THE EFFECTS OF TWO TRAINING PROGRAMS ON

SWIMMING SPEED, PHYSIOLOGICAL EFFICIENCY, AND

STRENGTH OF COLLEGE WOMEN

by

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CHAPTER I

INTRODUCTION

Programs of exercise are being used as supplements to training in particular sports events. These exercise programs are based upon the theory of overload which advocates developing strength by increasing the intensity of the exercise program. It is believed that an increase in strength, brought about by exercise programs, plus training in the specific sport will bring about better performance than would be possible by only training in the specific sport (1, 20).

Studies have been done which indicate that different types of exercise programs; namely, general conditioning exercises, weight training, or a combination of these, are beneficial to performance in swimming speed (55, 88, 100). As far as can be determined, there is a relatively small number of studies which have been devoted to conditioning programs in swimming for college women as compared with the number of studies which have been devoted to men's swimming programs. The majority of the evidence which is available concerning the effects of swimming training on the body has been obtained from data taken on college men and on women who have been on Olympic swimming teams (6).

In the college situation, some women are interested in competitive swimming, but have had little background or training in competitive swimming. In some cases, it is this type of college woman with whom the woman physical educator must work in building a swimming team for intramural or extramural competition. In such a situation, it is possible that a limited amount of time is available to get the women into optimum physical condition before participating in swimming competitions. In setting up conditioning and training schedules, it is valuable to have some concept of the patterns of response of college women to training programs.

This study was designed for the purpose of ascertaining what effects a conditioning and training program consisting of swimming workouts three times weekly for a period of two months, and a conditioning and training program consisting of exercise workouts three times weekly for one month and swimming workouts three times weekly for a second month would have on college women in regard to changes in strength, physiological efficiency, and speed in swimming fifty yards freestyle. The study also attempted to determine which of the two programs would bring about the greatest degree of change in strength, physiological efficiency, and speed in swimming. An attempt was made to ascertain whether a relationship existed between the changes in selected variables.

CHAPTER II

STATEMENT OF PROBLEM

This study was conducted to determine what effects two different training programs for swimming would have on abdominal strength, leg strength, shoulder strength, vital capacity, oxygen consumption, cardiovascular efficiency, and speed in swimming of college women as measured by selected strength and physiological tests and test of speed.

The statistical evidence obtained from such measures was used to indicate whether one type of training was more effective than the other in eliciting a significant directional change in the measured variables.

The study also attempted to determine whether a training program of two months' duration is sufficient to cause a significant directional change in the measured variables. In addition, the study attempted to ascertain whether changes which did occur in selected variables during the two months' program were related.

The statistical evidence thus obtained was considered as a basis for recommending a specific type of training program for college women engaging in swimming competition.

CHAPTER III

REVIEW OF LITERATURE

Conditioning and training programs appear to be the key to successful athletic performance. The different techniques used in an attempt to bring about greater performance range from nutritional conditioning by means of dietary control to muscular conditioning through exercise programs.

In the area of nutritional conditioning, Cureton (53) reported that wheat germ oil has been added to the diet of Australian swimmers in an attempt to improve swimming performance. Cerutty, as cited by Wind, (108) advocated diets which include dried fruit, nuts, and rolled oats. Kaczmarek (67), in a study concerning the effects of gelatin on work output, reported that there was a great gain in work output following a training period which included gelatin feeding to the subjects. Improved performance resulted, according to Dupain (58), following a training program in which dietary plans of athletes were altered, but training plans remained the same. Cureton (6) reported that a diet similar to that of the Japanese swimmers at the 1932 Olympic Games was used with Springfield College swimmers and that great improvement was shown in endurance by the men who were on the diet. Karpovich (68) has also discussed the use of ergogenic aids in athletics.

In the area of muscular conditioning, many coaches have followed the successful swimmers' training program used by Bob Kiphuth (former Yale coach); a program which combines exercises and swimming workouts.

Other coaches, as Tinkham (84) and Counsilman (93), have developed their own methods of physical conditioning using weights or other resistance exercises. Although the approaches to the conditioning and training programs differ with each coach, the objectives of these programs are similar; namely, to develop physical efficiency and skill. More specifically, Armbruster (1:209) stated that training is ". . . a process of adjustment to the competitive situation and improvement in the skill in which the athlete is to perform." The conditioning program is designed to increase bodily efficiency and to prepare the body for strenuous physical activity (1, 25, 104). In some cases, the conditioning program precedes the training program, while in other instances, both programs are carried on at the same time. Whatever the approach, the objectives must be met if good performance is desired.

Regardless of the different techniques and methods that are employed, conditioning programs generally follow a similar pattern. During conditioning, great demands are being placed upon the body. It is necessary, therefore, that the athlete follow a regulated living schedule which provides adequate nutrition and a regular time for meals, study, work, exercise, and rest (1, 15, 24, 27, 104). Such schedules are designed to keep the athlete alert and healthy (1, 104).

Before attempting to establish a conditioning program or a training program for a specific sport, it is essential to have a knowledge of the sports skills involved and also a knowledge of the muscles used in skillful performance. According to Armbruster (1), Madders (20), Wells (31), and Cureton (50), in swimming, although forward progress depends primarily upon the movement of the arms and legs, almost all muscles are used in the action. Some muscles are directly involved in propulsion, while others aid in the forward progress by maintaining the body in a straight line or by preventing lateral or unnecessary movements of the limbs and head.

The muscles of the back and the abdominal muscles stabilize the pelvis. This gives the legs a firm base upon which to move (1, 20, 50). The results of some studies by Cureton (50), seemed to indicate that the speed of the flutter kick used in the front crawl is in direct proportion to the strength of the abdominal and back muscles. These muscles aid in maintaining a streamlined, horizontal body position which minimizes water resistance. To overcome some of the water resistance, the muscles must be powerful. According to Armbruster, Allen, and Harlan (1), more strength is needed to overcome the increased water resistance which accompanies an increased rate of speed. More water resistance is created as the swimmer goes faster. The movement of the flutter kick is basically a whip-like action caused by the flexion and extension of the hip, knee, and ankle joints (50). The flexor and extensor muscles of these joints must be strong and trained in swimming if the kick is to be effective.

It is also essential that the muscles of the trunk, upper back, and shoulder girdle be powerful to provide a stable base for the vigorous arm action (1). A wide range of movement is necessary in the shoulder joint. This joint must be flexible for ease in recovery of the arm above the water following the underwater phase of the arm stroke. The arms provide most of the power in the front crawl. The effectiveness of the arm stroke depends upon the propulsive force exerted by the arm and hand under the water. Kiphuth, former swimming coach at Yale University, worked on the arm depressors, which he felt must be strengthened for the best results of the arm stroke (79).

According to Cureton (6) and Kiphuth (17), flexibility is an asset in swimming. From information based upon data collected from varsity swimmers at Yale University, Dartmouth, and Springfield College, and from data of the Los Angeles and Berlin Olympic Games, Fisher, as cited by Cureton (52), reported that flexibility of the back, shoulder, and ankle is very strongly associated with better swimming performance.

One of the most important skills in swimming is proper breathing. The environment in which a swimmer is placed requires a change in the regular breathing habits. Aycock, Graaff, and Tuttle (32) reported that the swimming process makes it impossible for the involuntary respiratory mechanism to control respiration. In order for a swimmer to get adequate ventilation, he must depend upon voluntary control of respiration. In an effort to get sufficient air, many swimmers upset the stroke rhythm by delaying the head action involved in breathing. The function of the head is to main body balance and the streamlined position as well as to control the breathing action. Although many swimmers breathe on only one side, Karpovich (70) stated that bi-lateral method of breathing may be recommended for better body development and balance. The head should be returned to its center position as quickly as possible after a breath is taken as a quick gasp in order to maintain body balance. The turning of the head for a breath is independent of the arm movement. Any excess raising of the head or rolling of the body in an attempt to get more air, or for any other reason, places the body in a state of imbalance, lowers buoyancy, increases water resistance (70), and reduces the propulsive power of the arms and legs.

As mentioned previously, the flutter kick depends upon the fixation of the abdominal muscles. According to Cureton (51) and Karpovich (70), breathing interferes with this fixation thereby reducing the effectiveness of the leg drive. During breathing, the abdominal muscles must relax to allow a deep breath which results in loss of leg power. Cureton (51) found that faster times can be made when fewer breaths are taken in a short sprint. Times become slower in proportion to the number of breaths taken. For efficiency in the 50 yard freestyle, it is recommended (25, 51) that one breath be taken before the turn and no more than two breaths on the way back.

In the conditioning program, exercise is one of the major considerations. It is through exercise that strength, flexibility, and endurance are developed and improved. According to DeLorme (9), Madders (20), Metheny (22), Reidman (27), Schneider and Karpovich (28), and Brassfield (33), muscles gain in strength when used against resistance. This is based upon the principle of overload. Morehouse and Rasch (24) explained that muscles gain in size and strength only when they are required to do work that places loads on them which are over and greater than previous load requirements. Overloading can be attained by increasing the resistance or weight against which the muscle is used.

Weights, springs, rubber, or even the body itself can be used for resistance.

The number of muscular contractions necessary for rapid increases in strength has not been determined. Morehouse and Rasch (24) suggested six repetitions for arm exercises and twelve repetitions for back and leg exercises. DeLorme and Watkins (9) stated that ten is an arbitrary number of contractions believed to bring about best results.

In developing a conditioning program for swimmers, a question arises as to which method of exercise to use, for it is in the area of exercise that the conditioning methods may differ. Exercise used to develop strength may be in the form of (1) weight training, (2) resistive exercises, (3) static contraction, (4) general conditioning exercises, or (5) practice in the skill of the specific sport. As far as can be determined, there has been no report as to which method is best.

Weight training is a process of exercising with gradually increasing weights for the purpose of strengthening muscle groups used in a certain activity. This is not to be confused with weight lifting which is for the purpose of increasing strength to be able to lift greater weight. Progressive resistance exercises are based upon the same principles as weight training. Both attempt to increase strength, flexibility, and endurance by gradually increasing the weight or the resistance against which a muscle contracts (9). The term weight training is frequently associated with athletics, while the term progressive resistance exercise is most frequently used in connection with rehabilitation of atrophied muscle. Weight training, in this study, refers to the process of using dumbbells, barbells, wall pulleys, or any heavy implement to overload the muscles for the purpose of increasing strength, flexibility, and endurance. DeLorme, as cited by Counsilman (48), stated that strength and power are built by high resistance, low repetition exercises; whereas endurance is produced by low resistance, high repetition exercises. Counsilman (48) mentioned that power, speed, strength, and flexibility seem to improve through weight training.

In this study, resistive exercise refers to those exercises which attempt to develop strength by increasing the resistance against which a muscle contracts without adding weights or heavy equipment. Implements used to give resistance may be surgical tubing, rubber, or metal springs which must be stretched a greater distance in order to increase the resistance.

General conditioning exercises are those exercises which utilize body weight, bodily movements, and gravity to increase strength. Into this classification fall such exercises as push-ups, sit-ups, running, squats, jumping, walking, etc. According to Karpovich and Murray (16), the physiological effect is the same whether barbells, or the weight of the body, or springs are used.

Strength may also be developed through static or isometric contractions. In static contraction, the muscle remains in complete or partial contraction without changing its length (31:27). According to Morehouse and Miller (23), the tension developed when a muscle is unable to shorten in isometric contraction eventually is dissipated as heat. There is no production of movement and no performance of work in the static type muscle contraction. Contraction in which a muscle shortens against a load, and in which movement is produced and work is performed, is called isotonic contraction (23:325).

From the results of a study concerning the development of strength by static contractions, Wolbers and Sills (109) concluded that static muscle contraction for a period of six seconds each day will bring about significant gains in strength for the particular muscle groups used in their study.

Matthews and Kruse (80), in a study on the effects of isometric and isotonic exercises, found that significant gains in strength resulted in a greater number of subjects using the isometric type of exercise than subjects using isotonic exercise.

Rarick and Larson (90), reporting on observations on isometric muscle contractions, stated that in the two experimental groups using isometric type exercise, at the end of a four-week training period, the strength gains were statistically significant. These studies support the findings of Müller and Hettinger concerning the effect of static contractions on strength.

According to Müller (87), muscular strength can be increased by one short, about half-maximal, isometric contraction once a day. More frequent contraction or more powerful contraction does not improve the resulting strength increases. Although this is a quick and inexpensive method of increasing strength, Müller further stated that the one, short contraction does not appreciably increase respiratory and circulatory functions. Hettinger and Müller (65) reported increases in strength on an average of five per cent each week using static contraction of only 1/3 maximal tension. One daily exercise of six seconds' duration had the same effect as one exercise to exhaustion (45 seconds). Hettinger and Müller also stated that static contraction allows a rapid muscle training with little time and energy expenditure.

However, Rasch and Morehouse (92) reported that after a six weeks' program in which isotonic and isometric exercises were employed, the group which showed the greatest strength gains was the group which performed the isotonic exercises. Rasch and Morehouse (92:34) stated that ". . . it is suggested that isotonic exercises probably produce better results from the psychological as well as the physiological aspects." The subjects in the groups used in the study stated that exerting their full strength and not seeing appreciable results was frustrating. They believed that this type of exercise was dull.

Wickstrom (105) stated that the normal or well-conditioned person responds less favorably to the single effort than does the extremely weak individual who will respond significantly. Wickstrom recommended that the data from studies on isometric contractions be carefully reviewed until further evidence has been given.

There are a number of approaches to swimming training and conditioning. Some people advocate the theory of overdistance, that is, to practice distances greater than that actually done in competition. Daviess (8), Handley (14), and Sheffield (30) advocated form and stroke perfection, endurance swims at moderate pace, and some sprinting. According to Handley (15), well known for his work with the Women's Swimming Association of New York, time trials are necessary, but constant fast swimming should be avoided. The distance swims are valuable not only for building strength and endurance, but also for stroke perfection and practice (30).

Morehouse and Rasch (24) acknowledged the value of exercise to strengthen weaknesses and improve endurance, but they stated that the best way to train for an event is to practice that event. Training for an athletic event is specific for that event. Certain demands are made in each event in terms of movement patterns, rate, load, duration, and repetition of the activity which are different from other events (24). DeLorme and Watkins (9) stated that an increase in absolute strength does not indicate that a person is equipped to do the work required in a specific area for which he has not trained. Morehouse and Miller (23) reported that Müller's study, "Die Pulszahl als Kennezeichen für Stoffaustausch und Ermudbarkeit des arbeitenden Muskels," gives evidence that performance in one type of activity does not necessarily improve following training in another activity. Morehouse and Rasch (24) also stated that neurophysiological adjustments to the demands of a certain athletic event are specific for that event. Müller (87:47) mentioned that a strong muscle does not necessarily mean better performance in practice whether in sports or in daily work. This information concerning the specificity of exercise indicates that although exercise is beneficial to increases in strength needed for a sport, practice in that sport is essential for good performance.

