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The Relationship between Body Composition and Chest Compression in Adult
-A Manikin Study-

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Abstract
This study analyzed the correlation between chest compression results and body composition over time in cardiac arrest patients.The experiment was conducted by 16 second grade students of the emergency rescue department who completed the CPR course. All the date were analyzed using the SPSS software 20.0(SPSS Inc., Chicago, IL, USA).The ability to maintain effective chest compressions declined rapidly over time, and in the female group, it was confirmed that it decreased significantly after 1 minute. For factors influencing the depth of compression, the higher the back-muscle strength, the better the compression depth was maintained. Also the lower the body fat percentage, the more effective chest compression was maintained.If the Cardiopulmonary resuscitation(CPR) is performed for more than 10 minutes, it seems desirable that more than 3 people take turns for chest compressions rather than 2 people.

Keywords:Chest compression; Compression depth; Back-muscle strength; Body composition; Release depth.

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Introduction

Smart advanced life support (SALS), which is implemented as a pilot project by the National Fire Agency and the Ministry of Health and Welfare, is performing more than 10 minutes of advanced life support to cardiac arrest patient in the field without immediate transferring the patient. This includes administration of epinephrine and amiodarone and advanced airway. According to the latest standard guidelines for field emergency treatment by special 119 emergency medical services, CPR time is recommended to be at least 5 minutes excluding CPR preparation, transfer, and other times. In addition, additional emergency treatment for drug administration during cardiac arrest is required to be conducted with an assist by the guidance physician. This is a nationwide pilot project to expand the scope of emergency treatment, and is interpreted as a qualitative improvement according to the increasing social demand for 119 emergency medical services.Type Effective CPR is needed for return of spontaneous circulation (ROSC) and to prevent neurological dysfunction after resuscitation in cardiac arrest patients. Especially, in order to maintain constant brain blood flow and coronary perfusion pressure, cessation of chest compression should be minimized. It is also known that chest compression of sufficient depth while maintaining a constant depth has a significant relationship with spontaneous circulation recovery of cardiac arrest patients (Vadeboncoeur T *et al*., 2014; Talikowska M *et al*., 2015). The depth of chest compressions announced by the American Heart Association (AHA) is recommended to be greater than 50 mm and not to exceed 60 mm (2015 AHA guidelines). It is recommended to be maintained at about 50 mm by the Korean Association of Cardiopulmonary Resuscitation (Song KJ *et al*., 2016).In this regard, it is judged that the CPR for cardiac arrest patient before pre-hospital admission can generally be performed for more than 10 minutes in the field, and maintaining a proper level of compression depth during continuous chest compression may affect spontaneous circulation recovery. Sustained chest compressions cause rapid fatigue which interferes with effective chest compressions. In the field, chest compression is an activity in which isotonic movement of the lower back and isometric movement of the upper and lower back muscles occur simultaneously with knees on the floor (Yang HB *et al*., 2006). Muscle strength is the ability of a muscle to exert consistent force. Because muscle mass and back muscle strength play important roles in physical activities and in maintaining posture, they are speculated to impact the quality of chest compression. Previous studies have examined the association between the quality of chest compression and muscle strength(Choi ss et al., 2013; Lim YD *etal*., 2006); association between quality of chest compression and back muscle strengthening(Yun sw., 2019); predictors of high-quality chest compressions(Kaminska

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H*etal*., 2018); and cardiopulmonary resuscitation (CPR) performance, perception, and posture(Oh YJ *et al*., 2018; Kong SJ *et al*., 2018; Yoon BG *et al*., 2019).This is a mannequin study, which aimed to investigate whether body composition impacts the quality of chest compression in adult cardiac arrest.As managing an appropriate level of muscle strength and body mass index (BMI) is presumed to be important to maintain high-quality chest compressions, we examined whether there is an association between them.

Materials and Methods

This study is a mannequin experiment, which compared the outcomes of chest compression according to InBody parameters and duration of chest compression in a cardiac arrest patient. The study period was from September 20 to October 10, 2019, and 16 second-year undergraduate students who provided consent to participate after being informed about the purpose and objective of the study by the author were enrolled. The participants completed CPR training per the 2015 American Heart Association (AHA) basic life support (BLS) algorithm. Participants' sex, age, body weight, and height were obtained via self-report.

