ELECTROCARDIOGRAPHIC FINDINGS DURING STANDARD HANDS ONLY CPR AND HANDS ONLY CPR PLUS PEDAL CPR IN SENIOR RESCUERS

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ABSTRACT

Electrocardiographic Findings During Standard Hands Only CPR and Hands Only CPR Plus Pedal CPR in Senior Rescuers

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The standard first aid for a heart attack resulting in cardiopulmonary arrest is effective cardiopulmonary resuscitation (CPR). Chest compressions are most commonly performed on a flat surface with the rescuer kneeling next to the victim with one hand on top of the other on the sternum and elbows straight. This technique of being on the ground may be challenging for those without the mobility and strength to get up and down from the ground. In 2005, the American Heart Association (AHA) Guidelines listed "pedal", or heel, compression as an acceptable alternative to standard chest compressions (Trenkamp & Perez, 2015). That same year, the recommended depth of a compression increased from 3.8 cm to 5.0 cm (Trenkamp & Perez, 2015). To attain such a depth, extra force and strength are required. The heel method may be especially reasonable for those rescuers who cannot attain the floor and those who do not have the cardiovascular or muscular strength to perform traditional chest compressions.

The purpose of this study was to evaluate the effects of performance of hands only (HO) versus the combination (CO) of hands only plus pedal CPR on the electrocardiogram, including heart rate and heart rhythm.

The subjects utilized in this investigation were six men and nine women between 56 and 71 years of age from San Luis Obispo County in California. Subjects underwent two trials with at least a 15 hour rest period in between but no more than one week.

Subjects were randomly assigned to either the Combination (CO) trial or the Hands Only (HO) trial. When they came back for their second trial, they did the trial that they did not do the first time.

On average, participants were able to sustain the combination of HO plus pedal CPR longer (9.47 minutes) than they were able to perform standard HO CPR (9.02 minutes) but this difference was not statistically significant ($p=0.16$). Mean maximum heart rate was 133 ± 23.7 bpm during the CO trial and 125.4 ± 21.9 bpm during the HO trial ($p=0.12$). Mean percentage of the HR reserve was 75.1% during the CO trial and 61.1% during the HO trial ($p=0.09$). Mean RPE was not significantly different between CO and HO trials ($p=0.2124$), nor between genders ($p=0.42090$). However, for both trials combined the mean RPE was significantly greater at 5 minutes of CPR (4.45 ± 0.53) than at 2 minutes of CPR (3.38 ± 0.31), ($p<0.0001$), and significantly greater at the end of the CPR trial (5.7 ± 0.32) than at minute 5 ($p<0.0001$). There were more ectopic beats observed during the HO trial (n=192) than during the CO trial (n=133). There was a strong, positive correlation between the percentage of ectopic beats each subject had between trials, which indicated a consistent amount of ectopy from trial to trial ($r=0.65$). There were also moderately positive correlations between CPR endurance times and grip strength of the left and right hand with Pearson Correlation values of $r=0.26$ and $r=0.34$, respectively.

It may take time for individuals to accept pedal CPR as a viable resuscitation method. With the majority of sudden cardiac arrests occurring in the home among older adults in society, it is important to recognize that pedal CPR is an acceptable method and

that a rescuer may have this choice if they either need a break from standard CPR or if they can not attain the ground.

Keywords: Pedal Chest Compressions, Cardiocerebral Resuscitation, Older Adults, Electrocardiography, Cardiac Ectopy

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Introduction

1.1 Background of the Study

There are about 790,000 heart attacks that occur each year, in the United States (Benjamin et al., 2017). The standard first aid for a heart attack resulting in cardiopulmonary arrest is effective cardiopulmonary resuscitation (CPR).

If those present at the scene of an acute coronary syndrome are able to effectively provide CPR and first aid, the chances of survival of those affected increases significantly (Trenkamp & Perez, 2015). Providing quality chest compressions during CPR is crucial to maintain "an adequate perfusion of oxygenated blood to the organs of the body necessary to sustain life" (Cassidy, 2014, p. iv). Chest compressions are most commonly performed on a flat surface with the rescuer kneeling next to the victim and with one hand on top of the other on the victim's sternum and elbows straight. This technique of being on the ground may be challenging for those without the mobility and strength to get up and down from the ground. Additionally, with the out-of-hospital cardiac arrest incidence being 350,000 per year, alternate modes of effective CPR are vital (AHA, 2018).

In 2005, the American Heart Association (AHA) Guidelines listed "pedal", or heel, compression as an acceptable alternative to CPR (Trenkamp & Perez, 2015). That same year, the recommended depth of compressions increased from 3.8 cm to 5.0 cm (Trenkamp & Perez, 2015). To attain such a depth, extra force and strength are required. The heel method may be especially reasonable for those rescuers who cannot attain the floor and those who do not have adequate cardiovascular or muscular strength.

Trenkamp and Perez (2015) conducted a study to compare the effectiveness of chest compression type: "pedal" or "hands only" (HO). It was found that "pedal" chest compressions benefitted most bystanders; this was done by evaluating the amount of time a bystander was able to do pedal or HO, standard chest compressions. It was reported that only 16% of subjects were able to sustain HO chest compressions for ten minutes. However, 65% of subjects were able to sustain "pedal" chest compressions for the ten minutes (Trenkamp & Perez, 2015). With most cardiac arrests occurring outside of the hospital, it is important that bystanders have the knowledge and ability to perform effective CPR until emergency rescue service providers can be summoned, arrive on scene, and begin compressions.

1.2 Significance of the Study

Each year in the U.S., there are about 790,000 heart attacks and approximately 356,500 of them are out-of-hospital cardiac arrests (OHCA) (Benjamin et al., 2017). In 2015, survival to hospital discharge after EMS-treated OHCA at U.S. Resuscitation Outcomes Consortium sites was only 11.4% (Benjamin et al., 2017, p. e470).

1.3 Statement of the Problem

In theory, survival from out-of-hospital cardiac arrest could be improved if bystander CPR was more effective in sustaining circulation until professional Emergency Medical Services (EMS) providers begin treatment of cardiac arrest. "Pedal" CPR is, to this day, not a popular nor widely known form of CPR (Trenkamp & Perez, 2015). Research is very limited in this area. Thus, the significance of this study is to present this alternate form of CPR and test its effectiveness, particularly in the elderly population.

To date, the effects of HO versus pedal CPR on rescuers' heart rate and the electrocardiogram have not been described.

1.4 Statement of the Purpose

The purpose of this study was to evaluate the effects of performance of hands only (HO) versus the combination of HO plus pedal CPR (CO) on the electrocardiogram, including heart rate and heart rhythm.

1.5 Delimitations

This study was delimited to the following parameters:

1. Data used in this study were collected between January, 2018, and April, 2019.
2. Subjects for this study were 6 men and 9 women between 56 and 71 years of age.
3. Data collected from each subject included ratings of perceived exertion, targeted medical history, CPR experience, grip strength, and the electrocardiogram.
4. Data were collected in the Webb Human Performance Laboratory on the campus of California Polytechnic State University, San Luis Obispo and in the Copeland Medical Education Pavilion on the campus of French Hospital Medical Center in San Luis Obispo.

1.6 Limitations

While this study simulated CPR on a human victim, during a real emergency, rescuers are likely to push themselves well beyond the limits described in this study, particularly if the victim is a relative or friend of the rescuer. Thus, performance data collected during this study may underrepresent performance during true cardiac arrests. Additionally, artifact in the ECG limited the ability to identify ST segment changes and, in some cases, cardiac ectopy.

1.7 Hypotheses

H_1: Senior adults will have limited endurance performance for "HO" CPR; they will not be able to sustain chest compressions for ten minutes.

H_2: Older adults will be able to sustain either "pedal" or a combination of standard *plus* "pedal" chest compressions longer than they can sustain HO CPR alone.

H_3: The heart rate response and relative aerobic exercise intensity of the rescuer will be lower while performing the combination of HO plus pedal CPR than while performing exclusively HO CPR.

H_4: Myocardial perfusion will be greater while performing combination CPR as indicated by less ST segment depression and fewer and less complex cardiac arrhythmias.

H_5: Hand grip strength, a global measure of overall muscular strength, will be positively correlated to CPR performance endurance.

1.8 Definition of Terms

1. Cardiac Arrest (CA): Sudden, unexpected cessation of heart function.
2. Cardiac Arrhythmia: Heart rhythm in which the heart beats irregularly, too slow, or too fast.
3. Cardiopulmonary Resuscitation (CPR): An emergency procedure in which a combination of chest compressions and ventilations are utilized to restore blood circulation and breathing in an individual who is in cardiac arrest.
4. CPR Endurance Time: The total time a subject could perform CPR at a compression rate of at least 80 per minute and a depth of at least 2 inches, up to ten minutes.

5. Electrocardiogram (ECG): The graphical representation of the electrical activity of the heart.
6. Hands-Only CPR (Cardiocerebral CPR): A method of CPR in which the rescuer uses both hands, superimposed on one another, to give chest compressions, but rescue breathing is not performed.
7. Myocardial Ischemia: A condition in which blood flow to the heart is reduced preventing the myocardium from obtaining sufficient amounts of oxygen.
8. P-wave: It is the first deflection on the ECG which represents the left and right atrial depolarization.
9. Pedal Cardiopulmonary Resuscitation (PCPR): A method of CPR deemed acceptable by the American Heart Association in 2005, in which the heel of the foot is used to give chest compressions, as opposed to classic CPR that utilizes the hands. The rescuer is standing giving pedal CPR while holding onto a chair or another fixture to obtain stability.
10. Premature Atrial Contraction (PAC): A type of heart arrhythmia in which premature heart beats occur, originating in one of the atria (the upper chamber regions of the heart). It is characterized by an abnormal P wave and a relatively short R-R interval on the ECG.
11. Premature Ventricular Contraction (PVC): A type of heart arrhythmia in which premature heart beats occur, originating in one of the ventricles (the lower chamber regions of the heart that collect and expel blood received to the body and lungs). It is characterized by a missing P wave, a short R-R interval, as well as a

wide, bizarre QRS complex; there is usually a fully compensatory pause after the QRS complex before the next heart beat occurs.

12. QRS complex: The three graphical deflections on an ECG representing ventricular depolarization; it is the main spike on a normal ECG.
13. S-T Segment: It is the flat section of the ECG after the QRS complex. It is measured from the end of the S wave (J point) to the beginning of the T wave. It represents the interval between the end of ventricular depolarization and the beginning of ventricular repolarization. Elevation or depression of the ST segment may indicate myocardial ischemia or myocardial injury.

Chapter 2

Review of the Literature

2.1 Heart Attacks and Senior Adults

In the United States, heart disease is the leading cause of death for both men and women (Centers for Disease Control and Prevention [CDC], 2017). Forty-nine percent of Americans have a major cardiac risk factor including: high blood pressure, high low density lipoprotien cholesterol, and smoking (CDC, 2017). According to the American Heart Association (AHA) (2018), an estimated 92.1 million American adults have one or more types of cardiovascular disease (CVD), increasing the likelihood of cardiac arrest (CA). For the 60-79 year old age groups, 69.6% of men and 68.6% of women have CVD; in the 80 and older age group, 84.4% of men and 86.5% of women have CVD (AHA, 2018).

2.2 Standard CPR

The most influential factor in explaining survival following sudden cardiac arrest is the delivery of CPR and electrical therapy within the first few minutes after collapse (Sanders, Kern, Atlas, Bragg, & Ewy, 1985). Survival from ventricular fibrillation decreases by 10-12% for every minute that defibrillation is delayed but when CPR is provided, the decline in survival is 3-4% per minute. Additionally, over the years evidence has accumulated suggesting that minimizing interruptions in chest compressions during CPR is crucial for survival in out of hospital cardiac arrest (OHCA). However, these chest compressions must be of high quality. Cardiopulmonary resuscitation must be interrupted to get reliable AED rhythm analysis due to the fact that mechanical activity

from chest compressions introduces artifacts and inhibits the AED's shock advice algorithm.

CPR has evolved over the years based on findings in related research. Most modifications have been dependent on newer understanding of myocardial perfusion during CPR. Myocardial perfusion pressure is known to decrease whenever chest compressions are discontinued, such as during ventilations in single rescuer CPR, or while allowing an AED to interpret the ECG rhythm. This has led to the acceptance of "HO" (a.k.a. "Compressions-Only") CPR as a viable alternative to Standard CPR with its combination of compressions and ventilations (Berg et al., 1993; Hallstrom, Cobb, Johnson, & Copass, 2000; Sanders et al., 1985). Some studies suggest HO CPR improves survival to hospital discharge following sudden cardiac arrest (Bobrow et al., 2010), but other research indicates that rescuers fatigue faster during HO CPR, resulting in fewer effective chest compressions than with Standard CPR (Shin et al., 2014). In addition, the recommended frequency of chest compressions has increased from 80 cpm to ≥ 100 cpm, and recommended depth of compression has increased from 3.8 cm to ≥ 5 cm (Trenkamp & Perez, 2015).

2.3 Pedal CPR

Eighty-eight percent of CAs occur in the home where the witness is most likely of older age (AHA, 2018). The ability to perform heel compressions as opposed to standard HO CPR is a skill that could be extremely beneficial, especially when considering a rescuer of an older age; they may not have the mobility to get down to their knees to provide standard, HO CPR. Additionally, they may not have the strength to provide the correct force to reach the very specific depth of chest compressions. Heel compression is

a mode of CPR that could increase a bystander's ability to provide "effective, uninterrupted compressions until EMS arrival" (Trenkamp & Perez, 2015, p. 1149).

