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DETERMINING THE EFFECTIVENESS OF CARDIOPULMONARY RESUSCITATION USING A CPR MANIKIN

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ABSTRACT

Objectives: Many studies have shown that people applying cardiopulmonary resuscitation (CPR) cannot make sustained and effective CPR due to fatigue, sweaty hands, broken ribs, inability to determine the correct area etc. Thus, this study aimed to determine the effectiveness and sustainability of CPR quality using a CPR manikin by following the 2015 CPR guidelines.

Material and Method: This study was carried out with 153 student volunteers from seven different health sciences programmes at Izmir University of Economics. All students were trained in first aid and basic life support in the previous school academic year. The time and effectiveness of CPR applied on a CPR manikin (Ambu® Manikin) were measured. The students' body positioning, blowing capacities, depth of pressures and effective pressure durations were evaluated and numerical data were analysed by t-test. P-value <0.05 was accepted as statistically significant. Data were analysed using SPSS version 21.

Results: Of the 153 student volunteers, 60.1% were female and 39.9% were male. The average student age was 20.32 ± 03 years, the average height was 169.20 ± 26 cm and the average weight was 65.12 ± 42 kg. The average effective CPR duration was 2.95 ± 0.86 min, the average pressure depth was 4.33 cm and the average depth of pressures and effective pressure was 0.6 liters. The position of the arms was correct in 83% of the students. In 81% of the cases, the application site was correctly determined. Moreover, 68.6% of the students were able to sustain the pumping activity of the heart. In all parameters other than the arms position, male students had better results than female students. CPR is a very important live-saving method to increase the chance of survival. However, this practice is ineffective unless applied correctly and timely.

Conclusion: This study showed that manual chest compression on the manikin became ineffective in both speed and effectiveness just within minutes. This shows that there is a very important deficiency in this area where human life depends on minutes. Thus, developing and commissioning auxiliary external chest compression device that can perform CPR, especially in pre-hospital setting, ambulance and emergency departments, is important.

Keywords: Resuscitation, Heart Failure, Resuscitation Training, Resuscitation Effectiveness, Resuscitation Research

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CPR MANKENİ ÜZERİNDE KARDİYOPULMONER RESUSİTASYON ETKİNLİĞİNİN SAPTANMASI

ÖZ

Amaç: Kardiyopulmoner resüsitasyon (CPR) uygulayan kişilerin yorgunluk, ellerin terlemesi, kaburgaların kırılması, doğru bölgenin belirlenememesi vb. nedenlerle kalıcı ve etkili KPR yapamadıkları birçok çalışmada gösterilmiştir Bu nedenle, bu çalışma, 2015 CPR yönergelerini izleyerek bir CPR mankeni kullanarak CPR kalitesinin etkinliğini ve sürdürülebilirliğini belirlemeyi amaçlamıştır.

Gereç ve Yöntem: Bu çalışma İzmir Ekonomi Üniversitesi'nde yedi farklı sağlık bilimleri programında okuyan 153 gönüllü öğrenci ile gerçekleştirildi. Tüm öğrencilere bir önceki eğitim öğretim yılında ilk yardım ve temel yaşam desteği eğitimi verildi. Bir CPR mankenine (Ambu® Manken) uygulanan CPR'nin süresi ve etkinliği ölçüldü. Öğrencilerin vücut pozisyonları, üfleme kapasiteleri, bası derinlikleri ve efektif bası süreleri değerlendirilmiş ve sayısal veriler t-testi ile analiz edilmiştir. P değeri <0,05 istatistiksel olarak anlamlı kabul edildi. Veriler SPSS 21 sürümü kullanılarak analiz edildi.