Study designs

The back strength and Inbody measurement was first performed and then the chest compression experiment was performed. Chest compressions were organized into 8 teams of 2 people. 4 of 8 teams were composed of males only, and the remaining 4 teams were composed of females only. Each team underwent chest compressions for 12 minutes with taking turns every 2 minutes with continuous chest compression. Chest compression was performed at a rate of 110 time per minute in accordance with the metronome speed. In the chest compression pre-practice, the subject practiced 10 minutes each using the feedback equipment, and the result showed a compression depth of 54.95 ± 1.554 mm in Fig. 1. Ventilation was performed every 6 seconds, and breathing volume was not measured.

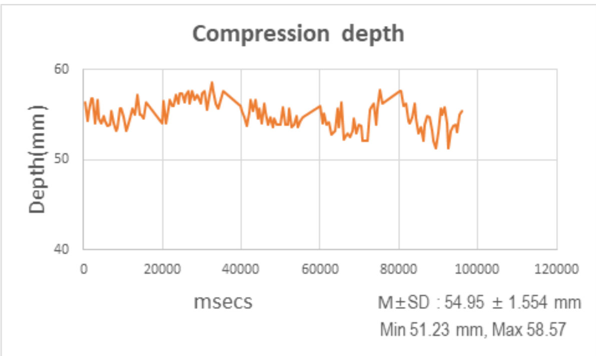

Figure 1: Pretest of chest compression depth

Simulator model

Important parameters of chest compression for a cardiac arrest patient include compression depth, rate per minute, incomplete relaxation, and compression pause. The manikin used for CPR is Resusci Anne QCPR® (Laerdal, Stavanger, Norway). The chest compression and specialized tracheal intubation are possible, and the depth, velocity, incomplete relaxation and artificial respiration rate of chest compression can be evaluated. Manikin and Sim Pad were connected to collect data.

Inbody index

BMI was computed by dividing the body weight of the participants by their height squared. A body fat analyzer was used to obtain skeletal muscle mass, BMI, and percent body fat.

Back strength

A back muscle analyzer was used; the measurement was taken with the participant standing upright with the knee and back muscles straightened and feet pointing forward, and after adjusting the length of the chains, the participant was instructed to grasp the middle part of the handles and pull up vertically by exerting force throughout the body. Prior to the measurement, participants stretched the joints and muscles in their shoulders and lower backs to prevent secondary injury. Measurements were retaken if the knees were bent, foot plates were moved, or feet were displaced from the foot plate. Three measurements were taken, and the highest records were used. Measurements were recorded in kg units.

Analysis

The mean, standard deviation, minimum, and maximum values of compression depth, number of incomplete relaxations, depth of complete relaxation, time between compressions, and compression rate were analyzed via frequency analysis, and the means between groups were analyzed with t-tests.The correlation between body composition and quality of chest compression was analyzed with Pearson’s correlation coefficients. All the data were analyzed using the SPSS software 20.0 (SPSS Inc., Chicago, IL, USA).

Results and Discussion

8 males (50%) and females (50%) participated in the study. For age, 9 people (56.3%) were 19, 4(25.0%) 21, and 3(18.7%) were etc. Heights of men were 172.37 ± 7.76 and women were 163.12 ± 3.83 cm. Male group weighed 69.58 ± 13.97 kg while female group weighed 57.72 ± 3.95 kg. BMI of male group was 23.31 ± 2.76 kg/m^2 and female groups was 21.68 ± 1.46 kg/m^2. Skeletal muscle mass of male group was 31.60 ± 5.47 kg, and female group was 21.025 ± 2.14 kg. For back muscle strength, male and female group showed 149.06 ± 19.68 and 81.31 ± 19.21, respectively. Body-fat percentage in male group showed 18.81 ± 3.94% while female group shoed 32.10 ± 4.44%. Compression depth was 56.30 ± 4.50 mm and 51.94 ± 6.43 mm in

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male and female group, respectively. Rates were 109.30 ± .49 and 109.87 ± .33 in male and female groupas shownin table 1.

