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The effects of feedback on the physical education majors' acquisition of cardiopulmonary resuscitation skills

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Abstract

Aim: To examine the effects of knowledge of results on CPR skill acquisition in undergraduate students. **Subjects:** Participants included fifty-one undergraduate physical education majors enrolled in the Healthcare Knowledge and First Aid course**. Method:** After receiving conventional four-hour CPR training, the participants completed a pre-test on CPR skill execution. Based on the pre-test scores, the participants were assigned to the following two groups: experimental (knowledge of results) and control. A week after the pre-test, participants practiced the CPR ventilation and compression skills. During this practice, the participants in the experimental group received feedback related to the results of their CPR skills measured by the Resusci Anne® SkillReporter™ manikin. The participants in the control group did not receive any feedback related to the outcome of their skills through the manikin. **Results:** Results showed that the conventional four-hour CPR training was not sufficient for undergraduate students to acquire the majority of the CPR skills. However, it was observed that receiving knowledge of results in practice significantly improved the experimental group's ventilation and compression skills. **Conclusion:** It seems important that health educators should consider including augmented feedback in the form of knowledge of results into their training programs when teaching CPR skills.

Keywords: Healthcare, first aid, first responder, CPR, feedback, KR

INTRODUCTION

Healthcare Knowledge and First Aid is one of the Turkish Physical Education Teacher Education Program's compulsory courses, and mainly focuses on to equip students with theoretical knowledge and practical application to administer basic and necessary first aid skills (Council of Higher Education-CoHE, 2006). These knowledge and skills are important because it helps to save lives of individuals. However, studies have shown that knowledge and skills acquired in first aid courses have not resulted in successful application of these knowledge and skills in actual emergency situations. In order to improve skill acquisition and retention during training European Resuscitation Council suggests the usage of feedback, especially from devices (Soar et al., 2010).

Feedback is one of the most critical and influential factors that affect motor skill learning and performance, and "task-intrinsic (or sensory)" and "augmented (or extrinsic)" feedbacks are two primary types of feedback (Magill, 2001; Sage, 1984). Task-intrinsic feedback is sensory feedback that is obtainable from sensory systems while performing a skill; but augmented feedback is mainly from a source, such as an instructor, a trainer, or a device, external to the performer (Magill, 2001). There are also different subtypes of augmented feedback, but this study is mainly focused on knowledge of results, in which the performer extrinsically provided by the feedback on the extent to which he/she was achieved the intended outcomes of performing a skill. Task-intrinsic and augmented feedbacks are interconnected; like other types of augmented feedback, knowledge of results facilitates task-intrinsic feedback (Magill, 2001; Sage, 1977; Schmidt, 2005; Shea et al., 1993). While the provision of task intrinsic feedback by various sensory systems during and/or after the movement contributes skill learning alone in some cases; there have been some other occasions where feedback from various external sources is inevitable (Swinnen et al., 1990). In contrast to the general belief, Magill reported that external feedback does not always benefit skill learning (Magill, 1994). He emphasized that augmented feedback has a variety of influences on skill learning depending on the characteristics of the learner, the characteristics of the skill being taught, and the characteristics and the meaningfulness of the augmented feedback that will be provided. He also suggests that when providing augmented feedback one should consider "what information to give, how and how often to give it." Considering that there are many different types of motor skills ranging from simple to complex, it is evident that the field is highly diverse and necessitates scientific understanding of the relationship between motor skill learning and feedback.

Cardiopulmonary Resuscitation (CPR), mostly recognized as complex, is one of those skills that make a difference between life and death (Madden, 2006; Spooner et al., 2007). Although compression only CPR has increasingly gained popularity in recent years, conventional CPR, which is a combination of mouth-to-mouth ventilations and chest compressions, is still one of the most essential lifesaving first aid skills (Ogawa et al., 2011). The quality of these skills, which provide oxygen and circulation to vital organs and the brain, has a critical impact on the survival of cardiac arrest victims. The components of high-quality CPR for adults include chest compressions of adequate rate and depth, allocation to complete chest recoil after each compression, minimization of interruptions during compression, and prevention of excessive ventilation (Travers et al., 2010). CPR is also a highly complicated technique that requires both cognitive and motor capacity and includes nine perceptive and eight physical proficiency capacities (Miyadahira, 2001). Due to the complexity of CPR skills, trainees have difficulty in acquiring those skills even shortly after receiving training (Miyadahira, 2001; Spooner et al., 2007). Despite its proven importance in saving lives when the heart stops its functions, studies have reported deficiencies in CPR skill performance even when performed by well-trained hospital staff (Abella et al., 2005; Losert et al., 2006; Semeraro et al., 2006). For example, Wik et al. (2005) examined the quality of out-of-hospital CPR performance by ambulance personnel and found that most of the time the personnel performed too shallow chest compressions and they did not perform chest compressions half of the time. Similarly, in a study examining the quality and efficiency of bystander CPR, Van Hoeyweghen et al. (1991) reported that bystanders performed CPR correctly half of the time.