Bulgular: 153 gönüllü öğrencinin %60,1'i kadın ve %39,9'u erkekti. Ortalama öğrencilerin yaşı 20,32 ± 03 yıl, ortalama boyları 169,20 ± 26 cm ve ortalama ağırlıkları 65,12 ± 42 kg idi. Ortalama etkili CPR süresi 2,95 ± 0,86 dakika, ortalama bası derinliği 4,33 cm ve ortalama etkili üfleme kapasitesi 0,6 litre idi. Kolların pozisyonu öğrencilerin %83'ünde doğruydu ve %81'inde bası yeri doğru olarak belirlenmiştir. Ayrıca öğrencilerin %68,6'sı kalbin pompalama aktivitesini ritmik olarak sürdürebilmiştir. Kol pozisyonu dışındaki tüm parametrelerde erkek öğrenciler kız öğrencilere göre daha iyi sonuçlar elde etmişlerdir. CPR, hayatta kalma şansını artırmak için çok önemli bir hayat kurtarma yöntemidir. Ancak bu uygulama doğru ve zamanında uygulanmadığında etkisizdir.

Sonuç: Bu çalışma, manken üzerindeki manuel göğüs kompresyonunun dakikalar içinde hem hız hem de etkinlik açısından etkisiz hale geldiğini göstermiştir. Bu durum insan hayatının dakikalara bağlı olduğu bu alanda çok önemli bir eksiklik olduğunu göstermektedir. Bu nedenle özellikle hastane öncesi ortamda, ambulans ve acil servislerde KPR yapabilen yardımcı harici göğüs kompresyon cihazının geliştirilmesi ve devreye alınması önemlidir.

Anahtar Kelimeler: Resüsitasyon, Kalp Yetmezliği, Resüsitasyon Eğitimi, Resüsitasyon Etkinliği, Resüsitasyon Araştırması

INTRODUCTION

Cardiopulmonary resuscitation (CPR) is a procedure applied to a patient experiencing cardiac or respiratory arrest and the technique includes external compression on the heart (chest compressions) from the outside through the use of hands and arms and breathing into the patient’s mouth or nose to protect brain functions by supporting blood circulation and

respiration. Cardiac arrest is caused by electrical problems in the heart, which prevents the pumping of blood through the body and brain. Respiratory arrest is the cessation of exhalation. According to the 2015 American Heart Association and European Resuscitation Council recommendations, 30 chest compressions, followed by two breaths (while the rescuer breathes, the chest should be monitored and several seconds should be spent on inflating the chest), is the appropriate number of chest compressions in adults. Breathing (by blowing or mechanical ventilation) should be performed to inflate the chest between compressions for at least 5 cm (Monsieurs et al., 2015), pressing up to 6 cm (2.4 inches) deep, with zero or minimal interruption to chest compressions to simulate a heart rate of at least 100–120 beats per minute, allowing the heart to refill (Zideman et al., 2015, Neumar et al., 2015). CPR alone is unlikely to restart the heart. To restore heart rhythm, it is necessary to supply electricity to the heart by defibrillation. However, defibrillation is effective only for certain cardiac rhythms, e.g. ventricular fibrillation or pulseless ventricular tachycardia. When appropriate, early shock is recommended. CPR and shock delivery can be effective. CPR should be continued until either spontaneous circulation returns or the person is considered dead (Atkins et al., 2015).

More than 135 million individuals worldwide die each year from cardiovascular causes (Ahern et al., 2011). According to 2018 Turkish statistics office (TUIK.,2018) data, circulatory system diseases, which account for 38.4% of all death cases (161.920 people), ranked first and 39.7% of these cases were caused by ischaemic heart disease and 22.4% by cerebrovascular diseases (TUIK.,2018). The first few minutes after a cardiac or respiratory arrest are crucial. If the heart stops and CPR is not initiated immediately, the heart and brain will be damaged due to oxygen deficiency; as the heart stops pumping blood, no blood will reach distant body parts and brain. Consciousness disappears within a few seconds. Measurable brain activity stops within 20–40 s (Lind et al., 1975). Within 4–10 min, irreversible injuries develop in the hippocampus, basal ganglia and cerebral cortex (Astrup et al., 1980, Smith et al., 1984). After 10 min, irreversible brain damage occurs and in 20 min, there is no chance of revival. Every minute spent in fibrillation reduces survival by 7%–10% (Smith et al., 1984). Most people regard cardiac arrest and heart attack as the same; in truth, heart attack can cause cardiac arrest. Three-quarters of deaths from coronary heart disease occur without warning outside the hospital setting (Sanchis-Gomar et al., 2016).

