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A Method for Evaluating Cardiovascular Conditioning in Swimmers

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A METHOD FOR EVALUATING CARDIOVASCULAR CONDITIONING IN SWIMMERS

by

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ACKNOWLEDGEMENTS

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A special note of thanks is extended to Arnold Keck and the University of North Dakota swim team who willingly contributed their time and assistance.

Finally, the researcher wishes to express his deepest appreciation to his wife, Marilyn, for her patience, encouragement, and understanding during this past year of graduate work.

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ABSTRACT

The purpose of this study was to determine if cardiovascular conditioning did take place during the swimmer's training season. This study was also concerned with developing an index for each swimmer. This index would give a coach a convenient and practical method of establishing the cardiovascular condition of his swimmers for a particular segment of the training season.

The subjects used in this study were two male Caucasians with previous competitive swimming experience. The subjects were tested twice a week during three predetermined segments of the training season. They were tested during the first ten minutes of the regular practice session.

Comparisons were made among the three different segments of the training to see if there was a trend toward cardiovascular conditioning. The index was used to see if it paralleled the testing results as an indicator of cardiovascular conditioning.

The conclusions indicated that cardiovascular conditioning did occur during the testing season. The results, in regard to the index, indicated that with one subject the index was not representative of the cardiovascular conditioning that occured during the season. With the second subject the index paralleled the cardiovascular

conditioning which occurred. The size of the test sample was too small to indicate a definitive relationship between the index and cardiovascular conditioning, but the use of the index does show promise.

CHAPTER I

INTRODUCTION

For many years swimming coaches have employed the overload principle in the overall conditioning of swimmers. Along with the overload principle, interval training has also been applied to competitive swimmers as a means of conditioning. In many cases, this conditioning has not allowed for the individual differences which occur among swimmers on any swim team. The conditioning of swimmers has been conducted, by a large number of swimming coaches, in a "shot gun" manner. The coach would construct the daily workout and then hope that all the swimmers developed cardiovascular conditioning at the same rate.

It was the writer's belief that a coach should allow for individual differences in the training of competitive swimmers. The writer's view was supported in a recent study by Lawrence.[1] After surveying 158 college swimming coaches by questionnaire, it was found that conditioning was largely an individual matter adapted to a particular swimmer in relation to a specific event.

Statement of the Problem

The purpose of this study was to determine possible improvement in the cardiovascular conditioning, as measured by the pulse rate and

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[1] Lawrence, Lee W., "Practices in Conditioning of Competitive Swimmers," (Unpublished M. S. thesis in Physical Education), Springfield College, Springfield, Massachusetts, 1966, pp. 23-25.

recovery time, of varsity swimmers during their season of competition. A second purpose of this study was to develop an index to determine if there was a convenient and practical way for a coach to measure the cardiovascular condition of individual swimmers.

Need for the Study

The writer believed that if a coach could use some type of simple test to indicate an individual swimmer's cardiovascular condition, then the coach could structure practice so as to continually challenge every swimmer. Every swimmer reaches his point of fatigue at a different time from his fellow swimmers. If the coach could know exactly when the swimmer reached his point of fatigue it would be of great aid in the construction of swimming workouts. Through development of an individual index for each swimmer, cardiovascular conditioning could be easily checked.

Delimitations of the Study

The writer delimited the study as follows:

1. The subjects were two skilled, male Caucasian swimmers who were members of the University of North Dakota swim team.

2. The two swimmers had previous instruction in stroke pattern and technique and a high degree of proficiency in their individual strokes.

3. The swimmers who were used were eighteen and nineteen years of age.

4. The testing was conducted in an indoor swimming pool with the water temperature between 74 degrees and 78 degrees Fahrenheit.

Limitations of the Study

The following limitations must be taken into consideration when interpreting the results of this study.

1. The size of the test sample was a limitation in that these were the only two swimmers who had the necessary background in competitive swimming.

2. Another limiting factor was lack of control over diet, the daily habits and the emotional make-up of the subjects. The results of this study could be influenced by these factors because of the operational setting in which the test was administered. For this reason, the controls of this study were not as rigorous as a study in a laboratory setting.

3. The use of the operational setting, as opposed to the rigidly controlled laboratory setting, was also a limitation. It was thought that if there were too many controls imposed on this study this would bias the study and not give a true indication of the cardiovascular conditioning of the subjects under natural conditions and in normal surroundings. The recognition that these influences do exist in the regular coaching situation in an operational setting, allowed the researcher to conduct the testing in a natural and normal way.

Definition of Terms

Interval Training--a controlled period of rest between each exercise.

Pulse Rate--the rate at which blood is pumped from the heart and surges through the arteries.

Initial Pulse Rate--the pulse reading after warmup and prior to the start of the exercise.

Recovery Time--the period of time beginning at the completion of the exercise to the return to the initial pulse rate.

Pace Time--swimming a given distance in a given period of time.

Carotid Artery--an artery through which blood is carried from the heart to the brain, located below the angle of the jaw.

Review of Related Literature

It has been found that interval training is the most widely used method of conditioning swimmers. Interval or speed practice, according to Matthews,[2] is a series of sprints over a distance from twenty-five yards up to seventy-five yards. These sprints are done with an established rest interval between each. "...it has been ascertained that 'interval swimming' will get a boy into better shape faster than will the distance type of training program."[3]

Along with interval training, the overload principle has also been applied to competitive swimmers as a means of conditioning. Maglischo,[4] Young,[5] and Counsilman[6] were all of the belief that in

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[2]Matthews, Dave, "Interval Training in Swimming," Scholastic Coach, Vol. 28, (November, 1958), p. 42.

[3]Ibid., p. 42.

[4]Maglischo, Ernest W., "Conditioning For Competitive Swimmers," Scholastic Coach, Vol. 35, (April, 1966), p. 62.

[5]Young, Leonard, "Characteristics of In-Water Training," Scholastic Coach, Vol. 34, (September, 1964), p. 64.

[6]Counsilman, James E., "Interval Training in Swimming," Athletic Journal, Vol. 42, (September, 1961), p. 20.

order for a muscle to increase in strength, it must work with loads near maximum. They believed that an increase in strength can contribute to an increase in swimming ability.

Both the overload principle and interval training are used by coaches in the conditioning of their swimmers. Most swimming coaches believed that if a swimmer could continually delay the onset of fatigue, his performance would improve.

In recent years, physiologists and swimming coaches have employed the pulse rate of the individual swimmer to indicate cardiovascular conditioning. In addition to the swimmer's pulse rate, the time between the active pulse rate and the normal or resting pulse rate has been of great concern in the establishment of cardiovascular condition.

In relation to pulse rate and recovery time, Caufield[7] felt that taking the swimmer's pulse after swimming a given task at 100 per cent effort and then allowing the swimmer time to recover, the swimmer would be able to perform that task several times in succession. It was his belief that after completion of the sprint, the individual's pulse rate would be high. Rest between each sprint until the swimmer's pulse was near normal was advised. After the near-normal pulse rate was reached, the individual should have been able to do another sprint at 100 percent effort approximating the same time that was recorded in the first sprint.

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[7]Caufield, Hal D., "Pulse Swimming," Athletic Journal, Vol. 46, (December, 1965), p. 14.

Counsilman[8] stated that during the practice situation the swimmer's heart rate should be elevated to the same level it would reach in a race. He suggested that if the swimmer could then rest long enough to recover slightly, the swimmer would be capable of further near-maximum performances. The slight recovery mentioned would refer to not letting the pulse rate drop more than fifteen beats per minute.

In the training of swimmers the amount of work required to achieve the physiological change is of interest to a coach. This is usually reflected by a lowered heart rate in the trained swimmer.

deVries[9] suggested that if the work load were kept constant over a period of time, a physiological change would occur; this physiological change would be the lowered heart rate in the individual performing the task. He explained this as "exercise tolerance." As the individual became accustomed to the work load his heart rate would decrease. If the work load were to be increased this would be reflected by an increase in the swimmer's heart beat. deVries stated that to improve the exercise tolerance of the heart, the work-out must be in excess of a critical threshold value. This value was expressed when the heart rate was 60 per cent between resting and maximum rate. For example, if the resting rate were 70 beats per minute and the maximum was 200, the critical threshold would equal 70 (.60 x (200-70)), or

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[8]Counsilman, James E., The Science of Swimming, Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1968, p. 220.

[9]deVries, Herbert A., Physiology of Exercise for Physical Education and Athletics, Iowa: Wm. C. Brown Co., Inc., 1966, p. 78.

148 beats per minute. Above this point, according to deVries, conditioning would be taking place. If a coach were to use the information presented here he must, if conditioning is to take place, get the athlete's heart rate above the critical threshold. As the athlete becomes accustomed to the work load his heart rate will decrease.

Montoye[10] concluded that the maximum pulse rate will decrease with training. Mathews stated that "...athletes in good condition seem to recover faster than individuals in poor condition."[11]

It has been stated by Faulkner and Dawson[12] "...that because of the linearity of pulse rate and work output, a pulse rate reading immediately after the event is an excellent indicator of the intensity of the swimmer's effort." They concluded that a pulse of 175 to 200 is maximum for most young adults, and that this figure showed how well trained and highly motivated was the swimmer. Faulkner and Dawson also pointed out that, for swimmers, the maximum pulse rate is usually attained by the third fifty-yard repeat at or near an all-out effort.

It has been observed by Nagle and Bedecki[13] that the use of the 180 heart rate served as a valid point in measuring circulo-

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[10]Montoye, Henry J., "Inter-Relation of Pulse Rate During Moderate Exercise, Recovery Pulse Rate and Past Exercise Blood Lactate," Research Quarterly, Vol. 24, (December, 1953), p. 453.

[11]Mathews, Donald K., Stacy, Ralph W., and Hoover, George N., Physiology of Muscular Activity and Exercise, p. 78.

[12]Faulkner, John A. and Dawson, Rosemary Mann, "Pulse Rate After 50-Meter Swim," Research Quarterly, Vol. 36, (May, 1966), p. 283.

[13]Nagle, Francis J. and Bedecki, Thomas G., "Use of The 180 Heart Rate Response as a Measure of Circulorespiratory Capacity," Research Quarterly, Vol, 34, (October, 1963), p..361.

respiratory efficiency under different exercise stress conditions. Their research indicated that if an athlete's heart rate was elevated up to or beyond 180 beats per minute he would have been performing that task at near maximum effort. They also pointed out that the use of the 180 beats per minute could be considered a valid point at which maximum effort was being applied to the task.

Karpovich[14] stated that "...research that had been conducted in dealing with heart rate and recovery time with regard to running may, on the whole, be applied to other methods of locomotion, such as swimming, skating and skiing." Also stated by Karpovich is the fact that pre-exercise pulse rate following a standard warm-up is more reliable than the pre-exercise resting pulse rate. The reason for the standard warm-up is to eliminate various factors which would influence a pre-exercise resting pulse rate.

Bailey and others[15] made a pertinent observation with reference to those athletes who ran the mile. They stated that the runner whose heart rate rose to a near maximum level in the shortest period of time also ran the one mile distance in the shortest period of time.