Pedal CPR has been deemed an accepted and alternative mode of resuscitation since 2005 by the American Heart Association. The depth guideline also increased from 3.8 cm to 5 cm at that same time. The attainment of extra depth requires about twice the compression force and heel CPR allows for application of this greater force (Trenkamp & Perez, 2015). Trenkamp and Perez (2015) found that while 16% of individuals participating in this study were able to provide correct HO CPR, 65% were able to perform heel compressions for the ten minutes. Three of the subjects in this study could not get to the ground, which provides even more of a reason why heel compressions are a crucial alternative that needs to be instructed to the public.

Rescuers providing standard CPR may be susceptible to back injury due to the biomechanics of delivering chest compressions with the hands and arms in the kneeling position (Jones, 2004; Jones & Lee, 2005). The risk of back injury may be reduced when delivering chest compressions from the standing position, or by using a combination of Standard and Pedal CPR during resuscitation.

2.4 Senior Citizens as Rescuers

The probability of surviving a CA depends on many factors such as the following: cause of CA, initial cardiac rhythm, as well as depth and rate of chest compressions. With older age, these factors change and the survival rate is lower.

Sixty-four lay rescuers, aged 50 to 75, were studied during ten minutes of CPR in one of two scenarios (Neset et al., 2012). Single rescuer CPR with a compression to ventilation ratio of 30:2, and a target compression rate of 120 cpm, was performed either

during a traditional classroom scenario or a more realistic staged scenario, on a modified Resusci Anne manikin. Heart rates (HR) were measured using a Polar watch, and maximum HRs averaged 76 ±11% and 73 ± 9% of age-predicted maximum HR in the traditional versus more realistic scenario, respectively. Only two participants were unable to complete ten minutes of CPR. Average compression depth was 42 ± 6 mm during the first minute, and 43 ± 5 mm during the 10th minute in the traditional scenario, and 43 ± 9 mm during the first minute, and 42 ± 6 mm during the 10th minute during the more realistic scenario. It was concluded that elderly lay rescuers are capable of performing chest compressions with acceptable quality for ten minutes of CPR. However, the ventilation quality and hands-off time were reported as deficient among these subjects.

Fatigue during nine minutes of "Standard CPR" versus "Hands-Only CPR (HO)" was studied in 17 doctors and nurses aged 60-84 years of age (Heidenreich, Bonner, & Sanders, 2012). During standard, single rescuer CPR subjects performed cycles of 30 compressions at a rate of 100 cpm, followed by two rescue breaths. While performing single rescuer HO CPR, subjects were asked to deliver 100 cpm without ventilations for a total of nine minutes. Subjects were randomly assigned to perform Standard CPR or HO CPR first, and then were tested using the other CPR method at least two days later. The number of adequate compressions significantly decreased during the HO trial between minutes one and nine, compared to during the standard trial. Also, significantly more compressions were delivered during the HO trial. Six of the participants took at least one rest break during HO CPR, whereas only one subject rested during Standard CPR. Two of the participants were unable to complete nine minutes of HO CPR, stopping after

minutes four and five, respectively, but all the subjects were able to complete nine minutes of Standard CPR. These data suggested that older subjects fatigued faster during HO CPR than during Standard CPR, perhaps because administration of ventilations during Standard CPR permits more rest.

Brinkrolf et al. (2017) reviewed the literature and found that older patients receive bystander CPR less frequently, however little is known as to why this finding is so. Their hypothesis was that lack of knowledge of CPR methods was a probable reason. Their investigations were done through computer-assisted telephone interviewing in which they compared the CPR knowledge and self-confidence between younger and older citizens in Münster, Germany.

With a range of 18-91 years of age, two groups were formed: interviewees up to and including age 64 (n=1451) and those 65 or older (n=551). It was found that the probability of a patient being resuscitated declined significantly with increasing age of the rescuer. Under the age of 65, 82.4% knew the correct emergency number and the correct compression depth and frequency for chest compressions. However, only 75.1% of those aged 65 and older gave the correct answers. In regards to detecting CA, among participants younger than 65, 58.0% were confident that they had the ability to do this. In those aged 65 and older, only 44.6% were confident. Also, 62.7% of the younger subjects were certain that they would know what to do during CPR as opposed to 51.3% of the older group. These results showed that older individuals have less information about correct lay person resuscitation procedures and knowledge; not only this, but they regard themselves as less capable of providing CPR. Additionally, data on bystander resuscitation was retrieved from the database of the German Resuscitation Registry and it

was found that the percentage of patients aged 64 and under who had their cardiac arrest at home was 54.7%, compared to 79.0% of those aged 65 and older (Brinkrolf et al., 2017).

One of the limitations of their study was that they did not identify the potential causes why older rescuers know less about CPR measures. The authors suggested that better training for older people is necessary, including the use of AEDs.

2.5 Electrocardiography in Rescuers

Electrocardiograms, blood pressures, and oxygen uptake were measured in six physician subjects, aged 25-40 years, performing CPR by Lonergan, Youngberg, and Kaplan (1981). All of the subjects had normal baseline ECGs. Fifteen chest compressions and two ventilations were administered every fifteen seconds for fifteen minutes by a single rescuer subject. HRs ranged from 70-85 bpm at rest, and increased to a mean high of 115 bpm during CPR. The maximum mean rate pressure product (RPP) was determined by multiplying resting HR by the systolic blood pressure; values above 10,000 indicate an increased risk for heart disease (NCSF, 2011). Maximal oxygen uptake (VO_2 max) is defined as the maximal exercise intensity that could not be increased despite further increases in exercise workload, thus "defining the limits of [one's] cardiorespiratory system" (Hawkins, Raven, Snell, Stray-Gundersen, & Levine, 2007). The RPP was 18,500, and the mean VO_2 max was approximately 11 $mlO_2 \times kg^{-1} \times min^{-1}$. Three of the subjects developed minor ST segment depression that was not considered ischemic. Two subjects had an occasional atrial ectopic beat, but there were no PVC's. These researchers concluded that although performance of CPR was submaximal for

these subjects, CPR could elicit ischemic symptoms in a rescuer with coronary artery disease.

The ECG, phonocardiograms and impedance cardiograms of ten men previously certified to perform CPR, mean age 25 ± 4.5 years, were recorded by Miles et al. (1984). Subjects performed ten minutes of one-person CPR, or ventilations or compressions as part of a two-person CPR team, from the kneeling position using a Resusci-Anne manikin. Under the guidelines for CPR at the time of this study during one-person CPR chest compressions were administered at a rate of 80 compressions per minute (cpm), with a compression to ventilation ratio of 15:2. During two-person CPR, ventilations were administered once every 5 compressions, with chest compressions administered at 60 cpm. Heart rates (HR) were determined on a beat-by-beat basis using the Q-Q interval from the ECG, but heart rhythms were not reported. Mean HRs during CPR were 115 ± 0.2 bpm during one-person CPR, 88 ± 1.6 bpm while performing ventilations as part of a two-person CPR team, and 104 ± 2.4 bpm while performing chest compressions as part of a two-person CPR team. These researchers concluded that "properly trained young men" could perform CPR efficiently for at least ten minutes with moderate physiological stress (50% of maximum HR) (Miles et al., 1984).

Sato et al., (2018) compared the electrocardiograms of thirty-three subjects, mean age 36 ± 9 years, range 20-58 years, performing eight minutes of CPR on a manikin under two ambient atmospheric conditions: 80 m above sea level and high altitude (3700 m above sea level simulated in a hypobaric chamber.) Subjects each performed two trials of one-person CPR under both ambient conditions; a compression-only trial (100 cpm) and a trial under the 2015 American Heart Association Guidelines (i.e., 30:2 compression

to ventilation ratio, ≥ 100 cpm, compression depth of 4-5 cm.) No lethal dysrhythmias were observed, though subjects did have premature atrial and ventricular contractions. Subjects experienced significant oxyhemoglobin desaturation while performing CPR at the simulated altitude of 3700 m, and HRs were significantly higher (mean approximately 110 bpm vs. approximately 100 bpm) under the hypoxic condition. It was concluded that compressions-only CPR might "deteriorate rescuer oxygenation", whereas CPR with breaths might "ameliorate" oxyhemoglobin desaturation.

Tramler, Becker, Hochstrasser, Marsch, and Hunziker (2018) studied variations in HR, and ST and T-wave morphology using the electrocardiograms of 126 healthy medical students recorded before, during and after CPR. Pre-exercise mean HR increased from 87 ±16 bpm to 97 ±19 bpm during CPR, and then decreased to 80 ± 14 bpm post-resuscitation. Mean HR was significantly greater for women (82 ± 12 bpm) than for men (78 ± 12 bpm). Maximal HRs were also significantly greater for women (136 ± 19 bpm) than for men (126 ± 20 bpm). There were either dynamic T-wave or ST-segment abnormalities in 37 of 126 subjects (29.4%). T-waves were inverted in 7 subjects (5.9%), biphasic in two individuals (1.7%) and temporarily flattened in 30 individuals (25.4%). Eight subjects had ST-segment depression (6.8%), and one male subject (0.8%) had ST-elevation.

Mpotos et al. (2016) compared the physiological responses of 50 women, 23 medical students and 27 physical education (PE) majors, during up to 30 minutes of CPR. Resuscitation was performed on a Resusci-Anne manikin using a 30:2 compression to ventilation ratio, at 100-120 chest compressions per minute. Six of the medical students and one of the physical education students could not complete the thirty minute CPR

trial. One medical student dropped out after ten minutes due to onset of atrial fibrillation, and one stopped after twenty minutes due to non-sustained ventricular tachycardia. Three medical students stopped early due to fatigue; one after ten minutes and two after twenty minutes. One medical student developed severe acidosis after ten minutes. In the PE group, one student was unable to maintain 5 cm of chest compressions after 18.5 minutes of CPR.

Chapter 3

Methods and Procedures

The research protocol for this study was approved by the Cal Poly Institutional Review Board on June 6, 2018.

3.1 Subjects

The subjects utilized in this investigation were six men and nine women between 56 and 71 years of age from San Luis Obispo County in California. This age range was utilized because heart attacks commonly occur in persons in this range, and this age group is likely to be required to perform CPR on their peers as lay rescuers. Subjects were recruited who were capable of performing HO and pedal CPR using convenience sampling.

Exclusion criteria included the ACSM Contraindications to Symptom-Limited Maximal Exercise Testing, (see Table 1), or any other condition which precluded performance of either HO or pedal CPR safely (e.g., poor balance, the inability to change from the kneeling to the standing position unassisted, orthostatic hypotension, musculoskeletal condition affecting ability to perform chest compressions with either the hands or the legs, etc.)

3.2 Procedures

The Procedures utilized in this study are illustrated in Figure 1. Informed consent was obtained (See Appendix A), and the PAR-Q Plus form (Appendix B) and a targeted medical history form (Appendix C) were used to identify risk factors, pathologies and conditions which might affect performance of CPR, and experience with CPR training and performance.

Table 1. ACSM Contraindications to Symptom-Limited Maximal Exercise Testing

(ACSM, 2018, p. 118.)

Absolute Contraindications
• Acute Myocardial Infarction Within 2 Days
• Ongoing Unstable Angina
• Uncontrolled Cardiac Arrhythmia with Hemodynamic Compromise
• Active Endocarditis
• Symptomatic Severe Aortic Stenosis
• Decompensated Heart Failure
• Acute Pulmonary Embolism, Pulmonary Infarction, or Deep Venous Thrombosis
• Acute Myocarditis or Pericarditis
• Acute Aortic Dissection
• Physical Disability that Precludes Safe and Adequate Testing
Relative Contraindications
• Known Obstructive Left Main Coronary Artery Stenosis
• Moderate to Severe Aortic Stenosis with Uncertain Relationship to Symptoms
• Tachyarrhythmias with Uncontrolled Ventricular Rates
• Acquired Advanced or Complete Heart Block
• Recent Stroke or Transient Ischemic Attack
• Mental Impairment with Limited Ability to Cooperate
• Resting Hypertension with Systolic > 200 mmHg or Diastolic > 110 mmHg
• Uncorrected Medical Conditions, Such as Significant Anemia, Important Electrolyte Imbalance, and Hyperthyroidism

Informed Consent Obtained

⬇

PAR-Q+ and Targeted History

⬇

Hand Grip Dynamometry Demonstration

⬇

Hand Grip Dynamometry Testing

⬇

CPR Demonstration ("Hands-Only" CPR & "Pedal" CPR) and Practice

⬇

Connect Ambulatory ECG

⬇

CPR Trial #1 (Videotaped)

(Either Standard "Hands-Only" @ ≥ 100 cpm → ≥ 80 cpm, up to 10 min

or

"Hands-Only " ≥ 100 cpm → "Hands-Only" and/or "Pedal Compressions" @ ≥ 80 cpm, up to 10 min)

⬇

Rest Period (≥ 15 hours, including overnight sleep, but < 1 week)

⬇

CPR Trial #2 (Use CPR method not used during CPR Trial #1, Videotaped)

⬇

Patient Debriefing & Thanks!