To lower the death ratio or early and late complications of cardiac arrest, community based basic life support courses are highly recommended by the American Heart Association (AHA) and The European Resuscitation Council (ERC). At our university, paramedic program gives basic life support courses to all students of life sciences according to the 2015 CPR

guidelines. Many studies have shown that people applying cardiopulmonary resuscitation (CPR) cannot make sustained and effective CPR due to fatigue, sweaty hands, broken ribs, inability to determine the correct area etc. The aim of this study was to determine, for each student just after completion of course season, the effectiveness of these courses by means of CPR and ventilation performed on a CPR manikin (Ambu ® model Manikin).

1. MATERIALS AND METHODS

This study was conducted between 2016 and 2018 at Izmir University of Economics Health Services Vocational School. During these academic years, out of 210 students who took first aid lessons, 153 students volunteered to participate in the study. First aid and basic life support training was carried out by 153 student volunteers from the following vocational school departments: medical laboratory techniques programme, medical imaging techniques programme, paramedic programme, elderly care programme, child development programme, physiotherapy programme and occupational health and safety programme.

Before the study, within the scope of the first aid course, theoretical and practical training for basic life support was given to the students for 3 weeks by the instructor of the course. All students performed practice on the mannequin one by one. This study was carried out with students who volunteered at the end of the course.

Students who voluntarily wanted to participate were determined. The aim and method of the study were explained to the volunteer students. Each student was taught all the steps of CPR according to the 2015 resuscitation guidelines (American Heart Association (AHA) and The European Resuscitation Council (ERC)) by the instructor. Assuming that the rescuers could be alone, the study focused on how long the participants would be able to perform CPR effectively, ignoring the recommendations of the guidelines to change persons in 2 minutes if enough people capable of CPR are present. This study was planned after realizing that the CPR procedure could not be performed effectively in first aid classes. Each student took a deep breath and closed the manikin's nose (AMBU ® (Ambu Man Full Body Adult Manikin-latest version)) and exhaled through the manikin's mouth into its lungs. The instructor observed and noted whether the students' hands were properly placed on the chest of the CPR manikin. Precise measurements such as hand position, depth, rate, breath volume were evaluated based on the indicators on the mannequin. In addition, proper arm position was observed to determine whether the students' body positions were correct and whether the hands, elbows, shoulders and legs were placed correctly.

Figure 1: Correct Body Position and Arm Placement on The Manikin.

Duration of the effective chest compressions applied on the mannequin before the students got tired was recorded. The gauge measured whether the depth of pressure was sufficient, i.e. whether the pressure applied to the chest was effective (target compression depth 5-6 cm). In addition, the effective CPR time (in minutes) and the degree to which rhythmic CPR was performed (for a regular rhythm, the CPR tempo was set at 110 / min) were measured. Data of each student were noted by the instructor.

Numerical data were analysed by Student's t-test, analysis of variance and chi square. P-value <0.05 was accepted statistically. Data were analysed using SPSS version 21 (IBM Corp., Armsonk, NY, USA). Approval was obtained from Izmir University of Economics Ethics Committee for this study. The ethical approval reference number is B.30.2.IEUSB.0.05.05-20-013 04/04/2018.

2. RESULTS

A total of 153 students participated in the study voluntarily. Of this number, 60.1% were female and 39.9% were male. The distribution of students according to their departments was as follows: 20.9% child development programme, 14.4% medical imaging techniques programme, 9.8% elderly care programme, 28.1% paramedic programme, 13.1% occupational health and safety programme, 7.8% physiotherapy programme, and 5.9% medical laboratory techniques programme. The average student age, height and weight were 20.32 + 03 years, 169.20 + 26 cm, and 65.12 + 42 kg, respectively. The average duration of sustained CPR was 2.95 ± 0,86 min. 34.6% of the students effectively performed CPR for <1 min, 43.1% for 2–3 min, 17.0% for 4–6 min, 3.3% for 7–9 min, and 2.0% for ≥10 min.

