POST-EXERCISE CAROTID AND RADIAL ARTERY PALPATION AS INDICATORS OF HEART RATE DURING EXERCISE

by

WILLIAM COULDRY

B.S.E., Missouri Western State College, 1979

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education, Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

Approved by:

Charles B. Corbin
Major Professor

DEDICATION

"Beside all great men stands a woman." The woman beside me is my wife. I dedicate all of this work to her and my family who gave up more than anyone should be required to give. Their love, hope, understanding and moral support made this possible. To you Shirley my loving wife and my children Richard, Chris, and Bill Ann thanks for making it worthwhile.

Love,

Bill

ACKNOWLEDGMENTS

Deepest and sincere appreciation is expressed to all who served on my committee, Dr. Charles Corbin, Chairman, Dr. Larry Noble and Dr. Dave Danskin. Special appreciation is expressed to Dr. Corbin for making his time available to me and also for invaluable assistance throughout this study. Much appreciation also goes to Dr. Tony Wilcox for his assistance and help in getting my study started and headed in the right direction. Also, to all the GTA's who gave me moral support especially Kent Fox and his wife Linda.

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Chapter 1

INTRODUCTION

Suggestions in recent studies that aerobic physical activities provide some protection against coronary disease have generated widespread interest in exercise programs (Karvonen, 1957; Cureton, 1969; Astrand, 1970; ACSM, 1978; DeVries, 1980; and McArdle et al., 1981). Though exercise is desirable for promoting many different aspects of health related fitness, it is generally acknowledged that there is an appropriate amount of exercise necessary for producing optimal fitness gains. Since cardiovascular fitness is perhaps the most important aspect of health related fitness, the determination of the correct intensity of exercise for building this aspect of fitness is especially important. Heart rate has long been used to monitor the intensity of the aerobic physical activity to insure that the activity level is sufficient to promote a "training" effect (Astrand, 1970; ACSM, 1978; Corbin et al., 1978; DeVries, 1980; and McArdle, 1981) but not so intense as to be dangerous to the individual.

Heart rate has a near linear relationship with oxygen uptake at maximal exercise levels (Rodahl et al., 1974). For this reason exercise heart rate is often used in submaximal fitness tests. During or after exercise, the heart rate is determined, the lower the heart rate for a given work load the better the predicted oxygen uptake or the better the cardiovascular fitness. Thus, post exercise heart rate is important in two ways: (1) to determine the appropriate intensity of exercise for promoting cardiovascular fitness gains, and (2) for making submaximal determination of cardiovascular fitness.

Accurate assessment of post exercise heart rates can be accomplished through laboratory techniques using the electrocardiogram and biotelemetry systems. However, these systems have limited value because they are not available to the average person. In most field situations individuals are forced to use palpation of arterial pulse to count heart rate. This procedure is easy to do and requires little equipment. The most common palpations currently used by exercisers are palpations of the radial and the carotid arteries.

Carotid artery palpation is recommended by several authorities (Byrd et al., 1972; Fletcher and Cartwell, 1974; Zohman, 1974; Wenger and MacHab, 1975; Pollock et al., 1977; and DeVries, 1980). However, some suggest that it may be dangerous. White's (1975, 1977) studies reflect the potential danger of carotid artery palpation. Physiological changes in some subjects were first reported by Weiss and Baker (1933) due to pressure on the carotid artery. One of the changes was slowing of the heart rate along with syncope and electrocardiographic changes. Guyton (1981) says pressure on the carotid sinuses can cause a strong response in older people that can stop the heart for seven to ten seconds.

For the reasons stated above there may be problems associated with the common procedure of using the carotid pulse in determining the intensity level of exercise based on heart rate. Since heart rate is used to determine the heart rate needed to have a "training" effect on the cardiovascular system, and since the carotid palpation may actually affect recovery heart rates, this procedure may cause an inaccurate post exercise heart rate count. Specifically, the possible slowing effect associated with taking the carotid pulse, may result in the intensity of exercise determined from post exercise palpations being overestimated. Thus the exerciser may work at a higher level of intensity than desired.

Though the possible problems with using the carotid pulse are documented in the previous section, not all experts agree on the subject. Pollock says there is no decrease in heart rate due to carotid artery palpation, nor is there significant difference between heart rate during exercise and post-exercise heart rates (1981). Another study by McArdle reports a rather significant change in post-exercise heart rate as an indicator of heart rate during exercise (1969). White's study showed drastic changes in post-exercise heart rate when palpated at the carotid artery (1975, 1977).

In summation there is a controversy in the research which needs to be settled. The use of palpation methods may affect the heart rate and the area of palpation can have an effect on the heart rate as criterion for heart rate during exercise. This information may effect people in physical education and related fields.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine if two palpation methods (carotid and radial) could be used to accurately assess heart rate. Specifically, the accuracy of the two methods was determined by comparing heart rate counts using these methods to three EKG criterion scores: (1) resting heart rate, (2) exercise heart rate, and (3) post-exercise heart rate.

LIMITATIONS

The following were considered as possible limitations of this study.

1. The ability of the subject to count their heart rate.
2. Errors that may arise in the use of the equipment or its functions.

DELIMITATIONS

The delimitations that were made to define the limits of this study follow:

1. Subjects were limited to the age group of thirty to forty years of age.
2. Sampling of this age group was also limited to those who have been exercising for a minimum of the last three months.
3. The sample size was limited to twenty people.
4. Subjects were limited to those at Kansas State University and the city of Manhattan, Kansas.
5. Only two palpation technique methods were used in this study.

Chapter 2

REVIEW OF THE LITERATURE

Individuals need to know what type of exercise to do, which ones are good and bad, and how to perform each exercise correctly. For cardiovascular fitness it is important for individuals to know the correct intensity of exercise necessary to produce a training benefit especially if the prevention of cardiovascular diseases is the goal. Cooper (1965) and others advocate the continuous type program such as walking, jogging, cycling, swimming, and running in place while Astrand (1970) and colleagues recommended the intermittent type program. To select an effective program it is important to be able to count exercise heart rate accurately. The literature has been reviewed to give the reader an overview of research related to various heart rate palpation techniques.