Summary of Review of Related Literature

The review of related literature in this investigation revealed the following conclusions:

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[14]Karpovich, Peter V., Physiology of Muscular Activity, p. 171.

[15]Bailey, Donald, et. al., "The Physiological Response of Athletes During All-Out Sports Performance as Monitored by Radio-Telemetry," Progress Report for Fitness and Amateur Sports Research Grant, Saskatoon: University of Saskatchewan, 1963, p. 39.

1. Interval training and the overload principle are widely used by coaches in the conditioning of swimmers.

2. Resting pulse rate was affected by a number of factors. It was thought that pulse rate after a standard exercise or warm-up was more reliable before performing the task than the pre-exercise resting pulse rate.

3. There is a linear relationship between work output and pulse rate.

4. If a swimmer's condition is to improve, his heart rate should be elevated to a level similar, in practice, to what it should reach in a race.

5. The pulse-rate reading immediately after an event is an excellent indicator of the intensity of the swimmer's effort.

6. A pulse rate near or over 180 beats per minute is considered a maximum effort.

7. The time required for the pulse rate to return to normal after exercise depends upon the intensity of the exercise and the condition of the swimmer.

8. As the heart responds to a standard exercise, over a period of time, the pulse rate will gradually begin to decrease.

9. The better the condition of the swimmer, the more rapid is the recovery time.

CHAPTER II

SELECTION OF SUBJECTS AND PROCEDURE

Subjects

The subjects selected for this study were two members of the University of North Dakota 1969-1970 swim team. The swimmers were two male Caucasians, eighteen and nineteen years of age. The reason for selecting these two swimmers was because of their past experience in competitive swimming.

The researcher wanted to use swimmers who had prior experience and who had instruction in stroke pattern and technique and a high degree of proficiency in their individual stroke. These were the only two swimmers on the swim team who had participated in the age group swimming program, high school competitive swimming and who successfully competed in the intercollegiate swimming program during the 1968-1969 school year.

In this study the researcher was very interested in the heart rate and recovery time of the swimmers. It was thought that if inexperienced swimmers were selected, the reduction of heart rate and recovery time would not solely be due to cardiovascular improvement but could possibly indicate an improvement in stroke efficiency and stroke pattern. It has been generally recognized that if two

individuals, one an experienced swimmer who had prior competitive experience and a swimmer who had very little or no competitive experience, were to swim a distance of 250 yards, the experienced swimmer would not labor his stroke as would the swimmer who had little or no competitive experience. The swimmer who had little or no competitive experience could have been in as good, if not better, condition than the experienced swimmer but his heart rate and recovery time would not indicate this fact. This would mean that the swimmer who had little or no competitive experience would have to work harder at swimming this distance than did the experienced swimmer.

Reliability of the Palpation Method

After reviewing the related literature the writer found that several authors used the palpation of the carotid artery to count the heart rate of the swimmers being tested. The researcher was concerned with the reliability of using the palpation method. The lack of information with reference to the reliability of this method was notably lacking.

To establish the reliability of the palpation method in counting the heart rate of the swimmer, the researcher employed a Physiograph "Six" recorder to mechanically measure the heart rate of a subject. While the Physiograph "Six" was recording the heart rate mechanically, the researcher was taking the heart rate of a subject using the palpation of the carotid artery. To establish the reliability

of the manual palpation method a correlation treatment was given to the raw data to indicate the relationship between the two methods.

The Test Used

The test which was used in this study consisted of each swimmer swimming five fifty-yard repeats or sprints at a predetermined pace time. Prior to the actual testing each swimmer swam a standard warm-up. The review of literature cited the fact that pulse rate after a standard exercise or warm-up was more reliable before performing the task than the pre-exercise resting pulse rate.

In accordance with the views held by Counsilman,[16] Faulkner and Dawson[17] and others, the pace time should be similar to the time the swimmer would record in a race. To establish the pace time each swimmer was timed in an all-out effort while covering the fifty yard distance. From the time each swimmer recorded, three seconds were added to establish each swimmer's pace time to be used in the test. For example, if the swimmer covered the fifty-yard distance in his all-out effort in 28.9 seconds, his pace time for the test would be 31.9 seconds. Also of great importance in the test was the period of rest between repeats. It was felt that if the rest period was too long it would give the swimmer's cardiovascular system a chance to make a slight recovery. It was thought desirable to keep the heart rate as

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[16]Counsilman, James E., The Science of Swimming, p. 220.

[17]Faulkner, John A. and Dawson, Rosemary Mann, "Pulse Rate After 50-Meter Swim," pp. 282-283.

high as possible during the period between repeats. For these reasons it was decided to allow only a ten-second rest period.

To insure that the swimmers would maintain the established pace time, a pacer would walk on the pool deck beside each swimmer, at the prescribed pace time. The pacer timed his walk using a stop watch (Sport Craft, by Hanhart).

As mentioned earlier the test consisted of swimming five fifty-yard repeats at a paced time with ten seconds rest between each repeat. Following the completion of the last fifty-yard repeat and as soon after touching the wall as possible, the swimmer would stand in the water with his back to the researcher who was kneeling on the deck of the pool. The researcher would count and record the pulse rate of the swimmer for a period of thirty seconds and then every other thirty second period thereafter. This was continued for five minutes and thirty seconds to record the recovery time for each swimmer (see Score card, Appendix A). Upon the completion of the fifth repeat, the times were added together to acquire the total time involved in the completion of the test.

The principal unit of measurement using the stop watches was recorded in seconds on the score card. The accuracy of this test was recorded to the tenth of a second when using the stop watches.

Training the Pacer

The researcher and one pacer were used to administer the test. The training of the pacer involved a two-week period prior to the actual testing.

During the actual testing of the swimmers the pacer was to walk along side of the swimmer, on the pool deck, at the swimmer's prescribed pace time. It was important that this person walk along side the swimmer at as close to the prescribed pace time as possible. To insure accuracy, the pacer underwent two weeks of training which consisted of his walking the fifty-yard distance while continually refering to the stop watch. In addition he was also checked by the researcher to insure the proper pace time.

Gathering the Data

The test was organized in three, two-week blocks. The two-week blocks were designated as early season, middle season, and late season. Early season covered the first two weeks of organized practice. Middle season covered the two weeks in the middle of the swimming schedule of the University. The late season covered the last two weeks of practice just before the conference swimming meet. During each of the two-week testing periods, the test was administered on Tuesday and Thursday during the first fifteen minutes of the regular practice. Raw data was recorded on the score card. See Appendix B for the raw data for all three segments of the testing.

CHAPTER III

ANALYSIS OF DATA

Introduction

The purpose of this study was to determine whether cardiovascular conditioning took place during the swimming season. In addition, this study was to possibly develop a convenient and practical method for assessing each individual swimmer's cardiovascular condition at a particular time. The analysis of data was done on the basis of a status study, i. e. a description of what occured to the two swimmers tested. The mean and standard deviation were used to indicate a trend in cardiovascular conditioning.

Reliability of the Palpation Method

The researcher was concerned about the reliability of the palpation method of measuring heart rate. To measure the reliability of the palpation method, a correlation treatment was applied between the mechanical method (using a Physiograph "Six" recorder) and the manual method (using the palpation of the carotid artery). It was found there was a correlation of r .9925 between the mechanical and the manual method of measuring heart rate. Table 1 lists the data computed for the correlation coeficient between the mechanical and manual method.

TABLE I

CORRELATION BETWEEN THE MANUAL METHOD AND THE MECHANICAL METHOD OF MEASURING HEART RATE OF TWO VARSITY SWIMMERS

	X	SD	r
Mechanical Method	34.643	4.031	.9925
Manual Method	35.000	3.922	

From the information presented above, it was found that the manual method of measuring heart rate using the palpation of the carotid artery was highly reliable.

Test Results

The data collected and compiled in this study were analyzed on the basis of three segments of the training season--early season, middle season, and late season. The data were analyzed statistically to determine if cardiovascular conditioning did occur. The single group design using the descriptive method was employed in reporting the results.

Complete data, which includes raw scores, mean, standard deviation and standard error of the mean for each testing period is presented in Appendix C.

Swimmer "D.S."

Table 2 is a graphical representation of the mean total time, in seconds, required to swim the five fifty-yard repeats, and the

standard deviation for all three segments of testing for swimmer "D.S.".

The mean total time in Segment Two showed a 3.73 second increase over that of Segment One. In examining the data further, it was found that the mean total time in Segment Three showed a 1.27 second decrease over Segment One, and a five second decrease over Segment Two. This indicated that during the last segment of the training season, the mean total time was lower, inferring that the subject swam the five fifty-yard repeats faster during the last segment.

TABLE 2

MEAN TOTAL TIME, IN SECONDS, AND STANDARD DEVIATION FOR THE FIVE FIFTY-YARD REPEATS FOR SWIMMER "D.S." FOR THE THREE TESTING SEGMENTS

