THE EFFECTS OF SPECIALIZED TRAINING ON THE PHYSICAL FITNESS OF UNIVERSITY COMPETITIVE SWIMMERS

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ABSTRACT

The purpose of this study was to determine the effect of specialized training on the physical fitness of twelve members of the University of British Columbia Swimming Team. The specialized training consisted of the Basic or General Circuit, the Interval Circuit and the Swim Circuit.

The areas of physical fitness that were being considered included dynamic strength, dynamometer or static strength, cardiovascular endurance, breathing capacity, reaction time and ankle flexibility. The subjects were tested on three occasions; first, previous to the commencement of the training programme, second, midway through the competitive swimming season, and finally, at the completion of training. The experiment covered a period of approximately six months.

Results were compared for the initial and intermediate tests, the initial and final tests and for the intermediate and final tests. Most notable improvement was shown in dynamic strength, whereas dynamometer strength evidenced no improvement. Significant improvement was also found in reaction time and ankle flexibility, but no improvement was indicated in cardiovascular endurance or breathing capacity.

TABLE OF CONTENTS

LIST OF TABLES

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CHAPTER I

INTRODUCTION

During the past decade remarkable improvements have been made in performance times in individual competitive sports, principally in the realm of swimming and track and field. In this period, record times have been lowered in almost every event (1) and there is every indication that this trend will continue. In spite of this, Carlile reflects with reference to swimming, that "training is still very largely unscientific, a case of the blind leading the blind." (2)

A closer look at the reason or reasons underlying these outstanding accomplishments would appear to be pertinent at this time. Initially, it might be said that the matter is related to motivation; the very fact that an existing mark is lowered, and in many instances before the previous one has been entered in the record book, provides the necessary impetus for other competitors to put forth that "extra effort" in an attempt to exceed the achievement of the record holder. Obviously this is not the whole story since such exceptional results must be due to something more tangible than the psychological factors. This gives rise to such factors as superior coaching, more proficient techniques, improved facilities and conditions, and immensely intensified training programmes. The latter, particularly as it is related to the development of physical fitness, is most noteworthy and it is within this realm that this study will be confined.

A high state of training in the athlete obviously denotes his physical fitness, particularly factors of muscular strength and endurance and cardiovascular endurance. Since these components of physical fitness, when achieved to the utmost, are vital to top swimming performance, a study of this area would appear to be of considerable significance. It is the intent of this research project, therefore, to determine the effect of specialized training on the physical fitness of selected swimmers.

Statement of the problem: The problem in this thesis is to determine by way of carefully selected tests, whether or not improvements take place in the physical fitness of university competitive swimmers during and following intensive training schedules of a specialized nature.

Purpose of the study: It is the purpose of this study to determine what effects such specialized conditioning as basic and interval circuit training and special weight training in the form of the Swim Circuit, in addition to routine swimming practice, have on the physical fitness of members of the University of British Columbia Swimming Team over a six month period during the normal competitive swimming season. Moreover, the study will attempt to resolve which factors of physical fitness are affected to the greatest degree under this kind of intensive training.

Specifically, the aim will be to determine the change that will take place in the physical fitness of each swimmer over the three test periods and whether there is a significant difference in physical fitness in comparing the results of the first and second, first and third and second and third times of testing.

The hypothesis: It is hypothesized that the physical fitness of the swimming team members will improve significantly when comparing the results of the second test period over the first test period, the third test period over the first test period and the third test period over the second test period.

Delimitations: The study will concern itself solely with members of the University of British Columbia Swimming Team, consisting of twelve male students.

Physical fitness will be determined by tests in muscular strength and endurance, cardiovascular endurance, flexibility, breathing capacity and reaction time.

Cardiovascular fitness will be determined by pulse rate after stepping, using the Harvard Step Test.

Muscular strength and endurance will be measured by tests of general motor ability and by static dynamometrical strength tests respectively.

The test of flexibility will be restricted to ankle flexibility.

The experiment will be conducted over a six month period.

The experimental group, being small in number and selective, cannot be considered a random sample of the population.

Available norms concerning the physical fitness of highly trained athletes are extremely limited. This factor necessitates the use of norms that apply to the normal healthy individual.

It is not known to what degree training under actual swimming conditions will have on the development of physical fitness in the experimental group.

Basic assumptions: Each subject will be sufficiently motivated to put forth his best possible effort during the performance of the various tests.

Testing procedures will be constant for all subjects.

The tests used will be recognized tests and will be administered by trained personnel.

Muscular strength and endurance, cardiovascular endurance, breathing capacity and flexibility, are important components of physical fitness.

Reaction time is closely related to fitness, particularly with reference to competitive swimming performance.

Any changes in test results will be due to alterations in physical fitness rather than to learning or motivation.

Physical fitness will be construed as that condition evidenced by the highly trained athlete which is distinctly superior to that of the normal healthy individual.

Definition of terms: For the purpose of this study "physical fitness" is defined as the ability to function physically at a high level of efficiency. (3)

"Muscular strength" is the maximum strength that is applied in a singular muscular contraction. (4)

"Muscular endurance" is the ability to continue muscular exertions of submaximal magnitude. (5)

"Cardiovascular endurance" refers to the condition of the circulatory system in adapting to work situations. (6)

"General motor ability," also known as general athletic ability, is the immediate capacity of an individual to perform in many varied stunts or athletic events. (7)

"Static dynamometrical strength" is strength that is performed in a relatively stationary position and which can be registered on a dynamometer. (8)

"Circuit training" describes that method of fitness training designed to develop muscular and cardiovascular fitness by the utilization of the overload principle (9) (10) and the theory of progressive resistance exercise. (11) It consists of a number of specific exercises arranged in a consecutive pattern in the form of a circuit, with progression measured initially by increasing the time of performance and secondly, by increasing the number of repetitions, depending upon the exercise tolerance of the individual. The target time or completion time is based upon the execution of three circuits of the course.