DETERMINING EXERCISE INTENSITY

Regardless of the type of exercise chosen, selection of the appropriate amount of exercise is critical. However, determining the amount of exercise can be a problem for the exerciser. Once the exercise modality is chosen, the problem is to determine the correct intensity (how hard), duration (how long), and frequency (how often). The questions "How much exercise is enough?" and "What type of exercise is best for developing and maintaining fitness?" are frequently asked.

For best results exercise must be done above the "Threshold of Training" (Chart 1). The "Threshold of Training" is the minimal amount of exercise necessary to benefit the cardiovascular system (McArdle et al., 1967; Astrand, 1970; Corbin et al., 1978; Terry et al., 1979; and DeVries, 1980). Exercise heart rate can be used to determine threshold values. While the threshold represents the lower level of heart rate necessary to produce cardiovascular fitness, the target zone represents the optimal level. In other words one must elevate the heart rate higher than the threshold and to an optimum target value if fitness is to be produced (see Chart 1).

Chart 1. Optimal Exercise Intensity

	EXERCISE IN EXCESS OF THAT NECESSARY TO IMPROVE FITNESS	MAXIMAL	HIGH INTENSITY	HIGH HR
THRESHOLD		UPPER THRESHOLD	↑	↑
OF		OPTIMAL OVERLOAD		
TRAINING		LOWER THRESHOLD	LOW INTENSITY	LOW HR
	EXERCISE NOT SUFFICIENT TO IMPROVE FITNESS	NORMAL		

Corbin, Dowell, Lindsey, and Tolson. Concepts in Physical Education--Instructor's Resource Manual, 3rd ed. Dubuque, Iowa: William C. Brown, 1978, pp. 75.

DeVries (1980) offers two ways to determine intensity levels, by dose (a given distance being covered) or response (based by heart rate). Heart rate is by far a safer and more practical method of prescription. Dose allows for no control of intensity--a set distance is given to be covered but no time. Whereas heart rate allows a control over the intensity.

It is generally accepted that the threshold heart rate is 60% of one's heart rate range and that the target zone is 60 to 80% of one's heart rate range (Karvonen, 1957). Maximum heart rate is established as 220 minus the person's age. Maximum heart rate minus resting heart rate times 60 percent plus resting heart rate is equal to the threshold of training. (Threshold of training = .60 [(220 - age) - Resting HR] + RHR.)

Costill (1968) used 5 well trained distance runners for whom the Karvonen Method overpredicted measured % $\dot{V}O_2$ max. Costill's finding showed the overprediction of exercise intensity to be 4% at 60% exercise intensity which falls in line with Davis (1977). Davis' (1975) study seems to be the first to systematically evaluate the accuracy of the Karvonen method to % $\dot{V}O_2$ max. None of the Karvonen method predictions of exercise intensity were significantly different from the measured values. The Karvonen method resulted in only a 2.6% above the Net $\dot{V}O_2$ max. Taylor's (1969) study of heart rate showed 50% $\dot{V}O_2$ max by Astrand method roughly corresponds with 6% max heart rate range by the Karvonen method. Though training intensity determined from measures of oxygen consumption is highly accurate, it is impossible without special equipment. The use of heart rate to establish exercise in terms of intensity is an effective alternative. The relationship between Astrand $\dot{V}O_2$ max and Karvonen heart rate range is very constant. This study shows the application of the progressive overload principle in that those of high fit were not stressing the system above the normal. Higher fit subjects need greater absolute intensity (higher workload) to stress the system. DeVries (1977) also feels heart rate max relates very closely to actual $\dot{V}O_2$. He feels there is a clear advantage in expressing the exercise heart rate in percent of heart rate max. McArdle et al. (1981) says that heart rate max and % $\dot{V}O_2$ max are related in a predictable way regardless of sex or age. He relates only an error of ±8% in predicting one from the other (Chart 2).

Chart 2. Relation between Percent Max $\dot{V}O_2$ and Percent Max Heart Rate

PERCENT MAX H.R.	PERCENT MAX $\dot{V}O_2$
50	28
60	42
70	56
80	70
90	83
100	100

William D. McArdle, Frank I. Katch, and Victor L. Katch. Exercise Physiology. Lea and Febiger, 1981.

Cureton (1969) indicated that a heart rate of 150 beats/min is essential for a training effect to occur, while Cooper (1965) has indicated by his point system that an inverse linear relationship exists between intensity and duration of training. Burke (1975) showed a minimum intensity requirement of 75% of heart rate max to show aerobic improvement. Atomi's (1978) study using young women indicates that intensity is a more important factor than frequency for improving $\dot{V}O_2$ max. His subjects showed improvement by working at 60% $\dot{V}O_2$ max--with heart rate range of 140-150 beats/min--for 8 weeks. Wenger (1975) had similar findings in that submaximal training was similar to heavy workloads as long as the relative training load is at least 60% $\dot{V}O_2$ max. He used two groups training at 100% and 60% of their $\dot{V}O_2$ max for 7 weeks comparing low fit subjects to high fit subjects. Gledhill (1972) compared high fit to low fit at the same intensity of 120 beats/min., only the low fit group improved significantly.

Astrand (1970) has a general principle to cover the low and high fit difference: "An adaptation to a given load takes place; in order to achieve further improvement, the training intensity has to be increased." The overload must increase as the body adjusts to the load to show more gain.

McArdle et al. (1981) uses the term "training-sensitive zone." He feels people should consider themselves "average" and use the age adjusted maximum heart rate in Chart 3. All people of particular age don't fit; there is usually a ±10 beat/min individual variation. He uses a "Rule of Thumb," maximum heart rate is established as 220 minus the person's age. By the chart (Chart 3) as long as the exercise heart rate is maintained within this zone a conditioning of the aerobic systems occurs.