According to Armbruster, Allen, and Harlan (1), Kiphuth (17), and Morehouse and Rasch (24), practice in swimming is not enough to develop the great strength needed for top performance. Many times, swimmers improve their speed because of skill improvement. Beyond this point, other increases in speed will depend upon increases in strength (1). Muscular weaknesses in some individuals may not be corrected by swimming alone. Exercises can be used to correct weaknesses in certain areas (25) and can quicken the conditioning process (20).

Kiphuth, from Yale, has long been known for his winning swimming teams. Kiphuth used dry-land exercises in the conditioning process before the swimming season. The program aimed to develop strength, flexibility, and endurance through the use of free exercise and pulley weights (17). It was Kiphuth's contention that the same amount of muscular power cannot be developed in the water in the same period of time as can be developed in the conditioning program that he has established. According to Morehouse and Rasch (24), the water does not provide enough resistance to develop strength in the swimmers. Once the swimming skill is learned, and improvement in speed accomplished as a result of the improved skill, the only way to increase speed, thereafter, is through increases in strength (1). Following the conditioning program, Kiphuth's swim teams undergo a vigorous water training program. It should be noted that record-breaking swimmers today supplement their water workouts with some form of dry-land exercises (16, 41, 79, 93, 108).

Thompson and Stull (100) studied the effects of five different training programs on speed of swimming thirty yards. The group which practiced swimming three times a week, the group which swam six times each week, and the group which did exercises with weights three times a week and swam three times a week all significantly improved their speed in swimming. The group which did no swimming or exercising and the group which participated in a weight training program three times a week did not significantly improve their time.

However, a study done by Davis (55) seemed to reveal that weight training is beneficial to swimming. In a program which consisted of weight training three times a week and in which the participants were permitted to go swimming only once a week, all participants significantly improved their swimming times in the crawl stroke.

Nunney (88) described circuit training as a method of training swimmers. He reported that a group using this method of training significantly improved in endurance swimming, speed swimming, chins, and push-ups. Circuit training is based upon progressive resistance and loading and is characterized by a circular arrangement of activities which include exercises with and without weights. Each activity, at submaximal capacity, is repeated three times and must be completed within a certain limit of time (88). Madders (20) also described circuit training as a method of conditioning for swimmers and stated that an appeal of circuit training is that each swimmer works at his own rate.

The effect of weight training on physical performance should be of concern to coaches who may wish to use weight training in conditioning programs. Some coaches believed that weight training results in a decrease in speed of movement and slows the athlete. Masley, Hairbedian, and Donaldson (78) in a report on weight training in relation to strength, speed, and coordination, stated that from their data, the notion that weight training contributes to a loss of coordination and speed of movement seemed to be refuted. In studies by Wilkins (106) on the effect of weight training on the speed of movement, and by Zorbas and Karpovich on the effect of weight lifting on speed of muscular contractions, as cited by Karpovich and Murray (16), it was found that using weights to increase strength did not result in a slowing effect on speed of arm movements. Increases in strength and power were the results of Chui's study on the effect of weight training on athletic power (42), and in Capen's study on the effect of weight training on speed, power, strength, and endurance (38).

In a study by Nunney (88:197) on the relation of circuit training to swimming, it was found that "There was no significant evidence to show that weight training was in any way detrimental to athletic performance."

The use of weights for conditioning is not limited to men. Karpovich and Murray (16) reported that the Town Club of Chicago employed weight training for the girls' swimming team in 1952. Some of these girls were in the 1952 Olympic Games. Leighton (77) suggested use of weights by girls for general improvement of physical appearance and conditioning.

A negative effect of weight training was found by Wilson, as cited by Counsilman (48), in a study of the effect of weight training on the physical fitness of young men. He reported that the endurance of subjects as measured by the time run on a treadmill was decreased by weight training. Counsilman (48) reported that this information confirms the opinion of Steinhaus and Karpovich that weight training decreases circulo-respiratory endurance. Morehouse and Rasch (24) also cautioned that if weight training is used exclusively for some time, the movement patterns from this activity may interfere with the movement patterns of a previously learned sport. It is necessary, then, to practice the movement patterns of the sport while engaging in weight training. These factors should be taken into consideration before establishing a conditioning program for swimmers.

Change in strength is one effect of conditioning and training. The increase in strength is accompanied by an increase in the size of a muscle. This increase in size is believed to be caused by the hypertrophy of the muscle fibers (9). Brassfield (33) stated that there are some muscle fibers which may have been unused and these, with other fibers, hypertrophy as greater demands are placed upon them. There is a thickening and toughening of the sarcolemma, the membrane which surrounds each muscle fiber, and also an increase in the amount of connective tissue in the muscle after conditioning (9, 13, 23, 28, 33).

The number of capillaries is increased in a muscle following conditioning (9). This provides for a better blood supply and, consequently, a greater supply of oxygen to the working muscles. Increase in phosphocreatine, muscle hemoglobin, and glycogen contents of the muscle which occur as a result of conditioning (9, 13, 23, 28) facilitate energy release and muscle contraction. These factors bring about an increase in the ability of the muscle to do work.

The cable tensiometer, the push-pull dynamometer, and the back and leg dynamometer are instruments which have been used to measure strength (29, 39, 40, 72, 107, 110, 111). Clark (46:263) stated that cable tension is obtained from the force needed to create offset on a riser in a cable stretched between two sectors. A calibration chart is needed to convert the tension into pounds. Clarke also devised thirty-eight different tests to measure strength of a muscle (4). According to Clarke (45), the cable tensiometer had the greatest precision for testing when compared with a strain gauge, a spring scale, and the myometer. An objectivity coefficient of 0.90 was reported.

Hunsiker and Donnelly (66) reported that because of its small size, the tensiometer is especially valuable in a test battery which involves testing the strength of movement in a number of joints.

Kennedy (72) reported that the cable tension method allows little displacement or stretch during a lift and the subject can remain at the maximum lifting angle throughout the entire lift. Testing techniques for the cable tensiometer can be found in Clarke's manual (4).

Scott and French (29) described several tests for measuring arm and shoulder girdle strength. These tests included the vertical pull with the dynamometer, vertical pull with the spring scale, push and pull dynamometer, push up on knees, pull up on horizontal bar, and hanging. Scott and French (29:292) also reported a reliability of 0.91

for the push-pull dynamometer on sixty-two college women.

Wilson (107), in a study of arm and shoulder girdle strength, reported a reliability coefficient of 0.89 for the pull on the dynamometer for fifty-two college women.

Carpenter (39), reported on a study of the factors determining effective strength tests, stated that the pull correlated more highly with muscle strength in the shoulder girdle than did chinning.

The back and leg dynamometer can be used to measure leg strength, according to Clarke (3), and Kennedy (72). Everts and Hathaway (60) reported that fitness testing can be made more efficient by using a belt when testing leg strength with the back and leg dynamometer. More objective results can be obtained by using the belt.

Carpenter (40) studied various angles of the knee joint in measuring leg strength with the back and leg dynamometer. From the results of the study, Carpenter reported that it would be reasonable to conclude that when the knee joint is at an angle of 115° to 124°, the maximum leg lift may be obtained.

Garfiel, as cited by Hult (111), used a leg dynamometer to test leg strength of college women and found a coefficient of 0.71. Glassow and Broer (11) found a reliability coefficient of 0.87 for testing leg strength with the leg dynamometer.

Abdominal strength has been tested by sit-ups (29), dynamometer (57), and the cable tensiometer (110). Scott and French (29) reported a 0.94 reliability for sit-ups as a test of abdominal strength in college women. DeWitt (57), reporting on a study of the sit-ups as a measure of abdominal strength, stated that the results indicate a low correlation between the ability to do sit-up type tests and abdominal strength. Abdominal strength, the power to pull the trunk toward a sitting position, was measured by the dynamometer. The value of the tensiometer as a measuring instrument has been previously discussed.

According to Knehr, Dill, and Neufeld (73), exercise repeatedly carried out leads to improved performance. Morehouse and Miller (23:258) stated,

> Psychological factors and specific skills are so important in determining individual performances in exhaustive exercise that improved performance can be acquired with almost no improvement in fundamental physiological capacities.

They also mentioned that to determine the physiological effects of conditioning, some direct physiological assessment, as measurement of oxygen debt, should be made.

Henry and Berg (64) reported that the results of a study on physiological and performance changes in athletic conditioning seemed to indicate that physiological measures, even though involving moderate exercise, are much more effective in determining the improved fitness that had resulted from conditioning than are measures of performance.

Physiological measures can be made to determine the effects of conditioning and training upon body efficiency. The factors which are frequently measured to determine the effect of conditioning on the cardiovascular system include resting pulse rate, blood pressure (diastolic and systolic), pulse rate response to exercise, and pulse pressure (3, 18, 75, 76).

A low resting heart rate is characteristic of the conditioned athlete. The heart rates of some athletes have been reported as low as 50 to 55 beats per minute (13). It has been reported by McCurdy and Larson (21), Morehouse and Miller (23), Reidman (27), Schneider and Karpovich (28), Brassfield (33), Dawson (56), Henry (63), Knehr, Dill, and Neufeld (73), and Walters (103) that a lowered resting heart rate is one effect of conditioning on the cardiovascular system. According to Cureton (7:121), pulse rate in the lying position taken after at least five minutes' rest is an indicator of fitness. The lower the pulse rate, the better the condition.

Henry (63) claimed that the resting heart rate does have validity as an indirect measure of athletic conditioning. It was further stated by Henry that at his laboratory considerable reliance has been placed upon change in the resting heart rate as an index of the physiological effect of conditioning.

Although a considerable amount of evidence supports a slower heart beat as a result of training and conditioning, Tuttle and Walker (102), using Tuttle's Pulse Ratio, found that a significant change had not occurred in the resting heart rate of high school boys following a season of training and competition in track. Yet, it was found that the recovery pulse decreased which indicated an improvement in physical condition. Fewer heart beats were needed in reaching the resting level following exercise. The recovery pulse represents the sum of the heart beats between the cessation of exercise and the time at which the resting rate is reached and maintained, minus the resting pulse for the same period of time.

In another study, Davis (54) found that no significant difference in cardiovascular condition had occurred, using Schneider's Cardiovascular Index, for non-varsity swimmers undergoing training and conditioning for the 200 yard crawl.

According to Larson (76:458), normal pulse rate is affected by exercise as well as by age, sex, diurnal changes, season and climate, altitude, air and water movement, loss of sleep, respiration, metabolic activity, changes in body posture, digestion, and emotional or nervous factors. Clarke (3:95) stated that these factors increase the complexity of cardiovascular measurement.

According to Cureton (6:178), the pulse rate response to a fairly strenuous, standard exercise is one of the most acceptable tests of circulatory-respiratory fitness. Clarke (3), McCurdy and Larson (21), Morehouse and Miller (23), Schneider and Karpovich (28), and Schneider (96) stated that the heart rate returns to normal more quickly following activity in a trained subject than in an untrained subject. Salit and Tuttle (94) reported similar findings in a study of the effects of prescribed strenuous exercise on the physical efficiency of women.

Walters (103) reported an improvement of recovery time and work efficiency following a short intensive training period. Montoye (85) analyzing data collected by Gallagher and Brouha on the evaluation and significance of physical fitness, reported that the post-exercise pulse rate is sensitive to a training program.

According to McCurdy and Larson (21), a trained swimming group has a heart rate which is lower while standing, less changeable, more rapid return to normal, lower increase on standing, and less rapid rate following an endurance swim than does a non-activity group.

However, Knehr, Dill, and Neufeld (73) reported that conditioning has no effect on the heart rate return to normal (resting level) following exercise to exhaustion. They claimed that conditioning has an effect on this measure when the exercise is of fixed intensity and duration.

Cogswell, Henderson, and Berryman (47), using the Harvard Step Test, treadmill and bicycle ergometer in observing the effects of training on pulse rate, blood pressure, and endurance in humans, stated that post-exercise pulse rate showed a decrease with training in submaximal exercise, but a similar response was not produced with maximal exercise.

Tuttle (101) stated that a standard exercise, applicable to all, must be used for comparing the heart rate response to exercise of different individuals or the same individual under different conditions.

The pulse ratio can be used as a test for physical efficiency (101). Pulse ratio is the relationship between resting pulse for one minute and the pulse after a known amount of standard exercise for two minutes (61). It is expressed as:

$$\text{pulse ratio} = \frac{\text{total pulse for two minutes after exercise}}{\text{normal resting pulse for one minute}}$$

Reporting on data on the Pulse Ratio Test, Phillips, Ridder, and Yeakel (89:68) stated that a reliability correlation of 0.774 is too low to make the Pulse Ratio Test valuable for individual measure.

The McCurdy-Larson Test of Organic Efficiency has been used as an index of endurance conditioning in swimming (82). Items included in this test are standing diastolic pressure, breath holding twenty seconds after a standard stair-stepping exercise, vital capacity, sitting pulse pressure divided by the sitting diastolic pressure, and the difference between standing normal pulse rate and pulse rate two minutes after exercise. According to McCurdy and Larson (82), this test is valid as an index of the functional condition of the circulatory-respiratory systems for endurance swimming.

Clarke (3) described the following cardiovascular type tests. Crampton Blood Ptosis Test was one of the earliest cardiovascular tests. It was based upon changes in heart rate and systolic pressure upon standing from a reclining position (3:97). The Barach Energy Index was based upon systolic and diastolic blood pressure and pulse rate per minute taken in the sitting position (3:98). Reclining pulse rate, standing pulse rate, increase in pulse rate on standing, increase in systolic blood pressure standing compared with reclining, pulse rate increase immediately after exercise, and the return of the pulse rate to standing normal after exercise are the items which constitute the Schneider Test (3:99).

Morehouse and Tuttle (86:8), in a study on the post-exercise heart rate, reported that there is no significant relationship between the resting pulse and recovery time at any intensity of the exercise. They further stated that recovery time is prolonged in relation to the intensity of the exercise and is not related to the resting pulse.

Elbel and Holmer (59) found an insignificant coefficient of correlation of 0.164 between the pre-exercise pulse rate and the amount of time needed for the post-exercise pulse rate return to the pre-exercise level.

Gallagher and Brouha (62:25) stated that the initial heart rate before exercise is not important and only the heart rate during the recovery period following exercise need be determined. They mentioned that fitness depends upon the rate at which an individual's heart slows after exercise and not on how fast it may have been beating before exercise. According to Gallagher and Brouha, there is not a significant relationship between the initial heart rate and an individual's fitness.

The Harvard Step Test, as described by Brouha (34), involves stepping up and down on a twenty inch bench at a rate of thirty steps per minute for a period of five minutes. The pulse counts are taken for one to one and one half minutes, two to two and one half minutes, and three to three and one half minutes after cessation of exercise. The score is calculated as follows:

$$\text{Fitness Index} = \frac{\text{duration of the exercise in seconds x 100}}{\text{2 x sum of the pulse counts in recovery}}$$

According to Brouha, Fradd, and Savage (36:224), this fitness index improves under regular training and declines when training is insufficient.

Brouha (34:31) stated that this test measures the general capacity of the body, particularly the cardiovascular system, to adapt itself to hard work and to recover from what it has done. It can be used in scoring general fitness and in following the change of fitness in a given individual (34:33). Keen and Sloan (71) also reported that the Step Test has value as an indicator of physical fitness for strenuous exertion.