"Basic circuit training" is a programme of circuit training generally prescribed for the development of physical fitness in normal healthy individuals.

"Interval circuit training" refers to an advanced type of the aforementioned conditioning programme specifically designed for highly competitive athletes. It consists of more strenuous exercises than those included in the basic circuit. The participant is required to complete five circuits with a target time of two minutes each and a one minute rest interval between each circuit. The last circuit is followed immediately by running eight laps of the running track or equivalent.

"The swim circuit" is an original special weight training programme that consists of specific conditioning exercises performed to develop strength and endurance in muscles that are involved in the various swimming strokes.

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CHAPTER II

JUSTIFICATION OF THE PROBLEM

In this age of highly specialized training in competitive athletics such as swimming and track and field, numerous systems are being employed in an attempt to develop an optimum degree of physical fitness which is a vital ingredient for the swimming champion. Up to the present time no single method has received universal acceptance in its entirety. (1) There are those who have advocated in-the-water training exclusively for the development of fitness as well as swimming performance. (2) The majority of the foremost coaches at the present time however, recommend dry land training, particularly with the use of weights. (3) Ideally then, it would seem that a balanced combination of these two systems would satisfy the requirements and desires of most competitors. (4) It is desirable to determine, therefore, whether the method of training described herein will develop a top level of physical fitness in competitive swimmers. In addition it is hoped, if certain aspects of physical fitness show improvement and the extent to which they improve, that this will provide a basis for formulating future training programmes.

Moreover, owing to the lack of indoor swimming facilities on the campus of the University of British Columbia, a sufficient amount of training under pool conditions is not possible. The members of the swimming team are required to travel to off-campus facilities at which time allotment is markedly restricted. Consequently it is also desirable to know, by the level of physical fitness attained, if the specialized training as outlined will supplement the limited programme of actual swimming.

Friermood (5) emphasizes the need for research in all phases of aquatics. It is suggested that training and conditioning have a place in future investigations. Accordingly, through the results and conclusions of the study, the advancement of research may be the outcome if even to a slight degree.

Dawson (6) notes that new ideas and methods should be attempted with a view towards the betterment of training programmes.

> Change and continued experimentation are psychological factors that can overcome even a negative physical factor. Swimmers simply want to try something new and anything new that works for the champion is worth trying. This makes sense and science is fighting human nature if it expects highly motivated athletes and coaches to wait for the completion of group laboratory study before trying something new. (7)

The specialized training upon which this study has its basis could conceivably open another door to training procedures.

Finally, since norms for athletes with respect to physical fitness are few in number, it is hoped that this study will contribute to the establishment of standards of this nature.

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CHAPTER III

REVIEW OF THE LITERATURE

A major part of the training of competitive swimmers necessarily pertains to the physical fitness of the performer and the expression "physical fitness" as related to such athletic events as swimming on a competitive basis could be very well defined as "the ability to function physically at a high level of efficiency." (1) This definition, then, would satisfy the age-old problem, "fitness for what?", when queried with respect to competitive swimming since it is readily conceivable precisely what degree of fitness is desirable for this activity.

In spite of the varied approaches to the development of physical fitness in swimmers, training on the whole, according to Carlile "remains very much an empirical, trial-and-error procedure." (2) This is assuredly due, in part at least, to the conflicting concepts with respect to the training methods that the experts have advocated in the past.

Fitness training for swimmers can be classified into two general categories, first that which is restricted to the water and secondly, dry-land training. For many years, and for that matter, until quite recently, it had been held that optimal fitness, and consequently top swimming performance, could be achieved solely by training in the water. In this regard, Carlile (3) notes that in 1962, leading Dutch coaches had denounced exercises for strength other than those which could be executed in the water. The belief here was that the swimmers would become muscle bound, a factor that would impede their swimming performance. Nevertheless, dry-land methods of training, notably with weights, are almost unanimously accepted at present.

> On the face of it, this has seemed a good reason in the past for exercising "only" in the water to gain swimming fitness. Up to 1948 practically every swimming trainer in the world agreed with this. Now, however, practical experience has proved them wrong and there are few top swimmers in the world who do 'not' work for strength out of the water in addition to their strenuous training in the water. (4)

Further confirmation of the advantages of out-of-water training is evidenced by conditioning programmes prescribed by the foremost swimming coaches in the United States today, namely Kiphuth, Counsilman, McCaffee, Higgins, Schlueter, and the Dawsons. (5) Counsilman predicts that:

> .... eventually most swimming coaches will agree that a mixed training program is necessary for the proper conditioning of swimmers . . . I am sure there will always be some disagreement among coaches on the amount of emphasis that should be placed on each type of swimming training. (6)

The objectives basic to the development of physical fitness in swimmers are concerned with muscular strength, muscular and cardiovascular endurance, or what is commonly referred to as stamina, and flexibility or suppleness. The strength factor has been the subject of considerable controversy among coaches over the years. There are those who would suggest that strength may not be an important ingredient for swimmers since many men and women who have tested low on physical strength are champion swimmers. (7) Faulkner (8) reflects that his Western Ontario University swimmers became weaker, as the season progressed, when tested for static strength although there was an improvement in stamina and performance, the latter being indicated by the faster times during time trials. Schlueter (9) and other prominent coaches propose that "too many of us have gone overboard on weights" for the purpose of developing strength. It is generally conceded by most of the experts that young swimmers can benefit greatly from a strength programme, whereas the well-developed champions can better utilize their time with other aspects of training. (10)