Pollock's (1981) study showed high intensity levels are not necessary to maintain cardiovascular fitness in middle-aged men. Using fourteen sedentary men in Pollock's data showed that intensity can be decreased provided that direction increases as long as total energy costs remain equal.

One of two methods can be used to determine what the "Target Heart Rate" needs to be to raise intensity to reach the "Threshold of Training."

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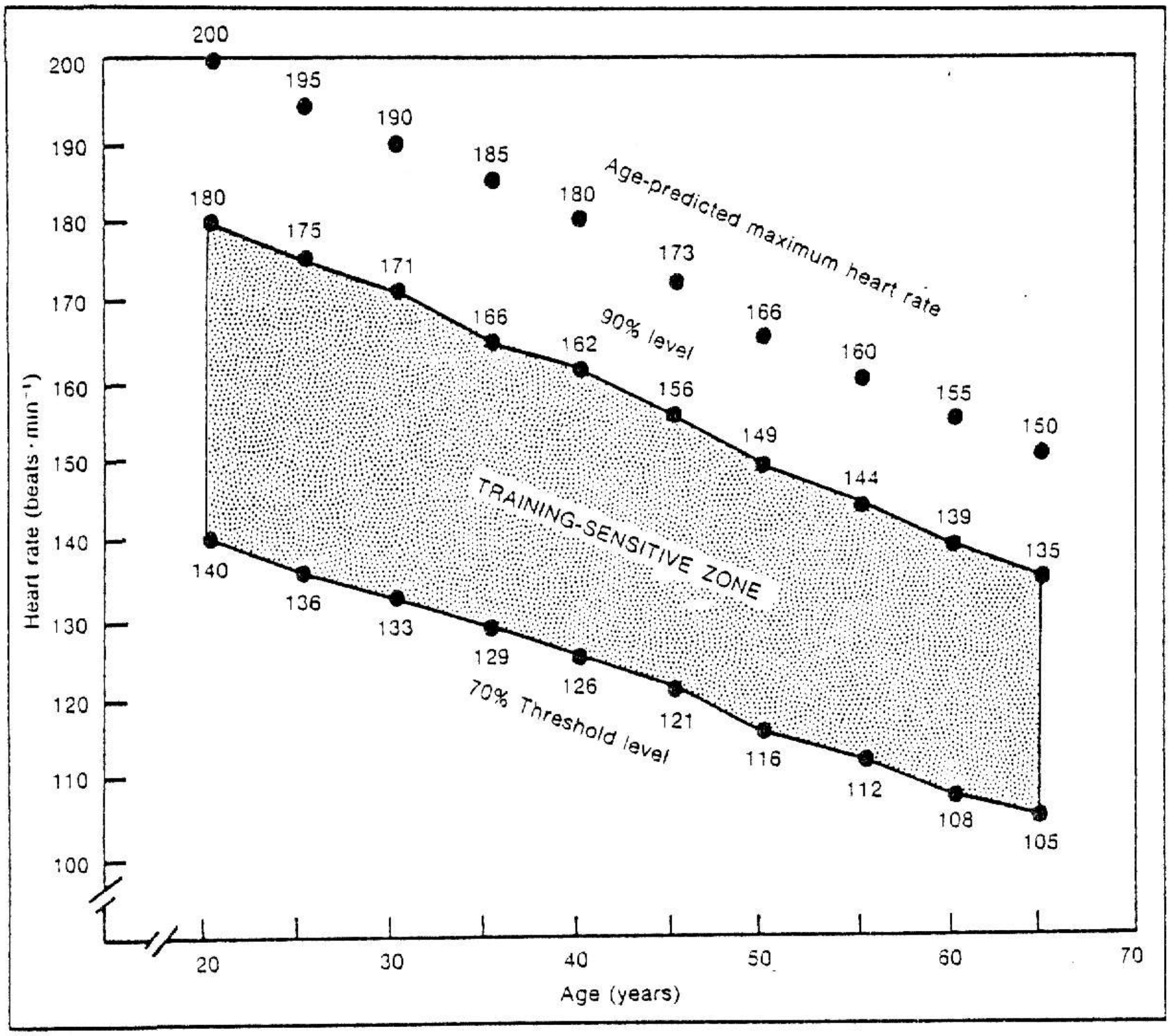
Chart 3. Maximal Heart Rates and Training-Sensitive Zones for Use in Aerobic Training Programs for People of Different Ages



Frank I. Katch and William D. McArdle. Nutrition, Weight Control, and Exercise. Houghton Mifflin Company, 1977.

(1) Karvonen method % heart rate range

(2) Astrand % $\dot{V}O_2$ max

Based on the evidence "Threshold of Training" is at least 60% of heart rate range or 50% of $\dot{V}O_2$ max.

METHODS OF DETERMINING HEART RATE

Heart rate response is a better method for determining intensity than is prescription, or even $\dot{V}O_2$ max. Heart rate range has its advantages in that sophisticated equipment is not necessary to predict or monitor it. The American College of Sports Medicine (1978) recognizes the need for guidelines and is in agreement with intensity levels along with frequency, duration, and mode of activity.

With the understanding of the threshold of training and target heart rate, we need a field procedure for monitoring based on the heart rate itself. This heart rate allows for the governing of the intensity level. Palpation of the carotid artery is recommended by various authorities. Included among these are authorities in exercise and coronary heart disease like Fletcher and Cartwell (1974), as well as Naughton and Hellerstein (1973). The use of target heart rate and carotid heart rate monitoring are tools of some Cardiac Rehabilitations and Exercise Prescriptionists. Carotid artery monitoring is also being advocated in books on exercising (Davies and Knibbs, 1971; Gledhill et al., 1972; Zohman, 1974; and Corbin et al., 1978).

One of the first studies approaching the possible problem of palpation techniques was a study by Cotton and Dill (1935). Their study dealt mainly with immediate recovery from strenuous work. They were studying the accuracy of prediction of true exercise heart rate from observations made in recovery. They found a ten second reading immediately after exercise to be the best way to approximate. Their study dealt with only immediate recovery from strenuous work.