The major reasons for a CPR skill deficiency, even among trained people, were reported as complexity and difficulty of CPR skills, poorly designed and inefficient curricula and instructor training to satisfy the needs of the trainees, lack of teaching programs in CPR trainer programs, lack of CPR skill practice time due to the presentation of irrelevant content during training, and poor supervision by trainers (Chamberlain & Hazinski, 2003). Several recommendations related to the structure of training programs have been made in order to solve problems of CPR skill acquisition. As mentioned before, CPR is composed of complex skills, it is very hard for trainers to perceive its effectiveness through direct observation during training, and CPR trainers might have some problems in providing corrective feedback, which is reported as a major element of effective skill learning (Buekers et al., 1992). For this reason, technological devices, which provide high quality and objective data on CPR, are strongly recommended during CPR training by authorities (Chamberlain & Hazinski, 2003; Soar et al., 2010; Spooner et al., 2007). Accordingly, in the recent years, there has been a growing interest in using feedback devices to enhance maximum CPR skill acquisition. Numerous studies have been conducted to determine the effects of different types of feedback devices on various elements of CPR skills and the findings of some of these studies confirmed the effectiveness of feedback on improvement of skills following training (De Regge et al., 2012; Li et al., 2013; Mpotos et al., 2013). However, some other studies reported opposing conclusions. While some studies indicated that these devices were effective, others claimed that the devices were ineffective, not better than training without device and in some occasions had disadvantages. For instance, Zapletal et al. (2014) compared three different CPR feedback devices with no feedback training and found that chest compression quality was not improved by using any of these devices compared to no feedback training; overall performance of participants was below the standard; and all feedback devices caused serious time lost for performers to start CPR (Zapletal et al., 2014). Gruber et al. (2012) also emphasized the complexity and difficulty of CPR procedures and reported that feedback systems increase the level of complexity level and burden. They also reported that, although these devices encourage bystanders to perform CPR and help them feel secure; bystanders still need to be able to perform CPR without using any device. When examining the number of cardiac arrest patients and bystanders in a global context, the probability of using such devices during training or during actual CPR appears to be very low. Presumably, in the case of a cardiac arrest, majority of interfering people will perform CPR without any feedback from any sources. It is still crucial that, during training, the learners should be provided with sufficient information in relation to their performance of the skill being learned. However, provision of such information too often negatively affects learning by preventing learner to use this information as a contributor to sensory information and performing the task independently (Magill, 1994).

Based on the above considerations, the present study aimed to explore the effects of knowledge of results on CPR ventilation and compression skill acquisition among university students. Knowledge of results, as an external source of information for learners, derived from the Resusci Anne® SkillReporter™ manikin in the form of printed feedback about the correctness of ventilations and chest compressions. This information expected to be used by participants to support their sensory information and accordingly improve their CPR performance. Whereas, the participants in the control group received no feedback from the manikin, and they were anticipated to use information that they gathered during training to support their sensory information. For this reason, it was hypothesized female and male students in knowledge of results group would perform better CPR compression and ventilation than female and male students in the control group.

METHODS

Participants

Participants were 51 first-year undergraduate physical education majors (24 female, 27 male) aged 18 to 23 years (M_{female}= 19.33, *SD*= 1.13, M_{male}= 20.52, *SD*= 1.25). The students were enrolled in a "Healthcare Knowledge and First Aid" course during the spring semester of 2012-13 academic years at a School of Physical Education and Sports, in Turkey. Participation was voluntary and informed consent was obtained. Participants were free to withdraw from the study at any time. None of the participants had prior hands-on CPR skill training or experience. Although participants of the study are limited to the students taking the "Healthcare Knowledge and First Aid" course, sample size of 51 is acceptable and sufficient to conduct experiential study and to conduct factorial ANOVA (Cohen, 1988; Fraenkel & Wallen, 2006).