The amount and type of training, whether its purpose be to develop strength, endurance or flexibility, is determined chiefly by the individual's body type and the particular stroke at which he specializes. (11) Cureton (12) shows that the majority of champion swimmers cluster decidedly toward the mesomorphic component of his somatotype triangle, with some tendency toward the ectomorphic-mesomorphic side. Few champions, if any, are above four in endomorphy, a characteristic that is apparent in almost all top athletes in most sporting events. With reference to the specific stroke at which the swimmer specializes it can be readily conceived that the type of training should be adequate to meet the needs of the specialty. Thus where the stroke demands a particular emphasis on the components of strength, endurance or flexibility, the training should be geared to obtain the optimum degree necessary. Indeed, the wise and ultimately successful coach will design a programme specifically suited to the requirements of his swimmers on an individual basis.

Dry-land exercises are as numerous as the coaches who propose them and each has its particular significance. They may vary from the conventional calisthenics with the use of little or no equipment, to the more complicated interval circuit training procedures. Other systems involve static tensions, bar bells, pulley weights, partner resistance, medicine balls, and endurance running. It is not uncommon to find a combination of the above items incorporated into one complete programme. Dawson (13) has compiled a collection of training procedures recommended by some of the most eminent coaches in the United States, Canada and Australia.

In the ensuing paragraphs, the literature pertaining to the effects of training on physical fitness will be reviewed with specific reference being made to various weight and circuit training programmes and the relationship to competitive swimming where applicable.

Howell and Morford (14) submit that there are many ways of attaining physical fitness and that the principal methods include weight training, circuit training, static and isometric contractions and progressive calisthenics. These authors advise variety in order to maintain the interest of the individual thus increasing the effectiveness of the programme.

> ..... a major factor in fitness training is the appearance of boredom by the repetition of an activity. Everyone should be aware of different methods of fitness training, and should change his program occasionally. (15)

Throughout the literature on circuit training the importance of systematic progressive loading is emphasized. Steinhaus states the following with relation to the overload theory, a fundamental principle of circuit training:

> ..... no matter how much a muscle is used, it will not grow larger or stronger until it is overloaded. This means that the intensity of the work required of it must be increased above that to which it is normally

> accustomed, i.e., it must be required to exert more power (foot pounds per minute) or work against greater resistance than before. (16)

Steinhaus further explains his theory of the overload principle in terms of intensive exercise with or without the use of weights.

> Weight training and heavy calisthenics are examples of what I choose to call formal overloading. Such activities can be used to strengthen any muscle or muscle group. They are easily described and graduated. They are effective to the extent that they develop the muscles that are important to the sport and do not increase inordinately the size and weight of muscles inappropriate to the sport in question. (17)

Functional overloading is described by Steinhaus as that which is directly related to the sport. Thus a basketball player trains with medicine balls, a boxer uses heavy punching bags and extra-heavy shoes, the swimmer works out in the pool with his legs tied fast, and so on. (18) Finally, Steinhaus proposes that muscles can be overloaded by self resistive exercise, a form of isometric contraction, whereby one group of muscles is used to resist another, at which time both groups may be simultaneously overloaded. (19)

McCloy (20) suggests that overload will result in a better blood supply which will correspondingly increase the oxygen supply and result in an improvement of endurance.

Hellebrandt and Houtz (21) discovered that both strength and endurance improved when work was performed against heavy resistance. Muller (22) considers tension to be the key factor in strength development and that the use of heavy resistance requiring a longer contraction time concurs with this principle.

Morgan and Adamson (23) indicate that circuit training "aims at the development of muscular and circulo-respiratory fitness." Adamson (24) had earlier suggested this when he found that there was a substantial per cent increase in means in the results of tests in static and dynamic strength, power and endurance in twenty university men who were involved in circuit training once a week over a period of two months.

Adamson (25) later interpreted this system of training in terms based upon the principle of progressive loading. He stated further that this progressive loading theory has been "unhappily named the overload principle."

> According to this principle, it is impossible to increase muscular strength or endurance except by the imposition of progressively heavier loads. A muscle can only increase in strength if it works at a greater rate than has been previously required. This, therefore, calls for some control of the work rate during training, so that a steady increase may be maintained . . . . . (26)

Cureton (27) claims that interval training in track and long distance running are the best methods of improving cardiovascular endurance. Banister (28) in his study with junior high school boys, showed that the interval circuit training method was more efficient than circuit training activity in the development of total fitness, dynamic strength and endurance.

Howell, et al, (29) in an experiment with two groups of university freshmen equated on their performance on the Roger's Short Strength Index and another two groups of university freshmen equated on the basis of the Larson Muscular Strength Test, came to the conslusion that circuit training caused statistically significant increases in strength and muscular endurance. Dennison, Howell and Morford (30) in a study comparing isometric and isotonic exercise methods with twenty required programme students, placed one half of the group on a regular weight training schedule for eight weeks and the other half on the thirteen exercises of the Commander Set group over the same period of time. The results indicated that both exercise programmes brought about significant improvement in muscular endurance of the upper arms on the basis of scores on the Arm Strength Index. The regular weight trained group, however, showed a tendency toward greater gains on the whole than did the Commander Set group, although the authors point out that the latter results were most encouraging considering the exercise time involved.

