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Comparison of the Physical Exertion of Two-Man Alternating and Two-Man Simultaneous Cardiopulmonary Resuscitation (CPR) Techniques

Ronald Myczek
Loyola University Chicago

COMPARISON OF THE PHYSICAL EXERTION OF TWO-MAN ALTERNATING AND TWO-MAN SIMULTANEOUS CARDIOPULMONARY RESUSCITATION (CPR) TECHNIQUES

by

Ronald Myczek, B.A.

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VITA

Ronald Myczek, the son of Mrs. Erna and Chester Myczek, was born May 5, 1955 in Chicago, Illinois.

His elementary education was obtained at Nazareth Lutheran School, Chicago, Illinois and secondary education at Luther High School South, Chicago, Illinois, where he graduated in 1973.

In September 1973, he entered Augustana College, Rock Island, Illinois, and in May 1977 received the degree of Bachelor of Arts with a major in pre-dentistry and biology.

In September of 1977, he entered the Oral Biology program of Loyola University of Chicago Graduate School. In June 1978 he was granted a teaching fellowship in the Department of Oral Biology. In December of 1978 he was accepted to the Loyola University School of Dentistry where his education will continue after obtaining his Masters of Science.

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INTRODUCTION AND LITERATURE REVIEW

According to the American Heart Association (1974), it is estimated that over 650,000 individuals die from cardiac arrests each year. About 350,000 of these deaths occur outside the hospital, usually within two hours after the onset of the symptons. With proper training and performance of cardiopulmonary resuscitation and emergency cardiac care, many of these lives could be saved or maintained until advanced life support is available. In addition, many victims who die as a result of such accidental causes as drowning, electrocution, suffocation, drug intoxication or automobile accidents could be saved by prompt and proper application of cardiopulmonary resuscitation. According to the National Academy of Sciences-National Research Council (1974) emergency cardiac care includes:

(1) Recognition of the early warning signs of heart attack;

(2) Provision of immediate basic life support at the scene;

(3) Provision of advanced life support at the scene; and

(4) Transference of the stabilized victim for continued cardiac care.

The second element, "basic life support", is the concern of this research project. The American Heart Association and the Research Council (1974) define basic life support as an emergency first aid procedure that consists of the recognition of airway obstruction, respiratory arrest, cardiac arrest, and the proper application of cardiopulmonary resuscitation (CPR). CPR consists of opening and maintaining

a patent airway, providing artificial ventilation by means of rescue breathing, and providing artificial circulation by means of external cardiac compression.

The accepted cardiopulmonary resuscitation techniques have been developed primarily by the American Heart Association and the American Medical Association. The goal of the National Research Council in 1973 was to recommend and provide a working guide for the performance of CPR. These were submitted and published in the Journal of the American Medical Association (1974).

When two trained rescuers are present for a cardiac arrest, the usual procedure is for one to compress the heart, while the other ventilates the lungs at a ratio of one ventilation per every five chest compressions. According to Wilder, et al (1963), the coordination of the two rescuers is difficult unless they have practiced together. Taylor, et al (1977), warns against the "quick jab" for compressions in order to accommodate the ventilation. Effrom (1977) states that external cardiac compression requires considerable exertion, therefore the rescuer performing cardiac compressions may fatigue and need to be relieved. The rescuer who was performing ventilations would switch to compressions and the compressor would now administer the artificial ventilation.

When only one rescuer is present for a cardiac arrest, he must perform both the compressions and the ventilations at a 15:2 ratio. Even if two rescuers are present, one rescuer may administer CPR according to this 15:2 pattern while the other summons aid or rests. When the rescuer administering CPR becomes fatigued, the second rescuer can take

over and continue the administration of CPR. With this technique, each rescuer "alternately" administers CPR.

A review of literature does not reveal any research which has correlated quantitatively cardiopulmonary resuscitation with other forms of physical exertion. Nor are there reports on a comparison between two-man simultaneous and two-man alternating or the physical exertion required by each method. All of the literature concerning CPR deals with the development of the techniques and instructional material.

Heart rate has been established as a quantitative indicator of physical exertion and its ease of monitoring has led to its frequent use. Schneider (1939) showed a linear relationship between heart rate and work load (foot-pounds per minute) in the case of a man working on a bicycle ergometer. Carlston and Grimby (1966) showed the effects of different levels of exercise on cardiovascular function and an increase in heart rate corresponding to an increase in work (kg-m/min). Wilmore (1975) states that use of heart rate as a parameter for measuring exercise intensity relates to the fact that the heart rate is a good indicator of actual work done by the heart. Wilson (1975) states that there is a direct correlation between increasing work load and heart rate during exercise in normal subjects.