Measures

Participants' CPR skill performance was measured electronically by the ResusciAnne® SkillReporter™ CPR training manikin, which provides a printed outcome report on ventilation (such as average volume of ventilations, the number of correct ventilations, percentage of correct ventilations, the number of too much ventilations with too much inflation, the number ventilations with too little inflation, and the number of too fast ventilations) and compression skills (such as average depth of compressions, the number of correct compressions, percentage of correct compressions, the number of too deep compressions, the number of too shallow compressions, the number of wrong hand positions, the number of too low hand positions, and the number of incomplete releases). Demographic information including participants' age and sex was obtained as well. 2010 ERC guidelines recommend a chest compression depth of at least 5 cm and at a rate of at least 100 per minute. Although no specific target values were given for appropriate ventilation, it was recommended by ERC that the rescuer should administer each breath over about 1 s by providing enough volume (approximately 500-600 ml) to make the chest rise. For effective chest compressions, hands of the rescuer recommended to be located in the center of the casualty’s chest along the breastbone by allowing full chest recoil of the chest compression after each chest compression.

Procedure

To determine the impact of knowledge of results on participants` achievement on CPR ventilation and compression skills, the current study was carried out using a quasi-experimental design consisting of pre-test, post-test and control group. CPR ventilation and compression skills were measured at pre-test and post-test. A quasi-experimental design was utilized since randomization of the participants was not possible. Either a convenience sample of participants in this study was not assigned randomly to the experimental or the control group, rather they were assigned purposively based on their ventilation and compression skill performance at the pre-test and by sex.

First, the participants were given a brief overview of the study. Next, they signed an informed consent form. The conventional four-hour CPR training, which was prepared based on the European Resuscitation Council-ERC Guidelines for Resuscitation, was delivered to the participants (Koster et al., 2010). The training included three phases: an initial face-to-face lecture, a question-answer period, and a practice session. The lecture phase included an explanation about the steps involved in performing adult CPR. At this phase, the participants were provided with an opportunity to reflect on their understanding of the information presented. Afterwards, the question and answer period was conducted. At this phase, the instructor answered the students’ questions and addressed their concerns. In the last phase, the participants were practiced the CPR ventilation and compression skills individually on a manikin. During the practice, the effectiveness of the participants’ performance was observed and assessed by the instructor. The feedback devices were not used; thus, the decisions related to the participants’ performance were made by the instructor who provided the necessary feedbacks. A week after the CPR training, a pre-test including 10 sets of 30:2 CPRs (1 set = 30 chest compressions and 2 ventilations) was conducted. The participants individually performed the CPR skills in an isolated laboratory environment. After the pre-test, the participants were ranged based on their sex and performance of ventilation and compression skills measured by the Resusci Anne® SkillReporter™ manikin at the pre-test. According to their performance scores, the participants were assigned one-by-one into either experimental group (n = 26) or control group (n = 25). This assignment was made to minimize the chance of sampling two groups that are not homogenous. Specifically, it was assumed that the assignment method produced two groups that are homogeneous with respect to achievement and sex. In order to prevent the CPR skill decay and maximize skill development and acquisition, the participants were asked to perform 5 sets of 30:2 CPR a week after the pre-test. After performing the CPR skills, all participants rested for 5 to 7 minutes. During this resting period, the participants in the knowledge of results group (i.e., the experimental group) received feedback in the form of printed CPR ventilation and compression skill performance, whereas the participants in the control group were not provided with any information related to their performance. The feedback related to knowledge of results included various numerical information on the elements of ventilation and compression skills (see the measure section above). Finally, the participants received a post-test containing 10 sets of 30:2 CPR executions that were administered at the pretest. The graphic depiction of the test procedure is shown in Figure 1.

