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The Effects of Visual Feedback on CPR Skill Retention in Graduate Student Athletic Trainers

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Context: Studies examining the effectiveness of cardiopulmonary resuscitation (CPR) chest compressions have found compression depth and rate to be less than optimal and recoil to full release to be incomplete. **Objective**: To determine if visual feedback affects the rate and depth of chest compressions and chest recoil values during CPR training of athletic trainers and to determine retention of proficiency over time. **Design**: Pre-test, post-test. Setting: Medical simulation laboratory. **Participants**: Eleven females and one male (23.08+/-.51 years old), from a Post-Professional Athletic Training Program. All participants were Certified Athletic Trainers (1.12+/-.46 years of experience) and certified in CPR for the Professional Rescuer. Interventions: Participants completed a pre-test, practice sessions, and a post-test on a SimMan® (Laerdal Medical) manikin with visual feedback of skills in real time. After the pre-test, participants received feedback by the investigators. Participants completed practice sessions as needed (range=1-4 sessions), until they reached 100% skill proficiency. After achieving proficiency, participants returned 8 weeks later to perform the CPR skills. Main Outcome Measures: The average of all compression outcome measures (rate, depth, recoil) was captured every 10 seconds (6x per min). All participants performed 5 cycles of 30 compressions. A two-tailed paired samples t-test (pre to post) was used to compare rate of chest compressions, depth of chest compressions, and recoil of the chest. Significance was set a priori at $p < .05$ **Results**: There was a significant difference between pre and post-test compression depth average, p=.002. The pre-depth average was 41mm + 9.83mm compared to the post-depth average of 52.26mm + 5mm. There were no significant differences between pre and post-test chest compression rates and recoil. **Conclusions**: The use of a simulated manikin with visual feedback facilitated participants to reach the recommended compression depth.

Key words: *proficiency, compressions, simulation*

Introduction

Cardiopulmonary resuscitation (CPR) is a lifesaving skill involving a combination of chest compressions and rescue breaths used to keep oxygen-filled blood circulating throughout the body in an effort to keep the body cells perused until advanced medical care is available.[1, 2] The American Red Cross and the 2010 Consensus on Science and Treatment Recommendations (CoSTR)[3] recommends the delivering of high-quality chest compressions to a depth of at least 2 inches (50 mm) at a rate of at least 100 compressions per minute with full chest recoil (0 mm) after each compression while minimizing interruptions in chest compressions. However, the recommended guidelines for completing quality CPR can be difficult to achieve. [4-6] Many studies have found chest compression depth and rate to be inadequate, even in professional health care providers.[4, 7-10] Abella et al.[4] found that compression depth was at least 12mm less than the 2010 CoSTR recommendations[3] in 37.4% of in-hospital cardiac arrest cases, and rates were significantly below recommended standards. Studies have also shown that in-hospital caregivers commonly failed to provide full recoil, or return to neutral chest position, as recommended.[11,12] Problems with performing adequate technique are also documented with out-of-hospital professional caregivers, such as emergency medical technicians.[10] Currently there is a lack of studies investigating the quality of CPR performance of athletic trainers. Since patient survival from cardiac arrest has been strongly linked to the quality of the CPR administered, [8,13] improving CPR technique acquisition is of concern to athletic trainers and other emergency care providers to benefit patient outcomes.

The use of audiovisual feedback during CPR training has been shown to improve performance of CPR skills.[5,14,15] Oermann et al.[16] contend that practice of CPR skills with specific and informative feedback allows laypersons to perfect their skills by correcting errors and gradually increasing their proficiency. Krasteva, et al. [14] found that when laypersons received audiovisual feedback, correct rate improved significantly over a control group. Yet, there is currently a lack of evidence to determine if this feedback improves retention of CPR skills. It is well documented that CPR skills can diminish relatively soon after training, [14,17-21]however the retention of skills when visual feedback is used in CPR training has not been well investigated. Therefore, the purpose of our study was to determine if visual feedback affects the rate and depth of chest compressions and chest recoil during CPR training of athletic trainers and to determine retention of proficiency over time.