PURPOSE

The standard technique of cardiopulmonary resuscitation by two rescuers involves having the two rescuers perform CPR together. The procedure is for one to ventilate the lungs while the other compresses the heart (two-man simultaneous rescue); one ventilation is given with each fifth compression. If only a single rescuer is available he must provide both the ventilations and the compressions; two ventilations are given after each fifteen compressions.

If two rescuers are present for a cardiac arrest, a decision may be made as to whether the two rescuers will work simultaneously (two-man simultaneous CPR) or, the two rescuers will work alternately (two-man alternating CPR). In this study the degree of physical exertion of each rescuer working simultaneously will be compared to the degree of physical exertion when the two rescuers alternately perform one-man rescue for a comparable period of rescue effort. Thus this study is not of the effectiveness of the rescue efforts of the "victim" but rather a comparison of the stress placed upon the rescuers. If two rescuers are confronted with an indeterminent period of administering cardiopulmonary resuscitation, which technique would allow for a longer performance: two-man alternating or two-man simultaneous?

In summary, the specific aim of this research project was to determine which technique of cardiopulmonary resuscitation requires less physical exertion on the part of the rescuer. Heart rate was the parameter measured throughout the study as the indicator of exertion.

MATERIALS AND METHODS

Data were collected from thirty male volunteers, all of whom had physical examinations including electrocardiograms prior to their use as subjects. These exams were required by the "Loyola University Medical Center Institutional Review Board for the Protection of Human Subjects." Electrocardiograms were taken by a technologist and each potential subject was then examined by a licensed physician in the Department of Medicine, Loyola University Medical Center. If the physician determined that the subject was in condition to perform the moderate physical activity required by CPR, he would sign an authorization.

The next step for a subject in the research project was to become trained and certified as a basic rescuer in cardiopulmonary resuscitation. Certification was given by Instructors of the American Heart Association after written and practical examinations.

The data collection periods involved one and one-half hours of uninterupted time and the coordination of two subjects. Upon arrival of the subjects at the data collection area in the Department of Physiology and Pharmacology at the Loyola University School of Dentistry, the subjects were given an explanation of the experiment and what was expected of them. They then signed a consent form which included the statement that if, at any time during the research project, a subject felt that he did not wish to continue he was free to discontinue his participation in the project. A Resusci-Anne mannikin was used for the

performance of the cardiopulmonary resuscitation technique. Appropriate materials for its maintenance and hygiene were also present. A Narco Physiograph with electrodes connected to the subjects' ankles and wrists was used to monitor the heart rates of the rescuers. For this, lead II (EKG) was recorded at a paper speed of one cm. per second.

The format of data collection during two-man alternating CPR was as follows: after signing the consent forms, both subjects had the electrodes attached and then lay beside the Resusci-Anne mannikin. Control heart rates were taken simultaneously for a three-minute period. After this initial three-minute period, one of the subjects, pre-designated subject A, would perform one-man cardiopulmonary resuscitation for the next three minutes, while the other subject, subject B, remained lying down. Each minute the rescuer performed 60 compressions and 8 ventilations (ie. four 15:2 cycles per minute). After this three-minute period, subject A would immediately lie down and subject B, who had been resting would begin his performance of one-man cardiopulmonary resuscitation. Upon completion of this second three-minute period, subject B would lie down again and subject A would continue the one-man technique. These alternating three-minute periods continued until each subject had performed one-man cardiopulmonary resuscitation for three, three-minute periods. The format of this data collection period is given in Table #1.

The format for collection of data during the two-man simultaneous CPR was as follows: after a three-minute period of base heart rate monitoring, subject A would initiate the two-man simultaneous technique by performing compressions first. The subject would perform compressions

TABLE #1

FORMAT OF DATA COLLECTION FOR TWO-MAN ALTERNATING CPR

3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.
SUBJECT A							
BASE HEART RATE TAKEN IN RESTING POSITION	PERFORMS CPR	ASSUMES RESTING POSITION	PERFORMS CPR	ASSUMES RESTING POSITION	PERFORMS CPR	POST PERF. HEART RATE TAKEN	
SUBJECT B							
BASE HEART RATE TAKEN IN RESTING POSITION	REMAINS IN RESTING POSITION	PERFORMS CPR	ASSUMES RESTING POSITION	PERFORMS CPR	ASSUMES RESTING POSITION	PERFORMS CPR	POST PERF. HEART RATE TAKEN
			TOTAL TIME ELAPSED				
3 MIN.	6 MIN.	9 MIN.	12 MIN.	15 MIN.	18 MIN.	21 MIN.	24 MIN.