Table 1: Personal characteristics

Variables	Male(SD)	Female(SD)	t(*p*)
Gender	8(50%)	8(50%)	
Age	20.87±1.35	19.12±.35	3.532(.003)
Height (cm)	172.37±7.76	163.12±3.83	3.022(.013)
Weight (kg)	69.58±13.97	57.72±3.95	2.310(.049)
Skeletal muscle mass (kg)	31.60±5.47	21.02±2.14	5.090(.001)
Body mass index (kg/m^2)	23.31±2.76	21.68±1.46	1.470(.164)
Back strength (kg)	149.06±19.68	81.31±19.21	6.878(.000)
Body fat percentage (%)	18.81±3.94	32.10±4.44	-6.321(.000)
Compression depth (mm)	56.30±4.50	51.94±6.43	40.392(.000)
Compression rate (min)	109.30±.49	109.87±.33	-2.639(.019)

The participants were classified into four groups, and the outcomes of chest compression were examinedas shownin table 2. The mean compression depth in men and women, respectively, was 55.58±4.30 mm and 58.79±3.64 mm in group 1, 57.85±3.58 mm and 52.84±4.20 mm in group 2, 55.37±5.73 mm and 49.23±4.78 mm in group 3, and 56.43±3.62 mm and 46.84±5.56 mm in group 4 (*p*=.000 in each group).

Table 2: Results of compression depth

Variables	Male(Min-Max)	Female(Min-Max)	t(p)
MCDTS (mm)	56.30±4.50(10.53-64.09)	51.94±6.43(16.25-63.86)	40.392(.000)
G1	55.58±4.30(10.53-62.95)	58.79±3.64(16.25-63.86)	-20.806(.000)
G2	57.85±3.58(12.11-63.41)	52.84±4.20(42.25-62.27)	32.998(.000)
G3	55.37±5.73(13.68-63.86)	49.23±4.78(32.86-62.05)	29.806(.000)
G4	56.43±3.62(13.16-64.09)	46.84±5.56(32.86-59.76)	52.415(.000)

* MCDTS; mean compression depth total score

The overall mean compression depth was 56.30 mm and 51.94 mm among men and women, respectively. A total of 7.01% of men and 28.35% of women showed a compression depth of below 50 mm, while 67.98% of men and 48.52% of women demonstrated an appropriate compression depth (50–59 mm). On the contrary, 25.01% of men and 13.13% of women implemented to achieve a compression depth of 60 mm or greater, showing that men demonstrated deeper compressions as shown in table 3.

Table 3: Results of compression depth

Variables	Mean(mm)	< 50	50 ~<60	≧ 60

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Male(N=5,289, %)	56.30	371(7.01)	3,595(67.98)	1,323(25.01)
Female(N=5,291, %)	51.94	2,029(38.35)	2,567(48.52)	695(13.13)

Over time, the depth of compression decreased, and the depth of compression decreased in the female group compared to the male group. The participants were classified into four groups, and the outcomes of chest compression were examined in fig. 2.