The average pressure depth ratio was 4.33 cm. Moreover, 28.1% of the students applied pressure <2 cm, 16.3% applied 3–4 cm, 54.9% applied 5–6 cm and 0.7% applied ≥7 cm. The average depth of pressures and effective pressure was 0.6/L, of which 25.5% of the students had

sufficient, 13.7% had less than insufficient and 60.8% had completely insufficient depth of pressures and effective pressure.

In this study, 68.6% of the students were able to maintain heart pressure regularly and 31.4% were not. In addition, 81% of the students placed their hands in the appropriate site on the manikin and 19.0% did not. The arms position was correct in 83% and wrong in 17% of the students. A statistically significant difference was found between the seven groups ($p < 0.005$). Adequate compression rates, blowing capacities and effective CPR times were higher in paramedic students than in other students ($p < 0.005$) (Table 1).

Table 1: Health Programmes Included in This Study

Programs	**Paramedic Prog. (n=43) (%)**	**Child Development Prog. (n=32) (%) (n=…) (%)**	**Business health prog. (n=20) (%)**	**medical Imaging Techniques prog. (n=22) (%)**	**Medical Laboratory Techniques prog. (…=9) (%)**	**Elderly Care Prog. (n=15) (%)**	**Physiotherapy prog. (n=12) (%)**	**Total (n=153) (%)**	**P***
Ventilation Activity?									
Adequate	38(24.8)	0	0	0	1(0.7)	0	0	**39(25.5)**	
Less than adequate	2(1.3)	0	12(7.8)	1(0.7)	4(2.6)	0	2(1.3)	**21(13.7)**	
Completely inadequate	3(2.0)	32(20.9)	8(5.2)	21(13.7)	4(2.6)	15(9.8)	10(6.5)	**93(60.8)**	
Toplam	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**
Cpr Location Suitability?									
Appropriate	43(28.1)	9(5.9)	20(13.1)	16(10.5)	9(5.9)	15(9.8)	12(7.8)	**124(81.0)**	
Inappropriate	0	23(15.0)	0	6(3.9)	0	0	0	**29(19.0)**	
Total	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**
Arm Position Compliance?									
Appropriate	39(25.5)	14(9.2)	18(11.8)	21(13.7)	9(5.9)	15(9.8)	11(7.2)	**127(83.0)**	
Not available	4(2.6)	18(11.8)	2(1.3)	1(0.7)	0	0	1(0.7)	**26(17.0)**	
Total	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**
Chest Compression Depth?									
Less than 2 cm	0	23(15.0)	0	14(9.2)	4(2.6)	2(1.3)	0	**43(28.1)**	
3-4 cm	5(3.3)	7(4.6)	0	1(0.7)	1(0.7)	6(3.9)	5(3.3)	**25(16.3)**	
5-6 cm	37(24.2)	2(1.3)	20(13.1)	7(4.6)	4(2.6)	7(4.6)	7(4.6)	**84(54.9)**	
6 and above	1(0.7)	0	0	0	0	0	0	**1(0.7)**	
Total	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**
Rhythm									
Regular	41(26.8)	**2(1.3)**	**18(11.8)**	**12(7.8)**	**9(5.9)**	15(9.8)	8(5.2)	**105(68.6)**	
Irregular	2(1.3)	**30(19.6)**	**2(1.3)**	**10(6.5)**	**0**	0	4(2.6)	**48(31.4)**	
Total	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**
Chest Compression Time?									
Under 2 min	1 (0.7)	30(19.6)	2(1.3)	7(4.6)	4(2.6)	2(1.3)	7(4.6)	**53(34.6)**	
2-3 minutes	19(12.4)	2(1.3)	12(7.8)	12(7.8)	4(2.6)	12(7.8)	5(3.3)	**66(43.1)**	
4-6 minutes	16(10.5)	0	5(3.3)	3(2.0)	1(0.7)	1(0.7)	0	**26(17.0)**	
7-9 minutes	4(2.6)	0	1(0.7)	0	0	0	0	**5(3.3)**	
10min and more	3(2.0)	0	0	0	0	0	0	**3(2.0)**	
Total	**43(28.1)**	**32(20.9)**	**20(13.1)**	**22(14.4)**	**9(5.9)**	**15(9.8)**	**12(7.8)**	**153(100.0)**	**000**