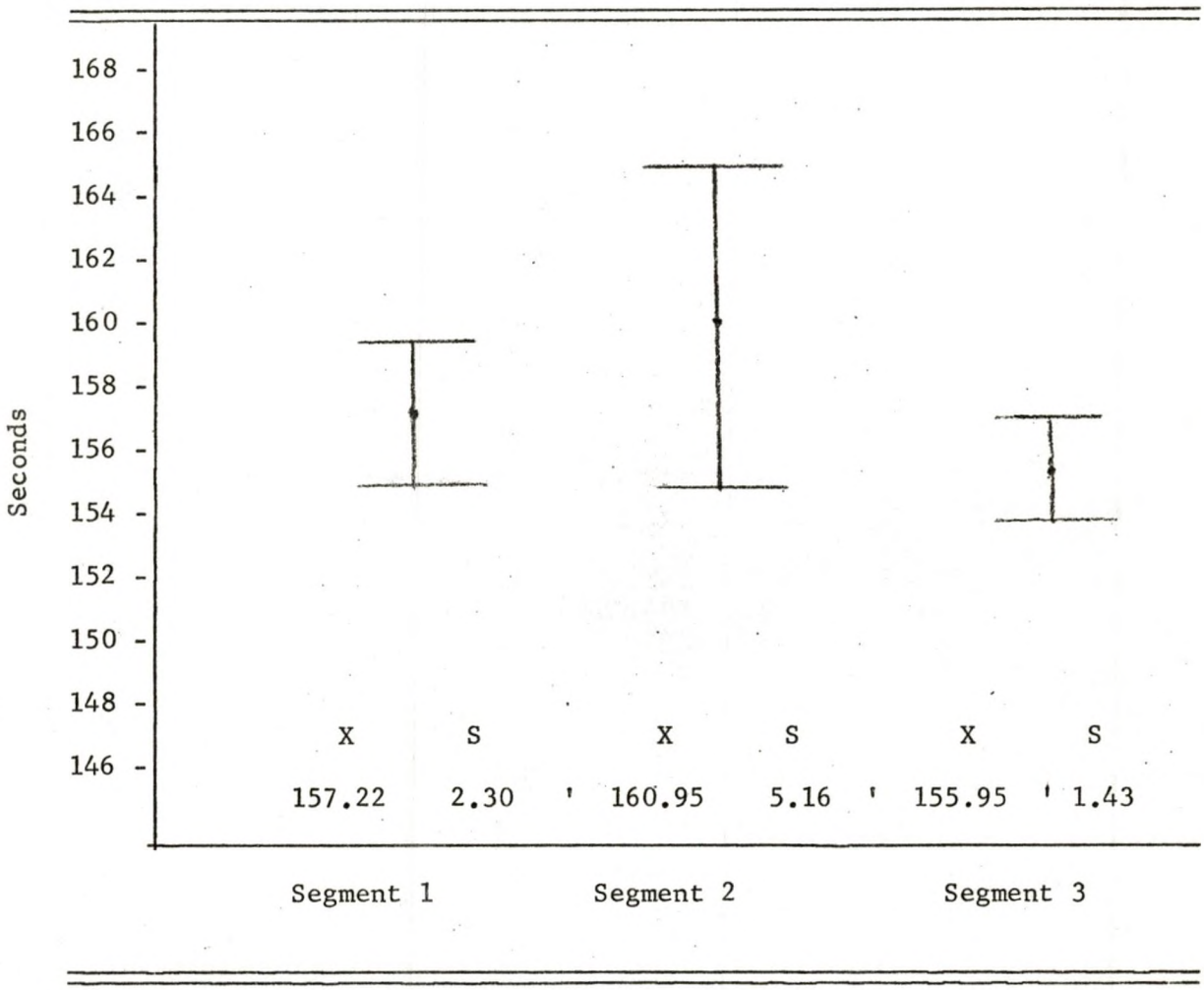


Table 3 presents the mean heart rate and the standard deviation for swimmer "D.S.". In comparing the three segments, it was found that the subject's mean heart rate in Segment Two increased 7.5 beats per minute but the standard deviation decreased slightly (.57) under that of Segment One. In examing Segment Three, it was discovered that the heart rate remained the same as presented in Segment Two but there was a marked decrease in the standard deviation of 2.13 compared to Segment One and a decrease of 1.56 compared to Segment Two.

TABLE 3

MEAN HEART RATE AND STANDARD DEVIATION FOR THE THREE TESTING SEGMENTS FOR SWIMMER "D.S."

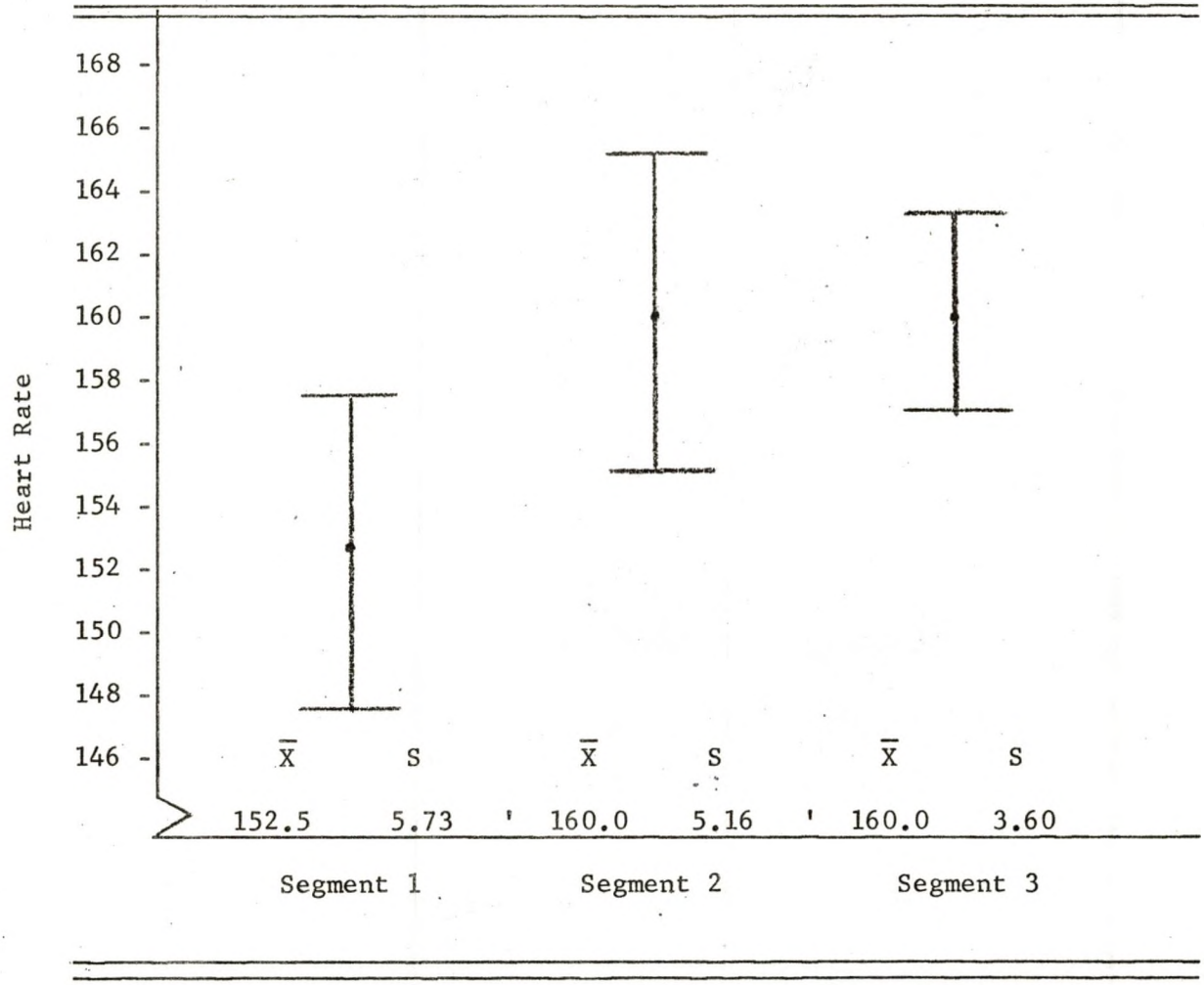


Table 4 is the graphical representation of the recovery curve for swimmer "D.S." for the first segment of testing. This table indicates that the heart rates in Segment One were not elevated to a point thought to be at near-maximum effort. The recovery during Test One was very slow, as the graph indicates. However, as the

testing continued the heart rate immediately following exercise increased and the recovery curve was more pronounced.

TABLE 4

RECOVERY CURVE FOR "D.S."
FOR THE FIRST TESTING SEGMENT

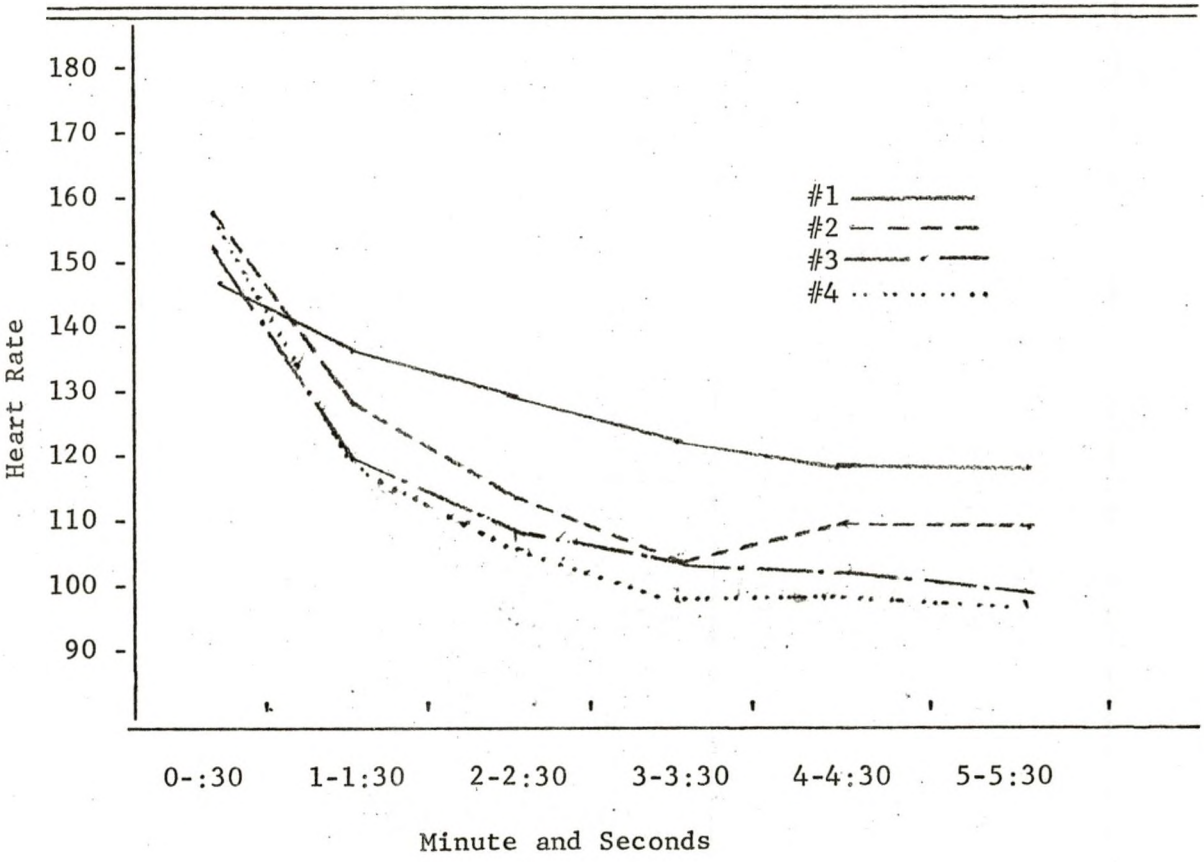


Table 5 represents the recovery curve for swimmer "D.S." for the second segment of testing. The heart rates immediately following exercise were slightly higher in this segment than they were in Segment

One. The recovery curves showed more varialibility in this segment than in Segment One.