Nunney (31), experimenting on swimmers in required physical education classes, discovered that students who participated in a combination of swimming and circuit training exercises, improved their swimming speed more than those who participated in swimming alone. The findings of Davis (32) revealed that after a period of weight training, all seventeen of his subjects increased their speed in swimming the crawl stroke. Similar results were obtained by Thompson and Stull (33) who tested six groups of subjects on different training programmes. They concluded that swimmers who did specific weight training three times weekly and swam three times weekly showed greater improvement in their swimming performance. Hutchinson (34), however, found that swimming plus weight training produced no better results than those that were achieved solely by swimming. Jensen (35) used five different training methods consisting of varying proportions of weight training and swimming and concluded that while swimming performance improved steadily after vigorous training thirty minutes each day for five days a week, no one method of training was superior to another.

Two studies reveal significant results pertaining to the effects of swimming on physical fitness. First, Davis (36) in analyzing the effects of training and conditioning for the two hundred yard crawl stroke upon the physical condition of non-varsity swimmers, found that scores on test batteries used to measure physical fitness, indicated that there was a decided improvement in motor fitness and gross strength although no significant difference was obtained for cardiovascular condition. Secondly, Cureton (37), evaluated the U. S. Navy's programme of training for underwater swimmers during one typical course of six weeks' duration. The thirty men who trained vigorously five hours per day, five days per week, both in and out of the water, showed improvement in muscular endurance and cardiovascular fitness as well as in the reduction of fat. Cureton also notes in this study that programmes of maximal duration, four to ten hours per week, result in the greater relative improvement in muscular endurance and that cardiovascular fitness improvements are influenced by time and intensity factors, with better results being obtained when the dosage is gradually increased over several months.

In summary, a review of some of the more pertinent information relevant to physical fitness as it applies to competitive swimming would seem worthwhile. Although other components of physical fitness may be apparent, muscular strength, muscular and cardiovascular endurance and flexibility are the three most vital to swimming performance. In spite of the fact that strength has been refuted by some as to its necessity for swimming success, most authorities agree as to its worth.

> An increase in swimming strength will enable the swimmer to produce a higher swimming output. Swimming strength can be built up on dry land as well as in the water. At the higher levels of competition, weight training and body exercise should be featured prominently in the swimmer's training programme. (38)

The foregoing quotation points out the need for dry-land training in addition to the regular swimming schedule. There is no longer the fear that the individual will become muscle bound, instead there is a desire to develop firm, well-conditioned muscles.

> Nowadays it is recognized that in order to be really fit, swimmers must take part in activities on land to strengthen them, and that a hard muscle is normally in a state of contraction indicating 'work'. A soft flabby muscle indicates weakness..... It can thus been (sic) seen that land conditioning is no longer a 'hit and miss' affair ..... (39)

To conclude this chapter, a survey of the literature relevant to the validity and reliability of the tests and testing instruments utilized in this study, will be presented.

McCloy reveals that the Harvard Step Test has been well validated as a measure of general endurance that might be highly desirable for the average citizen. ".....an 'r' of .70 has been obtained by a triserial correlation of the scores of two groups of rowers, varsity squad and beginners, and of an untrained group of men." Brouha (41) advocates that the step test is a measure of the general capacity of the body, in particular the cardiovascular system, to adapt itself to hard work and to recover from what it has done.

The elements of dynamic strength as measured by chinning, dipping and the vertical jump, according to Larson (42), yield a higher validity correlation when compared to the other types of strength tests.

McCloy (43) asserts that the test for ankle flexibility employed in this study, is useful primarily for swimming and the Dance. Utilizing this test of flexibility, Fisher (44) evidenced a coefficient of reliability of .73 in testing and retesting the varsity and freshman swimming squads at Springfield College.

Breathing capacity, states McCloy (45), has long been used as a measure of physical status and that the wet spirometer is a valid instrument for measuring this component of fitness. Moreover, Cureton claims that there is some indication that swimming develops breathing capacity. (46)

The vertical jump reaction time test, according to Cureton (47), is considered to be a reliable test to determine how quickly a person can react to a stimulus.

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CHAPTER IV

METHODS AND PROCEDURES

The experimental group was comprised of twelve male students who were members of the swimming team at the University of British Columbia. The experiment extended over a period of approximately six months throughout the university competitive swimming season.

Training programme: The specialized training to which the experimental group was subjected incorporated the Basic or General Circuit, the Interval Circuit and the Swim Circuit. The programme was initiated with the Basic Circuit which was used for the first month of training. This was succeeded by the Interval Circuit for two and one half months. The final phase of training was devoted to the Swim Circuit.

Table 1 outlines the Basic Circuit.

