Indian Journal of Science and Technology, *Vol 8(18), DOI: 10.17485/ijst/2015/v8i18/75912, August 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Effects of Rescuers' using a Smartphone-Band on the Quality of Chest Compression during Cardiopulmonary Resuscitation-Measured using a Manikin

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Abstract

This study aims to investigate the effects of rescuers' using a smartphone-band on the quality of chest compression.The participants in this study were those who had taken a regular course for the Cardio Pulmonary Resuscitation (CPR) and understood the purpose of this study and then agreed to participate. They were divided into the Smartphone-Band Group (SBG) (N=36) and the Standardized Traditional Group (STG) (N=35). A manikin was used to conduct measurements for two days from October 16 to 17, 2013. SPSS WIN Version 12.0 was used for analysis. The compression depth (mm) was reasonable in both groups: 54.97mm for the smartphone-band group and 57.54mm for the standardized traditional group (p<.001). The average compression velocity (time/min) was also within a normal scope in both groups: 108.97 time/min for the smartphone-band group and 120.80 time/min for the standardized traditional group (p<.001). Chest compression accuracy (%) was statistically significant in both of the groups.

Keywords: Band, Cardiopulmonary Resuscitation (CPR) Chest Compression, Smartphone

1. Introduction

Korea Association of Cardiopulmonary Resuscitation (KACPR)[1] reported that the occurrence of cardiac arrest is unpredictable and it is not possible to report it personally or go to a medical institution by themselves who were attacked, so witness needs to notify it to the emergency medical center and perform CPR as soon as possible. The 2011 annual statistics report on health and welfare by Ministry of Health and Welfare (MW)[2] showed that the mortality for a heart disease, one of the three most frequent causes of death, have been increased steadily: 36.9 out of 100,000 persons in 1995, 38.2 in 2000, 39.3 in 2005, and 46.9 in 2010. As the increase of heart disease mortality, a bystander needs to give the Cardiopulmonary Resuscitation (CPR) rapidly. However, even if a bystander gives CPR rapidly, it may cause a secondary damage to the patient when it is improper. Meron et al.[3] warned that CPR could injure the liver as a side effect. Jung et al.[4] contended that CPR could be followed by multiple liverlacerations. Ananiadou, et al.[5] reported that CPR could have such side effects as rib fracture and sternum fracture. Hong et al.[6] contended that CPR given by a bystander could cause gastric rupture. So a bystander who finds a patient with cardiac arrest needs to execute a rapid and accurate CPR. Those who are less confident and less positive are less likely to perform CPR. Lee et al.[7] contended that bystanders who are more confident in CPR were more willing to perform it. To make them more confident in CPR, it is important to arouse their interest in it. A smartphone

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is used to enhance interest and concerns. CPR using a smartphone is being distributed to meet the changes in the age of information. ZOLL[8], American Red Cross (ARC)[9] and Kovic[10] are actively using these changes. ZOLL[8] has developed Pocket CPR application contents. American Red Cross (ARC)[9] has developed First Aidapplication contents. Kovic[10] has developed and distributed CPR PRO application contents. National Emergency Management Agency (NEMA)[11], Korea Occupational Safety Health Agency (KOSHA)[12] and Ministry of Health and Welfare (MW)[13] are also developing and distributing contents concerning the methods to cope with an emergency situation, including CPR. Applications developed by ZOLL[8], American Red Cross (ARC)[9], Kovic[10], National Emergency Management Agency (NEMA)[11], Korea Occupational Safety Health Agency (KOSHA)[12] and Ministry of Health and Welfare (MW)[13] are considered to be contents useful in arousing interest in CPR. On the other hand, ZOLL[8] introduced 'Strap Device on Top of the Hand' by which one fixes a smartphone on the back of the hand and performs a chest compression while watching the Pocket CPR application screen. 'Strap Device on Top of the Hand' is to employ a smartphone actually in chest compression and can be called a smartphone-band method. On the other hand, Meron et al.[3], Jung et al.[4], Ananiadou et al.[5] and Hong et al.[6] contended that even if CPR was performed, it could cause secondary damage. This study intends to investigate the qualitative effects of chest compression with a smartphone fixed on the back of the hand. This study aimed to determine if the smartphone-band method was effective in improving the quality of chest compression in an experimental situation through using a manikin. It was performed since little research on the application of a smartphone in actual chest compression has been conducted. On this basis, it aims to provide efficient assistance in terms of how to give the chest compression for CPR.