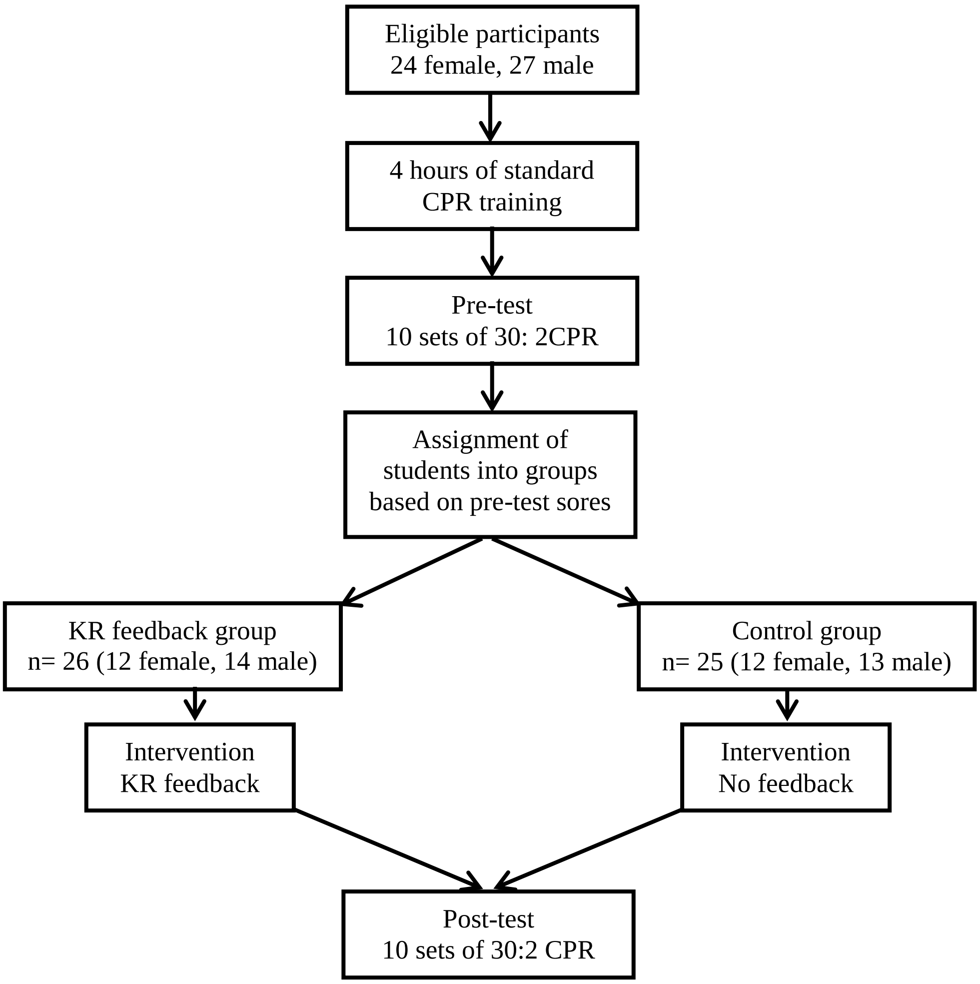

Figure 1. Flow chart of study design

Analysis

To find out the separate effects of test (pre-test, post-test), group (knowledge of results group, control group) and sex (female, male) on CPR ventilation and compression skills a three-way repeated measures ANOVA was used. Simple main effects analysis was used to determine the form of any significant interactions. Effect size for interaction and main effects was determined based on eta squared ($\eta 2$).