Modifications of the Step Test have been made for other than use by men. Woods (112) used an eighteen inch bench for stepping at a rate of thirty steps per minute for five minutes. Clarke (44) used stepping at a rate of thirty steps per minute for four minutes on an eighteen inch bench. She also used the men's classification of fitness in reporting on a functional fitness test for college women. The classifications are:

Index: below 55 - poor physical condition
55 to 64 - low average
65 to 79 - high average
80 to 89 - good
above 90 - excellent

Brouha and Gallagher (35) used a sixteen inch bench for high school girls stepping at a rate of thirty steps per minute for four minutes. Gallagher and Brouha (62) used the four minute stepping at thirty steps per minute on benches of eighteen inches for the smaller boys and twenty inches for the larger boys in high school. The higher the score, the fitter the boy.

Sloan (97) modified the Step Test for women and found that the Harvard Step Test is useful as a test of capacity for strenuous exertion by women. In this study, bench heights of sixteen, eighteen, and twenty inches were used by women and the results compared with those of men using the twenty inch bench. The results from the eighteen inch bench test correlated best with the men's scores. Another group was tested with eighteen, seventeen, and sixteen inch benches. In this comparison, the indexes of the group performing on the seventeen inch bench were in closest agreement with the men's scores. On the basis of these results, a bench height of seventeen inches was suggested for women.

It has been suggested by Brouha (34) and Brouha and Gallagher (35) that the pulse count be taken at the neck over the carotid artery where the beats are stronger after hard exercise than at the wrist. Phillips, Ridder, and Yeakel (89) reported that objectivity coefficients are high enough to justify obtaining the pulse rate at the carotid artery.

There are differences of opinion concerning the effect of conditioning on blood pressure. McCurdy and Larson (21), Reidman (27), Brassfield (33), and Dawson (56) indicated that no significant changes occur in the resting systolic and diastolic pressures as a result of conditioning. Salit and Tuttle (94:253), in a study of the validity of heart rate and blood pressure determinations as physical fitness measures, reported that blood pressure measurements appear to be useless in distinguishing between healthy young adults who obviously differ in physical fitness.

Cogswell, Henderson, and Berryman (47) reported that in the step test systolic blood pressure, resting and post-exercise, tended to decrease with training.

Cureton (7) mentioned that the higher the diastolic pressure the better is the condition of a young athlete.

There is a question as to which of the changes in blood pressure during or following exercise is most important in indicating cardiovascular efficiency. Morehouse and Miller (23:258) claimed that increased diastolic pressure following work is an outstanding effect of conditioning. Brassfield (33) stated that conditioning reduces the height to which the blood pressure may rise during work. Reidman (27) stated that in a standing position, the systolic pressure has been found to be lower in some athletes. Henry (63) reported that the confusion concerning the importance of resting blood pressure as an indication of cardiovascular efficiency is due to the fact that the measure is considered important in itself. According to Henry, the pressures are the result of other factors; namely, peripheral resistance, arterial elasticity, stroke volume, and heart rate.

According to Larson and Yocum (18) and Larson (76), measurements of resting respiration rate, oxygen consumption and carbon dioxide exhalation, and vital capacity are used to determine the effects of conditioning on respiration. According to Schneider and Karpovich (28), Brassfield (33), Knehr, Dill and Neufeld (73), Rasch and Brant (91), and Schneider (96), there is a decrease in the resting respiration rate accompanied by an increase in the depth of breathing following a conditioning program. From the air which is breathed, the conditioned person absorbs a greater proportion of oxygen than does the unconditioned person as indicated by McCurdy and Larson (21), Morehouse and Miller (23), Reidman (27), Schneider and Karpovich (28), Brassfield (33), and Schneider (96). There is an increase in the amount of oxygen consumed and in the amount of carbon dioxide expelled at work and at rest by an individual following conditioning. McNelly (83) found that, during exercise, the quantity of oxygen absorbed per 100 cc of air breathed was greater in trained subjects than in the untrained. According to Morehouse and Miller (23) and Walters (103), the conditioned athlete is also able to sustain a larger oxygen debt.

Karpovich and LeMaistre (69) investigated prediction time in swimming breaststroke as based upon oxygen consumption. They stated that the study showed that swimming improvement can be obtained only through an increase in oxygen intake, oxygen debt and improved efficiency of the stroke and that capacity for oxygen intake and debt will be increased through intensive training.

According to Carlson and Johnson (2), Guyton (13), and Pace and McCashland (26), there are two general types of apparatus which can be used in determining oxygen consumption. They are the closed circuit apparatus and the open circuit or air current apparatus. In the closed circuit, the subject breathes the air contained in a closed system. The carbon dioxide eliminated by the subject is removed by soda-lime and is weighed. A measured volume of oxygen is supplied to replenish that which has been absorbed. The air in the collecting chamber is analyzed at the end of the observation. The Benedict-Roth Apparatus is an example of a closed circuit apparatus (2).

In the open circuit apparatus, the subject breathes atmospheric air. The exhaled air is collected, measured, and analyzed for carbon dioxide and oxygen content. The Douglas Bag is a wedge-shaped rubber bag with a three-way valve and is used for collecting the expired air for analysis (23).

Oxygen consumption can also be determined with the Haldane-

Guthrie Gas Analysis Apparatus. In this open circuit apparatus, carbon dioxide and oxygen from a measured amount of expired air are selectively absorbed and removed by sodium hydroxide and alkaline pyragallol. The decrease in volume, measured at the original pressure and temperature serves to measure the volume percentage of the components removed.

Vital capacity is the total amount of air that a person can expire following maximal inspiration. According to Reidman (27), measures of vital capacity are not an accurate indication of conditioning, although conditioning may affect vital capacity. Some conditioned persons may have low vital capacities and some unconditioned persons may have high vital capacities. Cureton (49:92) stated that no positive relationship between vital capacity and organic condition can be claimed. Vital capacity is a reflection primarily of size as indicated mainly through surface area, height, weight, and chest size.

According to Guyton (13), Reidman (27), Brassfield (33), and Steinhaus (98), vital capacity can be improved by training and conditioning. Stuart and Collings (99), in a study comparing the vital capacity of athletes and non-athletes, found that the mean vital capacity score of the athlete was significantly higher than the mean vital capacity score of the non-athletes. They suggested that the increased development of the respiratory musculature accompanying regular physical training may be the reason for the difference in vital capacity.

Guyton (13) claimed that three factors influence vital capacity. These factors are the strength of the respiratory muscles, the distensibility of the lungs and chest cage, and the physical dimensions of the thoracic area. The main factor, according to Guyton, is the strength of the respiratory muscles. It is upon this one factor that conditioning has an effect on the vital capacity. According to Schneider and Karpovich (28) and Brassfield (33), chest expansion can be increased by strengthening the respiratory muscles. Cureton (6:342) stated that vital capacity can definitely be improved by means of swimming, regular deep breathing exercises, and by chest stretching. Cureton (5) also claimed that compared with people of the same age, swimmers have been found to be superior in vital capacity, inspiratory and expiratory strength, and breath holding. Conditioning, then, may lower the resting respiration rate, increase the oxygen consumption and carbon dioxide exhalation, and may improve the vital capacity.

The available evidence seems to indicate that physiological and strength changes accompany programs of training and conditioning. Changes in bodily efficiency are reflected in increases in strength, decreases in resting heart rate, increases in the return of the heart rate to resting level following exercise of fixed intensity, increases in oxygen consumption, decreases in resting respiration rate, and increases in vital capacity. Measures of physiological efficiency and strength may aid in determining the condition of athletes and in establishing training and conditioning programs geared to the athletes' condition levels. A knowledge of such measures, as well as knowledge of the different types of exercise and the effects of the exercises on the body, may also be a help in determining the period of time necessary to bring about top performance and condition in the athlete.

CHAPTER IV

PROCEDURE

The purpose of this study was to determine the effects of two specific training programs on strength, physiological efficiency, and speed in swimming.

Selection of Subjects

The subjects for the study were seven freshmen and five sophomores selected from among the undergraduate students enrolled at The Woman's College, University of North Carolina, for the Fall semester of 1960. These subjects, who had volunteered, held as a minimum a Junior Life Saving Certificate from the American Red Cross and were able to swim, freestyle, a distance of one hundred yards. The ages of the subjects ranged from seventeen years to nineteen years. The weights of the subjects ranged from 120 pounds to 150 pounds and the heights ranged from sixty-two inches to sixty-eight inches. The academic areas in which the subjects were concentrating included Biology, Chemistry, History, Home Economics, French, Liberal Arts, and Physical Education.

The exercise-swimming group consisted of a total of six freshmen and sophomores who had no physical handicaps and no medical restrictions. The subjects were enrolled in physical education classes other than swimming and were not involved in any clubs or recreation involving swimming.

The six subjects in the swimming group had no physical handicaps and no medical restrictions and were enrolled in physical education classes. Of this group, two subjects were in swimming classes which met twice a week, three subjects were in the synchronized swimming club which met once each week, and one subject was enrolled in a class other than swimming.

Selection of Measuring Instruments

Abdominal Strength

An aircraft tensiometer, as described by Clarke (4, 45), was employed to measure the abdominal strength of the subjects. The Pacific Scientific Company, Inc., Los Angeles, California, manufactured the tensiometer, Model T 5-6007-117-00, which was used in this study. It was calibrated for an "up-pull" on a cable to a maximum of one hundred pounds. The tensiometer had a maximum tension pointer which aided in the ease of reading the subject's score.

The subject assumed a supine lying position upon the testing table with the arms folded on the chest, hips in 180 degrees extension and adduction, and knees fully extended. A web belt with a hook for adjusting its length was strapped around the subject's chest close under the armpits. The pulling assembly was attached to the belt beneath the subject, through a slit in the table. The test administrator applied downward pressure upon the hips of the subjects to prevent the hips from rising. The subject was instructed to sit up exerting as much pressure as possible against the belt.

The pulling assembly consisted of a two-inch aluminum "C" clamp which was attached to the web belt and to a double hasp. The hasp was fastened to a three-inch aluminum clamp which was attached to two one-inch clamps. The second one-inch clamp was hooked on the end of a one-sixteenth inch cable. The cable was attached to a standard frame of the type used with the tensiometer when measuring grip strength. The frame was held securely in place on the bottom brace of the table, directly below the slit in the table, by two four-inch aluminum clamps and an iron bar. The cable tensiometer was held in place in the frame by means of a two-inch aluminum clamp.

Each subject was given three trials and the best score was recorded. The tension recorded on the tensiometer was converted into pounds by the use of a table for that purpose which was provided by the manufacturer. This table and conversion scores may be found in the Appendix on Table XII.

Shoulder-Girdle Strength

The shoulder-girdle strength of each subject was measured by a single pull on the grip dynamometer with a push-pull attachment as described by Scott and French (29).

The subject was instructed to hold the handles of the push-pull attachment with palms facing the body at sternum level, keeping the forearms horizontal. The subject was then instructed to pull as vigorously as possible without touching the dynamometer to any part of the body. The best score of three trials was recorded. A correction table was used to convert the raw score into pounds. A copy of the table may be found in the Appendix on Table XIII.

Leg Strength

The back and leg dynamometer, as described by Clarke (3) and

Everts and Hathaway (60), was used to measure leg strength. The best score of three trials was taken and converted into pounds by means of a correction table, a copy of which may be found in the Appendix on Table XIV.

The subject stood erect on a platform, specially constructed for use with the dynamometer, with the feet parallel and the center of the feet on a line with the chain which was located in the center of the leg-lift platform. A crossbar was held at arm's length resting at the hip joint. The loop end of the web belt was slipped onto one end of the bar. The free end of the belt was looped around the other end of the crossbar and tucked under the belt which was placed low over the hips and gluteal muscles of the subject.

The dynamometer attachment was hooked onto the crossbar and the subject was instructed to flex the knees and the hip joints keeping the back straight. When the angle formed by the thigh and lower leg reached 120 degrees, as measured by a goniometer, the other end of the dynamometer attachment was hooked to the chain on the platform maintaining the correct leg angle. The subject was then instructed to straighten the knees as much as possible keeping the back and arms straight and the head erect.

Cardiovascular Efficiency

The Harvard Step Test, as described by Clarke (44), was used to determine cardiovascular efficiency.

The subject was instructed to step up and down on an eighteen inch step for a period of four minutes at a rate of thirty steps per minute with the command "Up" coming every two seconds. At the end of the four-minute period, the subject sat down. Pulse counts were taken for thirty second intervals from one to one and one half, two to two and one half, and three to three and one half minutes following cessation of exercise. If the subject stopped before the four-minute period ended, she was instructed to sit down and the pulse counts were taken as described above.

To determine the subject's adaptation to and recovery from exercise, the pulse counts and duration of the exercise were subjected to the following formula:

$$\text{Recovery Index} = \frac{\text{duration of the exercise in seconds x 100}}{\text{2 x sum of the pulse counts in recovery}}$$

Vital Capacity

A Propper Compact Spirometer was used to measure vital capacity. The Propper Manufacturing Company, Incorporated, Long Island City, New York, manufactured the spirometer.

The subject was instructed to take as deep a breath as possible and then blow into the spirometer, expiring as fully as possible. The best of three scores, taken directly from the spirometer, was recorded.

Oxygen Consumption

The Haldane-Guthrie Gas Analysis Apparatus, which was used to measure oxygen consumption, was manufactured by the Fisher Scientific Company, Silver Springs, Maryland.

The subject took a deep breath and then expired into a tube which was connected to the gas burette on the apparatus. The volume of expired air was measured on the graduated gas burette. The carbon dioxide and the oxygen were selectively absorbed by sodium hydroxide and alkaline pyragallol. The decrease in volume of the expired air sample determined the percentage of carbon dioxide and oxygen removed. The following formulas were used to determine the percentages:

$$\% \text{ carbon dioxide} = \frac{V - V_1}{V} \times 100$$

$$\% \text{ oxygen} = \frac{V_1 - V_2}{V} \times 100$$

V = original volume of expired air

V_1 = volume of the sample after carbon dioxide absorption

V_2 = volume of the sample after oxygen absorption

Speed

The subjects were timed for swimming fifty yards freestyle in the Woman's College seventy-five foot pool. They were instructed to swim two lengths of the pool as fast as possible. Instructions for the start were given to each subject. The subject stood at the deep end of the pool and waited for the start, "Ready, Take Your Mark, Go!" The command of "Go" was given verbally. Each subject swam alone. No other person was in the pool when another subject was being timed. No person shouted encouragement to the subject being timed. The same stop watch and test administrator were used for all timing. There was no instruction given as to racing turns, in order that changes in speed could be attributed to factors other than turns. Hence, ability to turn with speed, remained fairly constant throughout the study.

Procedure

Initial Meeting

The investigator met with the volunteers on September 22, 1960. At that time, the purpose of the study and the part that the subjects would play in it were explained. The subjects agreed to spend three hours each week for a period of eight weeks in the exercise and/or swimming program. Initial testing took place during the week of October 2, 1960. The investigator was the sole test administrator throughout the entire study.