TABLE 5

RECOVERY CURVE FOR "D.S."
FOR THE SECOND TESTING SEGMENT

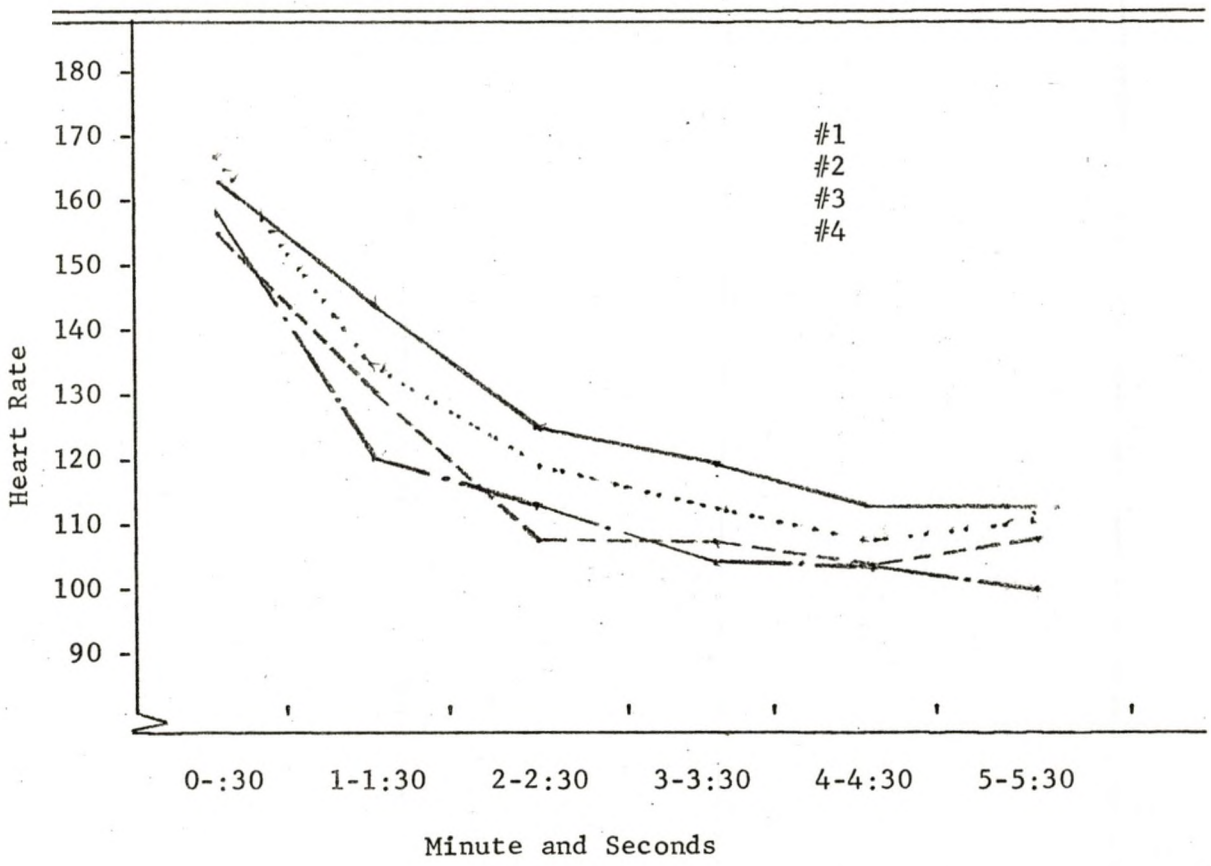
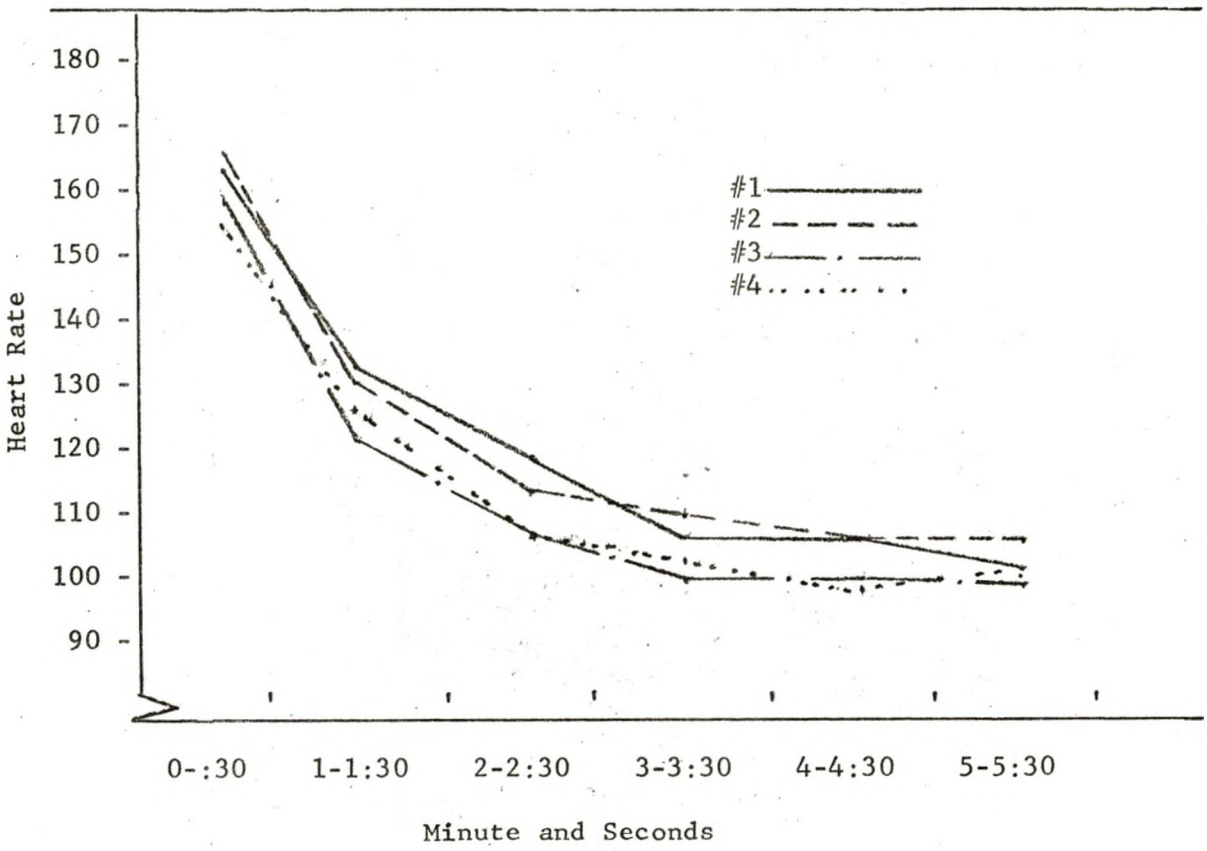


Table 6 is the graphical representation of the recovery curve for swimmer "D.S." for the third segment of testing. On this table it can be observed that the heart rates immediately following exercise

are fairly close together; there is only a range of six beats per minute between the highest and lowest recording in this segment. The recovery curve indicated that the swimmer was becoming accustomed to the workload.

TABLE 6

RECOVERY CURVE FOR "D.S."
FOR THE THIRD TESTING SEGMENT



Swimmer "A.B."

Table 7 records the results for swimmer "A.B." during the three segments of testing. This table graphically presents the mean total time, in seconds, required to swim the five fifty-yard repeats and the standard deviation for all three segments of testing for swimmer "A.B.". When comparing Segment One to Segment Two, it was found that there was a decrease of 2.82 seconds in mean total time in Segment Two. In comparing Segment One with Segment Three, it was discovered that there was a decrease of 1.57 seconds in mean total time in Segment Three under that of Segment One. There was a slight increase in Segment Two of 1.25 seconds in mean total time when comparing Segment Two to Segment Three. The results of the mean total time indicate that the subject was swimming each of the five fifty-yard repeats at approximately the same times.

TABLE 7

MEAN TOTAL TIME, IN SECONDS, AND STANDARD DEVIATION FOR THE FIVE FIFTY-YARD REPEATS FOR SWIMMER "A.B." FOR THE THREE TESTING SEGMENTS

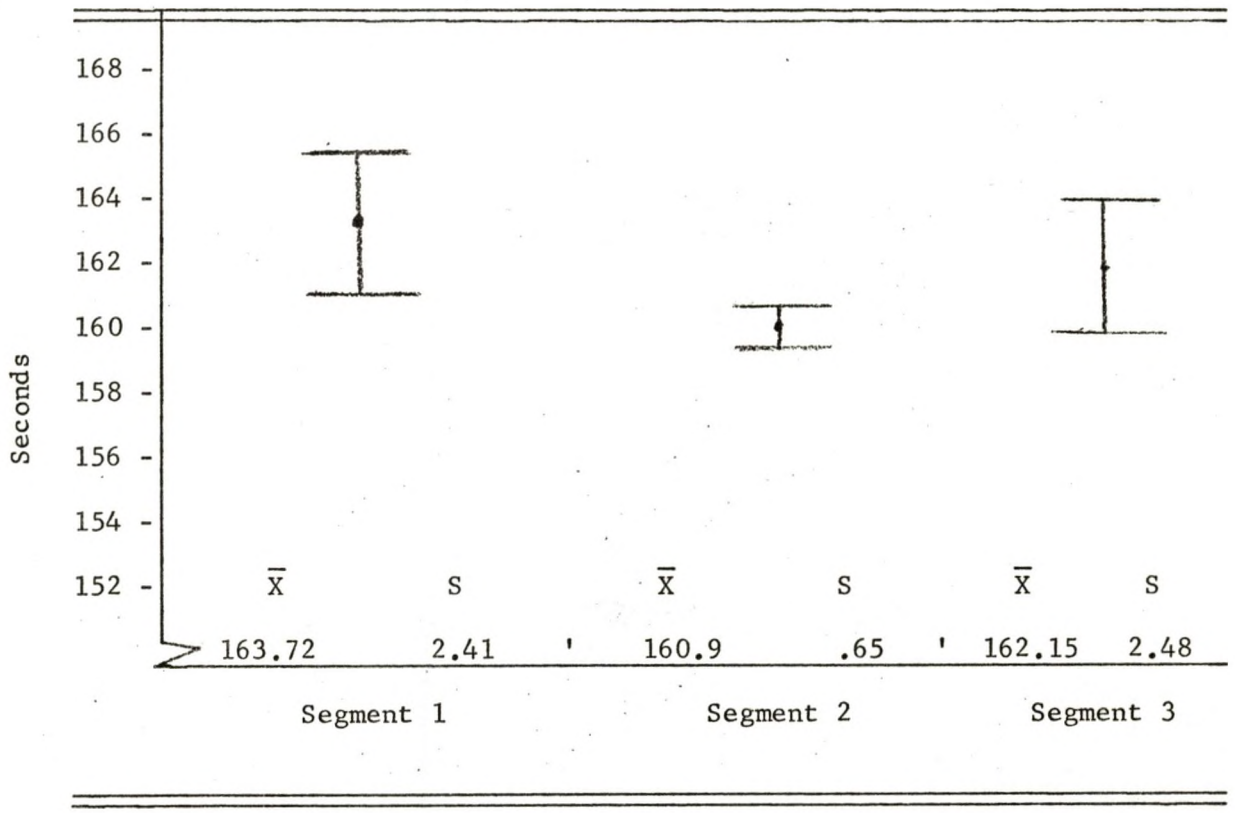


Table 8 represents the mean heart rate and the standard deviation for swimmer "A.B." during the three segments of testing. Table 8 indicates that there was a continual decrease in the heart rates in all testing segments. When comparing Segment One to Segment Two it was found that there was a decrease of one beat per minute in Segment Two. In comparing Segment One to Segment Three it was discovered that there was a decrease of 10.5 beats per minute in Segment Three. In examining Segment Two and comparing it to Segment Three it was found that there was a decrease of 9.5 beats per minute in Segment Three over that of Segment Two.