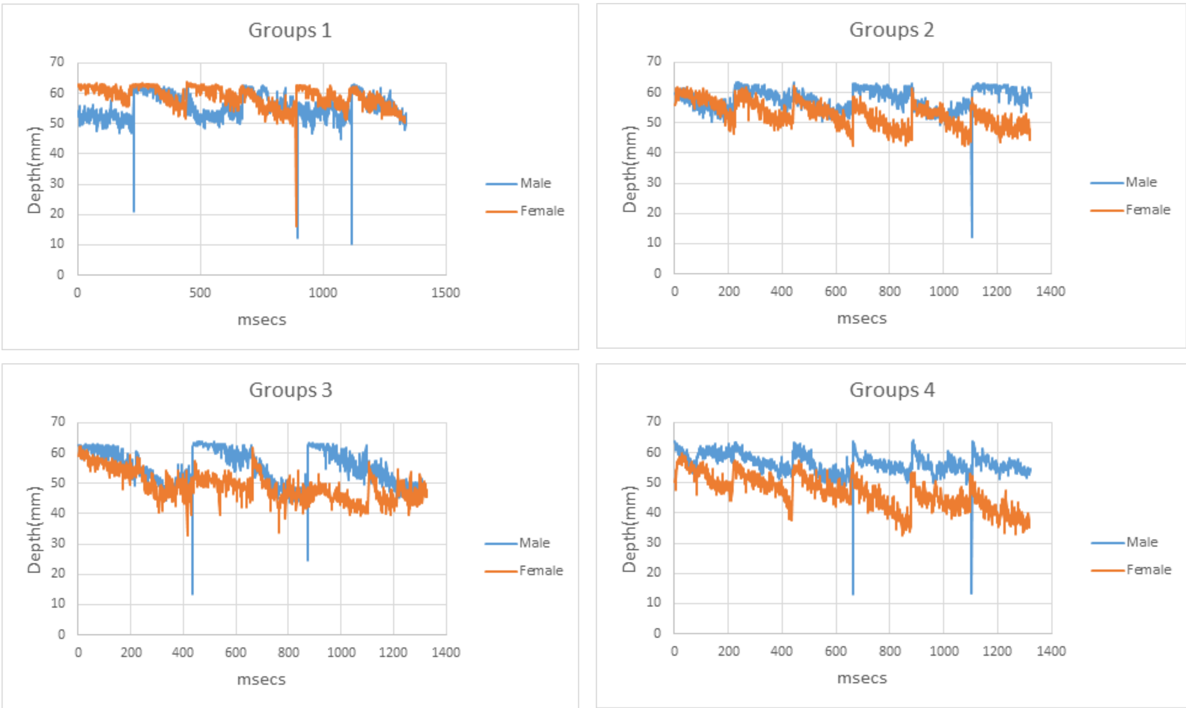

Figure 2: Comparison of chest compression over time in groups

Regarding the correlation between body composition and chest compression, body mass index(MBI), skeletal muscle mass (SMM), height, and weight were not significantly correlated with compression depth. Back strength(BS) was significantly positively correlated with compression depth (r=.524, p=.037), while body fat percentage(BFP) was significantly negatively correlated with compression depth (r=-.745, p=.001) as show in table 4.

Table 4: Correlation of body composition and compression depth

Variables	Depth		Depth	
	r	*p*	*β*	*p*
Gender			-4.908	.018
BMI	.024	.929	.046	.929
SMM	.411	.114	-.814	.267
BS	.524	.037	.033	.461
Height	.157	.517	-.015	.706
Weight	.089	.744	-.221	.888
BFP	-.745	.001	-.151	.870

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* BMI(Body mass index), SMM(Skeletal muscle mass), BS(Back strength), BFP(Body fat percentage)

Post-compression relaxation depth was examined. A depth of up to 5 mm was considered a normal relaxation and a depth of 5 mm or higher was considered an incomplete relaxation. The mean relaxation depth for the entire study population was 2.74±1.17 mm and 2.69±1.48 mm among men and women, respectively. The relaxation depths among men and women, respectively, were 2.46±.97 mm and 3.20±1.16 mm in group 1, 2.67±1.25 mm and 3.44±1.40 mm in group 2, 2.65±1.395 mm and 1.19±1.38 mm in group 3, and 3.20±.85 mm and 2.94±1.24 mm in group 4 (*p*=.000 in each group) as show in table5.