Exercise-Swimming Group

The subjects cooperated with the request not to participate in any swimming activities during the exercise part of the program. The subjects met as a group each Monday, Wednesday, and Friday at 4 P.M. in the corrective laboratory and on the athletic field at Woman's College for a period of four weeks. During each exercise session, the subjects performed the prescribed exercises under the supervision of the investigator. The exercises became progressively more difficult. The exercises were frequently changed to add interest to the program and to avoid boring workouts. During each exercise session, the number of successive executions of each exercise was increased by one, after increasing the repetition to four. The number of exercises in each set, as listed below, is represented by the first number following the name of the exercise. The second number represents the number of repetitions for each set.

The majority of the exercises, which were chosen for their supposed effect on strength, flexibility, and endurance, were obtained from swimming and body mechanics books. The complete description of each exercise and its reference may be found in the Appendix. The exercise-swimming group performed the following exercises:

First week:	Monday	Wednesday	Friday
sit-ups	4 x 3	4 x 4	testing
push-ups	4 x 3	4 x 4	completed
stretches	6 x 4	6 x 4	no exercise
rockers	6 x 3	6 x 4	or swimming
back raises	5 x 3	5 x 4	
pull-overs	4 x 3	4 x 4	
squat jumps	6 x 3	6 x 4	
arm strokes	½ minute	½ minute x 2	

Second week:	Monday	Wednesday	Friday
sit-ups	5 x 4	6 x 4	7 x 4
push-ups	5 x 4	6 x 4	7 x 4
squat jumps	5 x 4	6 x 4	7 x 4
arm strokes	½ minute x 3	½ minute x 4	½ minute x 5
stretches	5 x 4	6 x 4	7 x 4
bicycles	15	20	25

During the third and fourth weeks of exercise, a slightly different procedure was used. The exercise sessions were held outdoors on the athletic field . The subjects completed one set of each exercise and then ran one length of the hockey field, a distance of one hundred yards, for endurance and leg strength. The run of one hundred yards was done four times during the third week and five times during the fourth week.

Third week:	Monday	Wednesday	Friday
sit-ups	7 x 4	8 x 4	9 x 4
push-ups	7 x 4	8 x 4	9 x 4
squat jumps	7 x 4	8 x 4	9 x 4
arm strokes	½ minute x 4	½ minute x 4	½ minute x 4

Third week: (continued)	Monday	Wednesday	Friday
stretches	7 x 4	8 x 4	9 x 4
running	400 yards	400 yards	400 yards

Fourth week:	Monday	Wednesday	Friday
sit-ups	10 x 4	11 x 4	12 x 4
push-ups	10 x 4	11 x 4	12 x 4
stretches	10 x 4	11 x 4	12 x 4
squat jumps	10 x 4	11 x 4	12 x 4
arm strokes	½ minute x 4	½ minute x 4	½ minute x 4
running	500 yards	500 yards	500 yards

If a subject was unable to attend an exercise session, a special time was arranged for the exercises to be performed under the supervision of the investigator. Some subjects were unable to attend all sessions, due to class work or special activities. The number of times a subject attended the exercise sessions ranged from six to eleven.

Swimming Group

The swimming group performed the swimming workouts each Monday, Wednesday, and Friday at 5 P.M. under the supervision of the investigator for a period of four weeks. Swimming workouts were held at the Woman's College swimming pool. If a subject was unable to attend the scheduled practice sessions, arrangements were made for that subject to do the workouts during one of the recreational swimming periods which were held on Tuesday, Thursday, and Sunday. The workouts were done under the supervision of the investigator or the instructor in charge of the recreational swimming period. Some of the girls did not swim during their menstrual periods. The number of times that a subject attended the practice sessions ranged from eight to eleven.

The swimming workouts were established by the investigator following suggestions of such authorities as Armbruster (1), Kiphuth (17), and Karpovich (70) and according to the capabilities of the subjects as a group. Workouts were changed from week to week in order to promote interest, increase the distance, and to emphasize different aspects of swimming, as sprinting or stroke perfection. The following workouts were performed by the swimming group:

First week: total of 700 yards

1. swim 200 yards emphasizing three kicks to every arm stroke
2. kick 100 yards breathing on every six kicks
3. pull (using only arms) 100 yards
4. swim 100 yards counting kicks as in #1
5. swim four twenty-five yard sprints
6. swim 100 yards

Second week: total of 700 yards with more sprinting

1. swim 100 yards counting three kicks to every arm stroke
2. kick 100 yards
3. pull 100 yards
4. swim four twenty-five yard sprints
5. sprint two twenty-five yards kicking only
6. sprint two twenty-five yards pulling only
7. swim 100 yards

Third week: total of 900 yards

1. swim 150 yards, counting kicks
2. swim two twenty-five yard sprints
3. kick 125 yards, breathing every six kicks
4. swim two twenty-five yard sprints
5. swim 125 yards using only arms
6. swim seventy-five yards, breathing every third stroke (alternate breathing)
7. sprint seventy-five yards, first twenty-five using legs only, second twenty-five using arms only, third twenty-five using the whole stroke

5 minutes rest

8. 100 yard individual medley

Third week: (continued)

9. 100 yard individual medley
10. swim fifty yards alternate breathing

Fourth week: total of 1,000 yards

1. swim 150 yards using legs only
2. pull 150 yards - alternate breathing
3. swim two twenty-five yard sprints
4. swim 100 yards - alternate breathing
5. swim two twenty-five yard sprints

repeat entire workout

Second Testing

After the first four weeks' period was completed, both groups were given the tests and were timed for fifty yards front crawl following the procedures mentioned in connection with the first testing. Each subject reported at an arranged time and the tests were administered in the following order:

1. oxygen consumption
2. vital capacity
3. pull on the dynamometer
4. sit up against the tensiometer
5. leg lift with the dynamometer
6. step test

The timing for fifty yards was done on the Monday following the administration of the other tests. The same procedure was used as during the first timing.

Second Workout Period

The exercise-swimming group and the swimming group worked out together during the last three weeks of the program. Both groups did the same workouts and attended sessions each Monday, Wednesday, and Friday at 5 P.M. under the supervision of the investigator at the Woman's College pool. Workouts were changed each day to promote interest and to emphasize different aspects of swimming, as sprinting, starts, breathing, etc.

The following workouts were done by both groups:

Fifth week:

Monday
all subjects were timed for fifty yards front crawl

Wednesday: total of 375 yards
1. swim 150 yards alternate breathing
2. sprint seventy-five yards using legs only
3. sprint seventy-five yards using arms only
4. sprint seventy-five yards using whole stroke
5. practice starts and turns for twenty minutes

Friday: total of 900 yards
1. swim 150 yards alternate breathing
2. sprint seventy-five yards using legs only
3. sprint seventy-five yards using arms only
4. sprint seventy-five yards using the whole stroke
5. swim seventy-five yards easy
6. repeat the whole workout

Sixth week:

Monday: total of 900 yards concerned mainly with sprinting
1. swim seventy-five yards alternate breathing
2. sprint seventy-five yards
3. sprint seventy-five yards using legs only
4. sprint seventy-five yards using arms only
5. swim three twenty-five yard sprints using the whole stroke
6. swim seventy-five yards easy using any stroke
7. repeat entire workout

Wednesday: total of 900 yards concerned mainly with stroke perfection and rhythm
1. kick 150 yards counting six kicks on every breath
2. pull 150 yards alternate breathing
3. swim 150 yards alternate breathing
4. sprint fifty yards
5. kick 150 yards with one breath every six kicks
6. pull 150 yards alternate breathing
7. swim 150 yards alternate breathing
8. swim two twenty-five yard sprints
9. swim fifty yards any stroke

Sixth week: (continued)

Friday: total of 900 yards concerned mainly with sprinting

1. swim seventy-five yards alternate breathing
2. sprint seventy-five yards
3. sprint seventy-five yards using legs only
4. sprint seventy-five yards using arms only
5. swim three twenty-five yard sprints
6. swim seventy-five yards any stroke
7. swim seventy-five yards alternate breathing using flippers and mitts
8. sprint seventy-five yards using flippers and mitts
9. sprint seventy-five yards using legs only using flippers
10. sprint seventy-five yards using arms only using mitts
11. swim three twenty-five yard sprints without flippers or mitts
12. swim seventy-five yards easy any stroke

(The mitts are rubber, mitten-like devices worn on the hands for the purpose of creating a larger surface area with which to pull the water. The flippers were used on the feet.)

Seventh week:

Monday: total of 900 yards

1. swim 100 yards alternate breathing
2. kick 100 yards breathing every six kicks
3. sprint fifty yards
4. pull 100 yards alternate breathing
5. swim four twenty-five yard sprints
6. repeat the whole workout using flippers and mitts for the pulling and kicking items

Wednesday: total of 900 yards - mostly sprinting

1. kick 150 yards
2. sprint twenty-five yards with no more than two breaths for the distance
3. sprint fifty yards with no more than three breaths per twenty-five yards
4. sprint seventy-five yards with no more than four breaths per twenty-five yards
5. pull 150 yards
6. repeat items #2 to 4 using flippers and mitts
7. swim 150 yards using flippers and mitts alternate breathing
8. sprint seventy-five yards without flippers and mitts
9. sprint fifty yards
10. sprint twenty-five yards

Seventh week: (continued)

Friday: total of 850 yards
1. kick 200 yards
2. swim two twenty-five yard sprints
3. pull 200 yards
4. two twenty-five yard sprints
5. swim 200 yards
6. relays - each subject swam fifty yards three times

Eighth week:

Monday
all subjects timed for fifty yards

Final Testing

The final testing was done following the seventh week of the program. The same testing procedures were used as in the first and second testings, and were administered in the following order:

1. oxygen consumption
2. vital capacity
3. pull on the dynamometer
4. sit up against the tensiometer
5. leg lift with the dynamometer
6. step test

The final timing was done on the Monday of the eighth week.

CHAPTER V

PRESENTATION OF DATA

The purpose of the study was to determine the effects of two specific training programs on abdominal strength, shoulder strength, leg strength, oxygen consumption, vital capacity, cardiovascular efficiency, and speed in swimming. Prior to the specific training programs, two groups of college women were tested on the following items:

1. Speed in swimming fifty yards freestyle

   Each subject swam fifty yards freestyle. The swimming time was recorded in seconds.

2. Vital capacity

   A Propper Compact Spirometer was used to determine the vital capacity of each subject. Each subject was instructed to take as deep a breath as possible and then blow into the spirometer, expiring as fully as possible. The best of three trials, taken directly from the spirometer, was recorded in cubic centimeters.

3. Oxygen consumption

   The Haldane-Guthrie Gas Analysis Apparatus was used to measure oxygen consumption. Each subject took a deep breath and then expired into a tube which was connected to the gas burette on the apparatus. The volume of expired air was measured on the graduated gas burette. The carbon dioxide and the oxygen were selectively absorbed by sodium hydroxide and alkaline pyragallol. The decrease in volume of the expired gas sample divided by the original volume then multiplied by one hundred was recorded as the percentage of carbon dioxide and oxygen removed.

4. Cardiovascular efficiency

   The Harvard Step Test was used to determine cardiovascular efficiency. Each subject was instructed to step up and down on an eighteen inch step for a period of four minutes at the rate of thirty steps per minute. The subject sat down at the end of the four minute period. Pulse counts

4. Cardiovascular efficiency (continued)

were taken for thirty second intervals from one to one and one half minutes, two to two and one half minutes, and three to three and one half minutes following cessation of exercise. To determine the subject's adaptation to and recovery from exercise, the Recovery Index was obtained by dividing the duration of the exercise in seconds multiplied by one hundred divided by two times the sum of the pulse counts in recovery.

5. Abdominal strength

An aircraft tensiometer was used to measure abdominal strength. Each subject assumed a supine lying position upon the testing table with arms folded on the chest, hips in 180 degrees extension and adduction, and knees fully extended. A web belt was strapped around the subject's chest close under the armpits. The pulling assembly was attached to the belt beneath the subject through a slit in the table. The test administrator applied downward pressure upon the hips of the subject to prevent the hips from rising. The subject was instructed to sit up exerting as much pressure as possible against the belt. Each subject was given three trials and the best of the three trials was recorded. The tension recorded on the tensiometer was converted into pounds by the use of a conversion table provided by the manufacturer.

6. Leg strength

The back and leg dynamometer was employed to measure leg strength. Each subject stood erect on a platform specially constructed for use with the dynamometer with the feet parallel and the center of the feet on a line with the chain which was located in the center of the leg-lift platform. A crossbar was held at arm's length resting at the thigh joint. The loop end of the web belt was slipped onto one end of the bar. The free end of the belt was looped around the other end of the crossbar and tucked under the belt which was placed low over the hips and gluteal muscles of the subject. The dynamometer attachment was hooked onto the crossbar and the subject was instructed to flex the knees and hip joints keeping the back straight. When the angle formed by the thighs and the lower leg reached 120 degrees, as measured by a goniometer, the other end of the dynamometer attachment was hooked to the chain on the platform. The subject was then instructed to straighten the knees as much as possible keeping the back and arms straight and the head erect. The best score of three

6. Leg strength (continued)

trials was taken and converted into pounds by the use of a correction table.

7. Shoulder strength

Shoulder girdle strength was determined by the best of three trials of a pull on the grip dynamometer with a push-pull attachment. The best score was converted into pounds by means of a conversion table. Each subject was instructed to pull as vigorously as possible on the handles of the push-pull attachment. Forearms were kept horizontal and the dynamometer was kept at sternum level without touching the body.

Following the initial testing, the two groups participated in a two months' training program with the exercise-swimming group exercising on land three times weekly for one month and swimming three times weekly for a second month. The swimming group participated in swimming work-outs three times weekly for the two months' duration. Both groups were retested in the same variables after the first month of training and after the second month of training. The raw scores made in each test item by the two groups in the initial, second, and final tests may be found in the Appendix on Table XV and Table XVI.

At the end of the initial tests, the raw scores made by each subject in each test item were recorded. The range, mean, and standard deviation of each test item for the exercise-swimming group have been recorded on Table XVII in the Appendix. A similar procedure was followed for the swimming group and the range, mean, and standard deviation for each test item may be found on Table XVIII in the Appendix.

After participating three times weekly in the exercise program for one month, the exercise-swimming group was retested in the same variables as in the initial test. The range, mean, and standard deviation of the raw scores in each test item made by the exercise-swimming group were calculated and have been recorded on Table XIX which may be found in the Appendix. At the end of the one-month swimming program, the swimming group was also retested in the same test items as in the initial test. The range, mean, and standard deviation of the raw scores made by the swimming group in the second testing may be found on Table XX in the Appendix.

Following the second testing, both groups participated in a swimming program three times weekly for a period of one month. At the conclusion of the one-month period, both groups were tested again in the same variables as in the initial and the second testings. The range, mean, and standard deviation of the raw scores made by the exercise-swimming group in the final test may be found on Table XXI in the Appendix. The range, mean, and standard deviation of the raw scores made by the swimming group in the final test have been recorded on Table XXII which may be found in the Appendix.