TABLE 1

The Basic or General Circuit

EXERCISE	Red Circuit				Blue Circuit			
	Weight (Lbs.)	Repetitions 1	2	3	Weight (Lbs.)	Repetitions 1	2	3
1. Squat Thrust	-	10	12	15	-	18	21	25
2. Two Arm Curl	40	8	10	12	50	8	10	12
3. Two Arm Press	50	8	10	12	60	8	10	12
4. Straddle Bench Jumps	15	15	17	19	25	17	18	19
5. Lateral Raise	7-1/2	8	10	12	10	8	10	12
6. Lying Lateral Raise	10	8	10	12	15	8	10	12
7. Sit Ups	-	10	14	18	-	21	25	30
8. Bench Step Ups	-	15	17	20	-	23	26	30
9. Jump Chins	-	1	2	3	-	4	6	8
10. Bench Press	60	6	8	10	80	6	8	10
11. Trunk Extension	-	10	12	14	-	16	18	20
12. Bent Over Rowing	65	6	8	10	85	6	8	10
13. Stair Running	-	6	8	10	2 x 10	6	8	10

In performing the Basic Circuit each of the subjects commenced at Red 1. This entailed the performance of three laps of the entire circuit at the stated dose listed under Red 1 for each exercise. When this was accomplished in twenty-five minutes or less the subject performed at Red 2 and once again attempted to realize the target time of twenty-five minutes before moving to the Red 3, and so on.

Table 2 portrays the Interval Circuit.

TABLE 2

The Interval Circuit

EXERCISE	Weight (Lbs.)			
	1	2	3	4
1. Barbell Reverse Curl (Hands Overgrasp)	45	55	65	85
2. Barbell Curl (Hands Undergrasp)	45	55	65	85
3. Side Bends	40	50	60	80
4. Straddle Bench Jumps	2 x 40	2 x 50	2 x 60	2 x 70
5. Lying Lateral Raise	10	20	30	40
6. Sit Ups	10	20	30	40
7. Chins	0	10	20	30
8. Trunk Extension	10	20	40	50
9. Barbell Press	45	55	65	85
10. Tricep Snatch	20	40	60	-
11. Bent Over Rowing	45	55	65	85

The eleven exercises in the Interval Circuit were repeated three times, with the exception of the sit-up exercise, which was repeated five times. The subject selected the maximum weight he could lift from the poundages designated for each exercise and attempted to complete the circuit in two minutes or less. This sequence was repeated five times with a minute rest interval between each circuit. Immediately following the fifth circuit the subject ran eight laps of the running track. During inclement weather the running took place in the upper corridors of the gymnasium.

The Swim Circuit, as depicted in Table 3, is a circuit of relatively short duration, but one that can be extremely demanding if properly executed. The subjects worked through the circuit at a steady pace, resting for a maximum of thirty seconds after each exercise.

TABLE 3

The Swim Circuit

EXERCISE	Weight (Lbs.)	Repetitions	Sets
1. Straight Arm Pull Overs	30-70	30-50	1
2. Tricep Exercise (Extensors)	25-70	20-30	1
3. Running on the Spot - Knees Above Waist (one minute)	-	1	1
4. Arm Rotators	25-60	30-50	1
5. Backstroke Pulleys	20-40	40	1 *
6. Standing Pulls (Isotonic)	35-?	35	3
7. Three Position Holds (8 seconds) (Isometric)	35-?	10	2

* Backstroke and Individual Medley Specialists execute 3 sets of 30.

Testing procedure: The physical fitness and other tests used in this study are itemized below, with a description of what each test purports to measure. The testing instruments utilized and noted in the right hand column are recognized as standard testing equipment in physical education.

TEST	DESCRIPTION	TESTING DEVICES
1. Dynamometer Strength Hand grip - left and right Back lift Leg lift	Strength per pound of body weight - indirectly related to motor ability. The items form part of Rogers Strength Index (S1) which is a measure of general athletic ability. (1)	Manuometer
2. Larson's Muscular Strength Chins Dips Vertical jumps	Predicts motor ability (general athletic ability). (2)	Chinning Bar Parallel Bars
3. Breathing Capacity	Lung capacity - determines the amount of air that can be expired after the deepest possible inspiration (3) - usually expected that this should be above average in swimmers. (4)	Wet Spirometer
4. Vertical Jump Reaction Time	Measures the individual's ability to move the whole body quickly as a unit in response to a stimulus. (5) It is associated with the speed of starting in swimming. (6)	Selective Reaction Timer
5. Harvard Step Test	Determines cardiovascular efficiency - the ability of the body to adapt itself to hard work and recover from same. (7)	22" Stepping Bench Timer Stethoscope

TEST	DESCRIPTION	TESTING DEVICES
6. Ankle Flexibility	The range of motion in the ankle joint which is considered of great importance in specific events. Swimmers on the whole, require loose, flexible ankles since ankle flexibility is directly related to the flutter kick. "There is no doubt that better speed and endurance swimming performance parallel greater flexibility in the major joints." (8)	Tracing Board and Marking Sheet to trace ankle position at maximum flexion and extension.

The subjects were tested on three separate occasions during the experimental period; first at the beginning of the training programme, secondly, midway through the season and lastly, immediately following the final swimming competition.

All testing was conducted under the direction of the research professor in the School of Physical Education and Recreation at the University of British Columbia. All testing procedures were standardized for each of the subjects, in that the order of testing was identical and methods for the individual tests were administered by the same personnel. All testing took place in the physical education research laboratory at the aforementioned institution.

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5. Ibid., p. 95.

6. McCloy and Young, op. cit., p. 229.

7. Mathews, op. cit., p. 201.

8. Cureton, op. cit., p. 90.

CHAPTER V

RESULTS

The tests used in this study for the evaluation of the various components of physical fitness and related measures, have been subdivided into the individual test items, where necessary, for the purpose of more ably presenting the significant results.

The following tables show the information required for testing the significance between means of the paired observations for the initial and intermediate test period, the initial and final test period, and the intermediate and final test period. The resulting t statistic is also shown.