Figure 1. Procedures

3.3 Hand Grip Dynamometry

A calibrated Jamar hydraulic hand grip dynamometer was used to assess hand grip strength as a global measure of muscular strength. A researcher demonstrated use of the hand grip dynamometer, and then subjects were tested immediately after the demonstration. The hand grip strength measurement procedures recommended by the American Society of Hand Therapists were followed in this study. The subject was comfortably seated with the shoulder adducted, the elbow flexed to 90°, the forearm in neutral position, and wrist between 0° and 30° dorsiflexion and between 0° and 15° ulnar deviation. The dynamometer was put in the second handle position from the inside, and then placed in the subject's hand. During testing the dynamometer was gently supported by the researcher to prevent dropping and damaging the instrument (See Figure 2). After the individual was positioned properly, they were told, "Squeeze as hard as you can … harder! … harder! … relax." The right hand was tested first, with brief rests between each of three trials, and then the left hand was tested. Subjects were instructed to "exhale on effort" to avoid the Valsalva Maneuver. Hand grip strength scores were recorded on a data capture form (See Appendix D), and the mean score for the three trials for each hand were used for grip strength evaluation (See Appendix E) and statistical purposes. Hand grip scores within 2 standard deviation of the mean score for men or women of a given age were considered "normal".

Figure 2. Hand Grip Dynamometry

3.4 Cardiopulmonary Resuscitation Trials

Trials were conducted at Cal Poly (CP) and French Hospital (FH). Those that were completed at CP utilized a Prestan manikin (Figure 3). Trials at FH were completed using a Zoll CPR Training Kit that included a manikin and a SeeThru CPR simulator (Figure 3). This equipment was able to obtain chest compression fraction (CCF). This is the amount of time during a cardiac arrest that high-quality chest compressions are performed. According to the AHA (2015) "improving CCF to achieve the 80% threshold has been shown to increase survival by 200 to 300%" (p. 1). Additionally, the FH manikin was able to quantify total seconds without compressions (i.e., time without correct compressions), mean compression count, as well as mean compression rate. These types of CPR data were reviewed via Zoll RescueNet software. Subjects were consistent with the locations; in other words, wherever they attended the first trial was where their second trial took place.

3.4.1 "Hands-only" CPR

After hand grip dynamometry, subjects were taught to perform HO and pedal CPR. HO CPR was a variation of standard, single rescuer CPR in which chest compressions were administered at 100 per minute or faster, but compressions were not interrupted to perform ventilations. In living victims, the airway is opened before chest compressions were begun using the head tilt, chin thrust method. Oxygen and carbon dioxide gases diffuse passively between the environment and the pulmonary capillaries as the subject circulates the blood via chest compressions (Berg et al., 1993; Hallstrom et al., 2000).

Figure 3. Prestan Manikin (Bottom) and Zoll CPR Training Kit Manikin (Top)

In this study, subjects were taught to kneel at the side of the CPR manikin, bend at the waist over the chest, extend the arms at the elbows, and place their hands onthe sternum with their fingers interwoven. By leaning forwards and using upper body weight, with the waist as a fulcrum, the manikin's chest was compressed. See Figure 4. For those that participated at CP and used a Prestan manikin, each compression of at least 2 inches resulted in a "click", which was auditory feedback for successful chest compressions. The manikin also provided visual feedback about compression frequency via lights in the left shoulder. One red light indicated a compression rate of 1 to 59 per minute. One yellow light indicated 60 to 79 cpm, one green light indicated 80-99 cpm, and two green lights indicated greater than or equal to 100 cpm (See Figure 5.) Subjects were instructed to keep chest compression frequency high enough during CPR trials to keep both green lights lit. At FH, subjects obtained auditory feedback from the Zoll manikin such as "push harder" or "good compressions" as well as feedback from the researchers telling them their rate of compressions and depth.

In theory, "HO" CPR permits continuous myocardial perfusion without the decrease that normally occurs as ventilations are performed by the rescuer (Berg et al., 1993; Hallstrom et al., 2000). Possible disadvantages include decreased gas exchange when ventilations are not performed, as well as less rest for the rescuer who performs chest compressions without interruption (Berg et al., 1993; Hallstrom et al., 2000).

During HO trials subjects were asked to use this method exclusively for up to a maximum of ten minutes. If chest compression depth was less than 2 inches, indicated by a lack of "click" at CP or the monitor at FH indicated less than 2 inches, for 5 seconds, the test was discontinued. Similarly, if chest compression frequency dropped below 80

cpm, indicated by the light display going from one green light to one yellow light at CP or the monitor indicated less than 80 cpm at FH, for 5 consecutive seconds, the test was discontinued. The subject also had the option of discontinuing the CPR session at their discretion. Subjects were encouraged not to push themselves to the point where they would experience post-bout muscular pain or injury, and to discontinue the session if they felt chest pressure or pain, became light headed, short of breath, excessively fatigued, etc.

3 4.2 Pedal CPR

Subjects were also taught to perform "Pedal CPR", which was similar to HO CPR except that the chest compressions were administered using the heel of a foot instead of with the hands (See Figure 6). This method was adapted from the work of Trenkamp and Perez (2015). The rescuer stood over the patient and faced their legs. One foot was placed next to the manikin's ear, and the heel of the opposite foot was placed on the sternum. Subjects were required to use a chair for balance while performing pedal chest compressions, and to be careful not to put pressure on the xiphoid process.

During combination methods trials, involving both "HO" plus "Pedal" CPR, subjects were asked to start the trial in the kneeling position performing "HO" CPR. They were then encouraged to transition to the standing position to perform "Pedal" CPR at their discretion, and then vary the method ad libitum up to a maximum continual performance time of ten minutes.

Figure 4. Hands Only CPR

Figure 5. Light Biofeedback on Shoulder of CPR Manikin

Figure 6. Pedal CPR

3.4.3 Videotaping

CPR sessions were videotaped using a Panasonic HC-V250 10 Megapixel Digital Recorder. The video recordings were stored on a 2016 Macbook Pro.

3.4.4 Ambulatory ECG Monitoring

The electrocardiograms of subjects were recorded during CPR trials using an IQmark™ Digital Holter Recorder. Five Ambu "Blue Sensor" ECG electrodes were placed as illustrated in Figure 7. Electrode sites were prepared by wiping the skin with a cotton sponge soaked with isopropyl alcohol. Then the sites were lightly wiped with an abrasive pad to further reduce resistance between the skin and the electrodes. Electrode cables were connected to a recorder which stored the ECG data on a SanDisk 64 MB Compact Flash card.

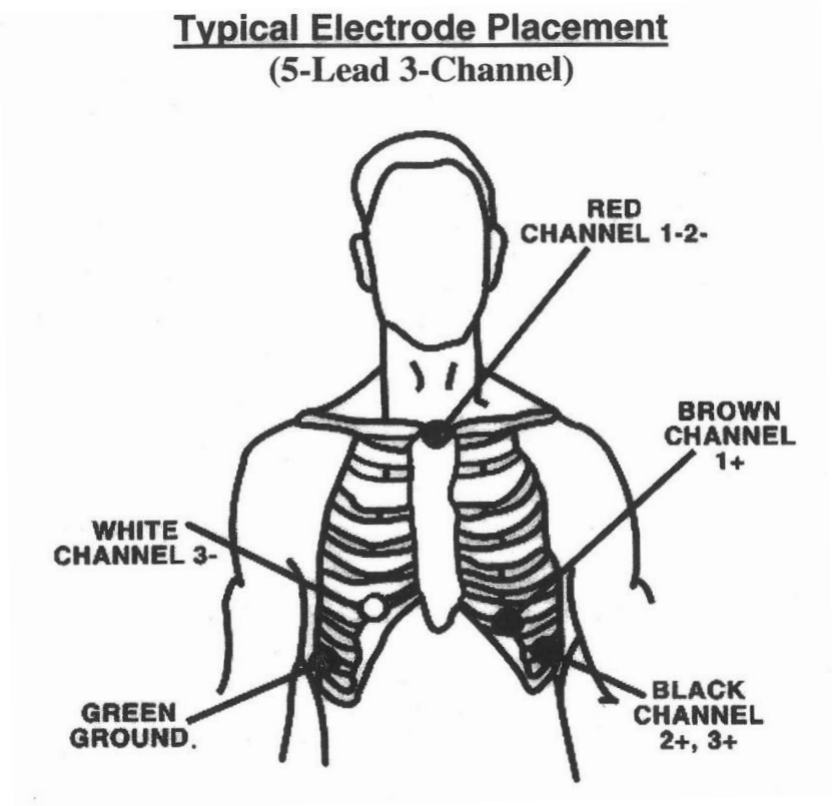

Figure 7. ECG Electrode Placement

After each CPR trial was completed, the ECG data were uploaded to a desktop computer and analyzed via IQ Mark Software. Each beat recorded was evaluated and interpreted as normal, supraventricular ectopic, or ventricular ectopic. Subsequently, the researcher scanned the ECG record and corrected the computer interpretations. Heart rates were calculated, as well as the prevalence of cardiac arrhythmias prior to, during, and following both the HO and CO method trials.

3.4.5 Rating of Perceived Exertion

Ratings of perceived exertion were determined using the Borg category-ratio scale (Figure 8). Subjects were asked to provide researchers with the number that corresponded to how they felt at specific points during the CPR trials.

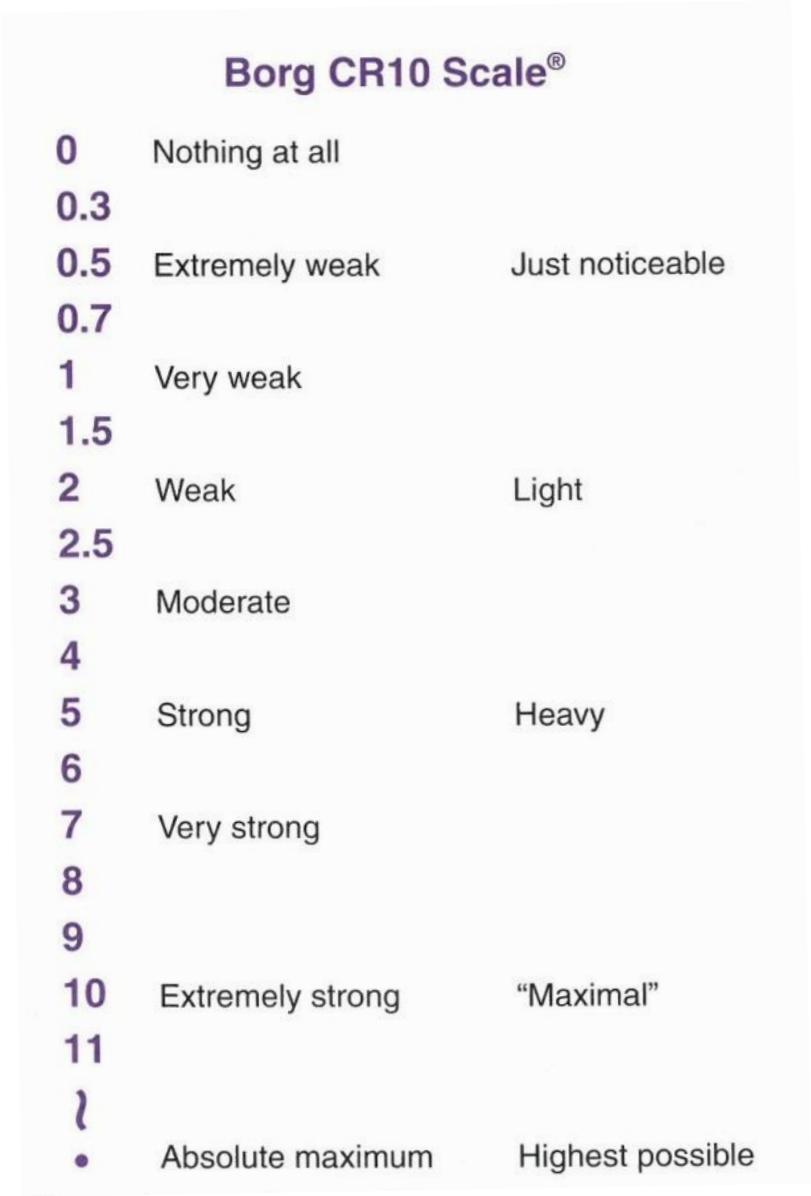

Figure 8. Borg Category – Ratio Scale (Borg, Borg, Larsson, Letzter, & Sunblad, 2010)

3.4.6 CPR Trials

After reviewing or being taught HO and pedal CPR, subjects were randomly assigned to either a HO trial first or a "HO Plus Pedal CPR trial" first. This random assignment was done by the flip of a coin in which "heads" indicated the HO trial and "tails" indicated the CO trial. Five participants performed the HO trial and 10 performed the CO trial first. During this initial test session subjects were asked to perform the assigned CPR method for up to ten minutes. During the trial the ambulatory ECG was monitored using an IQmark™ Digital Holter Recorder, and Ratings of Perceived Exertion were determined at 2 minutes, 5 minutes, and upon cessation of CPR. Subjects were filmed during the CPR trial using a Panasonic HC V250 digital recorder to provide a visual record of CPR performance from which to obtain data such as trial endurance time and length of time of "HO" vs. "Pedal" CPR during the combined-methods trial. During the combined methods trial subjects were asked to start in the standard kneeling position unless they could not kneel next to the manikin with comfort. Subjects were encouraged to transition from "HO" to "Pedal" CPR ad libitum, in order to simulate actual CPR choices and evaluate rescuer CPR method preference. Trials were discontinued if the subject wanted to stop, if they were unable to sustain a compression rate of at least 80 compressions per minute, if a compression depth of less than 5 cm was performed for 5 consecutive seconds (no "click" for 5 seconds), or if the subject's form deteriorated to the point that it was unlikely blood would be circulated appropriately in a living human victim. Subjects were asked the reason for discontinuing a trial that lasted less than ten minutes and about how they felt as they performed CPR.

