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The Effect of Trunk Muscle Exercise of Paramedic Student on Cardiopulmonary Resuscitation

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응급구조학과 학생들의 체간근육 훈련이 심폐소생술에 미치는 영향

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Abstract The present study aimed to find out how the trunk muscles, which are mainly used in Cardio-Pulmonary Resuscitation, affect chest compression through plank exercise. Study subjects participated in a 12-week program, and subjects performed only chest compressions for 8 minutes. Regarding their change in a muscle mass by plank exercise, there was a statistically significant difference in the change from 4th to 8th week after the program($p<.01$). The muscle activity change had a statistically significant difference from 3rd to 10th week($p<.01$). The chest compression depth had a statistically significant difference from 4th to 8th week($p<.01$). In addition, insufficient chest relaxation height after compression had a statistically significant difference from 4th to 10th week($p<.01$). The chest compression maintenance time had a statistically significant difference from 2nd to 12th week($p<.01$). The participants` muscle mass and muscle activity increased more after their participation in plank exercise program than before. All chest compression factors except for chest compression rate brought about positive results.

Key Words : Cardiopulmonary resuscitation, Plank exercise, Trunk muscles, Muscle activity, Chest compression

요 약 본 연구는 심폐소생술에 주로 사용되는 체간 근육이 플랭크 운동을 통해 가슴압박에 어떠한 영향을 미치는지 알아보고자 하였다. 연구대상자들은 12주 프로그램에 참여하였으며 한 명의 대상자가 8분 동안 가슴 압박만을 실시하였다. 플랭크 운동에 의한 근육량 변화는 프로그램 4주차부터 8주차까지 통계적으로 유의한 차이가 있었다($p<.01$). 근육 활동 변화는 3주부터 10주까지 통계적으로 유의한 차이를 보였다($p<.01$). 흉부 압박 깊이는 4주차부터 8주차까지 통계적으로 유의한 차이를 보였다($p<.01$). 또한 불완전한 압박 후 가슴 이완은 4주차부터 10주차까지 통계적으로 유의한 차이가 있었다($p<.01$). 가슴압박 유지 시간은 2주에서 12주까지 통계적으로 유의한 차이가 있었다($p<.01$). 연구대상자의 근육량과 근육 활동은 플랭크 운동 프로그램에 참여한 후 이전보다 더 많이 증가하여 가슴 압박에 도움이 된다는 것을 보여주었다.

주제어 : 심폐소생술, 플랭크 운동, 체간 근육, 근활성도, 가슴압박

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1. Introduction

Currently in Korea, two paramedics are in charge of assessment, first aid and transportation of patients from the field to the hospital [1]. Except for one ambulance driver, the number of first aid personnel can be regarded as one paramedic. Therefore, in case of cardiac arrest, one paramedic should perform CPR and all necessary first aid for an average time of 10 minutes[1]. However, in previous studies, the accuracy of chest compression decreased with increasing chest compression time[2], and it was appropriate to alternate the performers of chest compression two minutes after the onset of chest compression[3]. However, the current situation of the paramedics cannot apply these suggestions in practice. In general, chest compressions by only hands are reported to not provide enough blood flow as a life sustaining organ[4,5]. So an automated mechanical chest compression device is recommended[6-8], but it is not owned by 95% of 1,294 ambulances deployed in Korea[1]. In addition, due to personnel problems for the smooth use of mechanical chest compression devices, it is difficult to use in the field. Therefore, current cardiopulmonary resuscitation for cardiac arrest patients occurring out-of-hospital is forced to use chest compressions by only hands without the help of mechanical compression. In a previous study, when chest compressions were performed in the abdominal drawing-in state, activation of the trunk muscles increased over time[9], affecting the stability of the trunk, and directly affecting the depth and success rate of chest compressions[10]. In addition, it was confirmed that the trunk stability exercise is an effective exercise that can improve functional exercise, dynamic balance, and trunk stability[11]. However, there are limitations in learning the correct use of these tools for paramedics who encounter cardiac arrest patients outside of hospitals, and there are limitations in installing and purchasing the tools and devices. Based on the research that mainly uses erector spinae, pectoralis major, rectus abdominis during chest compressions[12], the researcher conducted a plank exercise to train trunk muscles anywhere, without any equipment. The first purpose of this study is to find out whether plank exercise is effective on the muscles used for chest compression, and the second is to find out the duration of plank exercise for effective chest compression. The final purpose is to find out the training method and training period for more effective chest compression in out-of-hospital cardiac arrest situations where mechanical chest compression devices cannot be used.