McArdle, Zwiren, and Magel used varying intensities along with different number of times to count post-exercise heart rates (1969). The heart rate was counted immediately following exercise, starting at four seconds and at ten seconds post-exercise. They found a 7.6 percent average error during the ten seconds of recovery period. In the four second recovery (four to fourteen seconds) the average underestimations increased to 5.7 percent in strenuous work and to a maximum of 13.5 percent in more moderate exercise. McArdle says, "This variability may introduce serious errors when the post-exercise heart rate is used to infer the heart rate during exercise." McArdle used only ten male volunteer students with a mean age of twenty years.

Pollock, Broida and Kendrick's study concluded that training heart rates of 80 percent to 90 percent magnitude can be accurately estimated during recovery for ten seconds (1981). The palpation technique for estimating heart rate can be adequately assessed by adult men while in training. They suggest post-exercise heart rate to within 2 percent for their age group of twenty-five to fifty-five year old males. They based their findings and study on maximum and percent of maximum heart rate values.

Though previous studies recommended the carotid pulse for counting heart rate, studies by White showed a cardiac slowing and occasionally cardiac abnormalities from palpation of the carotid artery (1975, 1977). White used 117 subjects between the ages of twenty-three and sixty-three, male and female. His study showed a 14 percent average decrease in heart rate due to carotid sinus reflex from palpation techniques. From these 117 subjects, 101 showed a significant decrease in heart rate following carotid artery palpation. Weiss and Baker state that the reduced heart rate is due to a reflex increase in the vagal nerve to the heart and a simultaneous reflex inhibition of the cardiac accelerator nerves (1933). Weiss and Baker claim that, in a small percentage of patients, "definite pathological changes" occur following carotid sinus simulation (1933).

SUMMARY

While there are not many studies in this area there is some discrepancy in findings. Cotton and Dill (1935), McArdle, Zwiren, and Magel (1969), and White (1975, 1977) show changes in the post-exerciser's heart rate of 5 percent to 14 percent as compared to actual heart rate. Pollock, Broida, and Kendrick (1981) only show a 2 percent change which would lead you to believe that post-exercise heart rates are good indicators of actual heart rate.

White's studies (1975, 1977) indicate that palpation of the carotid artery could be hazardous to health and also a poor indicator of heart rate. If so the radial artery palpation may be a better indicator of actual post heart rate.

Boone, Rape, Ribisl, and Miller (1980) state that "the carotid technique should be used with some caution when training cardiac patients to keep them from training at too high heart rate response during the endurance phase of a typical cardiac training session." Their study dealt with 40 patients from the Wake Forest Cardiac Rehabilitation Program. The experimenter palpated in the first minute and the subject in the third minute of resting, exercise, and recovery. There was a significant drop in heart rate during recovery with palpation by both experimenter and subject.

Chapter 3

PROCEDURES

SELECTION OF SUBJECTS

Subjects in this study were twenty healthy males and females (12 males and 8 females) between the ages of thirty and forty years ($\bar{X}$ = 33.8, S.D. 2.5) and who had pursued a program of aerobic exercise for at least three months.

PROCEDURES

Subjects reported to the laboratory for orientation which included (1) an introduction to procedures and equipment and methods of palpation of the carotid and radial arteries, and (2) a practice or trial run. Subsequently each subject reported to the lab two additional times. At these sessions heart rate was monitored for each subject at rest, during exercise, and immediately following exercise. A standard electrocardiogram (EKG) V-5 lead was used to determine the heart rate criterion for all three phases. Half of the subjects used carotid artery palpations during the first session and radial artery palpations during the second. The other group started with the radial artery and finished with carotid palpations. Random assignment was employed to determine which artery was initially palpated.

Palpation Techniques

Subjects were shown how to palpate the heart rate at two locations: at the carotid artery using the dominant hand, halfway between the thyroid cartilage and the prominent angle of the mandible at the level of the hyoid bone; at the radial artery using the dominant hand, on the anteriolateral aspect of the wrist at the level of the superficial palomar branch. Subjects practiced the palpation of both carotid and radial arteries on day one using ten second counts.

Testing Procedures

To establish the resting heart rate the subject lay for a five minute rest after instruction and EKG hook-up. When resting heart rate was established, a ten second EKG strip was recorded on a Narco Physiograph. The subjects then palpated the carotid and/or radial artery to determine resting heart rate by palpation method and an EKG was also taken at the same time for criterion counting. Subjects were instructed to palpate the artery and instruct the tester when they were ready to start counting. The stop watch, palpation count, and the EKG were all started together. They rested two minutes and repeated the same procedures for three trials. The Karvonen formula was used to establish a moderate work load of 60 percent of maximum heart rate range to determine predicted steady state level. The subject then had a trial introduction to the treadmill. Subject introduction to the treadmill was by instructor from Quinton Instruction Manual for Model 18-60 allowing for maximum feeling of security (1968, p. 7). The treadmill was operated at 3.3 miles per hour for all subjects. The speed was calibrated before testing each subject using the procedure in the manual. During the introduction the treadmill was inclined to an angle necessary to raise the subject to the predicted steady state level.

To evaluate the effect and accuracy of palpation immediately after exercising, the subjects exercised on the treadmill to the predetermined steady state level. After reaching this level the subjects had five seconds to step off the treadmill, palpate the carotid and/or radial artery, and count it for ten seconds. A ten second EKG recording was taken prior to stopping for exercise heart rate and a ten second strip was also recorded during palpation. After palpation for ten seconds, the subject again got on the treadmill, exercised for two minutes, and repeated the same procedure for three trials. This was also repeated on the third day for the other artery to be palpated.

Palpation techniques do not allow the subject to count fractions of a cardiac cycle. They were counted to the nearest heart beat. Heart rate counted on the EKG tracing was by QRS spikes within each time interval.

STATISTICAL ANALYSIS

ANOVA procedure was used on resting and working palpation techniques for (1) order effect; (2) counting; (3) post-exercise; and (4) mean heart rates. A Duncan's Post F test was also used on exercise heart rate for order effect. Correlation coefficients were also calculated to establish relationships between variables studied.