2. Methods

2.1 Subjects

The participants in this study were 74 randomly sampled persons who had taken a regular course for CPR and who understood the purpose of this study and then agreed to participate. For the purpose of this study, they were divided into two groups: One is the Smartphone-Band Group (SBG)(N=37) with a smartphone fixed on the back of the hand. The other is the Standardized Traditional Group (STG)(N=37) giving the traditional type of chest compression. With the withdrawal of 3 participants, 71(36 in the smartphone-band group and 35 in the standardized traditional group) ultimately participated in this study. The measurements were performed for two days from October 16 to 17, 2013. The composition of the participants is as presented in Table 1.

2.2 Measurement Methods

This study intends to investigate the effects of rescuers' application of a smartphone-band using a manikin on the quality of chest compression. The participants were divided into the Smartphone-Band Group and the traditional group and were given an explanation of the procedures and methods. The Smartphone-Band Group is referred to as SBG, and the Standardized Traditional Group as STG. The smartphone-band method is to perform chest compression, watching a screen of the smartphone fixed on the back of a hand. In this study, Velcro was attached to the smartphone on the basis of the demo image in Pocket CPR by ZOLL®[8].The smartphone screen is composed of pictures and graphs, which show 'right the location for chest compression', 'chest compression depth', 'beginning voice' and 'rhythm of the compression velocity'. The updated application also includes 'Push Harder' phrases and music. The Smartphone-Band Group (SBG) had nylon Velcro attached as a band. Android and iOS were the Operating Systems (OS) for application in this group. The method of chest compression in the standardized traditional group is the positioning of the hand as suggested by guidelines. It gives a chest compression without audio-visual assistance. The standard weight was 60.0kg, which was the revision of the application by Park and An[15] on the basis of the mean weight for males and females in their twenties (ranging from 20 to 29) presented by the Ministry of Health and Welfare (MW) and Korea Centers for Disease Control and Prevention (KCDC)[14]. The same manikin was used for

Table 1. Characteristics of participants

		SBG	STG	χ^2	P
		N:36, (%)	N:35, (%)		
Gender	Male	15(41.7)	19(54.3)	1.132	.287
	Female	21(58.3)	16(45.7)		
Weight	60≦	16(44.4)	17(48.6)	.122	.727
	>60	20(55.6)	18(51.4)		

SBG: Smartphone-Band Group. STG: Standardized Traditional Group.

pilot practice and the final test in both groups. Little Anne™ by laerdal (Norway) was used for pilot practice and Resusci Anne w/Skill reporter System® by the same manufacturer for the final test. The forms of the hand for both groups are as shown in Figure 1.

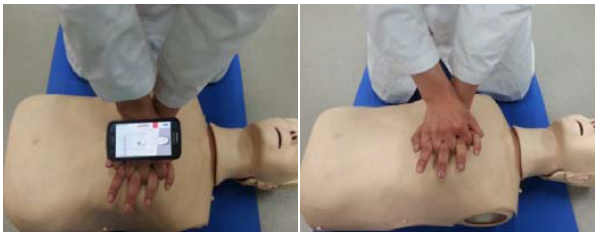
2.3 Assessment Items and Analysis

The criteria for assessing chest compression in both groups were based on the 2010 guidelines by Korea Association of Cardiopulmonary Resuscitation (KACPR)[1] and American Heart Association (AHA)[16]. The ratio of chest compression to artificial respiration was 30 to 2 (five cycles). Artificial respiration was excluded from the category of quality assessment. In the final assessment, the items for assessing the quality of chest compression in both groups were compression depth (mm), average compression velocity (time/min) and chest compression accuracy (%).The analysis in this study was performed using SPSS for Windows Version 12.0. The analysis methods included frequency and percentage, the mean and standard deviation, and nonparametric tests (Wilcoxon signed rank test and Mann-Whitney U test). The statistical significance level was set at $p<0.05$.

