANOVA).

RESULTS

A total of 99 year 1 students (81 female and 18 male students) were recruited in the study; mean age was 20.18 (range = 17 to 25), mean weight was 53.97 kilograms (kg) (range = 39.0 to 102.0), mean height was 1.62 metre (m) (range = 1.50 to 1.83), and mean body mass index (BMI) was 20.33 (range = 15.6 to 38.9). There were 30, 55 and 14 students who were underweight, normal weight and overweight respectively in this sample.

The chest compression rates were all within the desirable range of 100 – 120 per minute (Koster et al., 2010) disregard of BMI and time. BMI was found to have significant effects on the overall mean chest compression depth (Table 1), and that the underweight compressed shallower than the normal weight (p<.003). Participants

TABLE 1: Differences in overall chest compression performance by BMI

	BMI	Mean	95% CI	F	p
Depth (mm)	<18.5	42.39	40.59-44.19	6.38	.003
	18.5-22.9	45.36	44.03-46.69		
	≥23	47.76	45.13-50.40		
Rate (cpm)	〈18.5	114.92	110.34-119.51	.39	.68
	18.5-22.9	116.92	113.53-120.30		
	≥23	118.19	111.48-124.91		
Correct percentage (%)	<18.5	53.17	45.79-60.56	1.37	.26
	18.5-22.9	49.66	44.20-55.11		
	≥23	59.55	48.73-70.36		

p < .05 denotes statistical significance
All values are given in mean and (standard deviation)
Body mass index (BMI): <18.5=underweight; 18.5-22.9=normal weight; ≥23=overweight

TABLE 2: Effect of body mass index on chest compression performance at different time points

	Time	BMI			F	p
		<18.5	18.5-22.9	≥23		
Depth (mm)	T0	35.57 (7.57)	38.13 (11.43)	44.36 (10.51)	3.49	.03
	T1	44.97 (5.90)	48.42 (5.43)	49.00 (3.70)	4.67	.01
	T2	46.63 (3.67)	49.55 (4.18)	49.93 (2.34)	6.45	.00
Rate (cpm)	T0	113.23 (21.64)	122.73 (16.80)	120.64 (24.34)	2.33	.10
	T1	119.47 (13.34)	117.96 (16.21)	120.36 (11.17)	.20	.82
	T2	112.07 (14.94)	110.05 (15.45)	113.57 (11.99)	.39	.68
Correct percentage (%)	T0	23.09 (31.92)	15.04 (23.94)	31.45 (10.19)	2.10	.13
	T1	81.62 (22.74)	78.19 (26.62)	83.65 (16.06)	.38	.69
	T2	54.80 (39.55)	55.74 (37.01)	63.54 (29.64)	.30	.74

p < .05 denotes statistical significance
All values are given in mean and (standard deviation)
Body mass index (BMI): <18.5=underweight; 18.5-22.9=normal weight; ≥23=overweight

of different BMI were found to be significantly different in performing the chest compression depth over the three skills assessment time points (Table 2). From the results of post-hoc tests, overweight participants compressed significantly deeper than the underweight (p<.03) during pre-test (T0). The normal weight group compressed significantly deeper than the underweight (p<.02) during post-test (T1). And at the retention test (T2), the normal weight (p<.01) and the overweight (p<.03) group compressed significantly deeper than the underweight.

There were no significant differences observed in chest compression rate, and percentage of correct compressions (i.e. correct compression depth, hand release and hand position), against the BMI groups (Table 1 and 2). Nevertheless, significant difference was noted on the percentage in incomplete chest recoil between compressions over the three BMI groups (Table 3). Post-hoc analyses found that the overweight group tended to have more incomplete chest recoil between compressions than the underweight (p<.05).

TABLE 3: Differences in percentage of incomplete hand release (incomplete chest recoil) by BMI

BMI	n	Mean (%)	95% CI	F	p
<18.5 (Underweight)	30	.38	-2.21-2.97	3.12	.05
18.5-22.9 (Normal weight)	55	3.30	1.39-5.22		
≥23 (Overweight)	14	5.84	2.05-9.64		
Total	99	3.17	1.52-4.83		

p < .05 denotes statistical significance

DISCUSSION

In this study, about 30% of the subjects were underweight, 14% were overweight, and the remaining 56% were normal weight. Being overweight or obese may predispose individuals to chronic morbidities such as cardiovascular diseases and type 2 diabetes (NOEIE Panel, 1998), and shorter life expectancy (Peeters, 2003). Nevertheless, body weight had a positive effect on quality of chest compressions in terms of deeper compression depth. During pre-test (T0), only 11 participants [12.7% of the normal weight (n=7), 28.6% of the overweight (n=4)] compressed with the mean depth of 50-60mm, as recommended by the European Resuscitation Council guidelines for resuscitation 2010 (Koster et al., 2010). After the simulated skills training, there were respective increases of 40 [26.7% of the underweight (n=8), 47.3% of the normal weight (n=26), 42.9% of the overweight (n=6)] and 41 [23.3% of the underweight (n=7), 49.1% of the normal weight (n=27), 50% of the overweight (N=7)] nursing students who fulfilled the recommendation of chest compression depth during the post-test (T1) and retention-test (T2). The improved performance in chest compression of nursing students in this study were coherent with the results of previous studies about nursing professionals after training (Liberman, Golberg, Mulder & Sampalis, 2000; Madden, 2006; Nyman & Sihvonen, 2000; Roh & Lim, 2013).