2. Materials and Methods

The participants of this study were enrolled in the Department of Paramedicine in 2014 and enrolled in the same curriculum for 24 months in order to minimize technical differences between participants, and were recruited as students of the same grade. Based on the research by previous G*power 3.0, the effect size was 0.5, significance level α=.05, and power was 80%. Thus, 30 people were recruited. The target selection criteria were selected as students who do not use the health center or exercise regularly and can continue to participate in the program. After receiving the approval of the research committee of Chungnam National University Hospital (No.2015-10-035-005), an explanation of the exercise program was announced to recruit participants After participating in the experiment. Cases in which the study participants were unable to perform basic CPR due to health, etc. and did not agree to participate in the experiment were excluded from the study. The duration of this study was a schedule of applying a six-week programmed plank exercise based on previous studies[13]. After six weeks of plank exercise, a total of twelve weeks were conducted on a schedule of no exercise, including plank exercise. In order to prevent the participants from feeling uncomfortable, the indoor environment of the test and test sites was maintained at the comfort index to make the surrounding environment comfortable by setting the room temperature to 26 degrees and the humidity to 40%[14].

The muscle mass of the study participants was measured using Avis 333® (Jawon medical, Korea), a body composition measurement tool. A total of 13th measurements were recorded. Noraxon Clinical DTS 546® (Noraxon Inc., ARIZONA, USA) was used to determine the muscle activity of the erector spinae, pectoralis major, rectus abdominis and measured using four radiochannel surface electromyograms. The collected EMG digital signal was filtered and other signal processing on the computer using MR-XP Master program (Noraxon Inc., Arizona, USA). The electrode attachment point is Erector Spinae is 6 cm later from L1 spinous process, Pectoralis Major is (sternal portion) horizontally on the chest-wall over the muscle mass that arises (approximately 2 cm out from the axillary fold), Rectus Abdominis is 3 cm later from the umbilicus. With the use of a body composition analysis tool known as in-body, the student had a measurement one time before plank exercise. After their plank exercise, they had a remeasurement once every 7 days, and their change in a muscle mass was analyzed. With the use of electromyography activity, the muscle activity was analyzed. Plank exercise was performed in a single posture, maintaining the shoulder angle at 90 degrees based on previous study and no other postural changes were performed. The abdominal drawing-in maneuver was performed after maintaining the lumbar neutral posture. Three sets of one set at 10 times were performed by 30 seconds of exercise and 20 seconds of rest. Performed rest after each set of exercise to prevent fatigue. Chest compression was determined by a single rescuer performing continuous chest compressions only on a mannequin(Resusci Anne simulator®, Laerdal® PC skill reporting system, Stavanger, Norway) for 8 minutes without artificial respiration. Effective chest compression was defined as the number of chest compressions between 100~120 times per minute, chest compression depth of at least 50~60 mm, and chest compression recoil of the chest to 20 mm. During the experiment, no feedback was provided to the participants.

SPSS 21.0 for Windows was used for statistical analysis. The mean and standard deviation was used to analyze confidence in percent error values and bleeding estimation accuracy before and after simulation training. One-way ANOVA was used to analyze subjects' grade differences. If p value is less than 0.05, it is defined as statistically significant.

3. Results

3.1 General Characteristics of Subjects

Table 1 shows thirty participants 16 males (53.33%) and 14 females(46.66%) participated in this study. The average age was 23.33±1.68 years, the average height was 168.00±6.74 cm, and the average weight was 68.53±12.81 kg.

Table 1. General Characteristics of Subjects

Variable		n(%) or Mean ± Standard Deviation
Gender	Male	16(53.33)
	Female	14(46.66)
Age(years)		23.33 ± 1.68
Height(cm)		168.00 ± 6.74
Weight(kg)		68.53 ± 12.81

3.2 Analysis of Muscle Mass and Activation According to Trunk Muscle Training

Table 2 shows the results of repeated measures analysis of variance that muscle mass changes were statistically significant(F(12,348)=62.212, p〈.001). Changes in muscle activity were found in pectoralis major (F(12,348)=49.859, p〈.001), erector spinae (F(12,348)=40.898, p〈.001), rectus abdominis (F(12,348)=40.134, p〈.001).