To calculate the significance of difference of the mean score of each test item made by the exercise-swimming group between the initial and the second test, Fisher's "t" formula for correlated means was used (12:220). The "t" values and the mean of the differences between the initial and the second tests for the exercise-swimming group may be found on Table I. The results, as presented in Table I, indicate that the exercise-swimming group experienced a negative directional change in oxygen consumption significant at the two per cent level of confidence.

TABLE I

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND SECOND TEST RESULTS FOR THE EXERCISE-SWIMMING GROUP

Variables	Mean	"t"
speed	.70	1.11
vital capacity	116.66	1.3014
oxygen consumption	-6.78	3.6847**
cardiovascular efficiency	22.04	4.1506***
abdominal strength	7.85	3.1274*
leg strength	71.25	3.6764**
shoulder strength	-2.66	1.3039

* - Significant at the 5% level of confidence
** - Significant at the 2% level of confidence
*** - Significant at the 1% level of confidence

Positive directional change occurred in cardiovascular efficiency significant at the one per cent level of confidence, in abdominal strength significant at the five per cent level of confidence, and in leg strength significant at the two per cent level of confidence.

Values of "t" at the five per cent level of confidence or below have been accepted throughout this study as being statistically significant and have been an indication that the change occurring for each test item at such levels of confidence between two testing periods might be due to factors other than chance. In addition, any value significant below the forty per cent level of confidence has been reported as a possible trend. Although such significance is heavily weighted in favor of chance, the paucity of subjects suggested that indications of trends should be reflected in analysis and interpretation.

According to the results of Fisher's "t" test, as presented on Table II, the swimming group demonstrated a negative directional change, significant at the five per cent level of confidence, in oxygen consumption. Positive directional change in cardiovascular efficiency was significant at the five per cent level of confidence and positive directional change in leg strength was significant at the one per cent level of confidence.

Fisher's "t" was also used with the group as a whole. The mean of the difference and the "t" value for each test item made by the total group may be found on Table III. The total group showed a negative directional change in oxygen consumption significant at the one per cent level of confidence and positive directional change at the one per cent level of confidence in both cardiovascular efficiency and leg

TABLE II

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND SECOND TEST RESULTS FOR THE SWIMMING GROUP

Variables	Mean	"t"
speed	.23	.6571
vital capacity	58.33	.1605
oxygen consumption	-7.59	2.9192*
cardiovascular efficiency	28.05	2.8947*
abdominal strength	7.63	.9757
leg strength	119.08	5.2971***
shoulder strength	1.33	.4018

* - Significant at the 5% level of confidence
*** - Significant at the 1% level of confidence

TABLE III

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND SECOND TEST RESULTS FOR THE TOTAL GROUP

Variables	Mean	"t"
Speed	.46	1.3529
vital capacity	79.16	.4420
oxygen consumption	-7.19	4.8911***
cardiovascular efficiency	25.21	4.7209***
abdominal strength	6.96	1.7846
leg strength	95.17	5.7854***
shoulder strength	-.66	.3333

*** - Significant at the 1% level of confidence

strength.

The significance of difference of the mean was also calculated for each test item between the second test and the final test by Fisher's "t" formula for correlated means for the exercise-swimming group, the swimming group, and the total group. The means and "t" values for the exercise-swimming group may be found on Table IV. According to the results as presented on Table IV, positive directional change occurred in oxygen consumption at the one per cent level of confidence and in leg strength at the five per cent level of confidence.

The mean of the difference between the second test and the final test and the "t" value for each test item for the swimming group may be found on Table V. Positive directional change occurred in oxygen consumption, significant at the one per cent level of confidence, in abdominal strength significant at the one per cent level of confidence, and in cardiovascular efficiency and shoulder strength significant at the five per cent level of confidence.

The "t" values and the means for the total group may be found on Table VI. The scores of the total group changed in a positive direction in oxygen consumption significant at the one per cent level of confidence, in shoulder strength significant at the two per cent level of confidence, in abdominal strength significant at the five per cent level of confidence, and in leg strength significant at the one per cent level of confidence.

Fisher's "t" formula for correlated means was also used to determine the significance of difference between the means of the initial

TABLE IV

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN SECOND AND FINAL TEST RESULTS FOR THE EXERCISE-SWIMMING GROUP

Variables	Mean	"t"
speed	.61	.3961
vital capacity	175.00	.9140
oxygen consumption	10.97	9.0661***
cardiovascular efficiency	3.04	.5075
abdominal strength	.72	.1988
leg strength	36.25	3.1035*
shoulder strength	2.16	1.0693

* - Significant at the 5% level of confidence
*** - Significant at the 1% level of confidence

TABLE V

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN SECOND AND FINAL TEST RESULTS FOR THE SWIMMING GROUP

Variables	Mean	"t"
speed	.86	1.0487
vital capacity	125.00	.7066
oxygen consumption	9.65	8.8532***
cardiovascular efficiency	11.58	3.0314*
abdominal strength	14.93	5.9246***
leg strength	28.75	1.6428
shoulder strength	5.16	3.3076*

* - Significant at the 5% level of confidence
*** - Significant at the 1% level of confidence

TABLE VI

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN SECOND AND FINAL TEST RESULTS FOR THE TOTAL GROUP

Variables	Mean	"t"
speed	.74	.8916
vital capacity	150.00	1.2056
oxygen consumption	10.31	12.8875***
cardiovascular efficiency	7.31	2.0193
abdominal strength	7.55	2.4673*
leg strength	32.50	3.2210***
shoulder strength	3.66	2.8372**

* - Significant at the 5% level of confidence
** - Significant at the 2% level of confidence
*** - Significant at the 1% level of confidence

test and the final test for the exercise-swimming group. The means and the "t" values for the exercise-swimming group may be found on Table VII. Positive directional change was found to be significant at the one per cent level of confidence in leg strength, at the two per cent level of confidence in abdominal strength, and at the five per cent level of confidence in both cardiovascular efficiency and oxygen consumption.

The significance of difference between the means of the initial test and the final test for the swimming group was also determined by using Fisher's "t" formula for correlated means. The means and "t" values for the swimming group have been recorded on Table VIII. Positive directional change occurred in both cardiovascular efficiency and leg strength significant at the one per cent level of confidence.

The same procedure was followed in determining the significance of difference between the means of the initial test and final test for the total group. The means and "t" values for the total group can be found on Table IX. Positive directional change occurred in cardiovascular efficiency and leg strength significant at the one per cent level of confidence, in abdominal strength significant at the two per cent level of confidence, and in oxygen consumption significant at the five per cent level of confidence.

Significant directional change was not found in speed and vital capacity for any group between any two test periods. Shoulder strength measures from the initial test to the final test did not show significant directional change.

To determine whether a significant difference existed between the

TABLE VII

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND FINAL TEST RESULTS FOR THE EXERCISE-SWIMMING GROUP

Variables	Mean	"t"
speed	1.31	.8618
vital capacity	291.00	.1144
oxygen consumption	4.18	2.9645*
cardiovascular efficiency	25.92	2.7781*
abdominal strength	8.02	3.5330**
leg strength	107.50	4.0383***
shoulder strength	-.50	.1440

* - Significant at the 5% level of confidence
** - Significant at the 2% level of confidence
*** - Significant at the 1% level of confidence

TABLE VIII

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND FINAL TEST RESULTS FOR THE SWIMMING GROUP

Variables	Mean	"t"
speed	1.10	1.0185
vital capacity	166.66	.5959
oxygen consumption	2.05	.9360
cardiovascular efficiency	39.63	5.8451***
abdominal strength	20.17	2.1900
leg strength	147.00	4.1832***
shoulder strength	6.00	2.0979

*** - Significant at the 1% level of confidence

TABLE IX

MEANS AND SIGNIFICANCE OF DIFFERENCE OF THE MEANS BETWEEN INITIAL AND FINAL TEST RESULTS FOR THE TOTAL GROUP

Variables	Mean	"t"
speed	1.20	1.4285
vital capacity	229.16	1.2653
oxygen consumption	3.12	2.4375*
cardiovascular efficiency	32.77	5.5826***
abdominal strength	14.09	2.9932**
leg strength	127.25	6.5558***
shoulder strength	3.00	1.2605

* - Significant at the 5% level of confidence
** - Significant at the 2% level of confidence
*** - Significant at the 1% level of confidence

exercise-swimming group and the swimming group in each test item, Fisher's "t" formula for uncorrelated means was used (12:220). Table X demonstrates that significant differences did not exist in any test item in the initial test or in the second test. However, there was a significant difference at the five per cent level of confidence in swimming speed at the final test. There was no significant difference between the two groups in any other of the measured variables at the final test.

The mean of the difference between the initial test and the final test results in speed of the total group was correlated with the mean of the differences between the initial test and the final test results in cardiovascular efficiency of the total group by means of the Pearson Product Moment method of correlation for ungrouped data (12:139). A significant correlation did not exist. The r value may be found on Table XI. A similar procedure was used to determine whether a significant correlation existed between the mean of the difference in leg strength and the mean of the difference in cardiovascular efficiency as measured by the Harvard Step Test. The value of r, as presented in Table XI, indicates that a significant correlation existed between the two measures. The r value for the correlation of the mean of the difference of oxygen consumption and the mean of the difference of cardiovascular efficiency between the initial test and the final test of the total group may also be found on Table XI and indicates that a significant correlation did not exist.

From the data presented, it appears that the change which

TABLE X

SIGNIFICANCE OF DIFFERENCE BETWEEN THE MEANS OF THE EXERCISE-SWIMMING GROUP AND THE SWIMMING GROUP, IN INITIAL TESTS, SECOND TESTS, AND FINAL TESTS

Variables	Initial test "t"	Second test "t"	Final test "t"
speed	1.4554	1.3682	2.2677*
vital capacity	.3184	.3240	.0851
oxygen consumption	.7909	.9824	.2409
cardiovascular efficiency	.6800	.9022	1.6966
abdominal strength	.0668	.2788	1.6639
leg strength	.6338	1.8637	1.3642
shoulder strength	.1485	1.4018	2.0949

* - Significant at the 5% level of confidence

TABLE XI

COEFFICIENT OF CORRELATION OF THE MEAN OF THE DIFFERENCE BETWEEN THE INITIAL TEST AND FINAL TEST RESULTS FOR THE TOTAL GROUP BETWEEN SELECTED ITEMS

Variables	r
cardiovascular efficiency and speed	-.1101
cardiovascular efficiency and leg strength	.7962*
cardiovascular efficiency and oxygen consumption	.0365

* - Significant at the 1% level of confidence

occurred in swimming speed and the change in oxygen consumption were not related to the change which occurred in cardiovascular efficiency for the total group following two months of training.

CHAPTER VI

INTERPRETATION OF DATA

The purpose of this study was to determine the effects of two specific training programs in swimming for college women on strength, physiological efficiency, and speed in swimming fifty yards freestyle. Measurements of abdominal strength, leg strength, shoulder strength, vital capacity, oxygen consumption, cardiovascular efficiency, and speed in swimming were taken prior to the two months' training program, at the end of one month of the program, and again at the end of the two months' program. The subjects were divided into two groups. The exercise-swimming group participated in exercise workouts three times weekly for the first month and in swimming workouts during the second month three times weekly. The swimming group participated in swimming workouts three times weekly for the duration of two months.

The measurements for each group in each test item were treated statistically to ascertain the significance of difference of the means between the initial test and the second test, between the second test and the final test, and between the initial test and the final test, in regard to directional change. The same procedure was used considering the both groups as one total group. The measurements were also used to determine whether or not a significant difference existed between the two groups at the initial, second, and final testings. Statistical analysis was done also to determine the relationship between changes in selected variables for the total group.

SPEED

Evidence is available which indicates that exercise programs and swimming programs of six weeks' duration are sufficient to cause a significant improvement in swimming speed of college men. Thompson and Stull (100) found that a group which participated in swimming workouts three times weekly for six weeks and a group which practiced swimming six times per week for six weeks both significantly improved in swimming speed. They also found that swimming speed was not improved following a weight training program of six weeks' duration with three training sessions per week. Davis (55) reported that following a weight training program of six weeks' time in which the participants trained with weights three times weekly and were permitted to swim only once each week, all participants significantly improved in swimming speed.

According to DeLorme and Watkins (9), Morehouse and Miller (23), and Müller (87), exercise is specific. Morehouse and Rasch (24) stated that the best way to train for an event is to practice that event. From the evidence which has been presented, it appears that some practice in the skill of swimming is necessary for improvement in swimming speed.

In this study, there was no statistically significant difference in swimming speed between the exercise-swimming group and the swimming group at the initial test which was prior to the training program, or at the second test which followed one month of training. However, in the final test which followed two months of training, the difference between the two groups was statistically significant at the five per cent level of confidence. At the final test, the swimming group had faster mean swimming speed than the exercise-swimming group.

Following one month of exercise workouts, the exercise-swimming group improved in swimming speed. This change was not statistically significant. The swimming group, after one month of swimming workouts, also improved in swimming speed. This change was not statistically significant. There is the possibility that neither a swimming workout program nor an exercise workout program of four weeks' duration is sufficient to bring about a statistically significant increase in swimming speed for college women.

During the second month of the program, both groups participated in the same swimming workouts three times weekly. Following this second month of training, both the exercise-swimming group and the swimming group improved in swimming speed. This improvement in swimming speed was not statistically significant for either the exercise-swimming group or the swimming group. It is possible that a greater degree of neurophysiological adjustments specific to swimming were made by the swimming group than by the exercise-swimming group in the course of the second month of swimming training following the first month of swimming workouts. In addition, to possibly explaining why the swimming group had a greater improvement in swimming speed following the second month of swimming workouts, the concept of specificity of exercise may also account for the significant difference between the two groups in swimming speed which did not appear until the final test.

The increases in speed of swimming which occurred in both groups between the initial and final test were not statistically significant.

Although the mean speed changed about the same for both groups between the initial test and the final test, the mean speed for the exercise-swimming group changed steadily throughout the two months' program, while the change in speed for the swimming group following the second month of training was more than three times greater than the change following the first month.

It appears that, for the college women who participated in this study, neither a one-month exercise and a second month swimming program, nor a two months' swimming program is sufficient to bring about a statistically significant increase in swimming speed. It is possible that significant increases in speed might have occurred had the programs been of longer duration, or if there were more workout sessions per week during a two months' period. This may also indicate, in regard to the material presented concerning men's training for swimming, that the rate of improvement in swimming speed may differ between college men and college women. There is also the possibility that training schedules used by college men for competitive swimming may not be suitable for use by college women.

VITAL CAPACITY

To a great extent, vital capacity depends upon size; namely, surface area, height, weight, and chest size. It has been suggested by Stuart and Collings (99) and Guyton (13) that a strengthening of the respiratory muscles through a conditioning program may influence vital capacity. According to Cureton (6:342), vital capacity may be improved by means of swimming.

In this study, no significant difference existed between the exercise-swimming group and the swimming group in vital capacity at any of the test periods. Following the first month of workouts, both groups had an improvement in vital capacity. Although the increase in vital capacity was not statistically significant for either group, the increase made by the exercise-swimming group was greater than that of the swimming group. The exercise program and the one-month swimming program, as used in this study during the first month, appeared not to have been strenuous enough or of sufficient length of time to cause a statistically significant change in vital capacity.