The symbols used in the succeeding tables are listed below:

- T1 Initial test period.
- T2 Intermediate test period.
- T3 Final test period.
- $\bar{X}1$ Mean of initial scores.
- $\bar{X}2$ Mean of intermediate scores.
- $\bar{X}3$ Mean of final scores.
- $\sum d$ Sum of the differences between scores.
- $\sum d^2$ Sum of the squared differences between scores.

Dynamic strength: Statistical results for Chinning are shown in Table 4. Significant improvement was evident from the intermediate tests over the initial tests and from the final tests over the initial tests. * There was no significant improvement from the final tests over the intermediate tests.

* Significant improvement is indicated in the following tables at the .025 level of significance.

TABLE 4

Chinning

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	12.54	14.71		26.0	120.0	3.120 *
T1 - T3	12.54		14.25	20.5	61.75	3.438 *
T2 - T3		14.71	14.25	-5.5	49.75	-.766

* Significant at the .025 level of significance.

In Table 5, for the test item Dipping, significant improvement was notable in the results from the intermediate tests to those of the initial tests, from the final tests over the initial tests and from the final tests over the intermediate tests.

TABLE 5

Dipping

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	15.21	20.88		66.0	482.50	5.780 *
T1 - T3	15.21		22.83	91.5	885.75	6.388 *
T2 - T3		20.88	22.83	23.5		2.875 *

* Significant at the .025 level of significance.

For the test, Vertical Jump, the statistical results as shown in Table 6, indicate that there was no significant improvement in this item.

TABLE 6

Vertical Jump

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	21.08	21.04		-.5	5.25	-.6916
T1 - T3	21.08		21.33	3.0	13.5	.8070
T2 - T3		21.04	21.33	3.5	8.75	1.205

Table 7 presents the overall dynamic strength in Larson's Weighted Composite Score. Significant improvement is apparent from the results of the intermediate tests over the initial tests and the final tests over the initial tests.

TABLE 7

Larson's Muscular Strength - Weighted Composite Score

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	366.18	406.37		482.32	32,299.37	4.067 *
T1 - T3	366.18		412.50	555.89	38,045.03	4.800 *
T2 - T3		406.37	412.50	73.57	7,377.86	.846

* Significant at the .025 level of significance.

Dynamometer strength: In the comparison of the means of the three test periods for Right Grip and Left Grip, as depicted in Tables 8 and 9, respectively, there was no significant improvement.

TABLE 8

Right Grip

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	119.25	126.08		83	2,175	1.986
T1 - T3	119.25		121.17	23	1,055	.693
T2 - T3		126.08	121.17	59	1,425	1.677

TABLE 9

Left Grip

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	108.08	113.50		65	2,335	1.398
T1 - T3	108.08		112.92	58	1,854	1.399
T2 - T3		113.50	112.92	-7	899	-.071

Statistical results for the dynamometrical strength test items, Back Lift and Leg Lift, are shown in Tables 10 and 11. There was no significant improvement for these items.

TABLE 10

Back Lift

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	399.08	395.00		-49	46,648	-.218
T1 - T3	399.08		396.00	-137	19,625	-.976
T2 - T3		395.00	396.00	12	33,364	.063

TABLE 11

Leg Lift

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	939.08	986.92		574	124,514	1.764
T1 - T3	939.08		958.58	234	166,306	.557
T2 - T3		986.92	958.58	-340	277,242	-.629

The results of total dynamometer strength as shown in Table 12, indicate no significant improvements over the three test periods.

TABLE 12

Total Dynamometer Strength

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	1565.50	1611.25		519	254,411	1.032
T1 - T3	1565.50		1588.67	278	297,378	.494
T2 - T3		1611.25	1588.67	244	310,442	-.423

Strength per pound of Body Weight, as in Table 13, likewise showed no significant improvement.

TABLE 13

Strength per pound of Body Weight

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	9.97	10.25		3.32	11.79	.964
T1 - T3	9.97		10.04	1.41	7.54	.497
T2 - T3		10.25	10.04	-2.53	11.93	.718

Breathing capacity: Table 14 shows the statistical results for Breathing Capacity, in which there was no significant improvement.

TABLE 14

Breathing Capacity

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Σd	Σd^2	t
T1 - T2	341.33	341.42		1	2,119	.021
T1 - T3	341.33		345.42	49	1,253	1.446
T2 - T3		341.42	345.42	48	674	2.085

Reaction time: Reaction Time (Table 15) resulted in significant improvement in the final test period, over the initial tests. No significant improvement was evidenced from the intermediate tests over the initial test or the final tests over the intermediate tests.

TABLE 15

Reaction Time (Seconds)

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	.306	.301		.069	.003597	1.168
T1 - T3	.306		.292	.171	.007143	2.387 *
T2 - T3		.301	.292	.102	.003992	1.747

* Significant at the .025 level of significance.

Cardiovascular endurance: Table 16 shows a comparison of the statistical measures for Cardiovascular Endurance, as determined by the rating computed from the results of the Harvard Step Test, which indicates no significant improvement.

TABLE 16

Harvard Step Test Rating

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	92.58	94.00		15	771	.524
T1 - T3	92.58		98.17	67	1,493	1.918
T2 - T3		94.00	98.17	50	1,182	1.534

Ankle flexibility: Table 17 shows that there was significant improvement in Right Ankle Flexibility, according to the results obtained in intermediate tests, compared to the initial test period. Otherwise, no significant improvement was indicated.

TABLE 17

Right Ankle Flexibility

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	58.08	64.83		81	845	4.503 *
T1 - T3	58.08		63.83	69	1,399	2.091
T2 - T3		64.83	63.83	-12	526	-.507

* Significant at the .025 level of significance.