Table 2. Analysis of muscle mass and muscle activation according to plank exercise

		Muscle Mass from Plank Exercise			Muscle Activation from Chest Compression								
					Pectoralis Major			Erector Spinae			Rectus Abdominis		
		M±SD	F	*p*	M±SD	F	*p*	M±SD	F	*p*	M±SD	F	*p*
BL	0	28.66±6.04^{abc}			41.81±19.28^{a}			139.96 ±64.14^{a}			81.94±37.57^{a}		
PE	1	28.49±6.16^{ab}			41.77±19.26^{a}			139.96± 64.16^{a}			81.92±37.56^{a}		
	2	28.60±6.09^{ab}			41.71±19.20^{a}			140.00± 64.19^{a}			81.96±37.54^{a}		
	3	28.52±6.21^{ab}			43.03±19.59^{bc}			143.45 65.31^{b}			83.91±38.20^{b}		
	4	29.26±6.17^{d}			43.59±19.90^{cd}			145.31±66.36^{cd}			85.00±38.81^{cd}		
	5	29.68±6.17^{e}			44.16±20.10^{e}			147.21±67.03^{e}			86.12±39.21^{e}		
	6	29.96±6.20^{f}	62.212	〈.001	44.66±20.13^{f}	49.859	〈.001	148.90±67.13^{f}	40.898	〈.001	87.10±39.27^{f}	40.134	〈.001
NE	1	29.68±6.22^{e}			44.22±19.98^{e}			147.42±66.61^{e}			86.24±38.96^{e}		
	2	29.04±6.19^{cd}			43.73±19.80^{d}			145.79±66.00^{d}			85.28±38.61^{d}		
	3	28.73±6.19^{a}			43.21±19.60^{c}			144.03±65.34^{c}			84.26±38.22^{c}		
	4	28.52±6.20^{b}			42.81±19.46^{b}			142.71±64.87^{b}			83.48±37.95^{b}		
	5	28.59±6.16^{ab}			41.75±19.22^{a}			139.87±64.17^{a}			81.75±37.52^{a}		
	6	28.52±6.15^{ab}			41.70±19.23^{a}			139.91±64.18^{a}			81.94±37.53^{a}		
		Note. Significant differences between group means are indicated by different letters. Means having the same subscript are not significantly different.											

BL ; Base Line, PE ; Plank Exercise, NE ; Non Exercise, M±SD ; Mean±Standard Deviation
M±SD ; Mean±Standard Deviation, a ≦ b ≦ c 〈 d 〈 e 〈 f

Table 3. Analysis of chest compression quality according to Trunk Muscle Training

		Chest Compression Depth			Chest Compression Rate			Chest Compression Incomplete Recoil			Chest Compression Maintenance Time		
		M±SD	F	*p*	M±SD	F	*p*	M±SD	F	*p*	M±SD	F	*p*
BL	0	47.10±3.39^{a}			104.30±1.51			4.66±2.10^{a}			417.60±73.03^{a}		
PE	1	46.90±2.60^{a}			104.56±1.71			4.40±1.84^{ab}			417.06±72.86^{a}		
	2	47.16±2.37^{a}			104.13±1.61			4.53±1.99^{a}			425.43±63.78^{b}		
	3	47.36±2.51^{a}			104.26±1.63			4.40±1.92^{ab}			444.33±45.37^{c}		
	4	49.36±2.89^{b}			104.26±1.63			3.53±1.90^{c}			473.86±15.48^{de}		
	5	50.53±2.77^{c}			103.96±1.62			1.40±1.49^{e}			474.56±14.91^{de}		
	6	51.43±2.07^{d}	98.843	〈.001	104.16±1.53	1.882	.093	0.43±0.77^{f}	80.592	〈.001	479.00±5.47^{e}	19.017	〈.001
NE	1	50.46±2.27^{c}			104.23±1.27			0.86±0.77^{e}			479.53±2.55^{e}		
	2	50.06±2.25^{bc}			104.23±1.75			2.23±0.97^{d}			475.26±11.02^{cde}		
	3	47.00±2.28^{a}			104.40±1.61			2.90±1.06^{c}			467.13±22.36^{cde}		
	4	46.70±2.50^{a}			104.46±1.16			3.80±1.86^{bc}			458.96±28.82^{bcd}		
	5	47.03±2.68^{a}			104.70±1.76			4.33±1.64^{a}			441.93±42.80^{bc}		
	6	46.76±2.89^{a}			104.43±1.63			4.23±1.92^{ab}			447.36±38.47^{bc}		
		Note. Significant differences between group means are indicated by different letters. Means having the same subscript are not significantly different.											

BL ; Base Line, PE ; Plank Exercise, NE ; Non Exercise, M±SD ; Mean±Standard Deviation
M±SD ; Mean±Standard Deviation, a ≦ b ≦ c 〈 d 〈 e 〈 f

3.3 Analysis of Chest Compression Quality According to Trunk Muscle Training

Table 3 shows the change in chest compression depth was statistically significant (F(12,348)=98.843, p<.001). The change in the chest compressions rate due to flank exercise was not statistically significant for a total of 12 weeks (F(12,348)=1,882 p=.093). Insufficient recoil after chest compression was statistically significant (F(12,348)=80.592, p<.001). The change in effective chest compression maintenance time was statistically significant (F(12,348)=19.017, p<.001).