After a recovery period of at least 15 hours, including overnight sleep, but less than one week, a second CPR trial was conducted. During the second trial the opposite CPR method, either "HO" alone or "HO Plus "Pedal" CPR, was utilized.

3.5 Analysis of the Data

After data collection the following were determined: (1) total CPR endurance time for each trial; (2) ratings of perceived exertion at minutes 2, 5 and, 10 or at the end of the trial if the participant terminated CPR before ten minutes had elapsed; (3) total time performing chest compressions; (4) total time required to transition between Standard and Pedal chest compressions; (5) reasons for discontinuing CPR; and (6) subject perceptions of the advantages and disadvantages of Standard vs. Pedal chest compressions.

3.5.1 ECG Analysis

ECG data were downloaded from the Holter monitors to a desktop computer, and IQMark Data Analysis software was used for analysis. A standardized report was automatically generated which included HRs, and summaries of cardiac ectopy. The ECG record was manually scanned for ectopic beats and arrhythmias. Artifact was evaluated by the visually trained eye and was adjusted manually through the software.

3.5.2 Statistical Methods

A repeated measures experimental research design was used in this study (Huck, Cormier, & Bounds, 1974). Thus, each subject served as their own control for the purpose of comparisons between HOCPR and the combination of HO plus pedal CPR. Data were entered into an Excel spreadsheet and dependent t-tests were utilized to detect significant differences. Pearson correlational tests were used to determine relationships.

A three way analysis of variance with repeated measures was used to compare the ratings of perceived exertion. Factors included test trial, gender, and measurement time. Follow-up tests were used to identify differences in the event of significant interactions or main effects. The a priori level of significance for this study was $p < 0.05$.

Chapter 4

Results and Discussion

4.1 Results

4.1.1 Subjects

For this study, data were collected between January 29, 2019, and May 8, 2019. The sample size of this study included 15 subjects; six men and nine women. The mean age of the men was 64.8 ± 5.6 years of age and the mean age of the women was 61.3 ± 4.74 years of age.

Mean height and weight for men were 1.79 ± 0.07 m and 86.89 ± 5.98 kg respectively. Mean height and weight for women were 1.64 ± 0.06 m and 67.60 ± 7.07 kg, respectively. Mean body mass index (BMI) for men was 27.12 kg/m^2. For women, mean BMI was 25.13 kg/m^2.

Among the 15 subjects, 100% had been trained in CPR and 87% had been or were CPR certified. Five subjects out of the 15 had previously performed CPR on a real victim. None of the participants reported any limitations, pacemakers, implantable cardioverter defibrillator (ICD), or had previous cardiac surgery. Importantly, none reported balance difficulty but one individual reported kneeling difficulty as well as difficulty transitioning from standing to kneeling, or vice versa. Eight subjects performed their trials at French Hospital (FH); seven subjects were tested at Cal Poly (CP). All completed an informed consent form as well as a history and PARQ+ form.

4.1.2 Hand Grip Dynamometry

Hand grip dynamometry was done prior to the first trial to measure overall strength. Left and right hand grip strength were measured in kilograms (kg). Mean hand

grip strength for men on the left and right hands were 48.33 ± 11.94 kg and 47.12 ± 5.55 kg, respectively. Grip strength norms for men aged 60-64 average 34.9 ± 9.2 kg and 40.8 ± 9.3 kg for the left and right hands, respectively (Mathiowetz et al., 1985). Mean hand grip strength for women on the left and right hand were 27.44 ± 3.34 kg and 28.77 ± 4.78 kg, respectively. Norms for women aged 60-64 average 20.8 ± 4.6 kg and 25.0 ± 4.6 kg, respectively (Mathiowetz et al., 1985). See Figure 9. There was a weak, positive correlation between CPR endurance times and grip strength of the left and right hand with Pearson Correlation values of r=0.26 and r=0.34, respectively. See Figures 10 and 11.

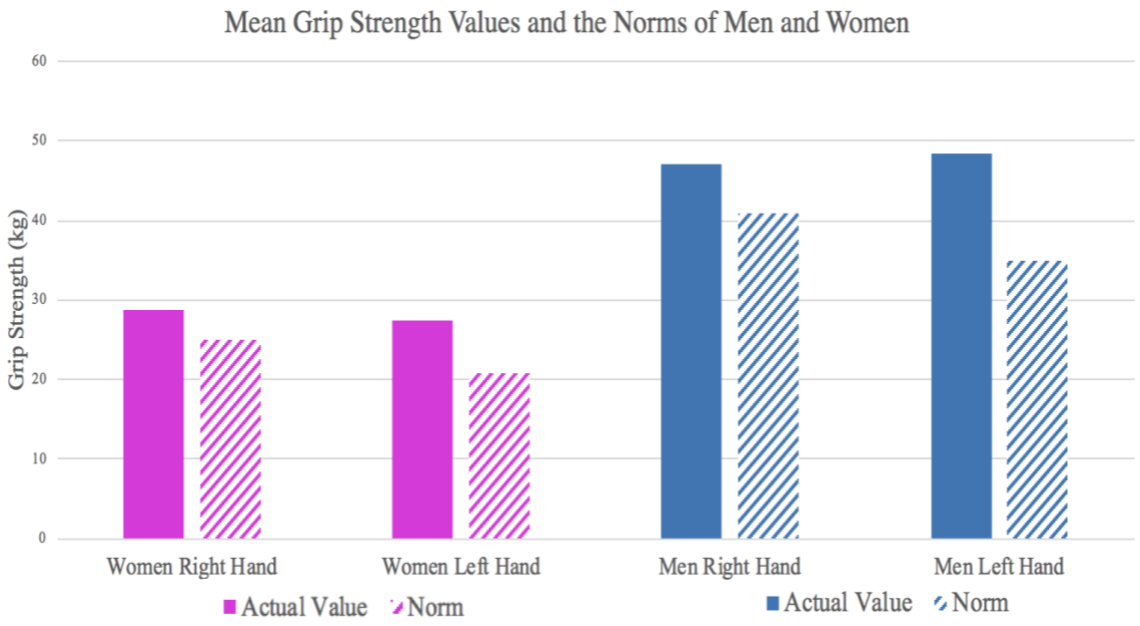

Figure 9. Mean Grip Strength in Relation to Norm Values between Men and Women

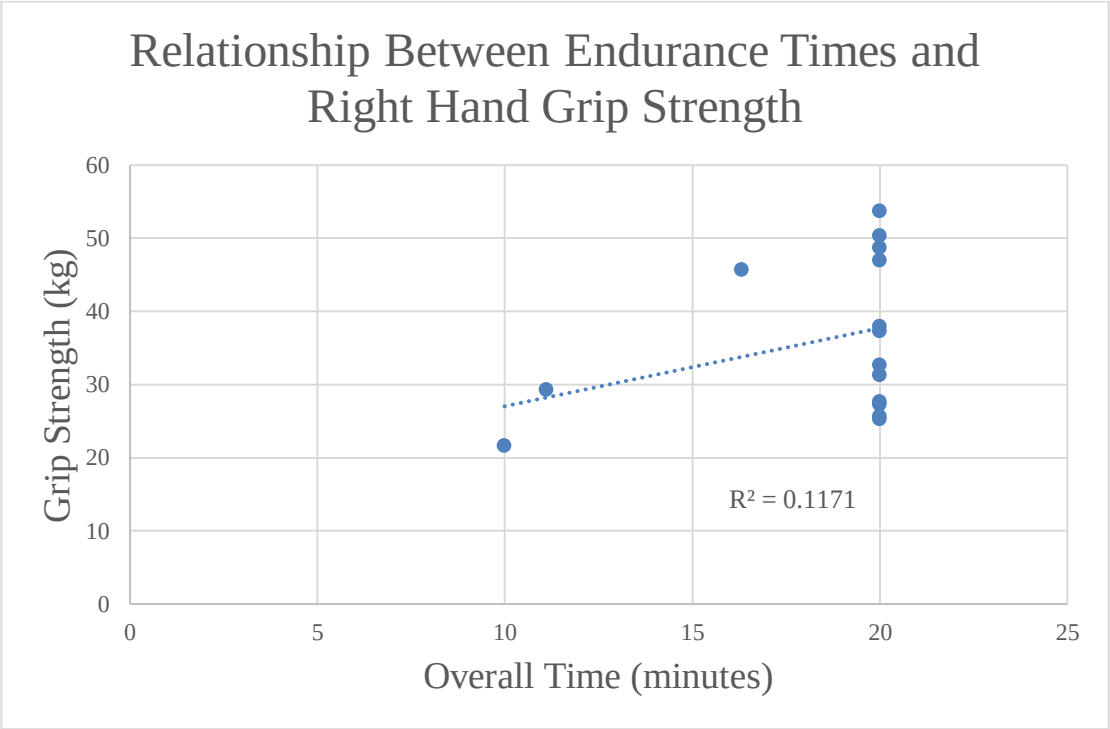

Figure 10. Relationship Between Endurance Times and Right Hand Grip Strength

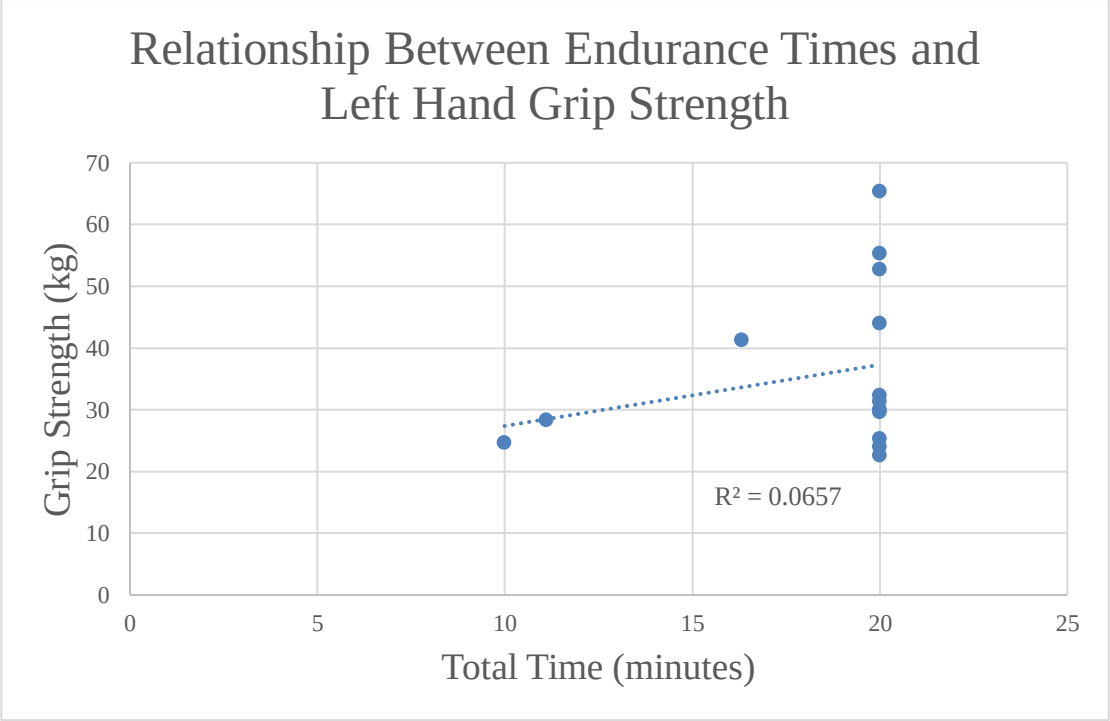

Figure 11. Relationship Between Endurance Times and Left Hand Grip Strength

4.1.3 Ratings of Perceived Exertion

Ratings of Perceived Exertion (RPE), on a scale from 0-10 (0 meaning no exertion at all; 10 meaning maximal exertion) (Borg, 1998), were measured at minutes 2, 5, and end of test (EOT), with a maximum time limit of 10 minutes. Figure 12 describes the differences between RPE during CO and HO trials in men and women. Table 2 describes the RPE during both trials. An analysis of variance found that there was no significant difference between RPE and gender ($p=0.4209$) nor RPE and test type ($p=0.2124$). However, it was found that there was a significant difference between RPE at the different times of minutes 2, 5, and EOT ($p<0.0001$). There is evidence that there was a statistical difference between RPE at minutes 2, 5, and EOT. However, follow up tests were necessary to determine where those differences lay. As expected, there was a difference between minutes 2 and 5 ($p<0.0001$), 5 and EOT ($p<0.0001$), and evidently, 2 and EOT ($p<0.0001$).