Methods

Design. We conducted a pre-test/post-test pre-experimental design to investigate the impact of visual feedback during practice sessions in skill retention of CPR compressions. Participants underwent a pre-test followed by practice sessions on a SimMan 3G manikin utilizing visual feedback until they reached 100% proficiency in rate, depth, and recoil of chest compressions based upon CoSTR recommendations. A post-test was conducted on participants eight weeks after obtaining CPR proficiency.

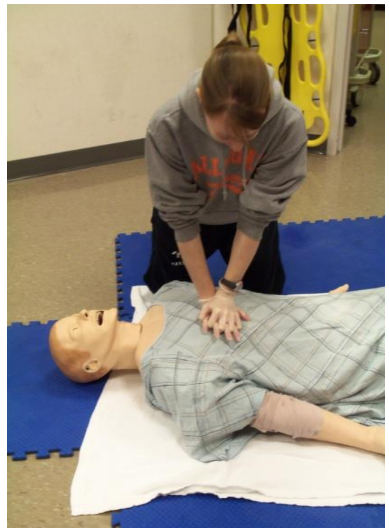
Participants. Eleven females and one male, with an average age of 23.08 ± .51 years, were recruited from a Post-Professional athletic training graduate program in the Midwest. All participants were certified athletic trainers with 1.12 ± .46 years of experience and were certified in CPR for the Professional Rescuer through the American Red Cross. All who responded signed an informed consent approved by the institution's Human Subjects Institutional Review Board.

Instrumentation. The instrument used in the study was the SimMan 3G (Laerdal Medical, Stavanger, Norway) manikin equipped with the Instructor Application 2.3 ver_020301 (Laerdal Medical) computer software to record participant data. This system includes a visual feedback system that shows performance of chest compressions in real time (depth, rate of compressions, and recoil) on a computer screen (See Figure 1).

Figure 1: The left side indicates complete recoil. The bottom light indicates the subject has compressed the manikin to a depth of at least 50mm. The right top meter indicates a correct compression rate when the needle is within the green highlighted section.

Procedures. For the pre-test, the SimMan manikin was placed supine on the ground with the participant kneeling adjacent to the manikin (Figure 2). The screen that offered visual feedback of skills in real time was not visible to the participants during the pre-test. As participants performed chest compressions, the computer system recorded rate (measured in compressions per minute or

Figure 2: Subject performing compressions on SimMan.



cpm), depth (measured in millimeters), and recoil (measured in percent returned to normal state). The data recording software recorded the average of each individual skill (rate, depth, and recoil) during 10-second increments (6x per minute). Participants performed 5 cycles of 30 compressions. Between each compression cycle, participants would pause while 2 breaths were given to the manikin via bag valve mask by a member of the research team.

After the pre-test data was collected, the participants were shown their results of rate, depth and recoil from the computerized software and given feedback by the researchers on correcting their skills for the practice sessions. The feedback included suggestions relating to the rate (more or fewer compressions per minute), the depth (deeper or more shallow), and if they performed complete recoil between compressions based upon the results of the pre-test.

After receiving input on their pre-test performance, participants completed practice sessions with the visual feedback system, showing rate, depth and recoil while performing chest compressions. Participants were then required to complete as many practice sessions as necessary until they reached 100% proficiency (range 1-4 sessions). To achieve 100% proficiency, the average depth of all chest compressions reached a minimum of 50mm, an average rate of 100 cpm, and percentage of return from a 50mm compression depth to the normal state of 0mm compression, or full recoil. During practice sessions, participants completed 5 CPR cycles, following the same criteria for the pre-test. Once participants attained proficiency, they were scheduled to return to the lab in 8 weeks to complete a post-test skill assessment. Participants were asked not to practice CPR skills during those 8 weeks unless needed in an emergency situation.

For the post-test, participants were required to perform the same 5 cycles of 30 chest compressions as the pre-test with the visual feedback screen removed from the subject's view. Data from each skill (rate, depth, and recoil) was recorded and averaged in the same manner as the pre-test.