Although the directional change was not statistically significant, the vital capacity of both groups increased following the second month of workouts. The increase for the exercise-swimming group was greater than that of the swimming group. It is possible that the swimming workout program during the second month of training will bring about a greater change in vital capacity if it is preceded by a one-month exercise conditioning program than if it is preceded by a one-month swiming conditioning program.

Although both groups increased in vital capacity between the initial test and the final test, the increase was not statistically significant. The exercise-swimming group had a higher mean change in vital capacity than did the swimming group. Both groups had the greatest change in vital capacity during the second month of training. Apparently, continued conditioning will bring about greater changes in vital capacity. It appears that a program consisting of one month of exercise workouts and a second month of swimming workouts is more effective in influencing vital capacity than is a two months' swimming workout program.

OXYGEN CONSUMPTION

Following conditioning, there is an increase in the amount of oxygen consumed and in the amount of carbon dioxide expelled by an individual. According to McCurdy and Larson (21), Morehouse and Miller (23), Reidman (27), Schneider and Karpovich (28), and Brassfield (33), a greater proportion of oxygen is absorbed from the air which is breathed by a person who has been conditioned for strenuous work than by an unconditioned person.

In this study, a reduction in oxygen consumption, statistically significant at the two per cent level of confidence, occurred for the exercise-swimming group and statistically significant at the five per cent level of confidence for the swimming group. It is possible that increased mechanical efficiency resulted from the exercise program and from the swimming program and with it a decrease in the amount of oxygen needed for basic physiological function.

Both groups had a positive directional change, statistically significant at the one per cent level of confidence, in oxygen consumption between the second test and the final test. However, the exercise-swimming group had a higher mean change than did the swimming group. It is possible that both groups had adjusted to an increased level of efficiency in which less oxygen is needed for physiological functions and at the conclusion of the second month of training, an improvement had been made in the ability of the body to utilize oxygen, resulting in an increased percentage of the oxygen available being consumed. It appears that the swimming program during the second month was effective in influencing the oxygen consumption of both groups.

There was no significant statistical difference in oxygen consumption between the two groups at the initial test, the second test, or the final test. Between the initial and the final tests, the exercise-swimming group had an increase in oxygen consumption which was significant at the five per cent level of confidence. The swimming group had an increase which was not statistically significant. Both groups had a similar pattern of change in oxygen consumption. There was a statistically significant reduction following the first month conditioning program, and a significant statistical increase following the second month swimming program. However, it appears that a program of one month of exercise and a second month of swimming was more effective in causing a change in oxygen consumption over a two-month period than was a two months' swimming program.

CARDIOVASCULAR EFFICIENCY

Cardiovascular efficiency is sensitive to a conditioning program as reported by Gallagher and Brouha, as cited by Montoye (85). According to Cureton (6), McCurdy and Larson (21), Morehouse and Miller (23), Schneider and Karpovich (28), and Salit and Tuttle (94), conditioning can affect the ability of the heart to adapt to and recover from hard work.

There was no statistically significant difference between the two groups in cardiovascular efficiency in this study at the initial test, at the second test, and at the final test. Following the first month of conditioning, both groups had significant increases in cardiovascular efficiency. For the exercise-swimming group, the increase was statistically significant at the one per cent level of confidence. Of the seven variables measured for the exercise-swimming group, cardiovascular efficiency showed the highest degree of statistically significant change following the first month of workouts. The swimming group had a significant statistical change at the five per cent level of confidence. It appears that a one-month exercise program, as used in this study, is more effective in causing a statistically significant change in cardiovascular efficiency than is a swimming workout program, although both could be used to cause a change.

Following the second month of training, there was a slight increase in cardiovascular efficiency for the exercise-swimming group, but an increase statistically significant at the five per cent level of confidence for the swimming group. This may indicate that the swimming program did not make as great demands on the circulatory system of the experimental group as it did on the swimming group. Although there was no significant difference between the groups at either the initial or the second tests, it is possible that the exercise-swimming group experienced a greater change in cardiovascular efficiency during the first month and may have reached a level of efficiency which was not affected by the swimming training.

At both the initial test and the final test, there was no significant statistical difference in cardiovascular efficiency between the two groups. Both groups had an increase in cardiovascular efficiency following the two-month program, but the increase for the exercise-swimming group was significant at the five per cent level of confidence, while the increase for the swimming group was significant at the one per cent level of confidence.

Both groups followed a similar pattern of change in cardiovascular efficiency throughout the two-month program. The greatest change for both groups occurred during the first month, but the swimming group continued a significant increase during the second month for an overall increase which was statistically significant at the one per cent level of confidence. This seems to indicate that a two-month swimming program has a greater effect on cardiovascular efficiency than does a program of one month exercise workouts and a second month swimming workouts.

STRENGTH

According to DeLorme (9), Madders (20), Metheny (22), Reidman (27), Schneider and Karpovich (28), and Brassfield (33), muscles gain in strength when used against resistance. Morehouse and Rasch (24) explained that muscles gain in size and strength only when they are required to do work that places loads on them which are greater than previous load requirements. According to Armbruster, Allen, and Harlan (1), and Kiphuth (17), practice in swimming alone is not enough to develop the great strength needed in top swimming performance. It is Kiphuth's contention that the same amount of muscular power cannot be developed in the water in the same period of time as can be developed in a conditioning program utilizing dry-land exercise. However, Müller mentioned that a strong muscle does not necessarily mean better performance in practice whether in sports or in daily life. DeLorme and Watkins (9) stated that an increase in absolute strength does not indicate that a person is equipped to do the work in a specific area for which he has not trained. According to Armbruster (1), increases in swimming speed eventually depend upon increases in strength. Morehouse and Rasch (24) acknowledged the value of exercise to strengthen muscular weaknesses, but have also stated that the best way to train for an event is to practice that event.

Abdominal. According to Armbruster (1), Madders (20), and Cureton (50), strength of the abdominal muscles is necessary in swimming. The abdominal muscles aid in stabilizing the pelvis, thereby giving the legs a firm base upon which to move. Cureton (50) also reported that the speed of the flutter kick used in swimming the front crawl seems to be in direct proportion to the strength of the abdominal muscles. These muscles are used in maintaining a streamlined, horizontal body position which minimizes water resistance.

In this study, there was no significant statistical difference in abdominal strength between the exercise-swimming group and the swimming group at the initial test, at the second test, or at the final test. However, at the final test, the swimming group had the higher mean score in abdominal strength.

Following the first month of conditioning, the exercise-swimming group had an increase in abdominal strength which was statistically significant at the five per cent level of confidence. The increase for the swimming group was not statistically significant. This indicates that the prescribed exercises, as used by the exercise-swimming group, were adequate to cause a significant increase in abdominal strength. The one-month swimming program appeared to be not strenuous enough to bring about statistically significant change in abdominal strength.

After the second month of swimming training, the exercise-swimming group had no significant increase in abdominal strength. The swimming group, however, had an increase in abdominal strength which was statistically significant at the one per cent level of confidence. These results seem to indicate that the significant increase in abdominal strength of the swimming group was not immediate and reached a statistically significant level only after the second month of swimming workouts. The swimming workouts were sufficient to bring about a statistically significant increase in abdominal strength in the group which had previously participated in swimming workouts.

Between the initial test and the final test, the exercise-swimming group had an increase in abdominal strength which was statistically significant at better than the two per cent level of confidence. However, the greatest change in abdominal strength occurred during the first month of exercise workouts. There was a very slight change in abdominal strength following the one month of swimming workouts for the exercise-swimming group. It is possible that the swimming workouts were not strenuous enough to cause a statistically significant increase in abdominal strength for the exercise-swimming group immediately following strength increases from the exercise workouts, but that a combination of exercise and swimming workouts over a period of two months was sufficient to elicit an increase in abdominal strength which was statistically significant.

The swimming group had an increase in abdominal strength between the initial test and the final test which was not statistically significant. The greatest degree of change in abdominal strength for the swimming group occurred following the second month of swimming workouts. It appears that the exercise and swimming program was more effective in increasing abdominal strength over a period of two months than was the two-month swimming program.

Leg. There was no statistically significant difference in leg strength between the two groups at the initial test, at the second test, or at the final test. However, at the final test the swimming group had the higher mean score in leg strength.

Following one month of exercise workouts, the exercise-swimming group had an increase in leg strength which was statistically significant at the two per cent level of confidence. There was also a statistically significant increase in leg strength at the one per cent level of confidence for the swimming group after one month of swimming workouts. It appears that the exercises used by the exercise-swimming group were strenuous enough to cause a significant improvement in leg strength. It also appears that the swimming group had a greater change in leg strength than did the exercise-swimming group. There is the possibility that swimming workouts for one month are more effective in influencing leg strength than is an exercise workout program as used in this study.

After the second month of training, the swimming group had an increase in leg strength which was not statistically significant. The exercise-swimming group had an increase in leg strength which was statistically significant at the five per cent level of confidence. It appears that for the exercise-swimming group, the swimming workouts during the second month of training placed a great enough load on the muscles of the leg to cause a significant increase in strength. However, for the swimming group, which had participated in swimming workouts during the first month, the swimming workouts during the second month of training did not overload the muscles of the legs of the participants sufficiently to cause a statistically significant increase in strength.

Between the initial test and the final test, both groups had an increase in leg strength which was statistically significant at the one per cent level of confidence, but the mean change for the swimming group was higher than that of the exercise-swimming group. The greatest degree of change for both groups throughout the two months occurred during the first month of conditioning. Although both groups had a statistically significant improvement in leg strength, it is possible that a two-month swimming workout program is more effective in influencing strength of the legs than is a program of one month of exercise workouts and a second month of swimming workouts.

Shoulder. Although there was no significant statistical difference between the two groups at the initial test, at the second test, or at the final test, the difference at the final test was significant at better than the ten per cent level of confidence with the swimming group having the higher mean score in shoulder strength, indicating a possible trend.

Between the initial test and the second test, the exercise-swimming group had a reduction of shoulder strength which was not statistically significant. This gives an indication that the exercises used for increasing shoulder strength were not strenuous enough to significantly increase shoulder girdle strength as measured by a pull on the dynamometer.

Although shoulder strength increased for the swimming group, the increase was not statistically significant. However, the swimming group had a greater positive change in shoulder strength than did the exercise-swimming group. The swimming workouts might not have been strenuous enough to cause the change to be statistically significant. There is also the possibility that the swimming group had sufficient strength and was not affected by the work in swimming.

Following the second month of training, there was a statistically significant increase at the five per cent level of confidence for the swimming group in shoulder strength. An increase which was not statistically significant occurred in shoulder strength of the exercise-swimming group. Although the water workout was identical for both groups, it appears that it was more effective in increasing the shoulder strength of the swimming group. It is also possible that with the swimming group, there was a further increase in the skill of swimming and in the correct usage of the arms and shoulders in swimming the front crawl, a factor which may have allowed those muscles to gain in strength.

From the initial test to the final test, the swimming group had an increase in shoulder strength which was not statistically significant. The exercise-swimming group had a reduction in shoulder strength which was not statistically significant. This was the same pattern which occurred between the initial test and the second test for the exercise-swimming group. Both groups had the greatest degree of change during the second month. It appears that swimming workouts for two months may be more effective in increasing shoulder strength than exercise and swimming workouts, although the change which occurred with such a program was significant at the ten per cent level of confidence.

It appears that with the exception of abdominal strength, the swimming group showed greater gains in strength than did the exercise-swimming group especially in leg strength and shoulder strength. Although there was a statistically significant increase in abdominal strength of the exercise-swimming group and in leg strength for both groups, there was not a statistically significant increase in swimming speed.

It should be noted that the training program between the second test and the final test was the same for both groups. It is possible that changes which occurred following the second month of training were influenced, to a great degree, by the first month conditioning program as well as the second month program. This may be substantiated by the fact that, excepting oxygen consumption for the exercise-swimming group, those variables which showed the greatest degree of change during the first month of conditioning; namely, cardiovascular efficiency and leg strength of the swimming group, and cardiovascular efficiency, abdominal strength, and leg strength of the exercise-swimming group, were the same variables which had changed significantly from the initial to the final test.

TOTAL GROUP

In considering both groups as one total group undergoing a conditioning program, it is possible to get an indication of changes that may occur following a conditioning program. Between the initial and second test, for the total group, the increases noted in speed, vital capacity, and abdominal strength were not statistically significant. One month conditioning did cause a change, but it was not sufficient to cause a significant statistical change in those variables. A reduction was noted in shoulder strength and in oxygen consumption. The change in shoulder strength was not statistically significant, but the change in oxygen consumption was statistically significant at the one per cent level of confidence. Conditioning may cause a reduction in oxygen consumption after one month of the program, which may indicate that an improvement occurred in respiratory efficiency.

Increase in cardiovascular efficiency and leg strengh were statistically significant at the one per cent level of confidence. It appears that one month conditioning is effective in eliciting a statistically significant improvement in cardiovascular efficiency and leg strength. The increase in efficiency may account for the decrease in oxygen consumption, for as the body adjusts to greater demands and becomes more efficient, the distribution of oxygen may be facilitated by the cardiovascular system.

During the second month of training, the total group made increases in speed, vital capacity, and cardiovascular efficiency which were not statistically significant. There was a statistically significant increase in oxygen consumption and in leg strength at the one per cent level of confidence, in shoulder strength at the two per cent level of confidence, and in abdominal strength at the five per cent level of confidence. Leg strength continued to improve. The improvement in shoulder strength was greater when the total group was considered than when the exercise-swimming group or the swimming group was considered alone.

The overall change from the initial test to the final test was in a positive direction and although the increase in speed, vital capacity, and shoulder strength for the total group were not statistically significant, there was a trend toward significant change in these variables. There were statistically significant increases at the one per cent level of confidence in leg strength and cardiovascular efficiency, which repeated the pattern of the first month conditioning results. Significant statistical improvement in abdominal strength occurred at the two per cent level of confidence and statistically significant increase at the five per cent level of confidence occurred in oxygen consumption.

According to these results, statistically significant improvement in cardiovascular efficiency, leg strength, abdominal strength, and oxygen consumption may follow a two months' conditioning program which involves swimming at one part of the program. Change may also occur in swimming speed, vital capacity, and shoulder strength, but the change may be significant at only the thirty per cent level of confidence.

VARIABLE RELATIONSHIPS

Since it appears from the data that significant increases in strength were not accompanied by increases in swimming speed, it is possible that a change in speed may be related to a change in cardiovascular efficiency, in the ability of the heart to adapt to hard work and recover from it. However, a statistically significant coefficient of correlation did not exist between the change in cardiovascular efficiency and the change in speed following two months of conditioning by the total group.

It is possible that a change in oxygen consumption may be related to a change in cardiovascular efficiency. There may be an improvement in the ability to transport and utilize the available oxygen. However, in this study, a statistically significant coefficient of correlation did not exist between the change in cardiovascular efficiency and the change in oxygen consumption for the total group between the initial test and the final test.