Chapter 4

RESULTS

This chapter presents the results of the study. For clarity, the results are presented under the following headings: subjects, order effect, resting heart rate counting, exercise heart rate counting, recovery heart rates, and correlation coefficients.

SUBJECTS

Twelve male and eight female Kansas State University faculty, staff, and students volunteered to participate as subjects for this experiment. Subjects ranged in age from 30 to 40 years of age with a mean age of 33.7; S.D. 2.4. The preceding age category was selected because it seems to be the age group leading a sedentary life style before starting an exercise program. Table 1 presents the means and standard deviations of the subjects' ages (in months), length (inches), weight (lb) and percent of body fat on these subjects.

ORDER EFFECT

Resting EKGs were taken on all subjects to establish a baseline RHR. All subjects palpated RHR 6 times (3 carotid, 3 radial), half starting with carotid palpation and half radial palpation in an attempt to prevent any order effect.

Table 1

Means and Standard Deviations of the Subjects

	Male		Female		All	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age	33.3	2.03	34.3	2.89	33.7	2.4
Height (inch)	70.3	4.61	65.6	3.96	68.5	3.2
Weight (lb.)	166.6	14.63	134.1	17.31	153.6	22.4
% Fat	10	1.99	18.8	2.54	13.5	5.1
N	12		8		20	

An ANOVA for order (regardless of which palpation was made first) was used for the principal variables of interest. This analysis yielded no significant difference for order for resting heart rates, $F(5,114) = 0.26$, $\underline{P} > .05$. Regardless of which palpation technique was used first (carotid or radial) the first count was the same as the last count. Either method can be used to determine RHR.

Working EKGs were taken on all subjects at the end of a 6 minute exercise bout. All subjects palpated WHR 6 times (3 carotid, 3 radial), half starting with carotid palpation and half radial during session II and III in an attempt to prevent any order effect.

A second ANOVA for order (exercise heart rate) was also calculated. This analysis yielded no significant difference for order for work heart rates, $F(5,114) = 0.96$, $\underline{P} > .05$. Regardless of which palpation technique was used first the counts were the same. There was no order effect.

RESTING HEART RATE COUNTING

An ANOVA procedure was used to determine if differences existed between mean heart rates as determined from different palpation procedures and to determine if resting rates determined by palpation differed from resting rates determined by EKG heart rate counting. Carotid and radial arteries palpation counting was used for the analysis and EKG was used as criterion for comparison.

This analysis yielded no significant effects between the means for the two types of palpations, $F(1,228) = 0.27$, $\underline{P} > .05$ nor did heart rates determined by palpation differ from those determined by EKG counting $F(1,228) = 0.07$, $\underline{P} > .05$. The analyses show no differences between the three trials for counting resting heart rates, $F(2,228) = 0.64$, $\underline{P} > .05$. Finally there were no significant interactions. Mean resting heart rates are presented in Table 2 for the reader's information.

Table 2

Resting Heart Rates

	Carotid		Radial		Totals
	Pal.	EKG	Pal.	EKG	
Trial 1	11.25	11.41	11.75	11.85	11.56
Trial 2	11.35	11.50	11.55	11.40	11.45
Trial 3	11.25	11.30	11.10	11.20	11.21
Total	11.28	11.40	11.47	11.48	11.40

DURING EXERCISE HEART RATES

While heart rates were not counted by palpation during exercise, heart rates were monitored using EKG tracings during exercise. To determine if palpations after exercise were effective in assessing during exercise heart rates, a 2 (type of palpation) x 2 (recovery vs during) x 3 (trials) ANOVA was used. There was no significant mean effect for type of palpation $F(1,228) = 0.57$, $\underline{P} < .05$, nor was there a main effect for differences between recovery heart rate (palpation) and during exercise heart as measured by EKGs $F(1,228) = 4.53$, $\underline{P} < .05$. There was no significant interaction between variables. These results are in agreement with those of Pollock (1981) which suggest that post exercise artery palpations can be accurate predictors of exercise heart rates. The steady state heart rates (60%) were lower than those of Pollock (70-80%) but indicated similar counts for post exercise palpations and during exercise EKG counts.

Table 3

Mean Heart Rates for EKG's During Exercise and Palpations During Recovery (10 sec)

	Carotid Pal. (Recovery)	EKG Count Prior to Carotid Palpation	Radial Pal. (Recovery)	EKG Count Prior to Radial Palpation
Trial 1	22.37	23.11	22.74	22.79
Trial 2	21.74	22.32	21.95	22.34
Trial 3	22.11	22.47	21.63	22.11

The lack of a difference between carotid and radial palpations coupled with no significant interaction suggests that either type palpation can be used to assess during exercise heart rates if done immediately after exercise. Previously presented analyses indicated that the order of treatments did not affect heart rate counting. Nevertheless, an analysis to determine if heart rates taken earlier might differ from those taken later in the study was calculated.

Exercise heart rates were established 6 different times and palpations were made after each of these different EKG counts. During exercise session II subjects were exercised until the criterion heart rate level was reached. A ten second heart rate was determined during the last few seconds of this exercise bout. Subsequently an immediate post exercise (10 sec.) rate was counted (using either the radial or carotid artery). The subjects alternately exercised and counted post exercise rates until a total of 6 counts were made (3 during exercise, 3 immediately after exercise). On the third testing day, session III, the same procedure was followed but a different palpation procedure was used. An analysis of variance was calculated to determine if mean heart rates for any of the 12 trials differed. The analysis indicated that differences between means existed $F(11,228) = 2.45$, $\underline{P} < .05$. All heart rates both during and after exercise were counted from the EKG printouts. Thus, as shown in Table 4 the 1st, 3rd, and 5th trials represent during exercise rates for session II while 2nd, 4th, and 6th represent immediate post exercise heart rates for session II. Trials 7, 9, and 11 represent during exercise rates for session III while 8, 10, and 12 represent immediate post exercise heart rates for session III.