Statistical results for Left Ankle Flexibility are shown in Table 18. Significant improvement was evidenced from the final tests over the initial tests. No significant improvement was apparent from the intermediate tests over the initial tests or from the final tests as compared to the intermediate tests.

TABLE 18

Left Ankle Flexibility

	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	$\sum d$	$\sum d^2$	t
T1 - T2	60.50	63.83		40	630	1.718
T1 - T3	60.50		66.50	72	1,022	3.053 *
T2 - T3		63.83	66.50	32	382	1.779

* Significant at the .025 level of significance.

CHAPTER VI

DISCUSSION OF RESULTS

It is interesting to note that all significant improvement, with one exception, occurred between the intermediate tests over the initial tests and the final tests over the initial tests. The one exception concerned the dynamic strength test item, Dipping, in which there was significant improvement in the final test over the intermediate test. This may suggest that a "peak" in the physical fitness of the subjects was attained between the intermediate and final test periods.

Most notable improvements in the physical fitness of the swimmers were made in the dynamic strength test items of Chinning and Dipping, in addition to the overall dynamic strength as presented in the Weighted Composite Score of Larson's Muscular Strength Test. These findings concur with those of Hellebrandt and Houtz (1), who found that muscular strength and endurance improved following work performed against heavy resistance, which would assimilate the type of exercises that constituted the specialized training described in this study. Dennison, Howell and Morford (2) also found that strength and muscular endurance improved markedly after a programme of circuit and weight training.

The results of the test item, Vertical Jump, in which there was no improvement of statistical significance, do not agree with the conclusions advanced by Berger (3), which state that dynamically trained groups significantly improved their vertical jumping ability.

All phases of dynamometer or static strength manifested no significant improvement with this experimental group. These findings corroborate the opinions proposed by Faulkner (4) who noted that university swimmers became weaker as the season progressed, when tested for static strength. This may indicate that dynamometer strength is less important to swimmers than is dynamic strength.

There was significant improvement in the test item, Reaction Time, in this study. These findings substantiate, to some degree, the views expressed by some authors who suggest that reaction time may be improved through training. (5) On the other hand, Rarick (6) concluded that speed of movement in highly skilled individuals cannot be appreciably increased.

The improvements evidenced in ankle flexibility in this study may be more directly related to the training under actual swimming conditions rather than to the specialized training.

The lack of improvement concerning such phases of physical fitness as cardiovascular endurance and breathing capacity, leads the author to agree with Tweit and others, (7) who intimate that it is difficult to detect any changes in highly skilled athletes since they may be approaching their physiological limit.

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CHAPTER VII

SUMMARY AND CONCLUSIONS

The subjects of this study were twelve members of the Swimming Team at the University of British Columbia. The purpose of the study was to determine the changes in the physical fitness of the subjects while participating in a specialized training programme.

The study covered a period of approximately six months, which was the normal competitive swimming season. The specialized training consisted of the Basic or General Circuit for the first two months, the Interval Circuit for the next two months, with the final two months being devoted to the Swim Circuit, the latter being a specially devised programme involving the use of weights and pulleys.

The experimental group was tested prior to the commencement of their training, midway through the competitive swimming season, and finally, at the completion of the training schedule. Physical fitness was measured in terms of dynamic strength, dynamometer or static strength, cardiovascular endurance, breathing capacity, reaction time, and ankle flexibility.

The results revealed significant improvement in the dynamic strength items, particularly with regard to Chinning and Dipping and overall dynamic strength. Reaction Time and Ankle Flexibility results also disclosed significant improvements.

The following conclusions are warranted as a result of the specialized training:

1. There was significant improvement in these aspects of physical fitness; dynamic strength, reaction time, and ankle flexibility.

2. No significant improvement was evidenced in dynamometer strength, cardiovascular endurance and breathing capacity.

In the light of these conclusions it sould be noted that the fitness standards attained were generally at a high level. It is difficult to determine precisely what level of fitness was reached, however, owing to the lack of norms for highly trained athletes.

Although not directly investigated in this study, it is interesting to note that there was notable improvement in swimming performance, evidenced by the fact that all swimmers tested recorded their fastest times. Two of the swimming team members each set two national intercollegiate records. The swimmers involved in this study had been accustomed to training an average of eleven hours per week in the water with their respective highly competitive age-group swimming clubs. In comparison, the University of British Columbia Swimming Team has been limited to four hours of water time per week. It is reasonable to assume, therefore, that the specialized training programme adequately supplemented the limited water training time.

Recommendations for future study

In consideration of the results in this study pertaining to the time during which greatest improvements in physical fitness were made, it has been suggested in Chapter VI that a plateau may have been reached concerning the swimmers' fitness. This may indicate that a tapering-off in training take place in future experiments, rather than the continued rigorous training throughout the entire programme, as was performed in this study.

A future study of this nature may be attacked from the comparative point of view in which two sample groups would be involved. One group would be trained entirely in the water while the control group would use dry land methods in addition to the regular swimming practice sessions.

The possibilities of further research in the realm of physical fitness as it pertains to the superbly conditioned athlete, are considerable. There is much that can be done with regard to competitive swimmers, specifically with reference to the relationship between physical fitness and swimming performance, a subject that was not directly investigated in this study.

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APPENDICES

APPENDIX A

STATISTICAL TREATMENT

Study Design

Single group, triple test experiment.