Results of this study showed that the more overweight the participants were, the deeper the compressions were. This finding was consistent in the overall mean chest compression depth (Table 1), and at different time points of measurement (T0 to T2) (Table 2). However, mean compression depths in all the three BMI groups were below the 2010 ERC recommendation of minimal 50mm (Berg et al., 2010), but not more than 60mm (Koster et al., 2010). This result echoed with the condition found in other studies that most people could not compress deep enough to meet the recommendations (Krikscionaitiene et al., 2013; Stiell et al., 2012); while deeper compressions were more likely to result in rib and sterna fractures, as well as their related complications like pneumothorax and chest wall haematoma (Young, Cook & Gillies, 2011). The strike of best training for the desirable chest compression depth and clear feedback of performance for improvement of the trainees continues, and that the emphasis should be placed on the practice of using body weight in chest compressions.

A study (Idris et al., 2012) postulated that return of spontaneous circulation was peak at 125 chest compressions per minute, and declined when exceeded. The European Resuscitation Council pragmatically recommended 100 – 120 compressions per minute (Koster et al., 2010). The results of this study showed that the participants could consistently meet the recommended rate, disregard of BMI and time factors. Full chest recoil was being emphasized to prevent a decrease in blood flow to the heart, as incomplete chest release between compressions could negatively affect venous return and cardiac output (Meaney et al., 2013). Results of this study revealed that the overweight may be more effective to achieve the desirable compression depth (Table 1 & 2) but were more likely to have incomplete chest recoil between compressions (Table 3). Apart from better training to the underweight for proper positioning and use of body weight (Krikscionaitiene et al., 2013), the overweight should also be reinforced the current compression depth recommendation and the importance to allow full chest recoil, with the aid of audiovisual prompts and simulation feedback systems. A better simulation system which is capable of visually and verbally indicating the extent of chest recoil and compression depth during practice can enhance the effects of simulation training.

LIMITATION

The study was not conducted with a more robust design of randomization control, which was subject to more potential bias due to confounders. And it was performed with simulation manikins rather than on patients, which might not represent the real practice. The timing of skill retention evaluation after four weeks with weekly practice may not be representing. The chest compression could be assessed for a longer period of time than four weeks, in order to observe if chest compression depth would sustain in relation to BMI without regular practice. Further, significant fatigue and shallow compressions usually arises after CPR for one minute (Manders & Geijsel, 2009), and this study only captured the data during the known peak performance.

IMPLICATIONS FOR NURSES

By using the BMI cut-offs for Asians, this study discovered that the overweight could achieve deeper chest compressions; but there was insufficient compression depth and higher incidence in incomplete chest recoils in the overweight. Highlights of training should be made to all trainees disregard BMI in ensuring adequate chest compression depth; while more focus on the overweight in avoiding incomplete chest recoil between chest compressions. It should be emphasized that rescuers should switch roles or be changed before fatigue (Zhang, Yan, Huang & Bai, 2013). More advanced simulators like voice advisory manikins may be used to prompt the trainees to have full chest recoils, and a more power audio-visual automatic feedback system should be established to instantly alert the trainees of their performance. These functions may also be incorporated in a CPR training smartphone app, which can also promote self-initiation and interest in continuous refresher training. Instructors should emphasize the correct positioning and utilization of body mechanics to the underweight trainees in order to achieve better chest compression depth. All nurses should also be alerted of the poor overall chest compression depth and chest recoil, and that regular refresher practice and training are of utmost important to assure high quality CPR.

CONCLUSION

During the typical simulation training with resuscitation manikins, BMI cut-offs in a Chinese sample of student nurses was found to have significant effects in mean chest compression depths with the overweight achieved the relatively more desirable depth at a statistical significant level disregard of time four weeks after training. However, the percentage of incomplete hand release (insufficient chest recoil) of the overweight was significantly higher than the underweight and normal weight. There were no significant differences in other parameters for high quality chest compressions like the rate, and correct percentage, between the three BMI groups. It was also alarming that among all the BMI groups, there were only around 40% of all participants who accomplished the recommended compression depth of 50 – 60mm after the simulated CPR training. There is a need to pay more focuses and use more advanced simulation equipment (e.g. instant audio-visual feedback and smartphone app) on the training of high quality chest compression in terms of the recommended desirable depth and chest recoil.

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