Cardiovascular efficiency was determined by the use of the Harvard Step Test which involves stepping up and down on an eighteen inch bench at the rate of thirty steps per minute for four minutes. It is possible that a change in leg strength may be related to a change in cardiovascular efficiency as measured by the step test. A coefficient of correlation statistically significant at the one per cent level of confidence was found between the change in leg strength and the change in cardiovascular occurring between the initial test and the final test for the total group.

CHAPTER VII

SUMMARY AND CONCLUSIONS

This study was conducted to determine the effects of two specific training programs in swimming for college women on strength, physiological efficiency, and speed in swimming fifty yards freestyle. Measurements of abdominal strength, shoulder strength, leg strength, oxygen consumption, vital capacity, cardiovascular efficiency, and speed in swimming were taken prior to the two months' training program, at the end of one month of the program, and again at the end of the two months' program. The subjects were divided into two groups. The exercise-swimming group participated in exercise workouts three times weekly for the first month and in swimming workouts three times weekly during the second month. The swimming group participated in swimming workouts three times weekly for the duration of two months.

The measurements for each group in each test item were treated statistically to ascertain the significance of difference of the means between the initial test and the second test, between the second test and the final test, and between the initial test and the final test, in regard to directional change. The same procedure was used considering the both groups as one total group. The measurements were also used to determine whether or not a significant difference existed between the two groups at the initial test, the second test, and the final test. Statistical analysis was done also to determine the relationship between changes in selected variables for the total group.

Findings

Speed

1. There was no significant statistical difference between the two groups in swimming speed at the initial test or at the second test.

2. There was a statistically significant difference at the five per cent level of confidence between the two groups in speed at the final test. The swimming group had the faster mean swimming speed.

3. It was found that the exercise-swimming group had an increase in speed following the first month of exercise workouts. The increase in swimming speed was not statistically significant.

4. The swimming group had an increase in swimming speed following the first month of swimming workouts, but this increase in speed was not statistically significant.

5. Following the second month of swimming training, both the exercise-swimming group and the swimming group improved in swimming speed. The improvement in speed was not statistically significant for either group.

6. The mean speed for both the exercise-swimming group and the swimming group changed about the same between the initial test and the final test, but the improvement in swimming speed was not statistically significant for either group.

7. The mean speed for the exercise-swimming group changed steadily throughout the two months.

8. The mean speed for the swimming group had a greater change during the second month of training. There was a slight change follow-

ing the first month. The change, however, was not statistically significant.

9. The increase in speed of the swimming group between the initial test and the final test was significant at the thirty per cent level of confidence indicating a possible trend.

10. The increase in speed of the total group between the initial test and the final test was not statistically significant.

11. The mean speed for the total group showed the greatest change between the second and final tests.

Vital Capacity

1. There was no significant statistical difference between the exercise-swimming group and the swimming group at the initial test, at the second test, or at the final test in vital capacity.

2. Following the first month of conditioning, both the exercise-swimming group and the swimming group had an improvement in vital capacity. The improvement which occurred was not statistically significant for either the exercise-swimming group or the swimming group.

3. After the second month of swimming training, both the exercise-swimming group and the swimming group had an improvement in vital capacity. The improvement in vital capacity which occurred at this time was not statistically significant for either the exercise-swimming group or the swimming group.

4. Although both groups increased in vital capacity between the initial test and the final test, the increase was not statistically significant.

5. The exercise-swimming group had a higher mean change in vital capacity between the initial and final tests than did the swimming group, although the change was not statistically significant.

6. Both groups had the greatest change in vital capacity between the second test and the final test.

7. The total group had increases in vital capacity between the initial test and the second test, between the second test and the final test, and between the initial test and the final test, but these increases were not statistically significant.

Oxygen Consumption

1. There was no statistically significant difference between the two groups at the initial test, at the second test, or at the final test in oxygen consumption.

2. The exercise-swimming group had a decrease in oxygen consumption which was statistically significant at the two per cent level of confidence following one month of exercise workouts.

3. The swimming group had a decrease in oxygen consumption following one month of swimming workouts. The directional change was statistically significant at the five per cent level of confidence.

4. Both groups had a statistically significant increase at the one per cent level of confidence in oxygen consumption between the second test and the final test.

5. The mean change in oxygen consumption between the second test and the final test was greater for the exercise-swimming group than for the swimming group.

6. Between the initial test and the final test, the exercise-swimming group had an increase in oxygen consumption which was statistically significant at the five per cent level of confidence.

7. The swimming group had an increase in oxygen consumption which was not statistically significant between the initial test and the final test.

8. Both groups followed the same pattern of change in regard to oxygen consumption. Following the first month of conditioning, there was a reduction in oxygen consumption. After the second month of workouts, both groups had an increase in oxygen consumption.

9. The total group had an increase in oxygen consumption which was statistically significant at the five per cent level of confidence between the initial test and the final test.

10. The total group had a statistically significant decrease in oxygen consumption at the one per cent level of confidence between the initial test and the second test.

11. The total group had an increase in oxygen consumption between the second test and the final test which was statistically significant at the one per cent level of confidence.

Cardiovascular Efficiency

1. There was no statistically significant difference between the exercise-swimming group and the swimming group at the initial test, at the second test, or at the final test. At the final test, there was statistical significance at better than the twenty per cent level of confidence with the swimming group having the higher mean score indicat-

ing a possible trend.

2. Following one month of exercise workouts, the exercise-swimming group had an increase in cardiovascular efficiency which was statistically significant at the one per cent level of confidence.

3. The swimming group had an increase in cardiovascular efficiency which was statistically significant at the five per cent level of confidence following one month of swimming workouts.

4. Following the second month of training, the exercise-swimming group had an increase in cardiovascular efficiency which was not statistically significant.

5. The swimming group had an increase in cardiovascular efficiency which was statistically significant at the five per cent level of confidence following the second month of swimming training.

6. Between the initial test and the final test, there was a statistically significant change at the five per cent level of confidence in cardiovascular efficiency for the exercise-swimming group.

7. Between the initial test and the final test, the swimming group had an increase in cardiovascular efficiency which was statistically significant at the one per cent level of confidence.

8. The greatest degree of change in cardiovascular efficiency for the exercise-swimming group occurred between the initial test and the second test.

9. Although the change in cardiovascular efficiency for the swimming group was statistically significant at the five per cent level of confidence between the initial test and the second test, and also be-

tween the second test and final test, the greatest degree of change occurred between the initial and second tests.

10. The total group had an increase in cardiovascular efficiency between the initial test and the second test which was statistically significant at the one per cent level of confidence. The increase in cardiovascular efficiency between the second test and the final test was not statistically significant, but the increase between the initial test and the final test was statistically significant at the one per cent level of confidence.

Abdominal Strength

1. There was no significant statistical difference between the two groups at the initial test, at the second test, or at the final test. However, at the final test, the difference was significant at better than the twenty per cent level of confidence, with the swimming group having the higher mean score in abdominal strength, indicating a possible trend.

2. Following the first month of conditioning, the exercise-swimming group had an increase in abdominal strength which was statistically significant at the five per cent level of confidence.

3. The increase in abdominal strength of the swimming group, following one month of swimming workouts, was not statistically significant.

4. The exercise-swimming group, between the second test and the final test, had an increase in abdominal strength which was not statistically significant.

5. After the second month of swimming workouts, the swimming group had an increase in abdominal strength which was significant at the one per cent level of confidence.

6. Between the initial test and the final test, the exercise-swimming group had an increase in abdominal strength which was statistically significant at better than the two per cent level of confidence.

7. The greatest degree of change in abdominal strength for the exercise-swimming program occurred during the first month of exercise workouts.

8. The swimming group had an increase in abdominal strength between the initial test and the final test which was not statistically significant.

9. The greatest degree of change in abdominal strength of the swimming group occurred following the second month of swimming workouts.

10. Between the initial test and the second test, there was no statistically significant change in abdominal strength for the total group.

11. There was an increase in abdominal strength of the total group which was significant at the five per cent level of confidence between the second test and the final test.

12. The total group had an increase in abdominal strength which was statistically significant at the two per cent level of confidence between the initial test and the final test.

Leg Strength

1. There was no statistically significant difference between the

exercise-swimming group and the swimming group at the initial test, at the second test, or at the final test. At the final test, however, there seemed to be a trend toward strength improvement with the swimming group having the higher mean score in leg strength.

2. Following one month of exercise workouts, the exercise-swimming group had an increase in leg strength which was statistically significant at the two per cent level of confidence.

3. After one month of swimming workouts, the swimming group had an increase in leg strength which was statistically significant at the one per cent level of confidence.

4. The exercise group, after the second month of training, had an increase in leg strength which was statistically significant at the five per cent level of confidence.

5. After the second month of training, the swimming group had a slight increase in leg strength which was not statistically significant.

6. Between the initial test and the final test, both groups had an increase in leg strength which was statistically significant at the one per cent level of confidence, but the mean change for the swimming group was higher than that of the exercise-swimming group.

7. The greatest degree of change in leg strength, for both groups, occurred during the first month of conditioning.

8. Between the initial test and the second test, between the second test and final test, and between the initial and final tests, for the total group, the increase in leg strength was statistically significant at the one per cent level of confidence.

Shoulder Strength

1. There was no statistically significant difference between the exercise-swimming group and the swimming group in shoulder strength at the initial test, at the second test, or at the final test. At the final test, the difference was significant at better than the ten per cent level of confidence with the swimming group having the higher mean score, indicating a possible trend.

2. Between the initial test and the second test, the exercise-swimming group had a reduction in shoulder strength which was not statistically significant.

3. The increase in shoulder strength for the swimming group between the initial test and the second test was not statistically significant.

4. After the second month of training, an increase which was not statistically significant occurred in the shoulder strength for the exercise-swimming group.

5. Following the second month of swimming workouts, there was a statistically significant increase at the five per cent level of confidence for the swimming group in shoulder strength.

6. From the initial test to the final test, the exercise-swimming group had a reduction in shoulder strength which was not statistically significant.

7. Between the initial test and the final test, the swimming group had an increase in shoulder strength which was not statistically significant.

8. Both groups had the greatest degree of change during the

second month of training.

9. For the total group, there was a reduction in shoulder strength which was not statistically significant between the initial test and the second test. Between the second test and the final test, the total group had an increase in shoulder strength which was statistically significant at the two per cent level of confidence. There was an increase in shoulder strength which was not statistically significant for the total group between the initial test and the final test.

Relationships Between Changes in Variables

1. It was found that there was no statistically significant correlation between change in speed and change in cardiovascular efficiency for the total group following two months of conditioning.

2. Following two months of conditioning, there was no statistically significant correlation between change in oxygen consumption and change in cardiovascular efficiency for the total group.

3. It was found that there was a correlation which was statistically significant at the five per cent level of confidence for the total group between change in leg strength and change in cardiovascular efficiency as measured by the Harvard Step Test.

Conclusions

Improvement in physiological efficiency, strength, and speed in swimming of college men may be brought about by conditioning programs of exercise and/or swimming, as reported by McCurdy and Larson (21), Montoye (85), Nunney (88), and Thompson and Stull (100). There are differences of opinion as to which type of conditioning program is most effective in producing change in swimming speed, strength, and physiological efficiency. The following conclusions have been made, based upon the data obtained in the present study, as to the effects of two different conditioning programs of two months' duration on college women.

1. A one-month conditioning program consisting of exercise workouts three times weekly, or consisting of swimming workouts three times weekly is not adequate to cause a significant increase in swimming speed, in vital capacity, or in shoulder strength of college women.

2. A one-month program of exercise workouts three times weekly is sufficient to bring about improvement in cardiovascular efficiency, abdominal strength, and leg strength.

3. A one-month program of swimming workouts three times weekly is sufficient to cause a significant improvement in cardiovascular efficiency and leg strength.

4. For college women participating in the swimming program for two months, the greatest amount of change in swimming speed, vital capacity, oxygen consumption, abdominal strength, and shoulder strength may occur during the second month of training. The greatest degree of change in leg strength and cardiovascular efficiency may occur during the first month.

5. The greatest amount of change in vital capacity, oxygen consumption, and shoulder strength may occur during the second month of training when the exercise-swimming program is used. Cardiovascular efficiency, abdominal strength, and leg strength may have the greatest

degree of change during the first month of conditioning.

6. Although the training program was identical for both groups during the second month of the program, the changes which occurred in the measured variables between the second test and the final test were different for both groups. It appears that the changes which occurred in the measured variables between the second test and the final test were influenced to a great extent by the workout program which was employed during the first month.

7. The changes which were statistically significant between the initial test and the final test, with the exception of oxygen consumption for the exercise-swimming group, were found to be the same changes which were statistically significant after the first month of conditioning. It appears that the changes which occur during the first month of a conditioning program give an indication of the overall changes that may occur over a period of two months.

8. It was also found that a program of one month of exercise workouts and a second month of swimming workouts resulted in significant improvement in oxygen consumption, cardiovascular efficiency, abdominal strength, and leg strength.

9. A program of swimming workouts three times weekly for a period of two months may result in significant improvement in cardiovascular efficiency and leg strength.

10. Although the change in swimming speed at the end of the two months' program was not statistically significant, the change in speed was significant below the forty per cent level of confidence. There is

the possibility that, had the program been continued for a longer period of time, the change in swimming speed might have reached statistical significance.

11. In regard to speed in swimming, college women do not improve at the same rate as do college men.

12. Following two months of workouts, the exercise-swimming group had statistically significant improvement in a greater number of measured variables than did the swimming group.

13. The swimming group had a greater change in cardiovascular efficiency than did the exercise-swimming group following two months of workouts.

14. The pattern of change in swimming speed for the swimming group appears to indicate that swimming workouts for two months or longer will bring about a greater improvement in speed than will a program consisting of one month exercise and one month swimming workouts.

15. Over a period of two months, the respiratory measures; namely, oxygen consumption and vital capacity, changed to a greater degree in the exercise-swimming group than in the swimming group.

16. The strength measures, with the exception of abdominal strength, changed more after a two-month program of swimming workouts than after one month exercise and one month swimming workouts.

Therefore, it appears that, for the subjects who participated in this study, the program of swimming workouts three times weekly for a period of two months resulted in a greater degree of change in cardiovascular efficiency, leg strength, shoulder strength, and speed in swimming than the change which occurred in these variables following a program of one month of exercise and a second month of swimming workouts.

It is recommended that further study be done in the area of the effects of conditioning programs for competitive swimming for college women. Investigations involving an increase in the length of conditioning programs, or in increasing the number of swimming workouts per week may contribute information concerning patterns of response to conditioning which are followed by college women. It is also suggested that the merits of different types of swimming workouts be an area of investigation concerning swimming programs for college women.