Table 4

Post F Test for Exercise Heart Rate Order Effect (Duncan's)

12th	8th	4th	10th	6th	2nd	11th	9th	3rd	5th	7th	1st
21.32	21.35	21.52	21.54	21.68	21.86	22.06	22.17	22.47	22.52	22.89	23.01

As can be seen in Table 4 all exercise heart rates (1, 3, 5, 7, 9, and 11) were statistically the same. Also all recovery heart rates (2, 4, 6, 8, 10, and 12) were statistically the same. As would be expected from the lack of differences between exercise heart rates and recovery rates as described on the previous pages, exercise heart rates and the recovery rate which immediately followed them (1 and 2, 3 and 4, 5 and 6, 7 and 8, 9 and 10, and 11 and 12) did not differ. In no case was the recovery rate different from the rate determined in the exercise immediately preceding the count. In other words post exercise heart rates as counted by EKG are statistically similar to during exercise heart rates, just as post exercise counts using palpation showed no difference when compared to during exercise counts.

Correlation coefficients presented in Table 5 illustrate the relationships between heart rates counted by EKG during exercise and those counted by palpation during recovery. As can be seen there is a moderate relationship between during exercise EKG counts and post exercise palpations. Both carotid and radial post exercise palpations showed similar relationships to actual during exercise EKG counts. Either procedure seems to be a reasonable technique for heart rate counting. The slightly lower correlation between carotid and EKG counts compared to radial and EKG counts could possibly be explained by the larger standard deviations for the carotid counts as compared to the radial counts (see Table 6).

Table 5

Correlation between Exercise Heart Rates Counted by Palpation and During Exercise Heart Rates Counted by EKG

Carotid		Radial	
Source	r	Source	r
Trial 1	.795	Trial 1	.756
Trial 2	.560	Trial 2	.753
Trial 3	.719	Trial 3	.760

Table 6

Means and Standard Deviations for Recovery Palpation Heart Rate Counts

	Carotid		Radial	
	Means	S.D.	Means	S.D.
Trial 1	22.37	2.50	21.74	1.76
Trial 2	21.74	2.36	21.95	1.68
Trial 3	22.11	1.92	21.63	1.79

RECOVERY HEART RATES

It was important to compare during exercise heart rates to recovery heart rates calculated by palpation to see how closely post exercise rates compared to actual during exercise counts. Also of importance was the comparison of post exercise heart rates as determined by EKG tracings and simultaneous post exercise heart rate counts done by palpation. To do this a 2 (type of palpation) x 2 (palpation vs. EKG) x 3 (trials) ANOVA was used. The analysis yielded no significant effects between the means for the two types of palpations; $F(1,228) = 0.19$, $\underline{P} > .05$. However post exercise heart rates determined by palpation differed from post exercise heart rates determined by EKG counting $F(1,228) = 3.85$, $\underline{P} > .05$. There were no significant interactions. Mean values for each of the different groups are presented in Table 7.

Table 7

Mean Heart Rates for EKG's During Recovery and Palpations During Recovery (10 sec)

	Carotid		Radial	
	Pal.	EKG	Pal.	EKG
Trial 1	22.37	21.26	22.74	21.95
Trial 2	21.74	21.31	21.95	21.74
Trial 3	22.11	21.53	21.63	21.47

As can be seen in Table 7, both types of palpations yield significantly higher heart rates than the EKG counts. However, the lack of a palpation mean effect and the absence of an interaction indicates that higher heart rate counts are not unique to one method of heart rate palpation.

Correlation coefficients calculated to determine relationships between post exercise EKG counts and post exercise palpations indicate strong relationships. These correlations are shown in Table 8. Palpations, regardless of type tend to overcount post exercise heart rates (see ANOVA results). This is probably because during palpation

Table 8

Correlation between Recovery Heart Rates Counted by Palpation and Recovery Heart Rates Counted by EKG

Carotid		Radial	
Source	r	Source	r
Trial 1	.835	Trial 1	.934
Trial 2	.909	Trial 2	.923
Trial 3	.727	Trial 3	.793

subjects are more likely to count an extra beat at the end of a ten second count than when the heart rate is counted by EKG and the time cutoff points are more clear-cut. However, the strong relation between EKG counts and palpations suggest that palpations are quite similar to EKG counts across the board. The lower r value for the third trial may indicate a lessening in concentration in counting when making repeated heart rate counts.

Group data presented here, clearly indicates for those who exercise regularly and show no evidence of coronary problems, carotid palpation didn't result in depressed heart rates as suggested by White (1975, 1977) and others (Cotton and Dill, 1935; McArdle, Zwiren, and Magel, 1969). If this had been the case there would have been lower heart rates for both carotid groups (EKG and palpation). This did not occur.

Table 9

Individual Heart Rates for EKG: During Exercise Compared with Carotid Palpations During Recovery (10 sec)

	Higher Carotid Counts (+ 2 or more beats)	Similar Counts (less than 2 deviations)	Lower Carotid Counts (-2 or more beats)
Trial 1	1	13	6
Trial 2	3	10	7
Trial 3	3	12	5

However, taking into consideration individual count and not group, Table 9 indicates that there was more underestimation than overestimation. Using the standard deviation from Table 6 only 7 of the 18 are outside of the standard deviation (4 in Trial 1; 2 in Trial 2; and 1 in Trial 3). This could possibly indicate that there is a chance for some individuals to have the carotid sinus depression. However, on the overall it does not have an effect.

Chapter 5

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The hypothesis put forward by White (1975, 1977) that the palpation of the carotid artery would cause change in heart rate during rest, exercise, and post-exercise has been suggested by others. Weiss and Baker (1933) claim a "Definite pathological change" in a small percentage of patients occurred following carotid sinus stimulation. Boone, Rape, Ribisel and Miller study (1980) also showed a significant drop in heart rate after palpation of carotid artery. Pollock study (1981) concluded that training heart rates of 80 percent to 90 percent magnitude can be accurately estimated by palpation technique. The purpose of this study was to determine whether the palpation of the carotid artery compared to the radial artery was a better indicator of exercise heart rate.