RESULTS

A 2 (sex: male and female) x 2 (groups: knowledge of results and control) x 2 (tests: pretest and post-test) analysis of variance (ANOVA) was conducted on participants' performance of ventilation skills. The results of this analysis as well as means and standard deviations are shown in Table 1. Three way interactions between sex, group, and test were not found to be significant, except average number of ventilations per minute [$F(1, 47) = 6.11$, $p = .02$, $\eta^2 = .099$]. There was a significant test and group interaction effect for number of correct ventilations [$F\ (1, 47) = 110.82$, $p = .001$, $\eta^2 = .426$], percent of correct ventilations [$F\ (1, 47) = 69.51$, $p = .001$, $\eta^2 = .384$], number of too much ventilations [$F\ (1, 47) = 10.76$, $p = .002$, $\eta^2 = .123$], and number of too fast ventilations [$F\ (1, 47) = 23.42$, $p = .001$, $\eta^2 = .298$]. Analysis of simple main effects showed that, for participants in the control group above skills were similar from pre-test to post-test. However, participants in the knowledge of results group improved their identified skills after receiving feedback. Additionally, simple main effects analysis showed no significant group difference in terms of ventilation skills was observed during the pre-test, but significant difference was found between the control knowledge of results groups during the post-test. Participants in the knowledge of results group improved significantly compared with participants in the control group. Group factor produced significant main effect on the number of correct ventilations [$F\ (1, 47) = 42.67$, $p = .001$, $\eta^2 = .475$], percentage of correct ventilations [$F\ (1, 47) = 37.97$, $p = .001$, $\eta^2 = .447$], and the number of too fast ventilations [$F\ (1, 47) = 23.21$, $p = .001$, $\eta^2 = .325$] indicating participants in the knowledge of results group performed better in above skills than the participants in the control group. Furthermore, the main effect of test was found to be statistically significant for average ventilation volume [$F\ (1, 47) = 31.22$, $p = .001$, $\eta^2 = .369$], average number of ventilations per minute[$F\ (1, 47) = 8.23$, $p = .006$, $\eta^2 = .134$], minute ventilation volume [$F\ (1, 47) = 7.85$, $p = .007$, $\eta^2 = .135$], total number of ventilations[$F\ (1, 47) = 9.44$, $p = .004$, $\eta^2 = .154$], the number of correct ventilations [$F\ (1, 47) = 97.54$, $p = .001$, $\eta^2 = .375$], percentage of correct ventilations [F (1, 47) = 53.31, p = .001, η^2 = .327], number of too much ventilations [F (1, 47) = 29.39, p = .001, η^2 = .337], and number of too fast ventilations [F (1, 47) = 7.75, p = .008, η^2 = .098] indicating that the groups performed better in ventilation skills in the posttest.

Table 1. Three-way repeated measure ANOVA of ventilation skills

		Control				Experimental			
		Women		Men		Women		Me	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Average volume[a]	Pre-test	805.00	377.30	1062.31	403.65	955.00	272.61	1110.71	372.90
	Post-test	710.00	191.41	767.69	190.49	662.50	50.65	656.43	86.88
Average no. per min.[a, e]	Pre-test	3.42	1.98	4.38	0.96	4.00	0.85	3.43	1.45
	Post-test	4.67	0.89	4.38	0.96	4.17	0.83	4.43	1.02
Minute volume[a]	Pre-test	3,175.00	2,163.45	4,533.85	1,781.18	3,827.50	1319.44	3,975.71	2,414.52
	Post-test	3,295.83	912.80	3,354.62	1,074.75	2,750.00	522.30	2,827.86	611.72
Total number[a]	Pre-test	15.83	7.49	19.46	1.56	18.50	2.58	17.86	4.42
	Post-test	19.75	1.60	19.31	2.18	20.25	0.75	20.57	1.50
Number correct[a, b, d]	Pre-test	3.00	5.19	3.31	4.92	2.33	2.96	3.57	6.01
	Post-test	3.00	4.82	2.46	3.62	17.50	2.28	14.93	2.97
Percent correct[a, b, d]	Pre-test	16.92	27.40	16.85	24.37	13.17	17.24	24.14	37.32
	Post-test	15.17	24.12	13.77	20.01	86.33	11.48	72.64	14.74
Too much[a, d]	Pre-test	8.50	9.02	12.00	8.98	13.08	7.45	12.64	8.07
	Post-test	5.75	8.55	8.77	9.60	0.42	1.44	1.00	2.54
Too little	Pre-test	0.92	1.38	0.54	1.66	1.25	1.82	0.64	1.01
	Post-test	2.75	6.33	1.92	3.66	0.42	0.79	2.29	1.64
Too fast[a, b, d]	Pre-test	0.92	1.38	0.54	1.66	1.25	1.82	0.64	1.01
	Post-test	2.75	6.33	1.92	3.66	0.42	0.79	2.29	1.64

Note:[a]Test main effect,[b]Group main effect,[c]Sex main effect,[d]Test×Group interaction effect,[e]Test×Group×Sex interaction effect