TABLE 8

MEAN HEART RATE AND STANDARD DEVIATION FOR
THE FIVE FIFTY-YARD REPEATS FOR
SWIMMER "A.B." FOR THE THREE TESTING SEGMENTS

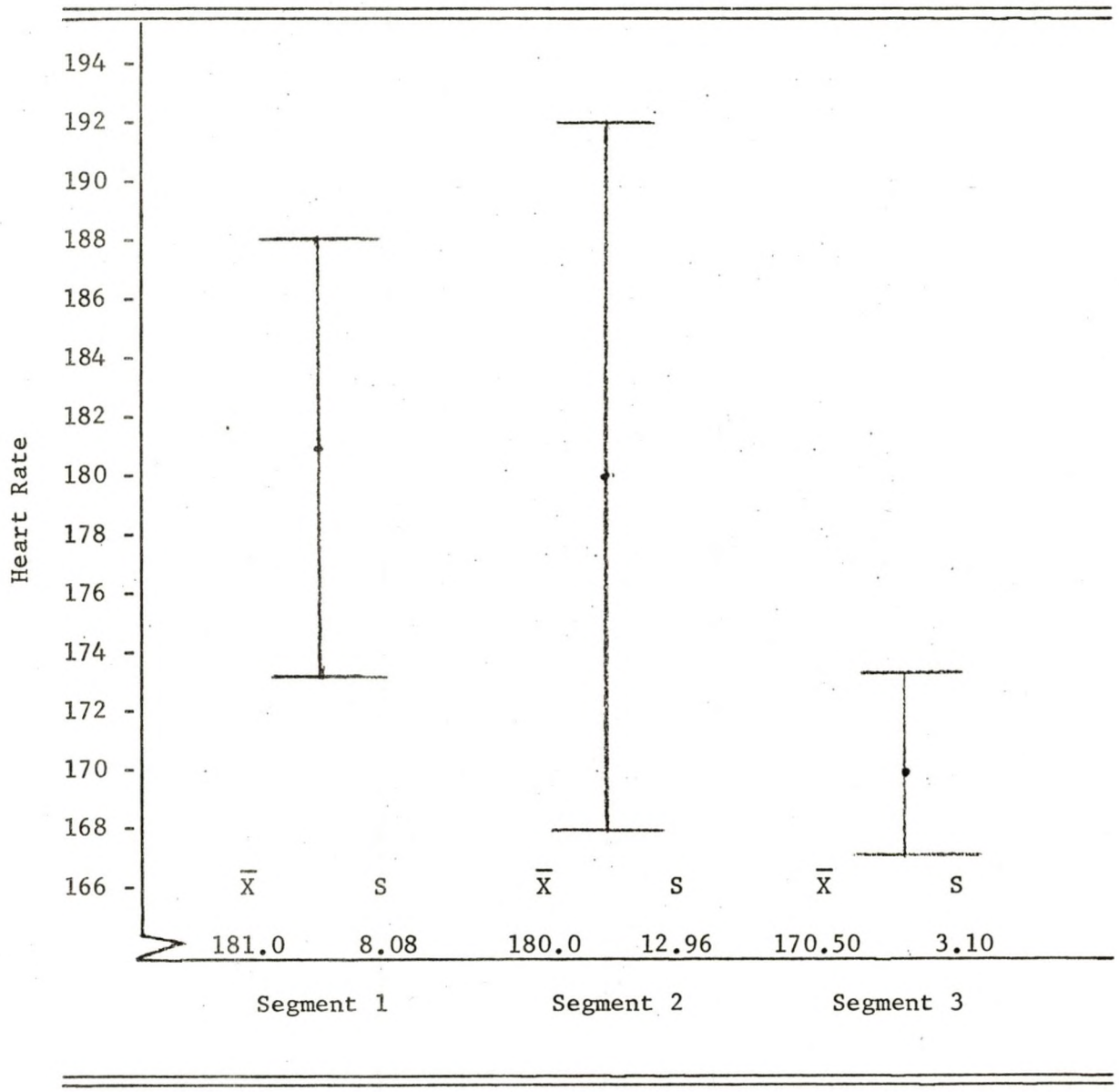


Table 9 is the graphical representation of the recovery curve for swimmer "A.B." for the first segment of testing. This table shows that this swimmer's heart rate had been elevated, in test one, two and three, to a point of maximum effort. In test four the heart rate is ten beats below the maximum level of 180 beats per minute. There is a range of eighteen beats per minute in the heart rate immediately following exercise. The recovery curve for this swimmer in the first testing segment is fairly regular, with the fastest recovery coming in test number four.

TABLE 9

RECOVERY CURVE FOR "A.B."
FOR THE FIRST TESTING SEGMENT

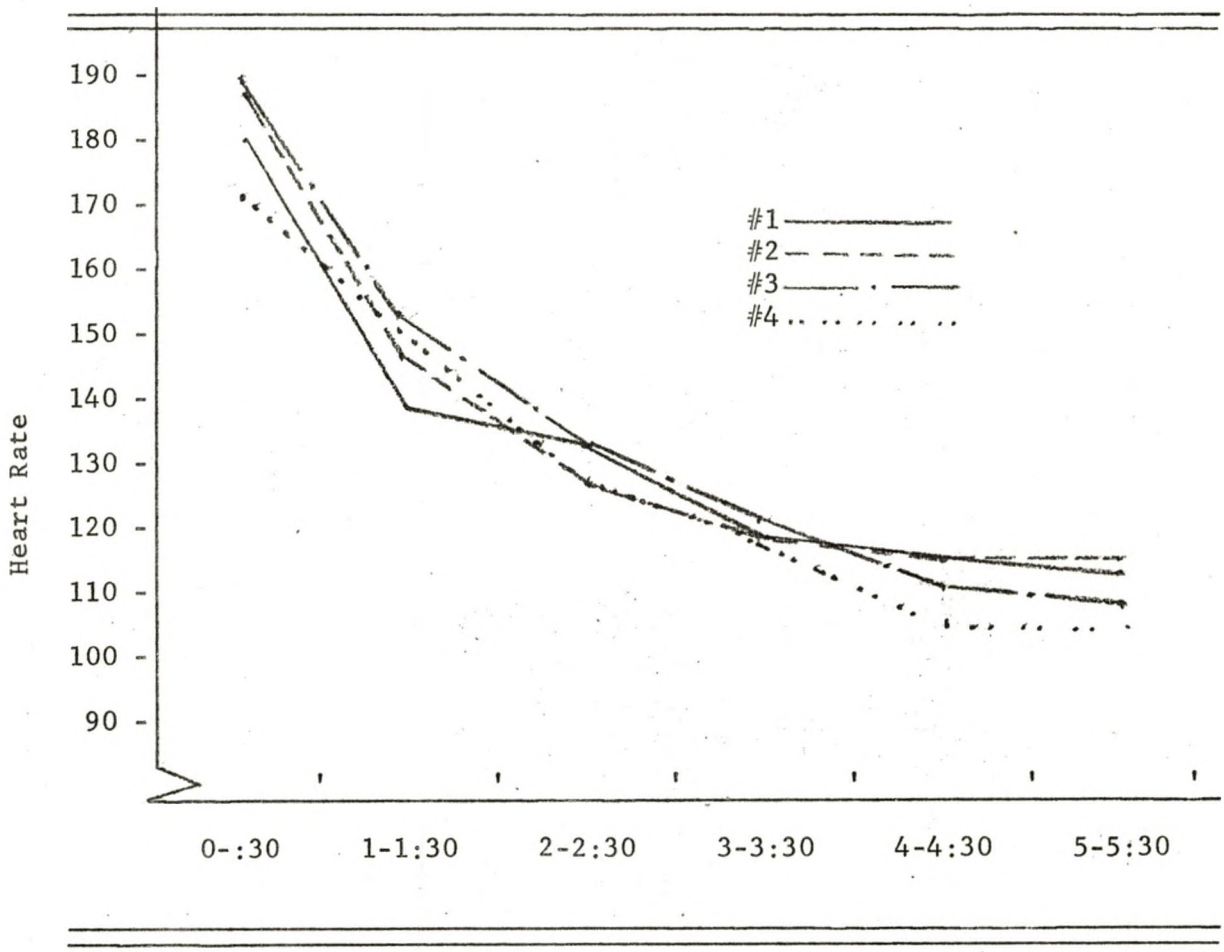


Table 10 represents the recovery curve for swimmer "A.B." during the second segment of testing, and shows that the heart rate immediately following exercise varied within a twenty beat per minute range. Although the heart rate immediately following exercise showed a great deal of variance, the recovery curve was fairly regular.