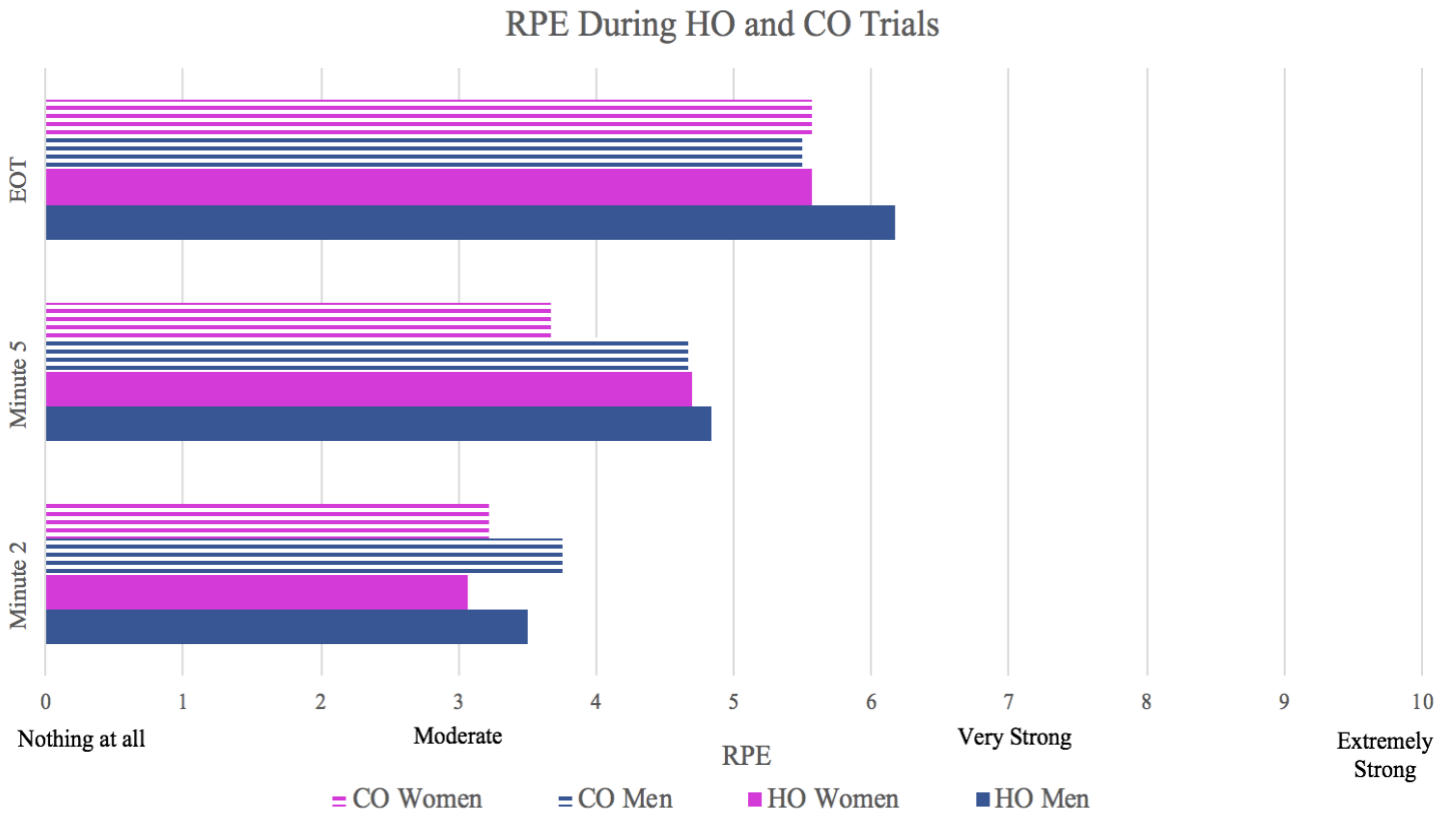

Figure 12. Mean RPE in Men and Women During HO and CO Trials

Table 2. Ratings of Perceived Exertion During CPR Trials

	Hands Only Trial		Combination Trial		Both Trials Combined
	Men	Women	Men	Women	Men and Women
Minute 2	3.5 ± 1.76	3.06 ± 1.01	3.75 ± 1.40	3.22 ± 1.79	3.38 ± 0.31
Minute 5	4.83 ± 1.33	4.69 ± 1.75	4.67 ± 1.37	3.67 ± 1	4.45 ± 0.53
End of Trial	6.17 ± 1.17	5.56 ± 2.46	5.5 ± 1.87	5.56 ± 2.45	5.7 ± 0.32

4.1.4 Chest Compression Tests

For the HO trial done at FH, two of the eight subjects did not have the data mentioned above due to technical difficulties. During the CO trials, only one out of the eight participants did not have data due to the same technical difficulties with the FH computer server.

The mean CCF during the HO trial was 97.43 ± 1.82%, total seconds without compressions was 16.33 ± 8.26 seconds, mean compression count was 106.39 ± 6.53 per minute, and mean compression rate was 109.07 ± 5.83 cpm. The mean CCF during the CO trial was 96.60 ± 2.27%; total seconds without compressions was 17.86 ± 12.4 seconds, mean compression count was 104.98 ± 4.34, and mean compression rate was 108.29 ± 3.7 cpm.

Three of the 15 subjects were unable to do HO compressions for the ten minutes with a mean total time of 9.02 minutes. Only 2 of the 15 subjects were unable to do the maximum of ten minutes during the CO trial with a mean total time of 9.47 minutes. See Figure 13.The difference was not statistically significant between the two trials (p=0.16).

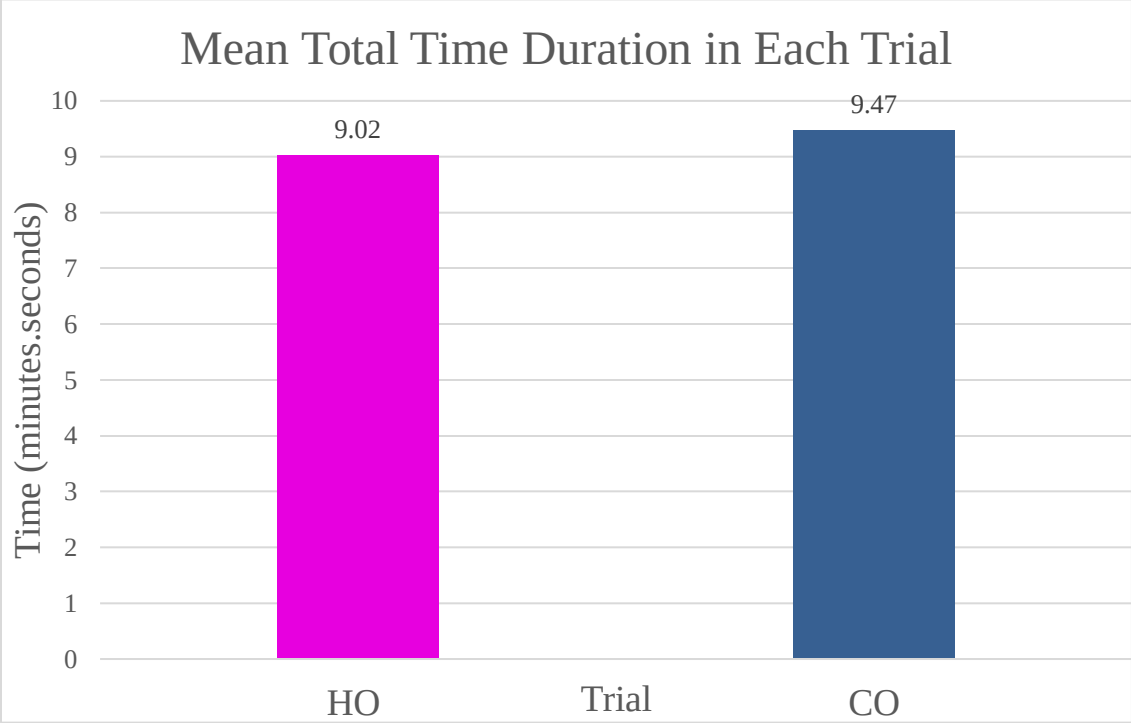

Figure 13. Mean CPR Duration in the HO and CO Trials

4.1.5 Combination Trial

The mean of total time spent in HO compressions during the CO trial was 4 minutes and 28 seconds. Whereas, the mean total time of performing the pedal compressions was 4 minutes and 47 seconds. See Figure 14. Mean total transition time during an entire trial was 15.2 seconds and average transition time was 5.46 seconds between kneeling to standing or vice versa, with 2.87 times of transitioning being the average.

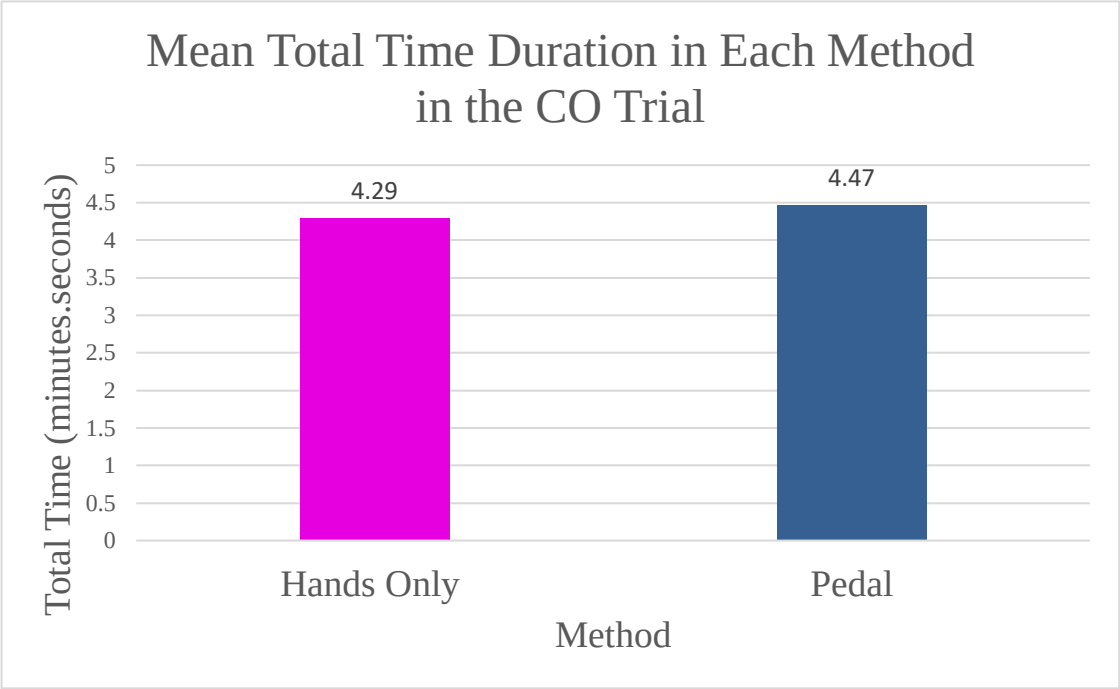

Figure 14. Mean CPR Duration in Each Method in CO Trial

4.1.6 Heart Rate

The mean HR max during the CO trial was 133.4 ± 23.7 bpm. During the HO trial, it was 125.4 ± 21.9 bpm. This difference was not statistically significant (p=0.12). See Figure 15.

Heart rate reserve (HRR) of each subject was calculated by: (HRmax – resting HR)/(age predicted max HR – resting HR) x 100. Subjects achieved a mean of 61.1% ± 24.1% of their HRR in the HO trial. In the CO trial, subjects achieved 75.1% ± 25.7% of their HRR. This difference was not statistically significant between the two trials (p=0.09). See Figure 16.