3. Findings

3.1 Comparison of Quality between Two Groups

The results of the two groups are presented in Table 2. Compression depth (mm) was reasonable in both groups - 54.97mm for the Smartphone-Band Group and 57.54mm for the standardized traditional group - and was statistically significant ($p<.001$). The average compression velocity (time/min) was also within a normal scope in both groups - 108.97 time/min for the Smartphone-Band Group and 120.80 time/min for the Standardized Traditional Group - and was statistically significant ($p<.001$). Chest compression accuracy (%) was statistically significant in neither of the groups.



(a) **(b)**

Figure 1. Chest compression type for two methods. **(a)** SBG chest-compression position. **(b)** STG chest-compression position.

Table 2. Comparison of quality between two groups

		SBG	STG	p value
		M±SD	M±SD	
Chest compression	A	54.97±3.86	57.54±2.54	.001***
	B	108.97±11.12	120.80±9.30	.000***
	C	86.65±21.39	90.57±12.61	.750

SBG: Smartphone-Band Group. STG: Standardized Traditional Group.
A: Compression depth (mm). B: Average compression, velocity (time/min). C: Chest compression (%).
***p<.001

3.2 Comparison of Quality by Gender

Table 3 shows gender differences of the qualitative effects between the Smartphone-Band Group and the Standardized Traditional Group. Both males (56.13mm) and females (54.14mm) in the Smartphone-Band Group showed reasonable compression depth (mm), with no statistical significance. Both males (58.73mm) and females (56.12mm) in the standardized traditional groupshowed reasonable compression depth, with statistical significance ($p<.01$).

3.3 Comparison of Quality by Weight

Table 4 shows differences in the quality of accuracy between the Smartphone-Band Group and the Standardized Traditional Group. Both those of 60kg or more (55.50mm) and those below 60kg (54.55mm) in the Smartphone-Band Group showed reasonable compression depth, with no statistical significance. Both those of 60kg or more (58.41mm) and those below 60 kg (56.72mm) in the standardized traditional group showed reasonable compression depth, with statistical significance ($p<.01$).

4. Discussion

The results showed no difference in the qualitative effects between the Smartphone-Band Group and the Standardized Traditional Group. Wyss et al.[17] reported that chest compression using a mechanical device was more accurate than a manual-based method. Cho et al.[18] suggested that chest compression using a mechanical device could make the rescuer more psychologically stable

Table 3. Comparison of quality by gender

		SBG		P value	STG		p value
		Male	Female		Male	Female	
		M±SD	M±SD		M±SD	M±SD	
Chest compression	A	56.13±3.64	54.14±3.79	.077	58.73±0.80	56.12±3.15	.003**
	B	111.06±14.40	107.33±7.69	.311	120.42±9.02	121.25±9.89	.894
	C	90.80±23.85	84.04±19.04	.075*	90.57±10.72	90.56±14.91	.441

SBG: Smartphone-Band Group. STG: Standardized Traditional Group.
A: Compression depth (mm). B: Average compression, velocity (time/min). C: Chest compression (%).
**p<.01

Table 4. Comparison of quality by weight

		SBG		p value	STG		p value
		60≦	>60		60≦	>60	
		M±SD	M±SD		M±SD	M±SD	
Chest compression	A	55.50±3.63	54.55±3.99	.403	58.41±2.26	56.72±2.58	.003**
	B	110.00±14.38	108.00±7.51	.577	123.76±11.37	118.00±5.85	.124
	C	89.62±23.16	84.65±19.66	.229*	91.47±10.92	89.72±14.28	.987