DISCUSSION

White (1975, 1977) and others (Cotton and Dill, 1935; McArdle, Zwiren, and Magel, 1969) say carotid artery palpation technique causes a change in heart rate due to carotid sinus reflex. The data from this study will not support this contention. Heart rates at rest taken by either procedure were quite similar. The same is also true for recovery heart rates. For the subjects used in this study, carotid and radial arteries palpation were similar and there were no statistical differences from actual EKG counts. Apparently no slowing of heart rate due to carotid artery palpation.

Results would support Pollock et al. (1981) study that palpation technique can adequately assess exercise heart rate. Actual post exercise palpations were higher possibly due to counting problems. The lower r values for the third trial may indicate onset of fatigue. Order was not a factor in any of the trials.

CONCLUSIONS

Based on the results of this study the following conclusions seem warranted.

1. For normal healthy exercising adults, carotid palpation does not seem to depress resting or post exercise heart rates.
2. Either type of palpation, carotid or radial, appears to be effective for determining during exercise heart rates when palpations are started immediately after exercise and counted for 10 second periods. However, radial counts seem to be less variable than carotid counts.
3. Palpations, by either the carotid or radial procedure, probably overcount actual recovery heart rates. Given the fact that the recovery rates as counted by palpation are quite similar to during exercise heart rates, this does not appear to pose a problem for those using palpations to count heart rate.
4. Palpation by the carotid artery by some individuals could cause a depressed heart rate. It would be suggested for

individuals to palpate both carotid and radial arteries to see if there is a change. Palpation of the carotid artery must be approached with caution.

RECOMMENDATIONS

Further research in this area seems warranted. Some factors which might identify important differences and which might be examined in future research are listed below:

1. Repeated study using sedentary cardiac patients, and physically active people.
2. Repeating this study using cardiac patients.
3. It might be fruitful to examine the same palpation effects by allowing some other person doing the palpations.

BIBLIOGRAPHY

1. American College of Sports Medicine. Position Statement: "The Recommended Quantity and Quality of Exercise for Developing and Maintaining Fitness in Healthy Adults," Medicine and Science in Sports, 10:7-10, 1978.

2. Astrand, P.O. and K. Rodahl. Textbook of Work Physiology. New York: McGraw-Hill, 1970.

3. Atomi, Y., K. Ito, H. Iwasaki, and M. Miyashita. "Effects of intensity and frequency of training on aerobic work capacity of young females," The Journal of Sports Medicine and Physical Fitness, 18:3-9, March, 1978.

4. Boone, W.T., S.M. Rape, P.M. Ribisl, and H.S. Miller. "Heart rate changes resulting from carotid artery palpation by the experimenter and the subject at rest, exercise, and recovery in cardiac patients," Medicine and Science in Sports and Exercise, 122:124, 1980.

5. Brigham Young University. "Run Dick, Run Jane." Dept. of Motion Pictures Production, Provo, Utah 84601.

6. Burke, E.J. and B.D. Franks. "Changes in VO_2 max resulting from bicycle training at different intensities holding total mechanical work constant," The Research Quarterly, 46:31-37, 1975.

7. Byrd, R.J. and F.M. Browning. A Laboratory Manual for Exercise Physiology. Charles Thomas, p. 9, 1972.

8. Cooper, K.H. Aerobics. New York: Evans and Co., 1965.

9. Corbin, C.B., L.J. Dowell, R. Lindsey, and H. Tolson. Concepts in Physical Education. 3rd ed. Dubuque, Iowa: William C. Brown, 1978, pp. 17, 145.

10. Costill, D.L. What research tells the coach about distance running. Washington, D.C.: AAHPER, p. 20, 1968.

11. Cotton, Fl, and D. Dill. "On the relation between the heart rate during exercise and that of immediate post-exercise period," American Journal of Physiology, 111:554-558, 1935.

12. Cureton, T.K. The Physiological Effects of Exercise Programs on Adults. Springfield, Ill.: Charles Thomas Co., 1969.

13. Davies, C.T.M. and A.V. Knibbs. The training stimulus the effects of intensity, duration and frequency of effort on maximum aerobic power output. International Zeitschrift fur Angewante Physiology, 29:299-305, 1971.

14. DeVries, H.A. and G.M. Adams. "Effect of the type of exercise upon the work of the heart in older men," Journal of Sports Medicine, 17:41-46, 1977.

15. DeVries, H.A. Physiology of Exercise. 3rd ed. Dubuque, Iowa: William C. Brown, 1980, pp. 280-298.

16. Fletcher, G.F. and J.D. Catwell. Exercise and Coronary Heart Disease. Charles Thomas, 1974, p. 161.

17. Garrison, L., L. Leslie, and D. Blackmore. Fitness and Figure Control. Mayfield Publishing Co., 1974, p. 73.

18. Gettman, L.R. Research related to the implementation of jogging programs. AAHPER Research Consortium Symposium Papers, Vol. 1, Book 2, 29-33, 1978.

19. Gledhill, N. and R. Eynon in Taylor, A.W. (Ed.). Training Scientific Basis and Application. Springfield: C.C. Thomas, 1972, pp. 97-102.

20. Guyton, Arthur C. Textbook of Medical Physiology. W.B. Saunders Company, 1981.

21. Hollmann, W. and H. Venrath. Experimentelle Untersuchungen zur Dauerbertzst Ungsgranze In Korbs (Ed.), Canldiem festschrift, W.U.A. Frankfurt/Wein, 1962.

22. Karvonen, M.J. "Effects of Vigorous Exercise on the Heart," Work and the Heart, edited by F.F. Rosenbaum and E.L. Belknap. New York: Paul B. Hoebner, 1959.

23. Karvonen, M.J., E. Kentola, and O. Muslala. Effects of training on heart rate: longitudinal study. Annales Medicinae Experimentalis et Biologiae Fenniae, 35:307-315, 1957.