When evaluated in terms of gender, the CPR sustainability time for the female students was as follows: 48.9% sustained CPR for <2 min, 40,2% for 2–3 min, 9.8% for 4–6 min and 1.1% for 7– 9 min. For male students, 13.1% sustained CPR for <2 min, 47.5% for 2–3 min, 27.9% for 4–6 min, 6.6% for 7–9 min and 4.9% for 10 min ($p < 0.005$).

As regards pressure depth, 43.5% of the female students applied pressure <2 cm, 21.7%, applied 3–4 cm, 33.7% applied 5–6 cm and 1.1% applied ≥7 cm. For male students, 2.0% applied <2 cm, 8.2% applied 3–4 cm and 86.9% applied 5–6 cm ($p < 0.005$).

In terms of depth of pressures and effective pressure, 14.1% of the female students had sufficient, 4.3% had less than sufficient and 81.5% had totally insufficient depth of pressures. For male students, 42.6% had effective and sufficient pressure ($p < 0.005$), 27.9% of the male students had less than sufficient and 29.5% had totally insufficient depth of pressures and effective pressure.

As regards maintenance of heart pressure, 52.2% vs 47.8% of the female students were able to maintain regular and irregular heart pressure, respectively. For male students, 93.4% vs 6.6% were able to maintain cardiac pressure regularly and irregularly, respectively ($p < 0.005$).

With regard to hand placement, 69.6% vs 30.4% of the female students placed their hands in the correct and wrong sites on the manikin, respectively. On the contrary, 98.4% vs 1.6% of the male students placed their hands in the correct and wrong sites on the manikin, respectively, showing significant gender difference between the two groups ($p < 0.005$).

Furthermore, 79.3% vs 20.7% of the female students demonstrated correct and incorrect arms positions, respectively. On the contrary, the arms position was correct in 88.5% and incorrect in 11.5% of the male students. No statistically significant gender difference in arms position was found between the two groups ($p > 0.005$) (Table 2).

3.DISCUSSION

In manual CPR, the paramedics try to maintain circulation by regularly pressing the patient's chest with hands before the defibrillator returns spontaneous circulation to normal. If necessary the process of actively pressing and exhaling should take for at least 30–45 min. In a previous study, Wik et al. revealed that early CPR significantly increases the patient's chance to survive (Wik et al., 2014).

In the present study, students of the paramedic programme showed better manikin CPR performence results than students of the other programmes. When the CPR times of the volunteer students were evaluated, 34.6% were able to perform CPR for <2 min and 43.1% for 2–3 min before stopping out of exhaustion. Of these, only 2.0% performed CPR for ≥10 min. Although the performances of the paramedic students were better than other students, they could not maintain effective CPR for a sufficient time. However, a patient with cardiac arrest may require effective CPR for at least 30–45 min without interruption. Aston et al. noted that at the

end of a 3-min CPR, practitioners show signs of fatigue (Ashton et al., 2002). Inadequately performed CPR is not effective. In the present study, all students showed fatigue during CPR. Therefore, it will be more effective to perform CPR in 2-4 -min cycles.