SBG: Smartphone-Band Group. STG: Standardized Traditional Group.
A: Compression depth (mm). B: Average compression, velocity (time/min). C: Chest compression (%).
**p<.01

and the compression more uniform than the standardized method. They also contended that it could help solve the safety problems for the rescuer and the qualitative problems caused by poor recoil. In contrast, Smekal et al.[19] reported that chest compression using a mechanical device was more likely to have such side effects as skin marks and sternal fracture than a manual-based method. Handley and Handley[20] introduced a revised over-the-head method for closed and restricted space. They suggested that the over-the-head method could be effective when the standardized method could not be used in narrow and closed space. Abella et al.[21] suggested that the CPR method using an audiovisual feedback device could help improve the quality of chest compression. This method is to perform chest compression, watching a monitor while maintaining the standardized method of chest compression. Studies with mechanical devices and diverse methods, including revised one, are continuously conducted to make CPR more convenient and accurate.

As mentioned above, a smartphone is used to enhance the rate of participation in CPR. The application developed by National Emergency Management Agency (NEMA)[11], Korea Occupational Safety Health Agency (KOSHA)[12], and Ministry of Health and Welfare (MW)[13] is a program for theoretical learning than for using skills. CPR can be performed by the standardized method after getting information through this application. Park[22] suggested that a bystander could approach CPR training easily if strengths and weaknesses of the animation application and the Pocket CPR application were complemented with each other. ZOLL®[8] and Kovic[10] are using both CPR theories and skills. The theories provide information about CPR methods. The skills include diverse methods directly using a smartphone: the method to hold a smartphone between hands, the method to fix it on the back of the hand, and visual feedback. However, some have a negative opinion about the application of a smartphone to actual skills as suggested by ZOLL®[8] and Kovic[10]. Cho et al.[23] suggested that chest compression using a smartphone might have negative qualitative effects. Although it was different from the method in this study, Cho et al.[23] obtained no result that the method using a smartphone was superior in the qualitative effects of chest compression. Cho et al.[23] compared three types of chest compression - 'method of holding in a hand' with a smartphone between hands, 'method of arm band' for wearing it on the upper arm, and 'method of arm band

on the back of the hand' for attaching it to the back of the hand - in terms of accuracy. The 'method of holding in a hand' got 2.1±13.3 mm, the 'method of arm band' 14.0±11.9 mm, and the 'method of arm band on the back of the hand' 8.6±9.6 mm. Cho et al.[23] noted that a smartphone is hard to be used in practice due to low accuracy and that the farther from the hand it is worn, the less accurate compression depth it gives.

The use of smartphone applications can be categorized into two types: theoretical methods and skills. It is possible to learn the theoretical use freely without temporal or spatial restrictions. The use of skills is to perform chest compression by fixing a smartphone on the back of a hand or by holding it in a hand. However, the actual application of a smartphone in chest compression can reduce solidity and a sense of stability. This is because if it is worn away from a hand, it can lower accuracy of compression depth, as suggested by Cho et al[23].

There are several cautions in employing the smartphone-band method in training: first, the fixed band shouldn't be moved; second, it shouldn't be slipped; third, it should be fixed firmly on the back of a hand; fourth, it should be fixed on the back of a hand, not on a finger; fifth, the band strap should be attached correctly; sixth, it is necessary to reduce the amount of time being taken to put on a smartphone.

Despite its significance, this research has a few limitations: first, the amount of time being taken to put on a smartphone was not measured; second, a manikin was used, instead of an actual situation; third, it didn't involve many subjects; fourth, it didn't involve diverse tools to measure the quality; fifth, it was restricted to a smartphone; sixth, it failed to measure the rescuer's physiological fatigue; seventh, it took single short-term measurement. Care should be taken in comparing with the results of other studies.

5. Conclusion

There was no difference in the qualitative effects between the smartphone-band method and the traditional method based on guidelines. However, the standardized traditional cardiopulmonary resuscitation skills based on cardiopulmonary resuscitation guidelines need to be employed. It is desirable to employ the smartphone-band method in training only after solving its problems with solidity, slippery, stability, time consumption, and accurate strap attachment.

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