A 2x2x2 ANOVA was also conducted on participants' performance of compression skills (Table 2). The results showed no interaction among sex, group and test, except number of too shallow compressions [F (1, 47) = 7.94, p = .007]. Simple main effects analysis showed that contrary to participants in control group, participants in the knowledge of results group decreased their number of too shallow chest compressions from pre-test to post-test, $p< .05$. The results also showed a significant test and group interaction for the skills of average depth [F (1, 47) = 20.56, p = .001, η^2 = .199], number of correct compressions [F (1, 47) = 181.17, p = .001, η^2= .427], percent of correct compressions [F (1, 47) = 181.26, p = .001, η^2 = 430], number of too shallow compressions [F (1, 47) = 44.82, p = .001, η^2= .295], number of wrong hand positions [F (1, 47) = 35.70, p = .001, η^2= .348], and number of too low hand positions [F (1, 47) = 6.13, p = .017, η^2 = .113]. Simple main effects analysis demonstrated that contrary to participants in control group, participants in the knowledge of results group improved these CPR compression skills from the pre-test to the post-test. Also, analysis showed no difference between the knowledge of results group and the control group in terms of compression skills in the pre-test; but showed significant difference in the post-test, indicating that participants in the knowledge of results group improved their skill performance due to feedback session during the post-test. The results also showed significant sex effects for average depth [F (1, 47) = 13.90, p = .001, η^2 = .164], number of too shallow compressions [F (1, 47) = 15.53, p = .001, η^2= .172], and number of incomplete releases [F (1, 47) = 7.74, p = .008, η^2 = .135] indicating that female participants performed the above skills differently compared with males. The results showed a significant group effect for average depth [F (1, 47) = 23.42, p = .001, η^2= .277], number of correct compressions [F (1, 47) = 46.26, p = .001, η^2 = .482], percent of correct compressions [F (1, 47) = 46.71, p = .001, η^2 = .486], and number of too shallow compressions [F (1, 47) = 27.95, p = .001, η^2 = .309], indicating an improvement in the knowledge of results group. The results showed significant test effects for average depth [F (1, 47) = 33.48, p = .001, η^2 = .324], number of correct compressions[F (1, 47) = 195.89, p = .001, η^2 = .461], percentage of correct compressions [F (1, 47) = 191.98, p = .001, η^2= .456], number of too shallow compressions [F (1, 47) = 52.12, p = .001, η^2 = .343], and number of wrong hand positions [F (1, 47) = 18.68, p = .001, η^2 = .182] indicating that groups did change in skills over time.

Table 2. Three-way repeated measure ANOVA of compression skills

		Control				Experimental			
		Women		Men		Women		Men	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Average depth[a, b, c, d]	Pre-test	35.92	7.73	41.92	8.95	37.67	6.54	45.50	8.71
	Post-test	36.25	6.81	44.69	11.59	52.75	2.53	56.00	2.22
Average no. per min.	Pre-test	82.25	32.61	76.31	12.95	73.58	10.38	66.93	14.78
	Post-test	76.83	9.02	77.54	11.32	71.50	11.07	73.21	12.27
Average compression rate	Pre-test	120.17	20.08	126.31	23.99	123.58	17.91	118.93	19.95
	Post-test	119.17	16.29	121.38	18.56	126.42	18.95	131.14	20.05
Total number	Pre-test	279.25	87.48	303.00	8.26	310.83	13.22	306.71	20.66
	Post-test	304.58	9.29	303.46	14.81	304.92	12.67	311.71	21.15
Number correct[a, b, d]	Pre-test	10.58	35.12	33.31	66.42	0.92	1.78	26.07	62.53
	Post-test	9.25	18.52	43.15	102.92	225.92	51.98	237.07	60.25
Percent correct[a, b, d]	Pre-test	3.42	11.52	10.77	21.91	0.17	0.39	8.36	20.64
	Post-test	2.83	6.13	13.38	31.88	74.00	18.08	76.29	20.38
Too deep	Pre-test								
	Post-test								
Too shallow[a, b, c, d, e]	Pre-test	260.33	103.20	225.38	95.96	299.58	20.30	178.43	132.56
	Post-test	294.58	23.26	175.38	142.75	48.00	45.66	11.93	9.17
Wrong hand position[a, d]	Pre-test	103.67	107.01	112.92	95.54	197.17	98.34	166.43	106.49
	Post-test	117.58	89.92	143.15	110.99	41.75	35.20	46.71	45.84
Hand position too low[d]	Pre-test	0.08	0.29	15.92	34.57	21.83	73.45	38.50	76.49
	Post-test	10.33	24.23	34.31	77.29	0.00	0.00	4.00	7.49
Incomplete release[c]	Pre-test	0.00	0.00	21.15	52.16	0.08	0.29	41.86	88.87
	Post-test	0.00	0.00	6.38	16.48	0.50	1.73	24.29	53.07