Table 2: Evaluation of The Research by Gender

Programs	**Women (n=92) (60.1%)**	**Percentage among women**	**Men (n=61)(39.9%)**	**Percentage among men**	**Total**	**p**
Ventilation Activity?						
Adequate	13(8.5)	14.1%	26(17.0)	42.6%	39(25.5)	
Less than adequate	4(2.6)	4.3%	17(11.1)	27.9%	21(13.7)	
Completely inadequate	75(49.0)	81.5%	18(11.8)	29.5%	93(60.8)	
Total	**92(60.1)**	100.0%	**61(39.9)**	100.0%	**153(100.0)**	**000**
Cpr Location Suitability?						
Appropriate	64(41.8)	69.6%	59(39.2)	98.4%	123(81.4)	
Inappropriate	28(18.3)	30.4%	2(1.3)	1.6%	30(19.6)	
Total	**92(60.1)**	100.0%	**61(39.9)**	100.0%	**153(100.0)**	**000**
Arm Position Compliance?						
Appropriate	73(47.7)	79.3%	54(35.3)	88.5%	124(81.0)	
Not available	19(12.4)	20.7%	7(4.6)	11.5%	29(19.0)	
Total	**92(60.1)**	100.0%	**61(39.9)**	100.0%	**153(100.0)**	**102**
Chest Compression Depth?						
Less than 2 cm	40(26.1)	43.5%	3(2.0)	4.9%	43(28.1)	
3-4 cm	20(13.1)	21.7%	5(3.3)	8.2%	25(16.3)	
5-6 cm	31(20.3)	33.7%	53(34.6)	86.9%	84(54.9)	
6 and above	1(0.7)	1.1%	0(0.0)	0(0.0)	1(0.7)	
Total	**92(60.1)**	100.0%	**61(39.9)**	**100.0%**	**153(100.0)**	**000**
Rhythm						
Regular	48(31.4)	52.2%	57(37.3)	93.4%	105(68.6)	
Irregular	44(28.8)	47.8%	4(2.6)	6.6%	48(31.4)	
Total	**92(60.1)**	100.0%	**61(39.9)**	100.0%	**153(100.0)**	**000**
Chest Compression Time?						
Under 2 min	45(29.4)	48.9%	8 (5.2)	13.1%	53(34.6)	
2-3 minutes	37(24.2)	40.2%	29(19.1)	47.5%	66(43.1)	
4-6 minutes	9(5.9)	9.8%	17(11.1)	27.9%	25(17.0)	
7-9 minutes	1(0.7)	1.1%	4(2.6)	6.6%	5(3.3)	
10min and more	0(0.0)	0(0.0)	3(2.0)	4.9%	3(2.0)	
Total	**92(60.1)**	100.0%	**61(39.9)**	100.0%	**153(100.0)**	**000**

In a previous study, Abella et al. reported that 85% of arrest survivors received more than 100 chest compressions per minute (Abella et al., 2005). If unskilled first aiders are left in the field without adequate resources and performed CPR when necessary, effective CPR is impossible. Patients who did not receive effective CPR died or become seriously injured before reaching the hospital. At the same time, if a first aider devotes all of his/her paramedic time to CPR, he has to ask his/her less skilled teammates to perform other tasks. Significantly, Eisenburger et al. reported that such situation increases the chance of performing effective CPR and achieving survival (Eisenburger et al., 2006).

The duration of CPR is an important factor in the prognosis of patients undergoing CPR. If no effective resuscitation effort is performed during the first 15 minutes following cardiac arrest the mortality rate is more than 95% and if it is longer than 30 min, life is impossible (Lyon, 2014).

In the present study, the average pressure depth was 4.33 cm and 28.1% of the students applied pressure <2 cm, 16.3% applied 3–4 cm, 54.9% applied 5–6 cm and 0.7% applied ≥7 cm. Thus, almost half of the students could not achieve sufficient pressure depth.

However, many studies have shown that the survival of arrest patients depend on the quality of CPR. In the study carried out by Stiell et al., survival rates decreased by 30% when rescuers could not achieve sufficient compression (<38 mm) (Stiell et al., 2012).