TABLE 10

RECOVERY CURVE FOR "A.B."
FOR THE SECOND SEGMENT OF TESTING

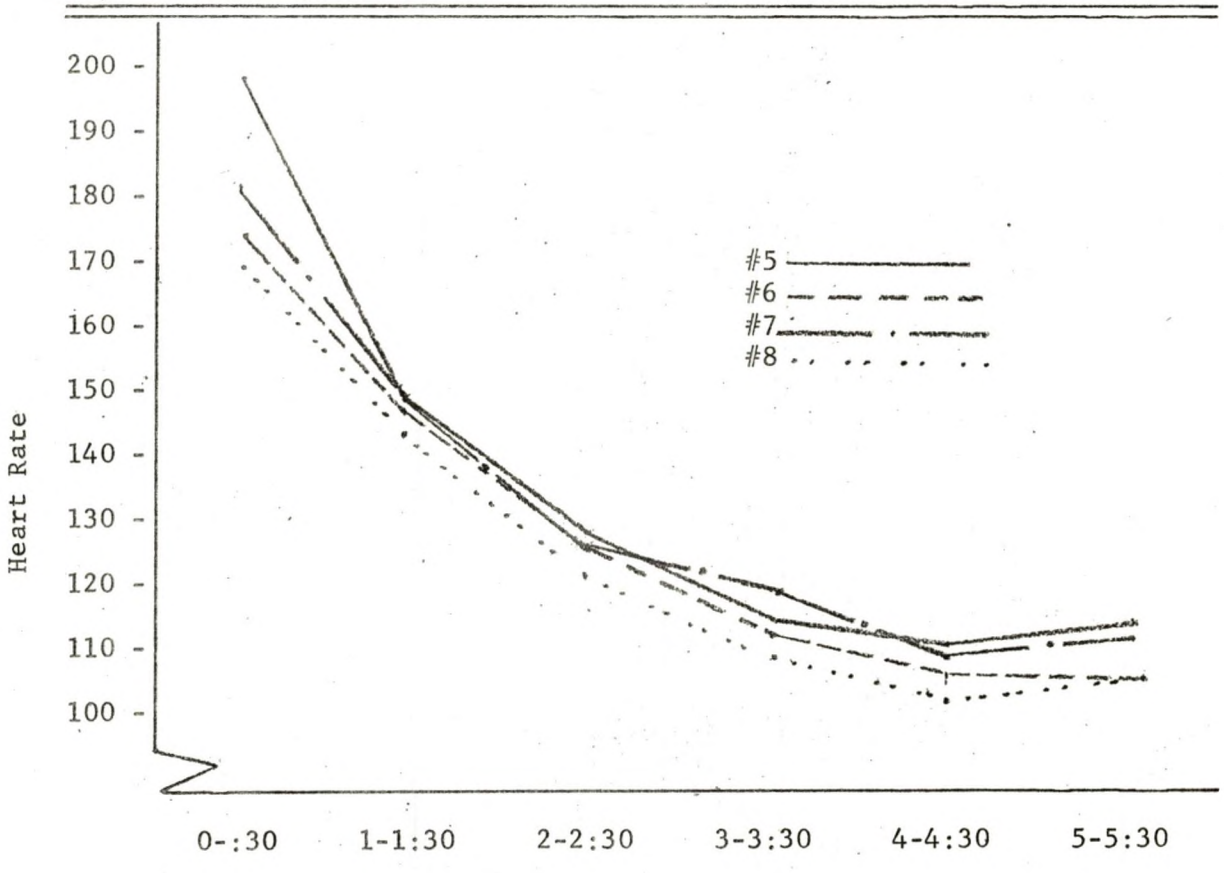
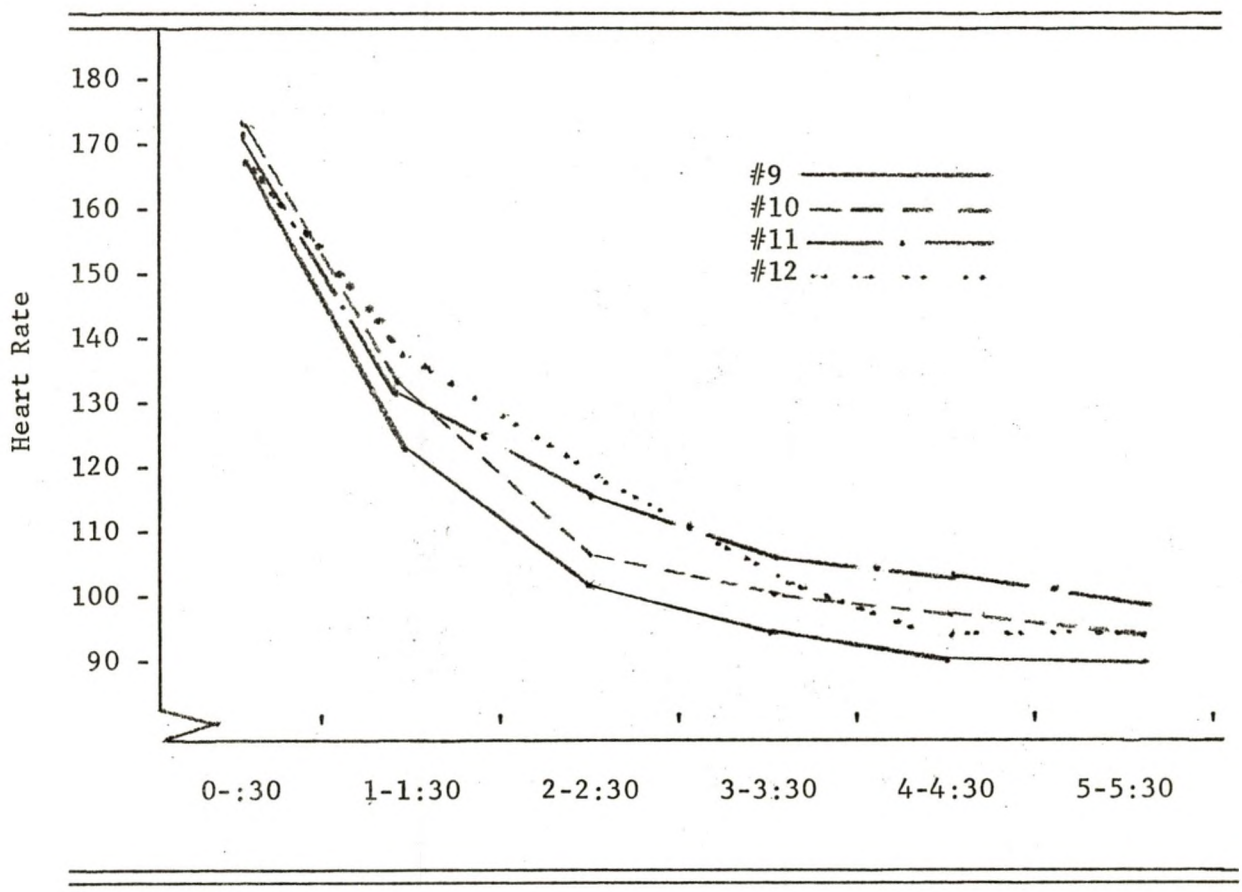


Table 11 shows the recovery curve for the third segment of testing for swimmer "A.B.". This table indicates that the heart rates immediately following exercise were grouped fairly close to one another. In this segment of testing there was a range of six beats per minute in the heart rate immediately following exercise. This would indicate that swimmer "A.B." was becoming accustomed to the

workload. At the completion of the last testing the recovery heart rate for the period of five minutes and thirty seconds was below 100 beats per minute. This was the lowest recorded reading for this swimmer for all three testing segments.

TABLE 11

RECOVERY CURVE FOR "A.B."
FOR THE THIRD TESTING SEGMENT



Establishment of Individual Conditioning Index

An additional consideration in this study was the development of a index for each individual swimmer. The use of the pulse reading recorded immediately following exercise, and the total elapsed time required to swim the five fifty-yard repeats, were employed. It was the researcher's intention to place the figures in a fractional form and compute, mathematically, a result which would represent the cardiovascular conditioning of each individual swimmer at a particular time in the training season. An example of the index is as follows:

$$\frac{\text{pulse rate immediately following exercise}}{\text{total elapsed time in swimming the five repeats}} = \text{individual conditioning index}$$

For example, if a swimmer's total elapsed time required to swim the five fifty-yard repeats was 164.1 seconds and his pulse rate immediately following exercise was 180 beats per minute his index for that particular testing would be 1.14. Example: $\frac{\text{pulse rate}}{\text{total time}} = \frac{164.1}{180.0} = 1.14.$

Listed below, in Table 12, are the index values for swimmer "D.S." for the three testing segments. It is shown that all readings are fairly close together. The lowest reading occurred in Segment Two and the highest in Segment Three.

TABLE 12

MEAN INDICIES FOR SWIMMER "D.S." FOR THE THREE TESTING SEGMENTS

	Segment One	Segment Two	Segment Three
Index	.917	.916	.919

Table 15 represents the mean indices for the three segments of testing for swimmer "A.B.". It is noted that there is a continual and steady decrease in the individual conditioning index with the biggest decrease occuring between Segment Two and Segment Three.

TABLE 13

MEAN INDICES FOR SWIMMER "A.B."
FOR THE THREE TESTING SEGMENTS

	Segment One	Segment Two	Segment Three
Index	1.14	1.11	1.04

CHAPTER IV

DISCUSSION

In reviewing the related literature it was discovered that information dealing with the reliability of using the palpation of the carotid artery was lacking. A high degree of correlation was found between the manual method and the mechanical method. The results indicated that the palpation method was a reliable and convenient method for measuring heart rate. Once the tester became acquainted with the palpation method it was very easy to use.

Both subjects employed in the study were very cooperative. However, only one of the subject's heart rate was elevated to a level where many authorities considered his performance to be at or near maximum output. The swimmer "D.S.", whose heart rate was not elevated to the maximum point cited in the review of literature, still swam faster in Segment Three than did he in Segments One and Two. This fact could be due to the possible improvement in cardiovascular conditioning.

Tables 2 and 3 presented the graphical representation of the mean and standard deviation for the total time and heart rate. The reasoning behind the use of these two measures is as follows.

As mentioned earlier, each swimmer was swimming the five fifty-yard repeats at a pace time. A pace time was used to standardize

the task; in other words, the swimmer would not be swimming in a all-out effort but at a pace that would challenge his heart rate.

As the swimmer swam the five fifty-yard repeats, his elapsed time, in seconds, was recorded on a score card. The times recorded for each segment were divided by four (the number of testing sessions in that segment) to arrive at a mean total time. A decrease in mean total time was an indication of the improvement in the swimmer's performance. As the conditioning of the swimmer improved the standard deviation also decreased. The decrease in the standard deviation implies that the subject is swimming the repeats at or near the prescribed pace time. (If the standard deviation had increased it would indicate that the subject varied or deviated from the prescribed pace time; the larger the standard deviation, the greater the variance from the prescribed pace time.) A coach possessing the information dealing with the decrease in the mean total time and a decrease in the standard deviation could continually challenge the swimmers and construct the workouts for each individual swimmer.

Table 2 showed that during the second segment of testing this swimmer's mean total time had increased. Table 3 pointed out an increase in the mean heart rate during the same segment. The second segment of testing was conducted one week after returning to school from Christmas vacation. This could infer that the swimmer did not maintain the degree of conditioning he acquired prior to vacation.

A second implication could be that during this segment of testing the swimmer's diet was not as it should have been, or he did not get the proper amount of rest, or he was not properly to swim at a level to elevate his heart rate to maximum or near maximum. The fact that this swimmer had a cold could also have had some baring on the outcome of the results. The medication which this swimmer was taking or the cold itself might have had a very marked effect in raising the heart rate and the mean total time to swim the five fifty-yard repeats.

Whatever the factors which cause a change (increase or decrease) in the mean total time and heart rate, this information would be extremely important to a swimming coach in the structuring of the workout for a swimmer. The change in either mean total time and/or heart rate would alert the coach as to some physiological or psychological change which is occurring.

The recovery curve for swimmer "D.S.", as presented in Table 4 indicated that as the testing continued, recovery in tests 2, 3, and 4 was more rapid than in test 1 of the first segment. This could indicate to the swimming coach that a certain degree of proficiency as far as cardiovascular conditioning could be occurring.

In Table 6 the recovery curve for "D.S." indicated that recovery during Segment Three was more rapid than during the previous two testing segments. Again, this could indicate to the coach that this swimmer has become accustomed to the workload and cardiovascular conditioning could be occurring. The fact that this swimmer has

become accustomed to the workload is supported by Table 2 which pointed out that in the last segment of testing the mean total time to swim the fifty-yard repeats decreased markedly.

It was the researcher's intention to use the results in computing the total time and the heart rate to develop an index which would be a convenient and practical method for a swimming coach to measure the cardiovascular condition of his swimmers. It was further thought that if the total time and heart rate of the swimmers decreased, indicating improvement in cardiovascular conditioning, that the index should also decrease.