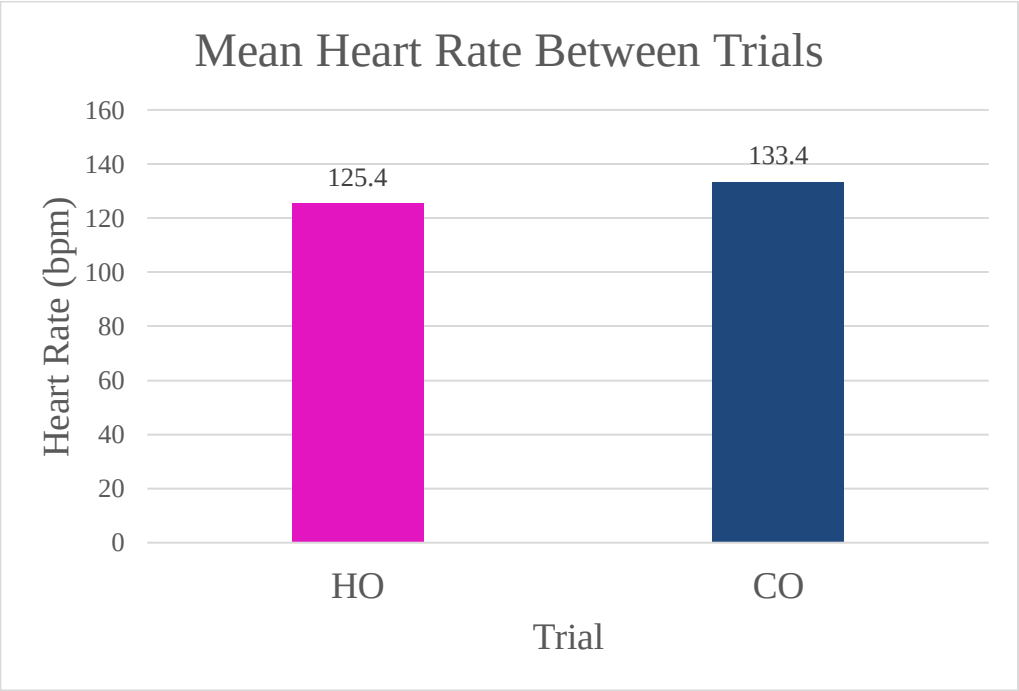

Figure 15. Mean Heart Rate Between Trials

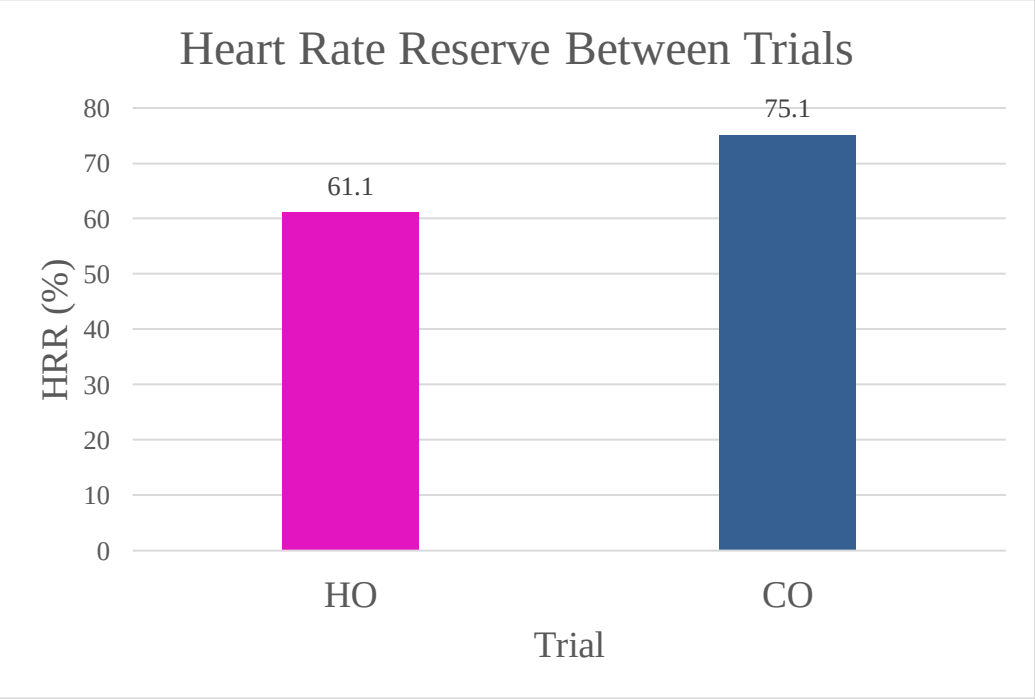

Figure 16. Heart Rate Reserve Between Trials

4.1.7 Electrocardiography

The number of ectopic beats (for the 5 min pre + 10 min during CPR trial + 5 min post) averaged 13.57 ± 27.9 beats for the HO trial and 9.71 ± 15.52 beats for the CO trial ($p=0.35$). Total number of number of ectopic beats 5 minutes pre, during, and 5 minutes post, during both trials (combined), was 42, 230, and 53, respectively. During the HO trial, there were a total of 150 PVCs and 42 PACs. In the CO trial, there were a total of 43 PVCs and 90 PACs. See Table 3.

The calculation of percent ectopic beats of the subjects was done by summing up the number of ectopic beats during each ECG recording (average of 37.54 ± 5.46 minutes) and dividing it by the total number of beats (normal and ectopic). There was no significant difference between the HO and CO trials ($p=0.77$). See Figure 17. However, there was a strong, positive relationship between the trials, which indicated a consistent amount of ectopy from trial to trial ($r=0.71$). See Figure 18.

Overall, it was not possible to evaluate ST segments, as desired, due to movement artifact and somatic tremor.

Table 3. Cardiac Ectopy of Subjects During CO and HO Trials.

Subject	Trial	Duration	5-2 Min Pre	2-0 Min Pre	Ectopy During CPR Trial	0-2 Post	2-5 Post
1	HO	10 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
	Combo	10 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
2	Combo	5:58 min	-	-	uninterpretable	-	-
	HO	5:52 min	4 PVCs	1 PVC 1 nodal beat	3 PVCs	1 nodal beat; 1 PVC	1 PAC
3	Combo	10 min	No ectopy	No ectopy	55 PACs	3 PACs	1 nodal beat
	HO	10 min	1 PAC	4 PACs	83 PACs	2 PVCs; 15 PACs	No ectopy
4	Combo	10 min	No ectopy	1 PAC	No ectopy	No ectopy	No ectopy
	HO	10 min	No ectopy	No ectopy	1 PVC	No ectopy	No ectopy
5	HO	10 min	8 PACs	11 PACs	10 PACs	No ectopy	3 PACs
	Combo	10 min	3 PACs	8 PACs	2 PACs	1 PAC	1 PAC
6	Combo	10 min	1 PAC	No ectopy	6 PVCs; 1 PAC	No ectopy	1 PAC
	HO	10 min	No ectopy	No ectopy	2 PVCs; 1 PAC	No ectopy	No ectopy
7	Combo	10 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
	HO	6:31 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
8	HO	10 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
	Combo	10 min	No ectopy	1 PAC	1 PAC	1 PAC	No ectopy
9	Combo	10 min	No ectopy	No ectopy	No ectopy obs.	2 PAC's (aber.)	5 PVCs (2 foci)
	HO	10 min	1 PVC	1 PVC	10 PVCs	1 PAC (aber.)	6 PVCs
10	Combo	6:53 min	No ectopy	No ectopy	No ectopy	No ectopy	1 PAC
	HO	3:46 min	No ectopy	No ectopy	4 PACs	4 PVCs	No ectopy
11	HO	10 min	No ectopy	No ectopy	No ectopy	No ectopy	No ectopy
	Combo	10 min	No ectopy	No ectopy	No ectopy	1 PVC	No ectopy
12	Combo	10 min	No ectopy	No ectopy	1 PVC	No ectopy	No ectopy
	HO	10 min	No ectopy	No ectopy	1 PVC	No ectopy	No ectopy
13	Combo	10 min	1 PVC	No ectopy	17 PVCs;3 PACs	No ectopy	No ectopy
	HO	10 min	No ectopy	No ectopy	2 PACs	No ectopy	No ectopy
14	Combo	10 min	No ectopy	No ectopy	5 PVCs;4 PACs	No ectopy	uninterpretable
	HO	10 min	No data	No ectopy	2 nodal beats; 2 PVCs	2 PVCs	No ectopy
15	Combo	10 min	No ectopy	1 PVC	4 PVCs	3 PVCs; 1 PAC	No data
	HO	10 min	No ectopy	No ectopy	9 PVCs 2 nodal beats	1 PVC 1 nodal beat	No ectopy

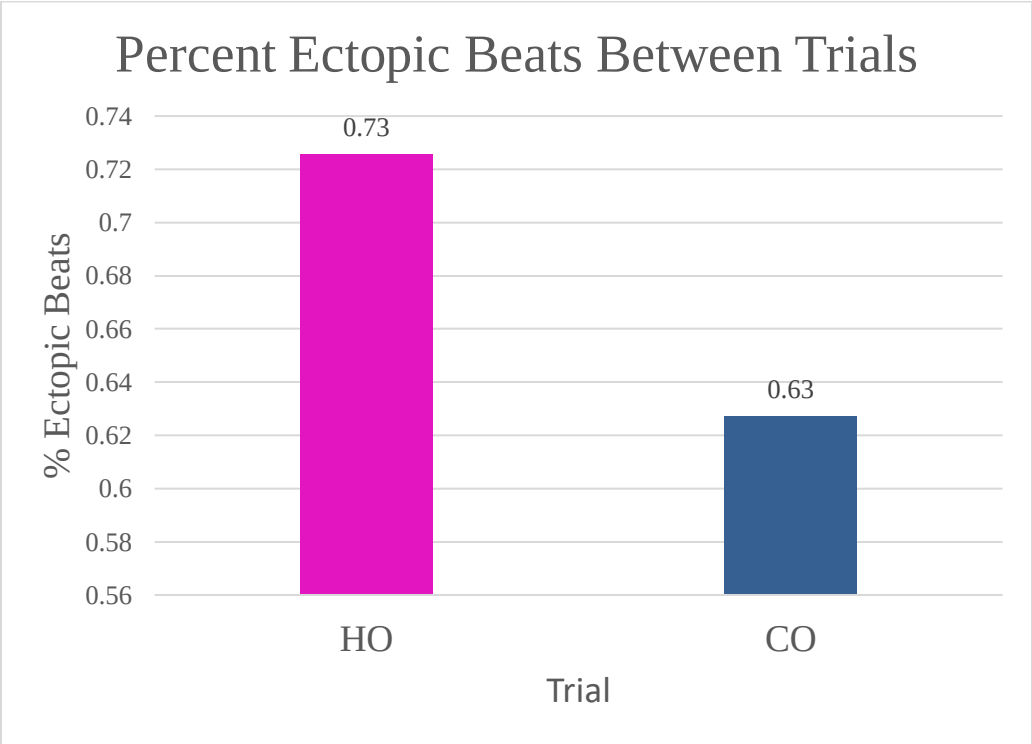

Figure 17. Percent Ectopic Beats Between Trials

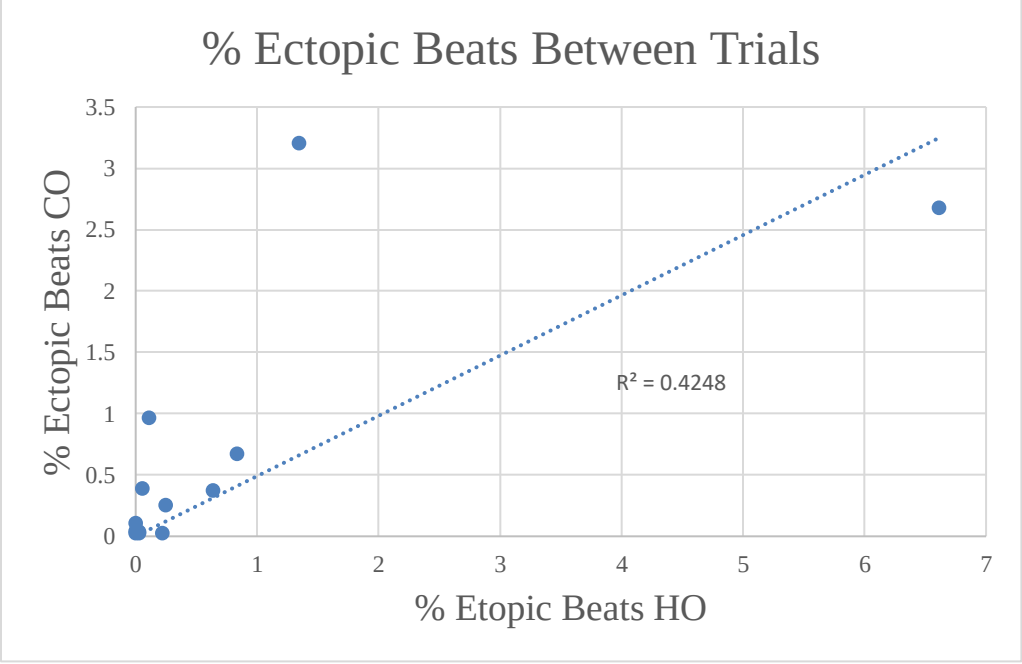

Figure 18. Relationship Between Percent Ectopic Beats in the CO Trial and Percent Ectopic Beats in the HO Trial

4.2 Discussion

4.2.1 Interpretation of Results

Among the 15 subjects, 87% had been CPR certified and 33% had previously performed CPR on a real victim; this could have allowed for more bias due to experience. Additionally, three were nurse practitioners and one was a physician. All the subjects indicated that they participated in some sort of physical activity on a weekly basis. These subjects were on the lower end of the age range (62.7 ± 5.21) as described by the inclusion criteria; thus, this could have allowed for longer HO compressions than what could have been witnessed in older subjects. A greater spread of ages would have allowed for a better generalization to the older adult population.

In the CO trial, it was often observed that coordination was the biggest issue in performing pedal CPR and the effort needed to attain such coordination. Perhaps a lack of experience and practice in the pedal method is also why individuals reported higher ratings of exertion.

A difference in manikin type could have allowed some location's trials to be easier or harder. The FH manikin was thicker and of different material. The Zoll CPR Training Kit provided auditory feedback such as "push harder" or "good compressions". The CP Prestan manikin was thinner making it easier to perform compressions. It also provided visual and auditory feedback via the lights for compression rate and auditory click for correct depth, respectively. See Figure 19. Additionally, it was observed that short rescuers had a more difficult time than average sized rescuers performing CPR on the Zoll CPR Training manikin. Shorter individuals had to lift their legs relatively higher to place them on the victim's (i.e., manikin's) chest, thus requiring more effort. Figure 20

shows chest compression data of an individual that experienced difficulty with pedal CPR due to short stature. Figure 21 shows chest compression data of an averaged sized individual that experienced less difficulty and was able to sustain CPR with less effort. The circled areas indicate where compression quality decreased. When comparing compression quality during CO trial in a shorter subject (i.e. height of 1.575 meters) and an average sized subject (i.e. height of 1.638 meters), the individual of shorter size demonstrated a worse quality (Figure 20) than an individual of average size (Figure 21) as shown by more of the data points “dropping off” at given time points within the ten minute trial.