24. McArdle, W.D., F.L. Katch, and V.L. Katch. Exercise Physiology. Philadelphia, PA: Lea and Febiger, 1981, pp. 273-278.

25. McArdle, William, Frank I. Katch, and Victor L. Katch. Exercise Physiology. Philadelphia, PA: Lea and Febiger, 1981.

26. McArdle, W., G. Foglia, and A. Patti. "Telemetered cardiac response to selected running events," Journal of Applied Physiology, 23:566-570, 1967.

27. McArdle, W., L. Zwiren, and J. Magel. "Validity of the post-exercise heart rate as a means of estimating heart rate during work of varying intensities," Research Quarterly, 40:523-528, 1969.

28. Naughton, J.P. and H.K. Hellerstein. Exercise Testing and Exercise Training in Coronary Heart Disease. Academic Press, 1973, p. 384.

29. Pollock, M.L., A. Ward, and J.J. Ayres. Cardiorespiratory Fitness: Response to differing intensities and duration of training. Archives of Physical Medicine and Rehabilitation, 58:467-473, 1977.

30. Pollock, Michael L., Jeffrey Broida, and Zebulon Kendrick. "Validity of the palpation technique of heart rate determination and its estimation of training heart rate," Research Quarterly, 43:77-81, .

31. Rodahl, K., Z. Vokac, P. Fugelli, O. Varge, and S. Maehlum: Circulatory strain, estimated energy output and catecholamine excretion in Norwegian costal fisherman, Engonomics, 17:585-602, 1974.

32. Shaver, L.G. Experiments in Physiology of Exercise. Burgess Publishing Co., 1973, p. 2.

33. Slater-Hamnel, A.T. and L. Butler. "Accuracy of securing pulse rates by palpation," Research Quarterly, 11:18-21, 1940.

34. Sinning, W.E. Experiments and Demonstrations in Exercise Physiology. W.B. Saunders Co., 1975, p. 104.

35. Taylor, H.L., W. Haskell, S.M. Fox, III, and H. Blackburn. Exercise tests; a summary of procedures and concepts of stress testing for cardiovascular diagnosis and function evaluation. Measurement in Exercise Electrocardiography. Springfield: C.C. Thomas, 1969, pp. 259-305.

36. Terry, J., C. Erickson, D. Johnson, and C. Pendergast. Physical Activity for All Ages. Dubuque, Iowa: Kendall/Hunt, 1979, pp. 59-62.

37. Wenger, H.D. and R.B.J. MacHab. Endurance training: The effects of intensity, total work, duration and initial fitness, Journal of Sports Medicine, 15:199-209, 1975.

38. Weiss, S. and J.P. Baker. "The carotid sinus reflex in health and disease," Medicine, 12:297-354, 1933.

39. White, James R. "EKG changes using carotid artery for heart rate monitoring," Medicine and Science in Sports, 9:88-94, 1977.

40. White, J.R. "The use of the carotid artery (neck pulse) for heart rate determination," Fitness and Health Symposium Proceedings, 1:24-29, April, 1975. Physical Education Department, University of California, San Diego, La Jolla, California 92093.

41. Zohman, L.R. "Exercise your way to fitness and heart health," American Heart Association and President's Council on Physical Fitness and Sports, 1974, p. 17.

APPENDIX A

APPENDIX A

INFORMED CONSENT FORM

Investigator: William Couldry

I, ________________________, do hereby volunteer to participate in an experiment designed to study heart rate. In the study, heart rate will be counted before, during, and after exercise by palpation (finger pressure) of the carotid and radial arteries and will be monitored using an electrocardiogram (EKG). Percent body fat, and resting heart rate will be determined.

I understand, I am free to discontinue my participation in the experiment at anytime.

I understand, I will be asked to give personal information concering my age, height, and weight. I will be asked to participate in three (3) sessions involving the use of EKG and treadmill. I understand the testing will be 35 to 45 minutes per session. Confidentiality will be maintained concering personal information collected and information is available for review if desired.

I understand that in event of physical injury resulting from the research procedures involved in the experiment, no financial compensation will be available, since state regulations prohibit Kansas State University from carrying insurance for such purposes.

To my knowledge, I am in a good state of health and have not had or now have any heart or cardiovascular problems.

I have read, (or had read to me), and understand the above statement and do hereby voluntarily consent to participate as a subject in this study.

________________________ (subject signature) ________________ (date)

________________________ (subject name printed)

POST-EXERCISE CAROTID AND RADIAL ARTERY PALPATION AS INDICATORS OF HEART RATE DURING EXERCISE

by

WILLIAM COULDRY

B.S.E., Missouri Western State College, 1979

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education, Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

The purpose of this study was to determine whether the carotid or radial artery palpation of post-exercise heart rate were good indicators of heart rate during exercise. An attempt was made to determine if there were differences between carotid and radial artery palpations and an EKG criterion.

Subjects were twelve male and eight female Kansas State University faculty, staff, and student volunteers. Ages of subjects ranged from thirty to forty years. All subjects had pursued a program of aerobic exercise for at least three months. Resting EKG and heart rates were established on the first day along with an introduction to the procedures and treadmill protocol. Subjects palpated either the carotid or radial artery to determine post-exercise heart rates. Each artery palpation was done three of each for ten second count. Subjects returned for second test to exercise on treadmill. Working heart rate was established by EKG tracing. Subjects then stepped off the treadmill and palpated one of the two arteries for ten seconds. The same procedures were used on the third test day as day two except the subjects palpated different arteries. Ten subjects palpated the carotid artery during the second session and the radial artery during the third. The other ten subjects palpated the two arteries in reverse order. Subjects were randomly assigned to groups to control for order effect. Analysis of variance revealed no significant differences and no interaction between the variables.

This study doesn't support the finding reported by White (1975, 1977). The finding of this study supports Pollock (1981) that carotid artery palpation shows no significant differences between heart rate during exercise and post-exercise heart rates. However it also indicates that radial palpation may be a better indicator in that it shows less deviation.