Note: [a]Test main effect, [b]Group main effect, [c]Sex main effect, [d]Test×Group interaction effect, [e]Test ×Group×Sex interaction effect

DISCUSSION

The present study examined the effects of knowledge of results on skill acquisition in two critical elements of CPR: ventilations and compressions. Participants in the knowledge of results group were provided with numerical information relating to their performance on 10 sets of 30:2 CPR. The effectiveness of knowledge of results was determined by comparing the knowledge of results group with the control group, which did not receive any feedback at the intervention on their ventilation and compression performance. Two important findings of this study were that most of the participants lacked ability to apply high quality ventilation and compression skills following the conventional CPR training; and knowledge of results improved ventilation (number of correct ventilations, percentage of correct ventilations, number of too much ventilations, and number of too fast ventilations) and compression (average depth, number of correct compressions, percent of correct compressions, number of too shallow compressions, number of wrong hand positions, number of too low hand positions) skills of university level students.

One of the two major findings of this study was that after completing the conventional CPR training, the pre-test average ventilation and compression performance scores of all participants was not very encouraging and in line with the existing body of evidence, which resulted in poor CPR quality after training (Bohn & Gude, 2008; Chamberlain et al., 2002; Perkins et al., 2008; Sutton et al., 2012). Similar to the current study's findings, previous studies have demonstrated that CPR performance was low after initial training (Abella et al., 2005; Eisenburger & Safar, 1999; Jabbour et al.,1996; Parnell & Larsen, 2007; Roh & Issenberg, 2014; Wik et al., 2005). For example, Abella, et al. (2005) demonstrated that the CPR quality did not meet recommended guidelines after training even by well-trained hospital staff (Abella et al., 2005). Furthermore, the pre-test results of the current study are in agreement with the results of Brennan and Braslow (1995, 1998) which aimed to investigate the effectiveness of CPR performance in training classes (Brennan & Braslow, 1995, 1998). Specifically, Brennan and Braslow found that less than 17% of the compressions and 27% of the ventilations were performed correctly by trainees following these CPR training classes. In the current study, participants both in knowledge of results and control group performed around 24% of total ventilation skills and 11% of total chest compression skills correctly a week after the training.

Failure to acquire the CPR skills after training can stem from many causes, such as learner with incompatible characteristics (age, physical strength, etc.), inappropriate training, or ineffective instructor, but feedback is one of the most important factors for all aspects of motor skill learning including CPR (Brennan, 1991; Brennan & Braslow, 1995; Sage, 1984; Shea et al., 1993). Considering the importance of feedback for acquisition of the CPR skills, the pre-test results can be interpreted as an absence or deficiency of sensory information (or task intrinsic feedback) for participants to determine the appropriateness of their actions. In the current study, CPR training sessions, even though offered without using any feedback devices, provided participants with a plenty of CPR related information, expected to enhance sensory feedback during post-test and improve CPR performance. However, according to the results obtained, all participants performed at lower proficiency levels. Schmidt and Lee indicated that during motor actions different sensory mechanisms provide performers with information regarding their movement (Schmidt & Lee, 2011). The performer receives intrinsic feedback from his/her muscles and joints during or after motor skill execution. Also the performer may feel, see or hear whether the movement was successful or not; and by using these sensory information he/she make necessary changes in the next attempt (Kerr, 1982; Sage, 1984). However, not all motor skills provide sufficient sensory information. Findings from this study highlight that, task intrinsic feedback during execution of CPR ventilation and compression skills are not easy to interpret. It is very hard for performers to feel or know if they are pushing down hard and fast enough during chest compressions, and or if they are exhaling enough air into victim's lungs. By using sensory feedback, a performer can reach a certain level of achievement, but attaining the highest levels of performance requires external sources of information. The knowledge of results provides learners with information about their success of skill performance or performance errors they made (Magill, 2001). Especially for complex skills, like CPR, augmented feedback is critical for skill learning, otherwise learners are likely to continue practicing same errors throughout training sessions if feedback is not provided (Magill, 2001). The findings of this study suggest that knowledge of results, as another source of information, is necessary and effective to support task-intrinsic feedback and improve CPR performance.