3.4 Relation between Muscle Mass, High Quality Depth, Compression Maintenance Time

Table 4 shows the correlation coefficient between muscle mass and effective compression depth was .79, which was very high. In other words, the greater the muscle mass, the deeper the depth of effective compression. The correlation coefficient between muscle mass and effective chest compression time was .61. In other words, the more muscle mass, the longer the effective chest compression time.

Table 4. Relation between Muscle Mass, High Quality Depth, Compression Maintenance Time

	High Quality Depth	Compression Maintenance Time
Muscle Mass	.79	.61

3.5 Relation between High Quality Depth, Compression Maintenance Time

Table 5 shows the correlation coefficient between effective chest compression depth and effective chest compression maintenance time was .58, which was high. In other words, the maintenance time to compression the chest to the effective depth is increased.

Table 5. Relation between High Quality Depth, Compression Maintenance Time

	Compression Maintenance Time
High Quality Depth	.58

4. Discussion

Six weeks of plank exercise had an effect on muscle mass and muscle activity. In particular, 4 weeks after the start of the plank exercise showed a significant effect, and even after stopping the plank exercise showed a significant result until 2 weeks. In addition, the pectoralis major, erector spinae and rectus abdominis which are mainly used for chest compressions, had a significant effect from 3 weeks after the start of the plank exercise and even after stopping the plank exercise showed a significant result until 4 weeks. These results showed the same results as the present study showing the increase in muscle activity in the major muscles including the abdominal muscle in a previously published study of muscle activity[15,16].

Analyzing the depth of chest compressions of the study participants, it showed a significant increase after 5 weeks of starting the plank exercise, and after 3 weeks of stopping the plank exercise, it did not become effective chest compression and continued to decrease afterwards. Although chest compression proficiency increases with increasing rate of chest compressions, the decrease in chest compression depth after stopping plank exercise is considered to be due to the change of muscle mass following plank exercise. As the activity of trunk muscles, which is mainly used for chest compression, increases the chest compression depth, which is a high level of force, through the plank exercise[17]. In addition, the previous study showed a rapid increase rate from 4 weeks to 6 weeks after the start of exercise. Since then, there is no significant change in the increase rate. According to these results, in order to achieve effective chest compression depth through plank exercise, plank exercise should be continued for at least 5 weeks, and should not have a break period of at least 2 weeks. As a result of analyzing the change in the rate of chest compressions, there was no significant result about the number of chest compressions by the plank exercise. This is because the depth of chest compression decreases significantly over time in several published studies, but the number of chest compressions is relatively free from problems such as physical consumption compared to chest compression. Incomplete chest compression recoil showed the highest duration of exercise in the effect of chest compression through plank exercise. However, 5 weeks after stopping the plank exercise, the incomplete recoil of chest compressions increases again, and it is thought that the plan should be continued for at least 4 weeks for effective chest compressions and there should be no break of at least 4 weeks. As a result of analyzing the chest compression maintenance time, as shown in the result of analyzing the incomplete chest compression rate, the plank exercise seems to be a result of the significant improvement of muscle endurance. In addition, the effective chest compression success rate increased significantly after 5 weeks of starting exercise, and significantly increased after until 2 weeks of stopping exercise. This means that the maintenance time to chest compression has been increased to the chest compression depth recommended by the 2015 AHA Guidelines. The plank exercise not only increased the maintenance time for chest compression, but also increased the maintenance time for effective chest compressions, which is practically helpful for cardiac arrest patients. The results of this study showed that for effective chest compressions, plank exercise was effective in increasing proper chest compression depth and muscle endurance for chest compressions. Through this, plank exercise is expected to be effective for long-term chest compression, and furthermore, it can reduce muscle fatigue by centering the trunk muscle. The limitations of this study are first, the number of study participants is difficult to generalize to 30, and secondly, the use of educational mannequins, it did not accurately reflect the anatomy of the chest. Third, it was that the laboratory was familiar to the participants, not the actual emergency. Fourth, the condition regarding diet that could affect muscles was not considered. Fifth, there is a possibility that psychological factors that subjects can speculate and control the results of research due to continuous experiments. Sixth, the study participants were composed of college students in their twenties and did not reflect the change according to age.

5. Conclusion

The participants muscle mass and muscle activity increased more after their participation in plank exercise program than before. All chest compression factors except for chest compression rate brought about positive results. Accordingly, when CPR was performed after trunk muscles were trained with plank exercise, it was found that the plank exercise positively influenced on chest compression. If the study subjects have three sets of plank exercise program for five weeks, which consisted of one set of 10 times of 30-second motion and 20-second rest and does not have up to two weeks of detraining, the plank exercise is considered to be helpful for them in out of hospital cardiac arrest at the time when there is no use of mechanical chest compression device.

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