Statistical Analysis. The data was analyzed with SPSS (version 20, Chicago, Illinois). A two-tailed paired samples t-test (pre to post) was used to compare rate of chest compressions, depth of chest compressions, and percent recoil of the chest. The significance level was set *a priori* at .05 for all analyses.

Results

Scores for pre and post-tests for rates, depth and recoil are found in table 1. A two-tailed paired samples t-test revealed that there was a significant difference between pre and post- compression depth average, $t(11) = -3.9$, $p=.002$. The pre-depth average of the participants was 41mm ± 9.83mm and their post-depth average was 52.26mm ± 5mm. There were no significant differences between pre and post-test chest compression rates and percent recoil.

Table 1. Pre and Post-Tests for Rate, Depth, and Recoil of Chest Compressions (Mean±SD)

	Pre-Test	Post-Test	*P*	95% CI Lower	95% CI Higher
Rate (cpm)	115.917 ± 16.07	119.913 ± 3.44	0.380	-13.62	5.62
Depth (mm)	41.000 ± 9.82	52.262 ± 5.05	0.002[a]	-17.51	-5.02
Recoil (%)	97.167 ± 8.59	99.315 ± 1.85	0.427	-7.88	3.59

[a] Indicates difference between Pre and Post-Tests

Discussion

In our study, the use of the visual feedback system during practice sessions allowed participants to make adjustments to compressions in real time to improve technique. However, the hypothesis that visual feedback would positively affect the depth and rate of chest compressions and chest recoil values over a two month period during CPR of athletic trainers was not fully supported by the results.

Depth of Compressions. Studies have also found chest compression depth to be inadequate.[4,7,9,23,24] Abella, et al.[4] found that compression depth was at least 12mm less than the 2010 CoSTR recommendation[3] of 50 mm in 37.4% of in-hospital cardiac arrest cases. Sutton et al.[9] reported similar findings in that compression depth was too shallow in 27.2% of the nearly 1000 compressions recorded. Focusing on the first five minutes of chest compressions revealed that 36.1% of the 144 30-second segments of active chest compressions were either too deep or too shallow. In a study by Wik et al.[24], only 28% of compressions performed by ambulance personnel during the entire CPR episode were between 38 and 51mm in depth with complete release. Niles et al.[7] compared relative and actual chest compression depths during cardiac arrest in children, adolescents, and young adults and found that chest compressions performed during in-hospital cardiac arrests were frequently below pediatric and adult target guidelines.

In our study, depth of compressions was the only skill that showed significant improvements. These results also can be supported by Creutzfeldt et al.[22] who found that participants who underwent CPR training in a virtual setting had more correct chest compressions compared to participants who underwent CPR training in a lecture format only. The recommended guidelines for completing quality CPR can be difficult to achieve, however. Our study showed the pre-test depth of compressions was below the recommended 50mm,[3] however after 8 weeks there was a 27.5% increase in depth of compressions..

Compression Rate. Abella, et al.[4] found that during in-hospital cardiac arrest, chest compression rates were too slow (<90 cpm) in 28.1% of cases. Patients who were given chest compressions at 90% of the recommended rate of 100 cpm had a higher survival rate versus those who were given compressions at a rate of 79%. Abella et al. also examined data from 813 minutes of in-hospital cardiac arrest and found chest compression rates were too slow (<80 cpm) in 36.9% of cases and less than 70 cpm in 21.7% of cases. In an additional study, Abella et al [13] found that higher chest compression rates had a direct impact on the successful resuscitation of patients in cardiac arrest (90±17 cpm) over failed resuscitation efforts (79±18 cpm). These findings also support the most recent CoSTR guidelines of optimal compression rates of 100-120 cpm.[8]

Participants in our study did similarly well on both pre and post-tests on compression rate. During the pre-test, 10 out of 12 participants reached the required 100 compressions per minute and all of the participants reached proficiency in compression rate in the post-test. The high proficiency in compression rate during the pre-test lessened the likelihood of improvements from the visual training.