In the observational studies conducted by Edelson et al. and Vadeboncoeur et al., deeper chest compression and higher defibrillation rate were associated with the return of the patients' spontaneous circulation and they reported that every 5-mm increase in mean pressure depth provided survival rate of >30% (Edelson et al., 2006).

Babbs et al. reported a linear correlation between pressure depth, cardiac output, mean arterial pressure and successful resuscitation in CPR. For example, a 1-cm reduction in compression depth resulted in a 50% reduction in cardiac output in an animal study and a 30% decrease in mean arterial pressure (Babbs et al., 1983, Vadeboncoeur et al., 2014).

In the present study, the average depth of pressures and effective pressure of the students was 600 mL and 25.5% had sufficient, 13.7% had less than sufficient and 60.8% had completely insufficient depth of pressures and effective pressure.

In the study conducted by Liberman et al., 49% of the total ventilation was below the minimum value (800 mL) recommended by the American Heart Association (Liberman et al., 1999, Chung et al., 2012). In the present study, 68.6% vs 31.4% of the students were able to maintain heart pressure regularly and irregularly, respectively. For regular rhythm, 110 compressions per minute were applied. In some studies, authors speculated that using tools such as a metronome will increase the effectiveness of CPR (Gündüz et al., 2019, Cheskes et al., 2011). The importance of early, high-quality chest compressions cannot be overemphasized in CPR to improve outcomes.

Another non-hospital research has shown that pauses in chest compressions reduce the chance of subsequent defibrillation success (Kleinman et al., 2018). Another study has shown that even short pauses in chest compressions negatively affect hemodynamics during resuscitation (Berg et al., 2001). Some studies have even found that performing chest

compressions early and without interruption increases the rate of survival and discharge from the hospital (Nichol et al., 2015, Svensson et al., 2010).

In the present study, 81% of the students placed their hands in the right place on the mannequin. Arm positions were correct in 83% of the students.

In the study conducted by McNally et al., the groups with a high probability of pre-hospital survival were those with ventricular fibrillation or pulse-free ventricular tachycardia and those who received CPR performed by first aiders. In this group, the survival rate at discharge was 30.1% (Girotra et al., 2016). At the same time, chest compression fraction time of at least 60% within the total CPR period increases the chance of survival (Christenson et al., 2009).

Hands often sweat during the resuscitation process. Sweating of the hands causes the hands to slip from the CPR area and the inability to apply to the correct area. In this study, it was observed that some students' hands were sweaty and a rib fracture sounded (due to a feature found in the mannequin, a rib fracture sound is heard when they place their hands in the wrong place) from the mannequin.

Sweaty hands during the resuscitation process can cause rib fractures if they slip from the correct area. CPR is often interrupted by other procedures and provider fatigue (López-González et al., 2015).

Although some studies did not find any difference between genders (Riera et al., 2007), the results of the present study showed that male students were more successful in providing effective CPR than female students and in other parameters except for arms position. Similar to this study, Park et al. found that male rescuers had higher endurance than their female counterparts during CPR (Park et al., 2013, Valenzuela et al., 2005).

In the present study, female students developed fatigue more quickly than male students and they generally did not reach the correct pressure depth. In other studies, male rescuers were able to apply chest compression depth more accurately and effectively than female rescuers (Körber, 2016, Russo et al., 2011).

CONCLUSION

CPR is a very important live-saving method that increases the chances of survival. However, this practice is ineffective unless applied correctly and timely. This study showed that manual chest compression on a manikin became ineffective after a while, revealing a very

important deficiency, since every minute is important in saving human life. Therefore, developing and commissioning the automated chest compression device to perform CPR, especially in pre- hospital setting, ambulance and emergency departments, is important. At the same time, CPR trainers should improve their awareness about various problematic areas mentioned in this study.

The main limitation of this study was that CPR was applied on a manikin, not on a real patient. Another limitation is that the sample was chosen from students. In future studies, it would be more appropriate to conduct such research on volunteer first aid workers, those working in the pre-hospital emergency system and those working in the emergency services of hospitals.

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