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APPENDIX

TABLE XII

CORRECTED SCORES FOR CABLE TENSIOMETER

Instrument Reading	Correction	Corrected Reading	Instrument Reading	Correction	Corrected Reading
0	0	0	17.5	.625	26.88
.5	1.250	1.25	18.0	.625	27.50
1.0	1.250	2.50	18.5	.625	28.13
1.5	1.250	3.75	19.0	.625	28.75
2.0	1.250	5.00	19.5	.625	29.38
2.5	.625	5.63	20.0	.625	30.00
3.0	.625	6.25	20.5	.833	30.83
3.5	.625	6.88	21.0	.833	31.67
4.0	.625	7.50	21.5	.834	32.50
4.5	.625	8.13	22.0	.833	33.33
5.0	.625	8.75	22.5	.833	34.17
5.5	.625	9.38	23.0	.834	35.00
6.0	.625	10.00	23.5	.625	35.63
6.5	1.250	11.25	24.0	.625	36.25
7.0	1.250	12.50	24.5	.625	36.88
7.5	1.250	13.75	25.0	.625	37.50
8.0	1.250	15.00	25.5	.625	38.13
8.5	.625	15.63	26.0	.625	38.75
9.0	.625	16.25	26.5	.625	39.38
9.5	.625	16.88	27.0	.625	40.00
10.0	.625	17.50	27.5	.833	40.83
10.5	.625	18.13	28.0	.833	41.67
11.0	.625	18.75	28.5	.834	42.50
11.5	.625	19.38	29.0	.833	43.33
12.0	.625	20.00	29.5	.833	44.17
12.5	.625	20.63	30.0	.834	45.00
13.0	.625	21.25	30.5	.833	45.83
13.5	.625	21.88	31.0	.833	46.67
14.0	.625	22.50	31.5	.834	47.50
14.5	.625	23.13	32.0	.833	48.33
15.0	.625	23.75	32.5	.833	49.17
15.5	.625	24.38	33.0	.834	50.00
16.0	.625	25.00	33.5	1.250	51.25
16.5	.625	25.63	34.0	1.250	52.50
17.0	.625	26.25	34.5	1.250	53.75

TABLE XII (continued)

Instrument Reading	Correction	Corrected Reading	Instrument Reading	Correction	Corrected Reading
35.0	1.250	55.00	42.5	1.250	66.25
35.5	.833	55.83	43.0	1.250	67.50
36.0	.833	56.67	43.5	1.250	67.75
36.5	.834	57.50	44.0	1.250	70.00
37.0	.833	58.33	44.5	1.250	71.25
37.5	.833	59.17	45.0	1.250	72.50
38.0	.834	60.00	45.5	1.250	73.75
38.5	.625	60.63	46.0	1.250	75.00
39.0	.625	61.25	46.5	.833	75.83
39.5	.625	61.88	47.0	.833	76.67
40.0	.625	62.50	47.5	.834	77.50
40.5	.625	63.13	48.0	.833	78.33
41.0	.625	63.75	48.5	.833	79.17
41.5	.625	64.38	49.0	.834	80.00
42.0	.625	65.00			

TABLE XIII

CORRECTED SCORES FOR PUSH-PULL DYNAMOMETER

Instrument Reading	Corrected Reading	Instrument Reading	Corrected Reading	Instrument Reading	Corrected Reading
0	0	32	27	63	62
1	0	33	28	64	63
2	0	34	29	65	64
3	0	35	30	66	65
4	0	36	31	67	66
5	0	37	33	68	67
6	0	38	34	69	68
7	0	39	35	70	69
9	0	40	36	71	71
9	1	41	37	72	72
10	2	42	38	73	73
11	3	43	39	74	74
12	4	44	40	75	75
13	6	45	42	76	76
14	7	46	43	77	77
15	8	47	44	78	78
16	9	48	45	79	79
17	10	49	46	80	81
18	11	50	47	81	82
19	12	51	49	82	83
20	13	52	50	83	84
21	14	53	51	84	85
22	16	54	52	85	86
23	17	55	53	86	87
24	18	56	54	87	88
25	19	57	55	88	89
26	20	58	56	89	91
27	21	59	57	90	92
28	22	60	58	91	93
29	24	61	59	92	94
30	25	62	61		
31	26				

TABLE XIV

CORRECTED SCORES FOR THE BACK AND LEG DYNAMOMETER

Instrument Reading	Corrected Reading	Instrument Reading	Corrected Reading
5	15	210	227.5
10	20	215	232.5
15	25	220	237.5
20	30	225	242.5
25	35	230	247.5
30	40	235	252.5
35	45	240	257.5
40	50	245	262.5
45	55	250	267.5
50	60	255	272.5
55	65	260	277.5
60	70	265	285
65	75	270	290
70	80	275	295
75	87.5	280	300
80	92.5	285	305
85	97.5	290	310
90	102.5	295	315
95	107.5	300	320
100	112.5	305	325
105	117.5	310	330
110	125.5	315	335
115	130	320	340
120	135	325	345
125	140	330	350
130	145	335	355
135	150	340	360
140	155	345	365
145	160	350	370
150	165	355	375
155	170	360	380
160	175	365	385
165	180	370	390
170	185	375	395
180	195	380	400
185	202.5	385	405
190	207.5	390	415
195	212.5	395	420
200	217.5	400	
205	222.5		

EXERCISES

Sit-ups (22:208)

Purpose:
to strengthen the abdominal muscles

Starting Position:
lying on the back, arms at sides, knees bent, feet as close to the buttocks as possible (partner may hold performer's feet on the floor)

Execution:
a) bring head and shoulders forward attempting to curl up into a sitting position without the use of the hands and without moving the feet
b) return to the lying position
c) repeat

Push-ups (19:85)

Purpose:
to strengthen the muscles of the arms and shoulder girdle

Starting Position:
a) take a position face down toward the floor in which the body is supported in a slanting position upon the hands and knees
b) the feet are up in the air with the knees bent at right angles
c) the arms are extended and straight with the hands directly under the shoulder joints, fingers parallel to the length of the body
d) the body must be in a straight line from head to knee

Execution:
a) lower the body slowly until the chin touches the floor
b) push up into the starting position (abdomen, hips, or legs must not touch the floor and there must be no motion anywhere in the body other than in the arms and shoulders)
c) repeat

Stretches (17:39)

Purpose:
to increase flexibility of the hips, stretching the long back muscles and the back thigh muscles

Stretches (17:39) (continued)

Starting Position:

sitting position with legs straight, arms either straight overhead with hands clasped or hands clasped behind the head with the elbows bent

Execution:

a) bend forward and downward as close to the knees as possible without bending the knees
b) raise to the sitting position
c) repeat

Back Raises (with pulley weights) (17:59)

Purpose:

to strengthen the arm depressors

Starting Position:

face the pulley weights and hold the handles at shoulder height with the arms straight, legs spread shoulder width and hips flexed so that the trunk is in a horizontal position as though lying in the water

Execution:

a) pull the arms downward and backward to a position alongside the hips
b) return to the starting position
c) repeat

Pullovers (with pulley weights) (17:61)

Purpose:

to strengthen the arm depressors

Starting Position:

lying on the back with arms extended overhead holding the handles close to the floor while keeping the legs straight

Execution:

a) pull the arms forward and downward to a position alongside the thighs
b) return to the starting position
c) repeat

Bicycles (17:39)

Purpose:

to strengthen the abdominals, hip joint flexors, and the

Bicycles (17:39) (continued)

knee extensors

Starting Position:

a) sitting position with the legs straight and off the floor throughout the entire exercise
b) hands may be on hips, in back of the neck, or extended overhead with fingers clasped

Execution:

a) raise the knees alternately in a motion similar to riding a bicycle
b) repeat in rhythm

Rockers (a combination of the wing lift and leg lift)

Purpose:

to strengthen the back muscles and to stretch the chest muscles and abdominal muscles

Starting Position:

lying in a prone position with the hands clasped behind the head with the elbows bent

Execution:

a) rock backward lifting the chest from the floor
b) rock forward, placing the chest on the floor and lifting legs and hips from the floor
c) repeat in rhythm lifting chest then hips and legs in a rocking motion

Arm Strokes (exercise simulating the arm stroke used in the front crawl)

Purpose:

to increase the flexibility of the shoulder joints

Starting Position:

standing with feet shoulder width apart, arms at sides

Execution:

a) circle arms forward alternately in the same pattern as in the front crawl
b) repeat

Squat Jumps (19:76)

Purpose:

to strengthen the muscles of the feet, legs, and thigh (the extensor muscles of the hip, knee, and ankle joints)

Squat Jumps (19:76) (continued)

Starting Position:
stand erect with the left foot about eight inches in front of the right foot with the hands placed on top of the head

Execution:
a) squat down until the buttocks touch the right heel and then immediately spring upward until the knees are straight and the feet just off the floor
b) drop down again into a full squat but with the feet reversed, the right foot about eight inches forward of the left foot
c) continue bouncing and springing upward, reversing the position of the feet on each jump

APPENDIX

TABLE XV

RAW SCORES FOR EXERCISE-SWIMMING GROUP IN SPEED, VITAL CAPACITY, OXYGEN CONSUMPTION, CARDIOVASCULAR EFFICIENCY, ABDOMINAL STRENGTH, LEG STRENGTH, AND SHOULDER STRENGTH AT INITIAL TEST, SECOND TEST, AND FINAL TEST

	Speed	Vital Cap.	O2 Cons.	C.V. Eff.	Abd. Str.	Leg Str.	Sh. Str.
				INITIAL TEST			
1.	57.4	3600	3.82	33.53	32.50	96.50	47
2.	35.0	4200	5.88	48.29	30.00	175.00	50
3.	37.6	4300	7.20	15.71	52.50	202.50	58
4.	40.8	3800	12.54	16.84	26.88	237.50	50
5.	46.1	3600	3.58	11.33	58.33	242.50	63
6.	42.8	4700	8.53	28.48	20.00	212.50	64
				SECOND TEST			
1.	57.9	4000	15.83	38.46	41.67	97.50	52
2.	35.0	4300	12.31	81.63	39.38	175.00	47
3.	38.4	4600	11.92	42.31	48.33	202.50	56
4.	38.6	3750	13.07	22.97	35.00	237.50	50
5.	46.2	3700	14.68	40.87	71.25	242.50	58
6.	39.8	4500	14.45	60.22	31.67	212.50	53
				FINAL TEST			
1.	50.8	4400	1.22	32.38	45.00	102.50	57
2.	37.8	4000	2.28	67.40	30.00	195.00	52

TABLE XV (continued)

FINAL TEST (continued)							
3.	40.8	5000	6.07	35.65	62.50	247.50	54
4.	38.4	4000	2.07	27.93	33.33	262.50	50
5.	43.6	4500	1.93	58.75	62.50	277.50	67
6.	40.4	4050	2.87	87.59	35.00	300.00	49

TABLE XVI

RAW SCORES FOR SWIMMING GROUP IN SPEED, VITAL CAPACITY, OXYGEN CONSUMPTION, CARDIOVASCULAR EFFICIENCY, ABDOMINAL STRENGTH, LEG STRENGTH, AND SHOULDER STRENGTH AT INITIAL TEST, SECOND TEST, AND FINAL TEST

	Speed	Vital Cap.	O2 Cons.	C.V. Eff.	Abd. Str.	Leg Str.	Sh. Str.
INITIAL TEST							
1.	35.2	2700	1.03	33.25	59.17	150.00	53
2.	38.0	4600	1.28	32.90	58.33	277.50	56
3.	47.6	4800	13.89	33.27	23.75	70.00	59
4.	31.2	4900	5.91	30.89	27.50	125.50	62
5.	37.4	4200	1.34	17.21	33.33	145.00	53
6.	35.4	3900	6.54	33.05	21.88	112.50	52
SECOND TEST							
1.	35.2	4200	14.84	62.82	50.00	330.00	60
2.	38.0	3950	11.41	47.81	35.00	330.00	47
3.	47.6	3800	9.16	31.17	49.17	170.00	52
4.	31.2	4950	14.83	49.25	30.00	305.00	63
5.	37.4	4050	11.06	83.33	55.00	295.00	65
6.	35.4	4400	14.28	74.53	36.25	165.00	56
FINAL TEST							
1.	37.3	3900	2.50	65.93	55.00	340.00	66
2.	38.2	4100	1.81	60.00	48.33	310.00	59

TABLE XVI (continued)

FINAL TEST (continued)							
3.	41.9	4200	2.34	58.43	62.50	155.50	54
4.	29.8	5500	2.57	65.57	46.67	385.00	69
5.	35.6	4500	4.96	85.71	72.50	360.00	67
6.	35.4	3900	3.48	82.75	60.00	217.50	59

TABLE XVII

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN INITIAL TEST FOR THE EXERCISE-SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	35.0 - 57.4	43.18	7.21
vital capacity	3600-4700	4033	404.7710
oxygen consumption	3.58- 12.54	6.92	3.0572
cardiovascular efficiency	11.33- 48.29	25.86	12.7182
abdominal strength	20.00- 58.33	36.70	13.8765
leg strength	70.00-212.50	123.33	52.8700
shoulder strength	47.00- 64.00	55.33	6.6742

TABLE XVIII

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN INITIAL TEST FOR THE SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	31.2 - 47.6	37.46	5.02
vital capacity	2700-4800	4150	718.2159
oxygen consumption	1.03- 13.89	4.99	4.5681
cardiovascular efficiency	17.21- 33.27	30.09	5.8205
abdominal strength	21.88- 59.17	37.32	15.5657
leg strength	70.00-277.50	146.75	64.0630
shoulder strength	52.00-62.00	55.83	3.6235

TABLE XIX

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN SECOND TEST FOR THE EXERCISE-SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	34.6 - 57.9	42.58	7.66
vital capacity	3700-4600	4150	360.5577
oxygen consumption	11.92- 15.83	13.71	1.3862
cardiovascular efficiency	22.97- 81.63	47.91	18.5767
abdominal strength	31.67- 71.25	44.55	13.0337
leg strength	97.50-242.50	194.58	48.8724
shoulder strength	47.00- 58.00	52.66	3.6354

TABLE XX

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN SECOND TEST FOR THE SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	31.8 - 45.8	37.23	4.30
vital capacity	3800-4950	4225	375.0003
oxygen consumption	9.16- 14.84	12.59	2.1760
cardiovascular efficiency	31.17- 83.33	58.15	17.4934
abdominal strength	30.00- 55.00	42.57	9.2060
leg strength	165.00-330.00	265.83	70.6766
shoulder strength	47.00- 65.00	57.16	6.2556

TABLE XXI

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN FINAL TEST FOR THE EXERCISE-SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	37.8 - 50.8	41.96	4.36
vital capacity	4000-5000	4325	360.2676
oxygen consumption	1.22- 6.07	2.74	1.5652
cardiovascular efficiency	27.93- 87.59	51.61	21.5257
abdominal strength	30.00- 65.50	45.22	14.0674
leg strength	102.50-300	230.83	65.8231
shoulder strength	50 - 67	54.83	6.0384

TABLE XXII

RAW SCORE RANGES, MEANS, AND STANDARD DEVIATIONS IN FINAL TEST FOR THE SWIMMING GROUP

Variables	Range	Mean	Standard Deviation
speed	29.8 - 38.2	36.2	3.70
vital capacity	3900-5500	4350	553.0241
oxygen consumption	1.81- 4.96	2.94	1.0263
cardiovascular efficiency	58.43- 85.71	69.73	10.6378
abdominal strength	46.67- 72.50	57.50	8.7926
leg strength	155.00-385.00	294.58	81.8344
shoulder strength	54.00- 69.00	62.33	5.3429

Typed by Kathleen Mitchell