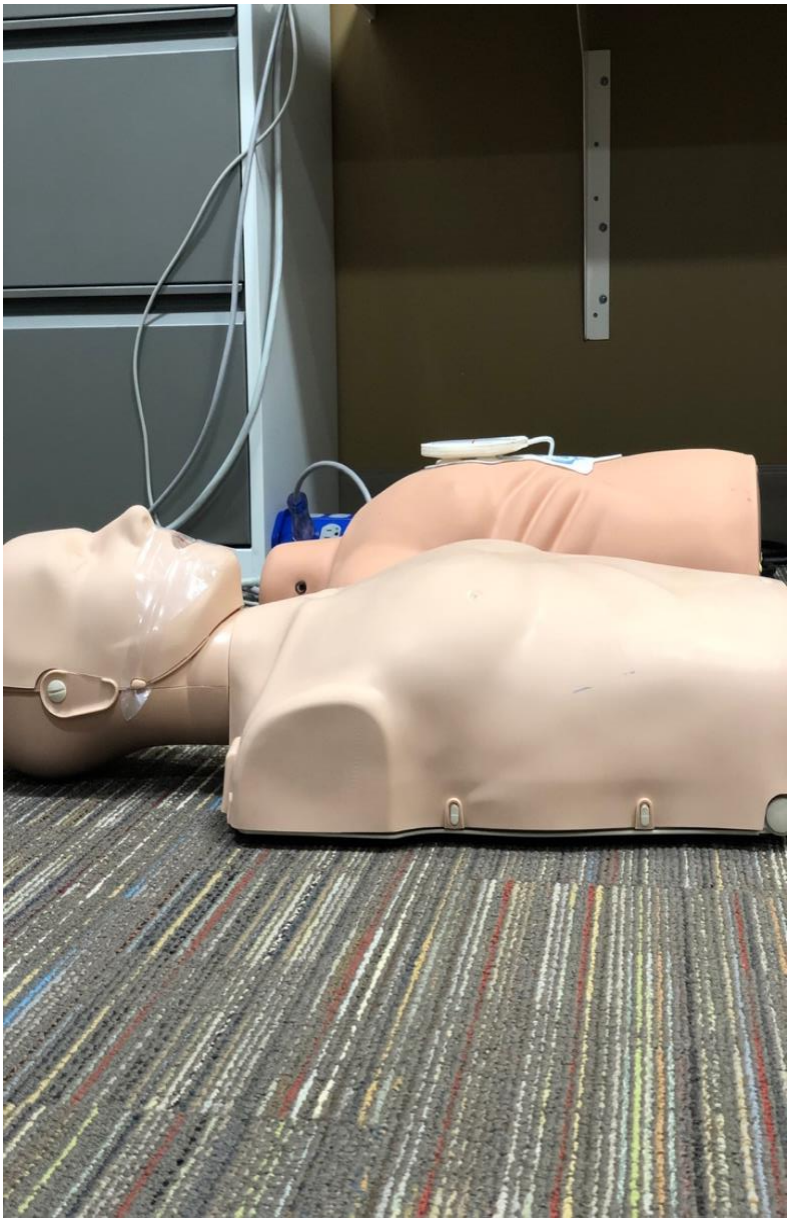

Figure 19. Prestan Manikin (Front) and Zoll CPR Training Kit Manikin (Back)

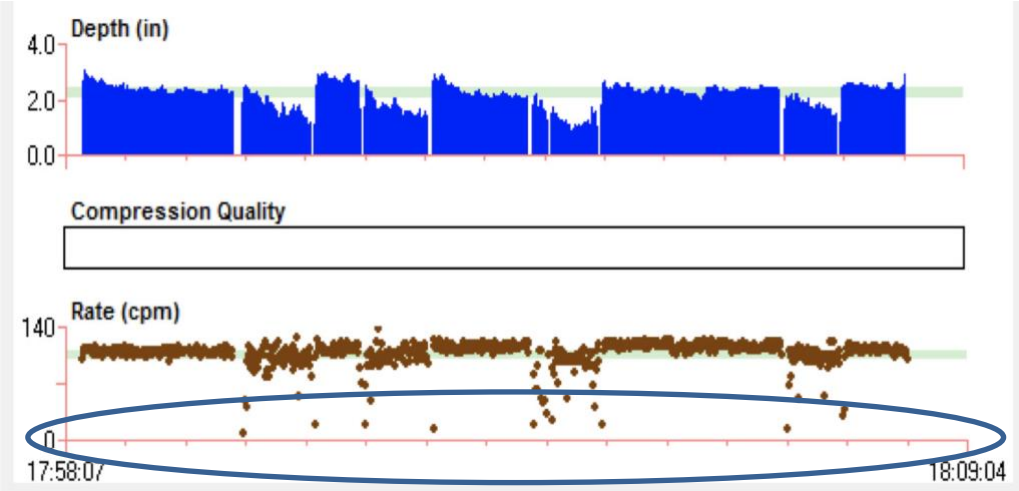

Figure 20. Compression Quality During CO Trial in Shorter Subject

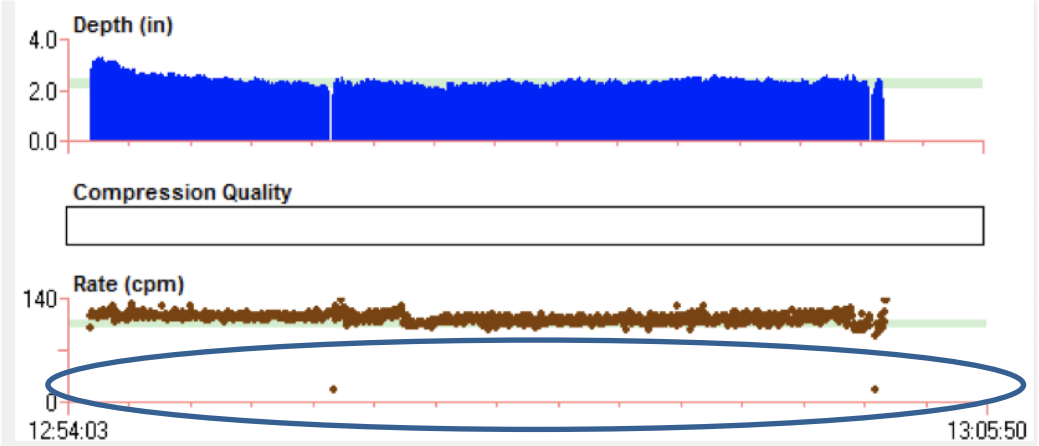

Figure 21. Compression Quality During CO Trial in Average Sized Subject

Additionally, mean max HR and mean HRR were observed as higher during the CO trial though the differences were not statistically significant; this may be due to activating upper and lower body muscles rather than utilizing body weight in the pedal method. This could have also been due to the fact that transitioning from one method to the other (i.e., ground to standing) requires additional strength and energy. Numerous studies have indicated that there is a positive linear relationship between HR and RPE (Gillach, Sallis, Buono, Patterson, & Nader, 1989). Thus, is interesting that HR was highest during the CO trial, but RPE did not appear to be highest during the CO trial. A higher HR could be due to a postural effect from standing.

For those that were unable to sustain either type of compression for the full ten minutes, all were able to last a longer amount of time during the CO trial than during the HO trial. Changing from the kneeling to the standing position permits a rest and recovery interval for the muscles which are utilized to perform CPR with the hands. Switching back and forth from standard to pedal CPR probably prolongs endurance because different muscles are prime movers.

In the EKG data, artifact was often an issue. This was most likely due to movement and electrode site preparation. One subject had largely uninterpretable results. Additionally, in both men and women, the leads from the Holter monitor could have been moved around during trials, contributing to artifact. These reasons could have led to incorrect measures of HR as calculated by the software, thus HR analysis was done manually.

In terms of ectopy seen in electrocardiograms, on average there was more seen during the HO trial than the CO trial. Particularly in one subject whose number of ectopic

beats during the HO trial was 105 and that same individual had 59 ectopic beats during the CO trial, with the majority of those ectopic beats being premature atrial contractions (PAC). Another subject, however, primarily had premature ventricular contractions (PVC) with 18 during the HO trial compared to five during the CO trial. Figure 22 depicts the amount of PVCs one particular individual had during and post HO trial. This individual had an unusual amount of ventricular ectopy which was worth highlighting.

The percent ectopic beats between the HO and CO trials of each subject were highly correlated. Subjects who had few or no ectopic beats during the HO trial also had few or no ectopic beats during the CO trial. Subjects who had high amounts of ectopic beats during the HO trial also had high amounts of ectopic beats during the CO trial.

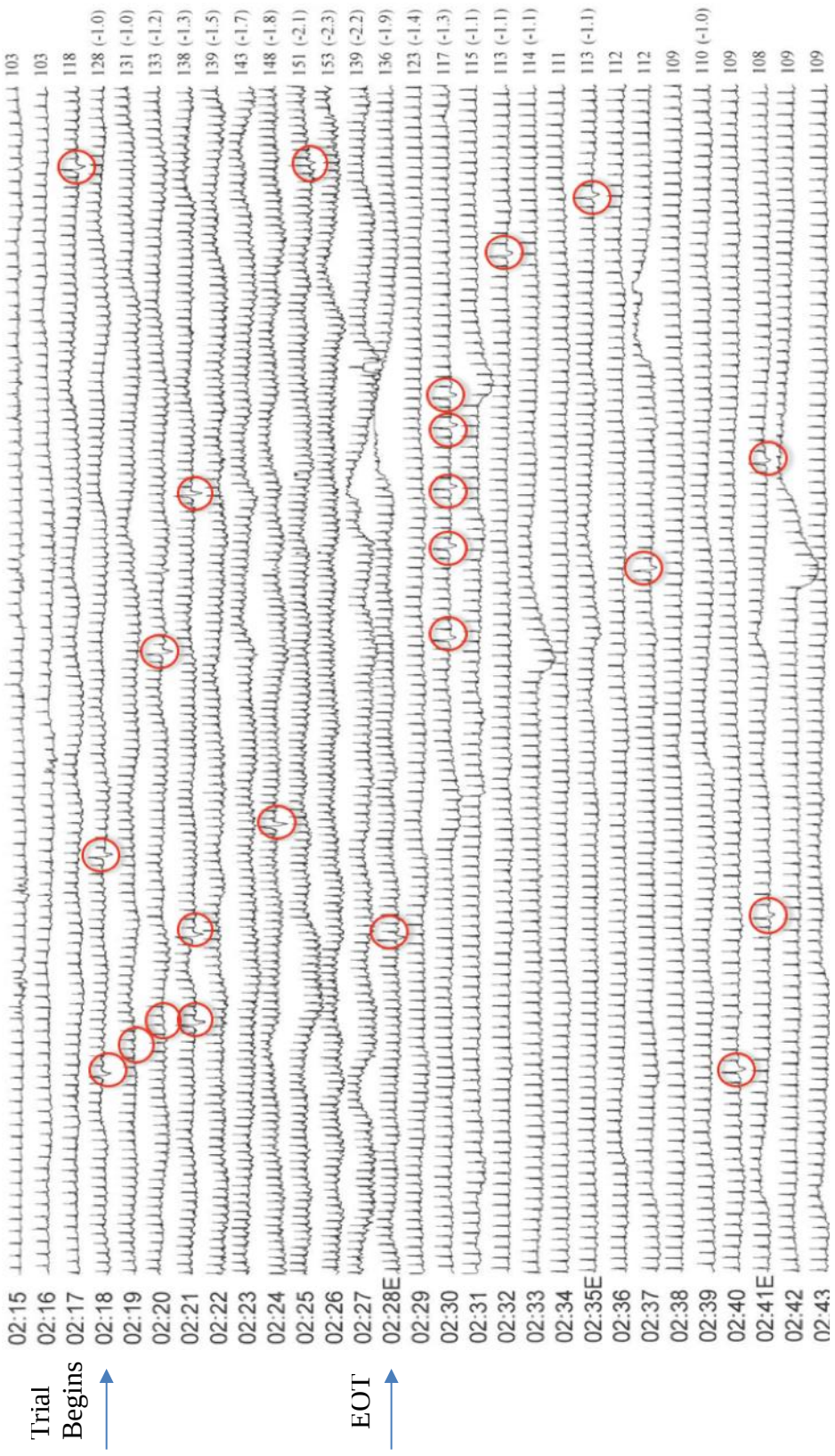

Figure 22. Subject with PVCs Before and After HO Trial

A larger sample size may have allowed for differences between the CO and HO trials to be statistically significant. Pedal CPR may be a viable option when rescuers perform CPR long enough to become fatigued with standard chest compressions. It may be that rescuers have difficulty assuming the kneeling position or using their arms, shoulders and back to perform standard chest compressions. Also, if rescuers are too light to compress the chest using their upper body weight combined with muscular strength in the arms, shoulders, and back, they may be able to more effectively perform chest compressions using their legs.

The general population is just now starting to accept compressions only CPR (cardiocerebral resuscitation) as opposed to compressions plus ventilation CPR (conventional CPR) (Berg et al., 1993; Hallstrom et al., 2000; Sanders et al., 1985). It may take a time for individuals to accept pedal CPR as a method but as it becomes introduced more to CPR training courses, it could become more accepted.

Chapter 5

Summary, Conclusions, and Recommendations

5.1 Summary

Providing quality chest compressions during CPR increases the chances of survival of those affected. In 2005, the AHA listed "pedal" chest compressions as an acceptable alternative to standard hands only chest compressions (Trenkamp & Perez, 2015). This heel method may be a reasonable alternative for those rescuers who cannot attain the floor and do not have the adequate cardiovascular or muscular strength. Additionally, in an emergency setting, being able to switch between methods may allow a rescuer to continue CPR until help arrives.