alone at the standard rate of 60 per minute as indicated by the mannikin's built-in metronome. He would perform these compressions for the first three-minute period while subject B was resting. After the first three-minute performance period, subject A would switch from compressions to ventilations and subject B would start compressions. For the next four three-minute periods they administered CPR as follows: compressions by one subject at the rate 60 per minute and ventilations by the other at 12 per minute. Each ventilation was performed on the upstroke of every fifth compression. During the next-to-last three-minute period, the subject who initially performed compressions assumed the resting position and had his heart rate recorded. Subject B performed compressions during this period, and then assumed the resting position to have his heart rate recorded. The format of this data collection period is in Table #2.

Although one of the subjects completed his performance prior to the other, he had initially begun the performance of CPR one period or three minutes prior to the other subject. Designation of subject A or B was random. A metronome, which is built into the mannikin, was used to ensure that the proper timing was maintained. The researcher monitored correct cardiopulmonary resuscitation techniques by observing the signal lights attached to the mannikin.

After both subjects completed part one, the leads were disconnected. The fifteen groups of two subjects per group were randomized in respect to which technique was performed first. Eight groups of subjects performed the two-man alternating (one-man CPR) followed by the twenty-minute rest period before performing the two-man simul-

TABLE #2

FORMAT OF DATA COLLECTION FOR TWO-MAN SIMULTANEOUS CPR

3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.	3 MIN.
SUBJECT A							
BASE HEART RATE TAKEN IN RESTING POSITION	COMPRESSES	VENTILATES	COMPRESSES	VENTILATES	COMPRESSES	POST PERF. HEART RATE TAKEN	
SUBJECT B							
BASE HEART RATE TAKEN IN RESTING POSITION	REMAINS IN RESTING POSITION	COMPRESSES	VENTILATES	COMPRESSES	VENTILATES	COMPRESSES	POST PERF. HEART RATE TAKEN

TOTAL TIME ELAPSED

3 MIN.	6 MIN.	9 MIN.	12 MIN.	15 MIN.	18 MIN.	21 MIN.	24 MIN.

taneous (two-man CPR). Seven groups performed the two-man simultaneous technique followed by a twenty-minute rest period and then performed the two-man alternating resuscitation.

The heart rates were counted using the R-wave as the indicator of each heart beat. If a PQRST complex was divided a time-interval, the top portion of the R-wave determined to which interval that particular heart beat correlated.

RESULTS

The results consisted of four three-minute periods of monitored heart rate per subject: before and after two-man alternating rescue, and before and after two-man simultaneous rescue. The base heart rates generally remained constant throughout the three-minute periods while the subjects were in the resting position, and were not broken down into smaller time intervals. The average was used for subsequent comparisons. The three-minute periods after the performance of the two methods of CPR administration were broken down into smaller intervals: the first fifteen seconds, the first thirty seconds, the first, second, and third minutes, and the entire three minute period.

The change from base rate after performing CPR was desired. The average base heart rates prior to performing two-man alternating and two-man simultaneous were 61.3 and 61.0 per minute respectively. The post-performance rates were converted to percentages of their respective base rates. If a subject's resting heart rate was 64 and after performing one of the techniques his rate for the first thirty seconds was 80, the percentage was 125. The percentages are given in Table #3 for two-man alternating and Table #4 for two-man simultaneous.

These percentages were then statistically analyzed, using the two-tailed t-test to determine if any significant differences ($P \leq .05$) existed between corresponding time intervals of the two techniques (Table #5). During the first fifteen seconds, the P-value is between 0.40 and 0.70. It drops off to a range of 0.30-0.40 for both the first