Recoil. Complete recoil of the chest is considered vital for optimal cardiac re-filling between compressions as well as its effect on the hemodynamics of CPR.[2,25] Incomplete decompression obstructs venous return, which in turn decreases the thoracic and cardiac pump preload.[25] However, there is limited research regarding recoil and its effect on patient survival.[26] No human studies specifically evaluate restoration of spontaneous circulation or survival to hospital discharge and chest wall recoil during CPR.[25] Chest recoil can be increased significantly with simple techniques; for example, lifting the heel of the hand slightly but completely off the chest during CPR improved chest recoil in a manikin model.[25] A pre-hospital case series found that the "hands-off" technique achieved the highest rate of complete chest wall recoil when compared to the standard hand position (95.0% versus 16.3%) and was 129 times more likely to provide complete chest wall recoil by professional rescuers using the CPR technique recommended in 2000.[10] Similarly, a randomized prospective trial was performed on an electronic test manikin found a "hands-off" technique achieved the highest rate of complete chest wall recoil when compared to the standard hand position (92.5% versus 24.1%) and was 46.3 times more likely to provide complete chest wall recoil by trained laypersons performing CPR.[27]

While there were no significant changes in compression recoil from pre to post-test in our study, the recoil values post-test were still lower than recommended guidelines. Our results showed 9 out of 12 (75%) participants met the minimum requirements of 100% recoil at post-test, which was the same value as their pre-test values. These results conflict with Krasteva et al.[14] that found compression recoils improved significantly using a cardio compression control device. Fried et al.[12] found that 91% of in-hospital cardiac arrest resuscitations had some degree of learning (failure to completely recoil) and that as rate of compressions increased, proficiency of recoil decreased. As such, more investigations are needed to determine recoil proficiency with CPR training.

Skill Retention. As with any skill, lack of practice of the skill leads to decay over time. Anderson et al. [19] found that physical skills deteriorated over time, anywhere between less than 1 month to over 3 years. Additionally, McKenna and Glendon[20] showed a 50% decline in skills over a 2-month period. In a study by Broomfield,[21] a "refresher" course showed initial improvement in CPR skills yet 10 weeks later skills had again deteriorated. While our study had 8 weeks between proficiency and post testing, it appears that the shorter the duration between skill assessment, the better the scores.[18-20] Based on this evidence, a longer time period between obtaining proficiency and post testing needs to be examined to ascertain at what time period skills diminish.

Despite the challenges to correct CPR performance in the literature, there have been some promising effects on CPR skill performance and retention with skill practice and feedback. Oermann et al.[16] contend that practice of CPR skills with specific and informative feedback allows laypersons to perfect their skills by correcting errors and gradually increasing their proficiency. Krasteva et al. [14] found that when laypersons received audiovisual feedback from a cardio compression control device during CPR performance rather than a short debriefing of basic life support protocol before CPR, correct rate improved significantly. Skorning et al. [15] found 94.6% of participants met the required criteria for compression rate using a stand-alone visual feedback device whereas only 62.4% of participants performed the compression rate correctly without the device. The positive results found in the literature and results from our study using visual feedback should encourage clinicians in determining best practices in the use of devices to improve quality of CPR in their educational or clinical settings.

Limitations

The computer software that was used to record the data may have affected our outcomes. Each 10 second increment was an average of all compressions performed within that timeframe used to calculate proficiency. Ideally, the recorded data for each individual should be based upon second increments, which may lead to differences in the variables studied. Also, the study utilized a pre-test/post-test design instead of a control group, which may have influenced the outcomes.

Clinical Implications and Conclusions

The Board of Certification requires certified athletic trainers to maintain certification in Emergency Cardiac Care;[28] however, proficiency in CPR rates, depths, and recoil skills is only demonstrated during the biannual recertification process. The findings of the current study support the use of visual feedback during CPR training to address deficiencies in effectiveness of compressions. Since many emergent skills, such as CPR, are not called upon on a daily basis, athletic trainers should consider the potential benefits of utilizing visual feedback systems on a consistent basis in order to make sure CPR rate, depth, and recoil of chest compressions meet current emergency cardiac care guidelines.

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