However, this was not the case with swimmer "D.S.". In examining Table 12 the lowest reading occurred in Segment Two and the highest reading in Segment Three. If these results in Table 12 were interpreted to mean that a decrease in the index would reflect improvement in cardiovascular conditioning, then this swimmer was in better cardiovascular condition during Segment Two. Further, Segment Three indicates that this swimmer was in the poorest cardiovascular condition during this segment than previously recorded.

For swimmer "D.S." the best performance was recorded during the last segment of testing and the index developed is contrary to this fact.

For swimmer "A.B.", the summary of results found in Tables 7 and 8 indicate that the mean total time was fairly constant and the

mean heart rate dropped continually. The point of major interest was the observation of the standard deviation in the second testing segment. Although the mean heart rate dropped one beat per minute there was a great deal of deviation in the individual heart rate readings which made up the mean heart rate. This could imply that although this swimmer was swimming the five fifty-yard repeats slightly faster and the mean heart rate dropped one beat per minute, he was swimming much harder to maintain his pace time. By examining the standard deviation for the mean total time this also indicated that there was only slight deviation in the speed at which he was swimming the repeats.

In examining the third segment of testing, the results indicate that swimmer "A.B.'s" mean total time is generally the same but there is a very marked drop in the mean heart rate. The inference made by these statistics is that this swimmer is swimming the five fifty-yard repeats at approximately the same time but using less energy to accomplish the task. As cited in the review of literature, as the individual becomes accustomed to a given workload a physiological change will occur. This physiological change will be reflected by the decrease in the individual's heart rate while performing a given task. The statistics showed that in Segment Three, swimmer "A.B." has become accustomed to the swimming of the five fifty-yard repeats.

In examining the recovery curve for this swimmer it was shown that as the season progressed the recovery curve reported a steady and continual decrease in recovery from the activity. Applying the same mathematical computations to the results of testing to develop an index of cardiovascular conditioning for this swimmer, it was found that there was a steady and continual decrease in the index. Table 13 represents the continual decrease in the index for swimmer "A.B.". The decrease in the index for this was supported by the results computed in Tables 7 and 8 as well as found in the recovery curves in Tables 9, 10 and 11. The use of the index to reflect cardiovascular conditioning in swimmer "A.B." seemed to be an accurate indication of what occurred during the training season.

It has been established that the palpation method to determine heart rate was highly reliable, and that cardiovascular conditioning may be determined through the use of the mean, standard deviation and graphical representation as cited earlier. The concept of an index to establish cardiovascular conditioning is, at this point, questionable. The size of the test sample was a definite limitation. If a larger number of subjects were used, the findings, in regard to the index might have been more substantial. The concept of an index to establish cardiovascular conditioning, however, does show promise. It is a convenient and practical method, as opposed to the use of the various mathematical computations employed in computing the mean, standard

deviation and the construction of the recovery curves. The fact that the index seemed to accurately indicate the cardiovascular conditioning of one of the two subjects used is encouraging.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to determine whether cardiovascular conditioning, as measured by heart rate and recovery time, did take place during the training season. An additional purpose of this study was to develop a convenient and practical method in establishing an index, for each individual swimmer, to indicate if cardiovascular conditioning was occurring. The subjects in this study were two varsity swimmers at the University of North Dakota during the 1969-70 swimming season. Both subjects were tested twice a week during the early, middle, and late segments of the training season. Measurement of heart rate and recovery time were taken using the palpation of the carotid artery immediately following exercise and during recovery.

Conclusions

1. The use of the palpation of the carotid artery can be employed by a swimming coach with a high degree of reliability providing that he acquaint himself with the method first.

2. Through the use of the results of the testing it was found that cardiovascular conditioning of the swimmers did improve during the training season.

3. Cardiovascular condition may be determined at various points during the training season through the use of the palpation of the carotid artery.

4. The use of an index to indicate cardiovascular conditioning, while not conclusive, does show some promise.

Recommendations

It is recommended that the following considerations be made if undertaking a similar study in the future.

1. An attempt should be made to limit the non-training time during Segment Two to see how much of a gain in cardiovascular conditioning can be made.

2. A larger group of subjects involving swimmers of various levels of skill, age and sex should be selected to verify or reject the results of this study.

3. Further consideration be given to the establishment of an index to determine cardiovascular conditioning.

APPENDIX

SCORE CARD

DATE _____ FASTEST 50 TIME _____ NAME _____

PACE TIME _____

TUESDAY	THURSDAY
1. 50 TIME_____	1. 50 TIME_____
2. " " _____	2. " " _____
3. " " _____	3. " " _____
4. " " _____	4. " " _____
5. " " _____	5. " " _____
TOTAL TIME_____	TOTAL TIME_____
HEART BEAT BEFORE ACTIVITY_____	HEART BEAT BEFORE ACTIVITY _____
1. 0-:30 sec._____x2_____	1. 0-:30 sec._____x2_____
2. 1:00-1:30_____x2_____	2. 1:00-1:30_____x2_____
3. 2:00-2:30_____x2_____	3. 2:00-2:30_____x2_____
4. 3:00-3:30_____x2_____	4. 3:00-3:30_____x2_____
5. 4:00-4:30_____x2_____	5. 4:00-4:30_____x2_____
6. 5:00-5:30_____x2_____	6. 5:00-5:30_____x2_____

SCORE CARD

DATE 12/2-4/69 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	27.5	1. 50 TIME	29.4
2. " "	30.0	2. " "	30.3
3. " "	31.7	3. " "	31.7
4. " "	32.8	4. " "	32.3
5. " "	33.4	5. " "	33.0
TOTAL TIME	155.4	TOTAL TIME	156.7

HEART BEAT BEFORE ACTIVITY	136	HEART BEAT BEFORE ACTIVITY	90
1. 0-:30 sec.	73 x2 146	1. 0-:30 sec.	79 x2 158
2. 1:00-1:30	69 x2 138	2. 1:00-1:30	64 x2 128
3. 2:00-2:30	65 x2 130	3. 2:00-2:30	57 x2 114
4. 3:00-3:30	62 x2 124	4. 3:00-3:30	54 x2 108
5. 4:00-4:30	60 x2 120	5. 4:00-4:30	55 x2 110
6. 5:00-5:30	60 x2 120	6. 5:00-5:30	55 x2 110

SCORE CARD

DATE 12/9-11/69 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	28.7	1. 50 TIME	27.6
2. " "	31.8	2. " "	30.5
3. " "	32.9	3. " "	32.0
4. " "	33.0	4. " "	32.8
5. " "	34.2	5. " "	33.3
TOTAL TIME	160.6	TOTAL TIME	156.2

HEART BEAT BEFORE ACTIVITY 122				HEART BEAT BEFORE ACTIVITY 104			
1. 0-:30 sec.	76	x2	152	1. 0-:30 sec.	79	x2	158
2. 1:00-1:30	60	x2	120	2. 1:00-1:30	60	x2	120
3. 2:00-2:30	55	x2	110	3. 2:00-2:30	53	x2	106
4. 3:00-3:30	54	x2	108	4. 3:00-3:30	50	x2	100
5. 4:00-4:30	53	x2	106	5. 4:00-4:30	51	x2	102
6. 5:00-5:30	52	x2	104	6. 5:00-5:30	51	x2	102

SCORE CARD

DATE 1/13-15/70 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	27.4	1. 50 TIME	30.2
2. " "	29.2	2. " "	31.7
3. " "	33.6	3. " "	32.6
4. " "	35.8	4. " "	32.5
5. " "	37.8	5. " "	33.3
TOTAL TIME	167.8	TOTAL TIME	160.3

HEART BEAT BEFORE ACTIVITY	116		HEART BEAT BEFORE ACTIVITY	118	
1. 0-:30 sec.	81	x2 162	1. 0-:30 sec.	77	x2 154
2. 1:00-1:30	71	x2 142	2. 1:00-1:30	65	x2 130
3. 2:00-2:30	63	x2 126	3. 2:00-2:30	54	x2 108
4. 3:00-3:30	60	x2 120	4. 3:00-3:30	54	x2 108
5. 4:00-4:30	58	x2 116	5. 4:00-4:30	53	x2 106
6. 5:00-5:30	58	x2 116	6. 5:00-5:30	54	x2 108

SCORE CARD

DATE 1/20-22/70 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	29.6	1. 50 TIME	28.5
2. " "	31.2	2. " "	29.7
3. " "	32.8	3. " "	31.5
4. " "	33.8	4. " "	32.6
5. " "	33.1	5. " "	32.9
TOTAL TIME	160.5	TOTAL TIME	155.2

HEART BEAT BEFORE ACTIVITY	126		HEART BEAT BEFORE ACTIVITY	132	
1. 0-:30 sec.	79	x2 158	1. 0-:30 sec.	83	x2 166
2. 1:00-1:30	59	x2 118	2. 1:00-1:30	66	x2 132
3. 2:00-2:30	56	x2 112	3. 2:00-2:30	61	x2 122
4. 3:00-3:30	53	x2 106	4. 3:00-3:30	57	x2 114
5. 4:00-4:30	53	x2 106	5. 4:00-4:30	55	x2 110
6. 5:00-5:30	51	x2 102	6. 5:00-5:30	67	x2 114

SCORE CARD

DATE 2/11-13/70 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	29.0	1. 50 TIME	29.1
2. " "	30.1	2. " "	31.3
3. " "	31.9	3. " "	31.2
4. " "	32.4	4. " "	31.7
5. " "	32.9	5. " "	30.9
TOTAL TIME	156.3	TOTAL TIME	154.2

HEART BEAT BEFORE ACTIVITY	134		HEART BEAT BEFORE ACTIVITY	152	
1. o-:30 sec.	81	x2 162	1. o-:30 sec.	82	x2 164
2. 1:00-1:30	66	x2 132	2. 1:00-1:30	65	x2 130
3. 2:00-2:30	60	x2 120	3. 2:00-2:30	58	x2 116
4. 3:00-3:30	54	x2 108	4. 3:00-3:30	56	x2 112
5. 4:00-4:30	54	x2 108	5. 4:00-4:30	54	x2 108
6. 5:00-5:30	53	x2 106	6. 5:00-5:30	54	x2 108

SCORE CARD

DATE 2/24-26/70 FASTEST 50 TIME 25.9 NAME D.S.