TABLE #3

HEART RATES FOLLOWING TWO-MAN ALTERNATING CPR

SUBJECT #	RESTING HEART RATE	POST-PERFORMANCE HEART RATE/PERCENTAGES OF RESTING HEART RATE SECONDS					
		0-15	0-30	0-60	61-120	121-180	0-180
1	72	84/117	76/106	70/97	61/82	60/80	63/86
2	56	92/164	88/157	84/150	77/138	70/125	77/138
3	52	80/154	74/142	68/130	57/110	54/104	60/115
4	68	92/135	86/124	81/119	68/100	69/109	73/107
5	52	96/185	86/165	77/148	63/121	59/113	66/127
6	72	104/144	98/136	93/129	85/118	79/109	86/119
7	76	116/153	98/129	87/114	80/115	82/108	83/109
8	68	80/117	82/120	77/113	72/106	68/100	72/106
9	60	80/133	72/120	65/108	58/97	54/89	59/98
10	76	112/147	104/137	95/125	87/114	85/112	89/117
11	84	124/148	120/143	116/138	109/130	100/119	108/129
12	64	108/169	90/141	82/128	73/114	73/114	76/119
13	100	104/104	106/106	101/101	99/99	87/87	96/96
14	76	112/147	104/137	97/128	88/116	88/116	91/120
15	52	88/169	84/162	76/146	62/119	60/115	66/127
16	52	84/162	72/138	67/129	53/102	54/104	58/112
17	56	84/150	76/136	69/123	57/102	55/98	61/109
18	72	100/139	98/136	93/129	79/110	82/114	85/118
19	72	124/172	112/156	98/136	78/108	91/126	89/123
20	48	64/133	58/121	54/112	50/104	46/96	50/104
21	100	116/116	112/112	107/107	106/106	104/104	102/102
22	64	100/156	92/144	85/133	70/109	64/100	73/114
23	80	112/140	102/128	97/121	86/108	81/101	88/110
24	76	132/174	118/155	107/141	89/117	84/111	93/122
25	100	156/156	150/150	138/138	121/121	113/113	124/124
26	88	124/141	110/125	98/111	81/91	79/87	86/98
27	84	120/143	107/127	100/119	85/101	82/98	89/106
28	74	106/143	100/135	95/128	87/118	81/109	88/119
29	64	84/131	76/119	69/108	62/97	58/92	63/98
30	98	114/116	110/112	105/107	104/106	102/104	100/102

TABLE #4

HEART RATES FOLLOWING TWO-MAN SIMULTANEOUS CPR

SUBJECT #	RESTING HEART RATE	POST-PERFORMANCE HEART RATE/PERCENTAGES OF RESTING HEART RATE SECONDS					
		0-15	0-30	0-60	61-120	121-180	0-180
1	64	88/138	76/119	69/108	62/197	59/92	64/100
2	68	104/153	98/144	91/134	79/116	74/109	81/119
3	52	68/131	64/123	60/115	52/100	52/100	55/106
4	72	80/111	74/103	74/103	69/96	68/94	70/97
5	56	92/164	84/150	75/134	59/105	56/100	64/114
6	72	112/156	102/142	96/133	87/121	79/110	87/121
7	76	88/116	82/108	78/103	74/97	77/101	76/100
8	64	80/125	76/119	74/116	65/102	65/102	68/106
9	52	72/138	66/127	61/117	56/108	53/102	57/110
10	72	116/161	102/142	94/131	86/119	81/113	87/121
11	88	136/154	130/148	124/141	113/128	103/117	113/128
12	68	80/118	76/112	72/106	64/94	65/95	67/97
13	108	112/104	108/100	102/94	94/85	91/81	96/88
14	88	92/104	86/98	82/93	73/80	76/84	77/86
15	56	84/150	74/132	69/123	61/109	55/98	62/89
16	56	80/143	70/125	62/111	51/90	51/90	55/98
17	52	76/146	70/135	66/127	57/110	56/108	60/115
18	76	116/153	102/134	89/117	71/93	71/93	77/101
19	64	132/206	118/184	106/165	94/147	97/152	99/155
20	52	64/123	58/112	54/104	51/98	49/94	51/98
21	96	116/121	112/117	109/114	105/109	105/109	106/110
22	68	92/135	84/124	77/113	65/95	66/97	69/101
23	72	114/144	96/133	91/126	83/115	80/111	85/118
24	76	128/168	118/155	104/136	93/122	85/112	94/124
25	78	136/174	134/171	127/162	114/146	112/143	117/150
26	86	108/126	102/119	94/109	91/106	80/98	88/102
27	80	124/155	112/140	104/130	98/123	96/120	99/124
28	76	116/153	106/140	100/131	91/120	81/107	91/120
29	58	78/134	72/124	67/116	62/107	59/102	63/109
30	100	120/120	116/116	113/113	109/109	109/109	110/110

thirty seconds and the first minute. For the second minute, the closeness of the means, 108.9 and 108.2 and the high P-value, continue to indicate no statistically significant differences between techniques. The final minute likewise shows no statistically significant difference between techniques, 105.2 and 104.9 for the mean percentages and a P-value of 0.90. For the entire three-minute period, the means differ by only 1.4%, and the P-value lies between 0.70 and 0.40.