Table 5: Comparison of release depth

Variables	M(SD)	0~4.9	≧5	t(p)
G1 Male(N=1,307) Female(N=1,328)	 2.46±.97 3.20±1.16	 1,181(90.36) 1,151(86.67)	 126(9.64) 177(13.33)	-17.79(.000)
G2 Male(N=1,324) Female(N=1,321)	 2.67±1.25 3.44±1.40	 1,243(93.88) 1,015(76.84)	 81(6.12) 306(23.16)	-14.95(.000)
G3 Male(N=1,308) Female(N=1,325)	 2.65±1.39 1.19±1.38	 1,183(90.44) 1,324(99.92)	 125(9.56) 1(.08)	31.83(.000)
G4 Male(N=1,322) Female(N=1,316)	 3.20±.85 2.94±1.24	 1,266(95.76) 1,201(91.26)	 56(4.26) 115(8.74)	6.16(.000)
Total Male(N=5,261) Female(N=5,290)	 2.74±1.17 2.69±.1.48			1.94(.052)

*MCDTS; mean compression depth total score

Effective chest compressions require an appropriate compression site, rate, and depth; appropriate relaxation depth; and minimal compression pause. Basal fitness is crucial to consistently maintain effective chest compressions. This study examined chest compression in relation to body composition. Higher back muscle strength predicted compression depth,and physical activities are closely associated with body composition and back muscle strength(Yoon JG *et al*., 2017). Back muscle strength helps maintain a stable posture, and enhancing back muscle strength reduces low back pain, which is the most common symptom induced from engaging in chest compressions (Lee WJ *et al*., 2018). Regarding the association between body composition and chest compression, there was a positive correlation between back muscle strength and compression depth. This was consistent with the results of previous studies (Choi *et al*., 2013; Lim YD *et al*., 2017;

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Kaminska H *et al*., 2018) and other findings that showed that gradual improvement of back muscle strength through training also enhances exercise skills (Shin YE., 2012; Shin DS *et al*., 2011). Enhancing back muscle strength lowers low back pain caused by engaging in chest compression, helps to maintain postural stability, and increases muscular endurance (Jang JH *et al*., 2003), thereby helping an individual to maintain effective chest compressions. Furthermore, enhancing physical fitness and muscle strength is effective in suppressing exercise-induced fatigue and producing anti-inflammatory effects (Park EC *et al*., 2012), which in turn decreases fatigue and enables individuals to provide high-quality chest compressions. Percent body fat was negatively correlated with compression depth. In other words, chest compressions were effectively maintained with lower percent body fat observed a positive correlation between fat free mass (FFM) and compression depth (KaminskaH *et al*., 2018). This suggests that higher FFM, which excludes body fat, and lower percent body fat are associated with greater compression depth. However, muscle mass, height, weight, and BMI were not significantly associated with compression depth. A previous study (KaminskaH *et al*., 2018) found that trunk muscle mass and arm muscle mass significantly predict compression depth. Such difference may be attributable to the individual traits of participants and sample size. Sex of the participants was also found to be a predictor of chest compression depth. Chest compression depth decreased more in women than in men over time. In particular, compression depth markedly decreased after 3 minutes, and 38.35% of women showed a compression depth of below 50 mm. It seems that the results pertaining to back muscle strength in men (149.06 kg)and women (81.81 kg) and those pertaining to percent body fat in men (18.31%) and women (32.10%) seem to have influenced maintaining compression depth for an extended period of time. Complete relaxation following chest compression may contribute to increasing and maintaining the coronary perfusion pressure. Inappropriate relaxation was more frequent among women than among men, and the rate of incomplete relaxation increased over time, that is, later in the experiment. This study has a few limitations. While back muscle strength and percent body fat were identified as predictors of compression depth, other basal fitness parameters that may impact back muscle strength and percent body fat were not taken into consideration. Furthermore, the position of the rescuer relative to the patient, posture, and number of rescuers, which may impact the quality of chest compressions, were not observed, which limited overinterpretation of our study findings.

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Conclusion

The ability to maintain effective chest compressions in cardiopulmonary resuscitation decreased rapidly over time, and it was found that in the female group, it decreased significantly after 1 minute. For factors influencing the depth of compression, the higher the back-muscle strength, the better the compression depth was maintained. Also the lower the body fat percentage, the more effective chest compression was maintained. If the CPR is performed for more than 10 minutes with changing person who performs CPR every 2 minutes, it seems desirable that more than 3 people take turns for chest compressions rather than 2 people. In addition, continuous muscle training is needed to lower body fat percentage and improve muscle strength, and CPR training programs for effective operation of smart advanced life support and special paramedics are needed.

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