The present study evaluated the effectiveness of pedal CPR in older adults ranging from 56 to 71 years of age. More specifically, in having the choice between using the hands or pedal method and the ability to sustain chest compressions for at least ten minutes.

It was hypothesized that pedal CPR would be the method of choice when given the option during the CO trial. However, it was shown that there was no significant difference between the total times of pedal versus standard CPR during the CO trials. Additionally, there was no significant difference shown between the times of CO and HO trials, indicating that these participants were able to sustain chest compressions for the same amount of time during both trials.

It was anticipated that the CO trial also would yield lower RPE values, but there were no significant differences between the two trials at minutes 2, 5, and EOT. Individuals reported how they felt at specific points during the CPR trials.

However, when the individuals made comments at the end of the trials, they were either relieved at the fact that they had the option of pedal or switching between the two. Some even reported that they liked the pedal method more even though more coordination was necessary to perform it.

It was found that there were positive correlations between grip strength of the left and right hands and the CPR endurance times. Hand grip dynamometry is a global measure of overall strength and this showed that increased strength was related to CPR endurance.

This study analyzed the electrocardiograms of individuals participating in both trials, examining HR and ectopy. Essentially, it was found that HR was higher during the CO trial. However, PVC and PAC counts were much greater during the HO trials.

Due to the fact that the majority of sudden cardiac arrests occur in the home and they occur with older adults in society, it is important for the rescuer to recognize that pedal CPR is an acceptable method and that a rescuer may have this choice if they either need a break from standard CPR or if they cannot attain the ground.

5.2 Conclusions

1. Most senior adults are able to sustain “HO” CPR for ten minutes.
2. There is no significant difference in the ability of the senior adults to sustain either standard HO CPR or a combination of “pedal” plus standard HO chest compressions.
3. Heart rate response and relative aerobic exercise intensity are higher while performing the CO of HO plus pedal CPR than when performing HO CPR alone.

4. More cardiac ectopy may occur during HO CPR than when performing HO CPR in combination with pedal CPR.
5. There is a positive relationship between hand grip strength of the left or right hand and CPR performance endurance.

5.3 Recommendations

5.3.1 Future Research

Future researchers should attempt to recruit participants with a wide variety of age ranges, while still utilizing the inclusion criteria of ages 55 to 85. Additionally, disqualifying individuals who perform CPR in their day to day profession such as a nurse or a physician would allow for analysis of the general population.

Future research should take into consideration using the same manikin. Specifically, using the FH Zoll manikin where a variety of variables can be evaluated, such as compression fraction (i.e., quality), exact compression depth and rate, and total seconds without compressions. It should also be taken into consideration to change or modify the termination criteria. In the present study, termination criteria were loosely utilized due to the fact that it was evident that some participants were able to continue on regardless of whether they were five seconds past the failure to perform compression rate or depth. Particularly in the CO trial if the participants saw that they were unable to continue with one method they would switch to the other.

5.3.2 Performance in Cardiocerebral Resuscitation

The teaching of the pedal method would allow individuals to practice more than just watching a video on it or even practicing it once. Since it is an acceptable method according to American Heart Association, it should be taught as a lesson in CPR training

courses (Trenkamp & Perez, 2015). Additionally, teaching pedal CPR would allow for the rescuer to develop coordination of such a movement to improve over time, which was genuinely a concern of individuals during the CO trial of this present study. Wrist and shoulder fatigue was a concern in some of the participants, thus the option of switching from one method to the other may allow for a break period for fatigued muscle groups.

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Appendix A

Informed Consent Form

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT:

"A Comparison of "Hands-Only" Cardiopulmonary Resuscitation (CPR) to "Pedal" CPR Among Senior Adults".

A research project comparing two different CPR methods is being conducted by Dr. Steve Davis, Laura Yassa, David Drake, Kirsten Davis, Max Meyer, and others. Dr. Davis, David Drake, and Max Meyer are faculty in the Kinesiology Department at Cal Poly – San Luis Obispo. David Drake is also a clinical exercise physiologist in the Cardiac Rehabilitation Program at French Hospital. Kirsten Davis is a registered nurse at French Hospital. The purpose of this study is to investigate whether performing chest compressions during CPR with the feet, alternating with the hands, allows a rescuer to perform longer than if they are just using their hands. Extra endurance could be important if only a single rescuer is available to perform CPR while awaiting Emergency Medical Services.

You are being asked to take part in this study by completing a Physical Activity Readiness Questionnaire (PAR-Q). If your responses to these and our follow-up questions indicate to us that it is safe, we will then ask you to perform a test to measure your hand grip strength. Next, we will teach you "hands only" and "pedal" CPR on a manikin and give you a chance to practice both techniques. After this we will prepare you for the first of two CPR trials. During the trials we will monitor your heart rate, and we may also monitor your electrocardiogram. This will require the placement of up to 5 electrodes on the surface of your torso and wearing a recorder or transmitter as you perform CPR. Prior to placing electrodes the sites will be cleaned and scrubbed a bit with a cotton sponge soaked in isopropyl alcohol. You will then be asked to perform either "hands-only" or "hands-only" plus "pedal" CPR for up to 10 consecutive minutes. The trial will be discontinued earlier if you want to stop, if you are unable to compress the chest of the mannequin at least 2 inches for more than 5 consecutive compressions, if you are unable to make at least 80 compressions per minute, or if there is a medical reason (e.g. angina pectoris, shortness of breath, etc.) to discontinue the test. During the CPR trial you will be videotaped so that we can measure aspects of your performance such as how long you are able to perform CPR, as well as how much time you spend performing compressions with the hands vs. the feet during the combined methods trial. We will also ask you to rate your level of exertion on a 10 point scale, and after the trial is over we will ask you questions about how you felt while performing CPR as well as at the end of your trial.

After completing your first CPR trial you will be asked to "rest" (i.e. not perform another bout of CPR) for at least 15 hours, but no more than one week (168 hours), before you perform another CPR trial using the opposite method. In other words, if you perform the "hands-only" trial first, we will ask you to rest for at least 15 hours before performing the "hands-only" plus "pedal" CPR trial. The order in which you perform the CPR trials will be assigned at random so that half of all subjects will perform the "hands-only" trial first, and half will perform the combination methods trial first.

You may come to the Webb Human Performance Laboratory at Cal Poly for testing, or we can bring the equipment to you and test you in a location that is more convenient for you.

If you volunteer to participate, your participation in all the procedures is anticipated to take up to 2 hours. Please be aware that you are not required to participate in this research and you may discontinue your participation at any time without penalty. You also do not have to answer any questions you choose not to answer.

There are possible physical risks associated with participation in this study. Physical complications may occur such as delayed onset muscle soreness and/or discomfort, injury to the extremities or lower back, and associated pain. As with all studies involving exercise, there is a very remote risk of sudden death due to heart attack. If you should experience physical complications, you may contact your primary care physician for assistance, but you will be responsible for any costs of your medical care.

We will keep your medical history data confidential by removing face sheets containing identifying information from questionnaires, substituting code numbers for names or other identifiers, limiting the number of individuals with access to data, and storing data in locked cabinets and on password protected computers. The subject list that matches the code number with your identity will be kept in a secure location separate from the data. Your name and video or photo image will not be used in any reports of this research without your permission.

Potential benefits to you associated with the study include learning "hands-only" and "pedal" CPR, as well as your "grip strength" rating. Your participation will also add to the CPR provider knowledge base and may help improve successful resuscitation rates. The data collected from this study may be used to develop a cell phone app which rescuers can use to summon Emergency Care Providers and receive guidance while performing lone rescuer CPR.

If you have questions regarding this study or would like to be informed of the results when the study is completed, please feel free to contact Dr. Steve Davis (sdavis@calpoly.edu, (805) 756-2754). If you have concerns regarding the manner in which the study is conducted, you may contact Dr. Michael Black, Chair of the Cal Poly Human Subjects Committee, at (805) 756-2894, or Dr. Christopher Kitts, Dean of Research at Cal Poly, at (805) 756-1508, ckitts@calpoly.edu.

If you agree to voluntarily participate in this research project as described, please indicate your agreement be signing below. Please keep one copy of this form for your reference, and thank you for you participation in this research.

_____	_____
Signature of Volunteer	Date
_____	_____
Signature of Researcher	Date

Appendix B

Par-Q Plus Form

2018 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** _____	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it ***does not limit your current ability*** to be physically active. **PLEASE LIST CONDITION(S) HERE:** _____	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION
If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness centre may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

01-11-2017

2018 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	YES ☐ NO ☐

3. Do you have a Heart or Cardiovascular Condition? *This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm*

If the above condition(s) is/are present, answer questions 3a-3d If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐

5. Do you have any Metabolic Conditions? *This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes*

If the above condition(s) is/are present, answer questions 5a-5e If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	YES ☐ NO ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	YES ☐ NO ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	YES ☐ NO ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	YES ☐ NO ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	YES ☐ NO ☐

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6. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome*

If the above condition(s) is/are present, answer questions 6a-6b If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES ☐ NO ☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 10a-10c If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: _____

_____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

01-11-2017

2018 PAR-Q+

If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

For more information, please contact

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Citation for PAR-Q+
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Key References

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01-11-2017

Appendix C

Targeted Medical History Form

History Form

Date: _____

Name: _____
First Middle Last

Birthdate: _____
Month Day Year

Current Age: _____ years

Height: _____ inches

Weight: _____ lbs.

Have you ever received training in the performance of cardiopulmonary resuscitation (CPR)? (Yes/No): _____

Have you ever been certified to perform CPR by the American Heart Association, the American Red Cross, or some other organization?

Answer (Yes/No): _____

Have you ever performed CPR on a real person? (Yes/No): _____

Is there any reason, including medication, that might affect your ability to perform CPR?

Answer (Yes/No): _____

If "Yes", what might restrict your ability?

_____

_____

_____

Do you have a pacemaker and/or implantable cardioverter/defibrillator? (Yes/No): _____

Have you ever had a heart attack (myocardial infarction)? (Yes/No): _____

Have you ever had cardiac surgery? (Yes/No): _____

If "Yes", what kind?: _____

_____

Do you have difficulty with balance while in the standing position? (Yes/No): ____

Do you have difficulty kneeling on the floor? (Yes/No): _____

Do you have difficulty moving between the kneeling position and standing?

Answer (Yes/No): _____
Do you have difficulty moving between the standing position and kneeling?

Answer (Yes/No): _____

Has a physician instructed you not to perform vigorous exercise at this time?

Answer (Yes/No): _____

Do you ever experience any of the following on exertion? (Please check any that apply.)

chest pressure, discomfort, or pain: _____

heart rhythm abnormalities: _____

shortness of breath: _____

dizziness, fainting or blackouts: _____

musculoskeletal discomfort or pain: _____

burning or cramping in your legs: _____

Do you currently engage in resistance exercise on a regular basis? _____

If so, what kind? _____

Do you currently engage in aerobic exercise on a regular basis? _____

If so, what kind? _____

Appendix D

Data Capture Form

Data Capture Form

Date of Trial: _____

Time of Day: _____

Name of Subject:

_____

Location of Test Site:

_____

Hand Grip Strength

	Right Hand	Left Hand
1st Measurement:	_____ kg	_____ kg
2nd Measurement:	_____ kg	_____ kg
3rd Measurement:	_____kg	_____kg
Mean:	_____ kg	_____kg

"Hands-Only" CPR Trial: _____

"Hands-Only" + "Pedal CPR" Trial: _____

RPE @ 2 min.: _____ @ 5 min. _____ @ EOT _____ @ 10:00

EOT Time: _____ min _____ sec

Reason for EOT: _____

Comments: _____

_____

Appendix E

Normative Grip Strength Data

Appendix E

Normative Grip Strength Data (lbs.)

Men

Age Range (years)	Hand	Mean	SD	SE	Low	High
55-59	Right	101.1	26.7	5.8	59	154
	Left	83.2	23.4	5.1	43	128
60 – 64	Right	89.7	20.4	4.2	51	137
	Left	76.8	20.3	4.1.	27	116
65 – 69	Right	91.1	20.6	4.0	56	131
	Left	76.8	19.8	3.8	43	117
70 – 74	Right	75.3	21.5	4.2	32	108
	Left	64.8	18.1	3.7	32	93
75+	Right	65.7	21.0	4.2	40	135
	Left	55.0	17.0	3.4	31	119

Source:

Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., & Rogers, S. (1985). Grip and Pinch Strength: Normative Data for Adults. *Archives of Physical Medicine and Rehabilitation, 66*(2), 69-74.

Appendix E

Normative Grip Strength Data (lbs.)

Women

Age Range (years)	Hand	Mean	SD	SE	Low	High
55-59	Right	57.3	12.5	2.5	33	86
	Left	47.3	11.9	2.4	31	76
60 – 64	Right	55.1	10.1	2.0	37	77
	Left	45.7	10.1	2.0	29	66
65 – 69	Right	49.6	9.7	1.8	35	74
	Left	41.0	8.2	1.5	29	63
70 – 74	Right	49.6	11.7	2.2	33	78
	Left	41.5	10.2	1.9	23	67
75+	Right	42.6	11.0	2.2	25	65
	Left	37.6	8.9	1.7	24	61

Source:

Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., & Rogers, S. (1985). Grip and Pinch Strength: Normative Data for Adults. *Archives of Physical Medicine and Rehabilitation, 66*(2), 69-74.