Another important finding of this study was that knowledge of results, provided by the Resusci Anne® SkillReporter™ manikin, has the potential to improve performance of previously mentioned CPR ventilation and compression skills. This finding is consistent with those of other studies and suggests that the providing knowledge of results to the learners related to their performance is one of the most critical factors for CPR skill acquisition. After observing trainers` ignorance of ventilation and compression skill deficiencies most of the time and not offering any correction or feedback for these deficiencies during CPR training classes, Brennan and Braslow (1995, 1998) recommended that using equipment, such as manikins, sound devices, lights, provides better feedback on students' performance. There are also similarities between the positive effects of knowledge of results on CPR performance found in this study and those conducted by Spooner, et al., in which they found that students who acquired objective feedback from the manikin improved their CPR skills compared with students who received no feedback from the manikin; and Platt, who supported an effectiveness of computer auditory and computer visual feedback, rather than instructor-driven feedback, on CPR skill acquisition (Platt, 2008; Spooner et al., 2007). The systematic review of the effectiveness of CPR feedback/prompt devices in CPR skill acquisition by Yeung et al. (2009) also showed that use of feedback/prompt devices have positive effect on CPR skill acquisition and retention. The use of devices that provide immediate feedback to maintain skill acquisition during CPR training was also recommended in 2010 Resuscitation Guidelines by European Resuscitation Council (Nolan et al., 2010; Soar et al., 2010).

Additionally, the results of this study indicated that both female and male participants were unable to perform recommended chest compressions with sufficient depth (at least 5 cm). However, chest compression depth was significantly lower and chest compressions were shallow in female participants than in males. The relationship between CPR quality and sex of the performer has been investigated by several researchers (Greenstein et al., 2011; Reddy et al., 2011); and consistent with the current study findings, the outcomes of these studies demonstrated that, contrary to males, females` CPR performance, especially of chest compressions, were ineffective (Greenstein et al., 2011; Peberdy et al., 2009; Sayee & McCluskey, 2012).

Cardiac arrest is common cause of death in the world; and the effectiveness and quality of CPR are important for the survival of the cardiac arrest patient. Individuals that respond to emergencies should be competent for maximally effective CPR. Several studies have been conducted to discover better ways to enable people to acquire and apply CPR knowledge and skills when needed. In line with the literature, the findings of the current study acknowledged that knowledge of results, gathered from the Resusci Anne® SkillReporter™, related to improved participants' performance of CPR ventilation and compression skills significantly. The findings also revealed that manikin is effective to provide feedback and improve ventilation and compression skills, and thus can be used in CPR training programs efficiently. In addition, study findings can be generalized and/or transferred to many other settings such as teaching sport skills, teaching driving different vehicles, or machines. Knowledge of results can be used effectively to enhance complex skills acquisition.

The findings of this study need to be interpreted in the context of two important limitations. First, the sample of the study was 1st year undergraduate university students majoring in physical education teaching program. Generalizability of the findings to the broader population of adults may not be evident. Second, the group assignment method that was used to create two homogenous groups (based on the pre-test scores) has some shortcomings. This purposive sampling method was actually preferred to construct identical groups in terms of sex and ventilation and compression skills (Fraenkel et al., 2012).

CPR is considered aerobic and intense exercise (Badaki-Makun et al., 2013; Van Hoeyweghen et al., 1991) and studies suggest that aerobic training or physical fitness activities may be beneficial in improving high quality CPR (Baubin et al., 1996; Lucia et al., 1999; Ock et al, 2011; Van Hoeyweghen et al., 1991). Although the current study did not ask specifically about participants' sport experiences, all students were required to pass the physical ability test to meet one of the requirements of PETE program. The students were also involved in wide range of sport activities in sport clubs and in PETE program. Accordingly, study participants' fitness level might be higher than sedentary individuals might and had an impact on ventilation and compression performance during pre-test and post-test. Thus, when interpreting results these issues should be considered.

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