TABLE #5

STATISTICAL ANALYSIS OF RESCUER HEART RATE CHANGES FOLLOWING CARDIOPULMONARY RESUSCITATION

TWO-MAN ALTERNATING CPR

BASE RATE AVERAGE--61.3

	SECONDS					
	0-15	0-30	0-60	61-120	121-180	0-180
MEAN PERCENTAGE OF BASE RATE	145	134	124	109	105	112
STANDARD DEVIATION	19	15	14	11	11	11

TWO-MAN SIMULTANEOUS CPR

BASE RATE AVERAGE--61.0

	0-15	0-30	0-60	61-120	121-180	0-180
MEAN PERCENTAGE OF BASE RATE	141	130	120	108	105	111
STANDARD DEVIATION	22	20	17	15	14	16

P-VALUE	0.70>P>0.40	0.40>P>0.30	0.40>P>0.30	0.90>P>0.80	0.90>P	0.70>P>0.40

DISCUSSION

The same number of ventilations and compressions were performed by the subjects during each technique. For two-man alternating, each subject performed 60 compressions per minute for nine minutes, and 8 ventilations per minute for nine minutes, for a total of 540 compressions and 72 ventilations. For two-man simultaneous, each subject performed nine minutes of compressions at 60 per minute and six minutes of ventilations at 12 per minute, for a total of 540 and 72 respectively. Also for both techniques the methods of external cardiac massage and mouth-to-mouth ventilations were identical, therefore, any differences in physical exertion would be attributed to the sequence of CPR administered during a rescue.

Heart rate has been established as an indicator of physical exertion. The rates after the performance of each technique were converted to percentages of the resting rate and used in comparison of the two techniques, utilizing the two-tailed t-test. The P-values for all comparisons of monitored heart rate indicate no statistically significant differences between two-man alternating and two-man simultaneous CPR.

Although no statistical difference was found between techniques, certain observations should be discussed. For two-man simultaneous CPR the coordination of the two subjects is difficult especially in regard to performing the ventilation on the upstroke of the fifth compression. In order to properly coordinate the fifth compression with the ventil-

ation, the compressor must count out loud so that the ventilator knows when to inflate the lungs. If this coordination is not properly achieved, the compressor ends up pressing down on a chest full of air. In order to accommodate the ventilator, the compressor may apply a "quick jab" to allow sufficient time to interpose the ventilation. Taylor, et al (1977), states that the effectiveness of external cardiac compression is dependent on duration of compression rather than rate. Also, Wilder, et al (1963), states it may be difficult to achieve coordination of compressions and ventilations unless the two rescuers have practiced together because when external compressions and ventilations are carried on independently during resuscitative efforts, it is difficult for the individual performing artificial respiration to determine whether or not he is moving the chest and providing adequate oxygenation. Finally, the constant performance of compressions and ventilations affords no rest period to recover from fatigue.

In a two-man alternating CPR rescue, the coordination of compressions and ventilations is much easier because of the fact that the same subject is performing both. However, a pause in artificial circulation occurs (approximately 4 seconds) while the rescuer administers the ventilations and 10 to 12 seconds elapse between the artificial ventilations in comparison to only 5 seconds during a two-man simultaneous CPR rescue. With two rescuers present and only one performing both compressions and ventilations, when the rescuer administering CPR becomes fatigued, he can be relieved by the other.

SUMMARY

If two trained rescuers are confronted with an indeterminent period of performing CPR, they may administer either as two-man alternating or two-man simultaneous rescue. For a comparable period of rescue effort, no statistically signifcant differences were found for the degree of physical exertion by the two methods of CPR administration. Heart rate was used as an indicator of physical exertion.

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APPROVAL SHEET

The thesis submitted by Ronald Myczek has been read and approved by the following committee:

Dr. Donald B. Doemling, Director
Professor, Physiology & Pharmacology, Loyola

Dr. Joseph Gowgiel
Associate Professor and Chairman, Anatomy, Loyola

Dr. Ioannis S. Scarpa
Assistant Professor and Chairman, Biochemistry, Loyola

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Masters of Science in Oral Biology.

December 14, 1979
Date

Donald B. Doemling
Director's Signature
Donald B. Doemling, Ph.D.