PACE TIME 29

TUESDAY		THURSDAY	
1. 50 TIME	29.9	1. 50 TIME	29.6
2. " "	31.4	2. " "	31.4
3. " "	31.7	3. " "	31.9
4. " "	31.7	4. " "	31.9
5. " "	31.9	5. " "	31.9
TOTAL TIME	156.6	TOTAL TIME	156.7

HEART BEAT BEFORE ACTIVITY 138			HEART BEAT BEFORE ACTIVITY 126		
1. 0-:30 sec.	79	x2 158	1. 0-:30 sec.	78	x2 156
2. 1:00-1:30	60	x2 120	2. 1:00-1:30	62	x2 124
3. 2:00-2:30	54	x2 108	3. 2:00-2:30	54	x2 108
4. 3:00-3:30	50	x2 100	4. 3:00-3:30	51	x2 102
5. 4:00-4:30	52	x2 104	5. 4:00-4:30	50	x2 100
6. 5:00-5:30	52	x2 104	6. 5:00-5:30	51	x2 102

SCORE CARD

DATE 12/2-4/69 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	28.5	1. 50 TIME	29.2
2. " "	32.5	2. " "	32.7
3. " "	33.0	3. " "	32.4
4. " "	35.2	4. " "	33.0
5. " "	34.9	5. " "	33.7
TOTAL TIME	164.1	TOTAL TIME	161.0

HEART BEAT BEFORE ACTIVITY 130			HEART BEAT BEFORE ACTIVITY 142		
1. 0-:30 sec.	90 x2	180	1. 0-:30 sec.	93 x2	186
2. 1:00-1:30	70 x2	140	2. 1:00-1:30	73 x2	146
3. 2:00-2:30	66 x2	132	3. 2:00-2:30	64 x2	128
4. 3:00-3:30	59 x2	118	4. 3:00-3:30	59 x2	118
5. 4:00-4:30	58 x2	116	5. 4:00-4:30	58 x2	116
6. 5:00-5:30	57 x2	114	6. 5:00-5:30	58 x2	116

SCORE CARD

DATE 12/9-11/69 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	32.3	1. 50 TIME	31.4
2. " "	31.9	2. " "	32.3
3. " "	32.9	3. " "	33.6
4. " "	32.8	4. " "	34.8
5. " "	33.2	5. " "	34.7
TOTAL TIME	163.0	TOTAL TIME	166.8

HEART BEAT BEFORE ACTIVITY 110			HEART BEAT BEFORE ACTIVITY 96		
1. 1-:30 sec.	94 x2	188	1. 0-:30 sec.	85 x2	170
2. 1:00-1:30	76 x2	152	2. 1:00-1:30	74 x2	148
3. 2:00-2:30	66 x2	132	3. 2:00-2:30	64 x2	128
4. 3:00-3:30	61 x2	121	4. 3:00-3:30	59 x2	118
5. 4:00-4:30	57 x2	114	5. 4:00-4:30	54 x2	108
6. 5:00-5:30	56 x2	112	6. 5:00-5:30	54 x2	108

SCORE CARD

DATE 1/13-15/70 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	31.2	1. 50 TIME	31.2
2. " "	32.1	2. " "	32.2
3. " "	32.1	3. " "	32.6
4. " "	33.2	4. " "	32.6
5. " "	32.4	5. " "	32.9
TOTAL TIME	161.0	TOTAL TIME	161.5

HEART BEAT BEFORE ACTIVITY 148				HEART BEAT BEFORE ACTIVITY 150			
1. 0-:30 sec.	99	x2	198	1. 0-:30 sec.	87	x2	174
2. 1:00-1:30	74	x2	148	2. 1:00-1:30	73	x2	146
3. 2:00-2:30	64	x2	128	3. 2:00-2:30	63	x2	126
4. 3:00-3:30	59	x2	118	4. 3:00-3:30	58	x2	116
5. 4:00-4:30	57	x2	114	5. 4:00-4:30	55	x2	110
6. 5:00-5:30	59	x2	118	6. 5:00-5:30	55	x2	110

SCORE CARD

DATE 1/20-22/70 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	30.4	1. 50 TIME	30.5
2. " "	32.7	2. " "	31.3
3. " "	33.1	3. " "	32.6
4. " "	32.5	4. " "	32.9
5. " "	32.5	5. " "	32.7
TOTAL TIME	161.2	TOTAL TIME	160.0

HEART BEAT BEFORE ACTIVITY	140		HEART BEAT BEFORE ACTIVITY	118	
1. 0-:30 sec.	90	x2 180	1. 0-:30 sec.	84	x2 168
2. 1:00-1:30	74	x2 148	2. 1:00-1:30	71	x2 142
3. 2:00-2:30	63	x2 126	3. 2:00-2:30	62	x2 124
4. 3:00-3:30	62	x2 124	4. 3:00-3:30	57	x2 114
5. 4:00-4:30	56	x2 112	5. 4:00-4:30	54	x2 108
6. 5:00-5:30	58	x2 116	6. 5:00-5:30	55	x2 110

SCORE CARD

DATE 2/11-13/70 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	31.2	1. 50 TIME	30.0
2. " "	33.3	2. " "	32.5
3. " "	32.8	3. " "	32.5
4. " "	34.2	4. " "	33.4
5. " "	34.3	5. " "	33.2
TOTAL TIME	165.8	TOTAL TIME	161.6

HEART BEAT BEFORE ACTIVITY 138			HEART BEAT BEFORE ACTIVITY 154		
1. 0-:30 sec.	84	x2 168	1. 0-:30 sec.	87	x2 174
2. 1:00-1:30	61	x2 122	2. 1:00-1:30	67	x2 134
3. 2:00-2:30	53	x2 106	3. 2:00-2:30	54	x2 108
4. 3:00-3:30	49	x2 98	4. 3:00-3:30	52	x2 104
5. 4:00-4:30	47	x2 94	5. 4:00-4:30	50	x2 100
6. 5:00-5:30	47	x2 94	6. 5:00-5:30	48	x2 96

SCORE CARD

DATE 2/24-26/70 FASTEST 50 TIME 29.7 NAME A.B.

PACE TIME 32

TUESDAY		THURSDAY	
1. 50 TIME	31.0	1. 50 TIME	31.0
2. " "	32.9	2. " "	32.1
3. " "	32.4	3. " "	32.0
4. " "	32.3	4. " "	32.3
5. " "	32.3	5. " "	33.0
TOTAL TIME	160.8	TOTAL TIME	160.4

HEART BEAT BEFORE ACTIVITY 120				HEART BEAT BEFORE ACTIVITY 134			
1. 0-:30 sec.	86	x2	172	1. 0-:30 sec.	84	x2	168
2. 1:00-1:30	66	x2	132	2. 1:00-1:30	68	x2	136
3. 2:00-2:30	58	x2	116	3. 2:00-2:30	59	x2	118
4. 3:00-3:30	54	x2	108	4. 3:00-3:30	51	x2	102
5. 4:00-4:40	53	x2	106	5. 4:00-4:30	48	x2	96
6. 5:00-5:30	50	x2	100	6. 5:00-5:30	48	x2	96

APPENDIX C

FIRST SEGMENT OF TESTING

FOR SWIMMER "D.S."

TOTAL TIME		HEART RATE	
ΣX =	628.9	ΣX =	614.0
X =	157.22	X =	152.5
ΣX^2 =	98,894.85	ΣX^2 =	94,348.00
cf =	98,878.80	cf =	94,249.06
Σx^2 =	16.05	Σx^2 =	98.84
s^2 =	5.35	s^2 =	32.94
s =	2.30	s =	5.73
$s_{\bar{X}}$ =	.577	$s_{\bar{X}}$ =	1.43

SECOND SEGMENT OF TESTING

TOTAL TIME		HEART RATE	
ΣX =	643.8	ΣX =	640.0
X =	160.9	X =	160.0
ΣX^2 =	103,700.22	ΣX^2 =	102,480.00
cf =	103,620.25	cf =	102,400.06
Σx^2 =	79.97	Σx^2 =	79.94
s^2 =	26.65	s^2 =	26.64
s =	5.16	s =	5.16
$s_{\bar{X}}$ =	1.29	$s_{\bar{X}}$ =	1.29

THIRD SEGMENT OF TESTING

TOTAL TIME		HEART RATE	
ΣX	623.8	ΣX	640.00
$\bar{X}$	155.95	$\bar{X}$	160.00
ΣX^2	97,285.78	ΣX^2	102,440.00
cf	97,281.61	cf	102,400.00
Σx^2	6.17	Σx^2	40.00
s^2	2.05	s^2	13.33
s	1.43	s	3.60
$s\bar{x}$	.35	$s\bar{x}$	.90

FIRST SEGMENT OF TESTING

FOR SWIMMER "A.B."

TOTAL TIME		HEART RATE	
ΣX	654.9	ΣX	724.0
$\bar{X}$	163.72	$\bar{X}$	181.0
ΣX^2	107,241.05	ΣX^2	131,240.0
cf	107,223.50	cf	131,044.0
Σx^2	17.55	Σx^2	196.0
s^2	5.85	s^2	65.33
s	2.41	s	8.08
$s\bar{x}$	.60	$s\bar{x}$	2.02

SECOND SEGMENT OF TESTING

TOTAL TIME		HEART RATE	
ΣX =	643.7	ΣX =	720.0
$\bar{X}$ =	160.9	$\bar{X}$ =	180.0
ΣX^2 =	103,588.69	ΣX^2 =	130,104.00
cf =	103,587.42	cf =	129,600.00
ΣX^2 =	1.27	ΣX^2 =	504.00
S^2 =	.42	S^2 =	168.00
S =	.65	S =	12.96
$S\bar{X}$ =	.26	$S\bar{X}$ =	3.24

THIRD SEGMENT OF TESTING

TOTAL TIME		HEART RATE	
ΣX =	648.6	ΣX =	682.0
$\bar{X}$ =	162.15	$\bar{X}$ =	170.5
ΣX^2 =	105,189.00	ΣX^2 =	116,308.00
cf =	105,170.49	cf =	116,281.00
ΣX^2 =	18.51	ΣX^2 =	29.00
S^2 =	6.17	S^2 =	9.66
S =	2.48	S =	3.10
$S\bar{X}$ =	.62	$S\bar{X}$ =	.77

APPENDIX D

SAMPLE OF EARLY SEASON WORKOUT

300 yard warm-up	
3 x 200's leaving every 4:30	600 yards
2 minutes rest between sets	
2 x 300's leaving every 4:30	600
2 minutes rest between sets	
1 x 400	400
3 minutes rest	
1 x 500	500
3 minutes rest	
1 x 400	400
2 minutes rest	
1 x 300	300
2 minutes rest	
3 x 200's leaving every 4:30	600
	3,400 yards

SAMPLE OF MIDDLE SEASON WORKOUT

200 warm-up	
6 x 100's leaving every 2:15	600 yards
4 minutes rest	
6 x 100's leaving every 2:15	600
4 minutes rest	
6 x 100's leaving every 2:15	600
8 minutes rest	
6 x 50's leaving every 1:05	300
4 minutes rest	
6 x 50's leaving every 1:05	300
4 minutes rest	
6 x 50's leaving every 1:05	300
4 minutes rest	
6 x 50's leaving every 1:05	300
	3,000 yards

SAMPLE OF LATE SEASON WORKOUT

6 x 50's leaving every :55 seconds	300 yards
5 minutes rest	
6 x 50's leaving every :55 seconds	300
5 minutes rest	
6 x 50's leaving every :55 seconds	300
5 minutes rest	
4 x 50's leaving every :55 seconds	200
4 minutes rest	
4 x 50's leaving every :55 seconds	200
4 minutes rest	
2 x 50's leaving every :55 seconds	100
4 minutes rest	
8 x 25's leaving every :30 seconds	200
3 minutes rest	
6 x 25's leaving every :30 seconds	150
	1,750

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