T2 vs T1

T3 vs T1

T3 vs T2

$N = 12$

Formula

$$t = \frac{\sum d}{\sqrt{\dfrac{N \sum d^2 - (\sum d)^2}{N - 1}}}$$

One-tailed test with N - 1 (11) degrees of freedom.

t - tabled = 2.201

Level of Significance

The .025 level of significance was chosen instead of .05 for the following reasons:

1. Three t-tests on three pairs of means are not independent and therefore the .05 level of significance does not hold as would be the case for dependent variables.

2. When all possible t-tests are done on a set of means instead of two randomly selected means, then some significant results could be expected purely by chance. For example, at the .05 level, five out of every one hundred results could be expected to be significant, even when all of the hypotheses were true. To guard against this, a more stringent level of significance has been used.

Procedure

The t statistic was calculated in the following manner:

The means of the raw scores for each test item on each of the three tests were calculated. ($\overline{X}$)

The sum of the difference of each pair of raw scores was calculated. ($\sum d$)

The sum of the squared differences of each pair of raw scores was calculated. ($\sum d^2$)

The above information was inserted in the aforementioned formula to determine the t statistic.

If the calculated t statistic was greater than t-tabled (2.201), then this was considered to be an indication of significant improvement. If it was less than t-tabled then it was assumed that there was no significant improvement.

PERSONAL DATA

NAME	AGE			HEIGHT (IN.)			WEIGHT		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Auld, G.	18	19	19	72.5	72.5	72.5	161	159	161.5
Baker, G.	18	18	18	69	69	69	151.5	152	154
Conroy, P.	18	18	18	68.5	69	69	139	144.5	146
Frewer, C.	17	17	17	69.5	69.5	69.5	130	131	131.5
Gillespie, G.W.	19	19	19	73	73	73	162.5	161	164.5
Griffiths, B.	20	21	21	68.5	68.5	68.5	175	180.5	183
Mansell, R.	18	18	18	72.5	72.5	72.5	159	161.5	162.5
Marks, E.	19	19	20	72.5	72.5	72.5	171	166	162.5
Pearce, J.D.	19	19	19	70	70	70	164	164	163
Smith, D.L.	21	21	22	66	66.5	66.5	146	146	147
Stafford, M.	24	24	24	73.5	73.5	74	175.5	171.5	174
Walker, R.	17	18	18	68.5	69	69	158	159	158

APPENDIX B

FITNESS RESULTS - LARSON'S MUSCULAR STRENGTH TEST

NAME	CHINS			DIPS			VERTICAL JUMP		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Auld, G.	13.5	16.5	14.5	10.5	19.5	19.5	19.5	19	18.5
Baker, G.	17.5	20.5	17.5	22.5	28.5	33.5	21.5	22	22
Conroy, P.	12.5	16	13.5	16	20	21	24	23.5	23
Frewer, C.	10.5	12.5	12.5	7.5	17.5	18	17.5	18	18.5
Gillespie, G.W.	14.5	16	16.5	18	25.5	26.5	21	20	19.5
Griffiths, B.	8.5	9	10.5	7.5	12.5	15	19.5	20	20
Mansell, R.	10.5	16	13.5	15	20	21.5	23	22.5	24.5
Marks, E.	13.5	15.5	15	24.5	30.5	33.5	21	22	21.5
Pearce, J.	8	6.5	10.5	10	9	14	19	19.5	20.5
Smith, D.L.	16	22.5	21.5	17	28	33.5	22	22.5	23
Stafford, M.	13.5	15	13.5	19	24	21.5	21	20.5	22
Walker, R.	12	10.5	12	15	15.5	16.5	24	23	23

APPENDIX C

APPENDIX D

FITNESS RESULTS - LARSON'S MUSCULAR STRENGTH TEST

NAME	WEIGHTED COMPOSITE SCORE			%ILE RANK		
	T1	T2	T3	T1	T2	T3
Auld, G.	337.90	392.13	367.25	81	97	92
Baker, G.	443.17	498.04	488.67	98	99	99
Conroy, P.	406.50	445.11	419.30	98	99	98
Frewer, C.	271.60	337.05	345.10	33	80	84
Gillespie, G. W.	394.10	422.66	422.23	97	98	98
Griffiths, B.	282.40	312.60	334.10	40	64	78
Mansell, R.	370.80	432.41	439.55	93	98	98
Marks, E.	406.83	459.09	457.82	98	99	99
Pearce, J.	279.90	268.80	337.95	39	32	80
Smith, D. L.	417.61	522.42	539.83	98	99	99
Stafford, M.	387.60	413.57	408.05	96	98	98
Walker, R.	395.70	372.55	390.15	97	93	96

FITNESS RESULTS - DYNAMOMETER STRENGTH (LBS.)

* Sore Back
** Badly Bruised Hand

NAME	RIGHT GRIP			LEFT GRIP			BACK LIFT			LEG LIFT		
	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Auld, G.	141	145	130	109	119	101	330	392	341	848	1045	900
Baker, G.	125	130	128	120	110	118	500	460	440	948	989	995
Conroy, P.	105	130	119	90	119	112	347	365	380	850	840	901
Frewer, C.	88	106	90	92	100	100	380	398	370	851	900	820
Gillespie, G.W.	120	139	131	110	110	109	292	371	362	875	838	1150
Griffiths, B.	110	118	105	103	100	105	442	278*	428	1063	1112	900
Mansell, R.	136	123	129	114	105	100	458	445	415	1057	1170	1040
Marks, E.	110	112	107**	110	103	116	470	428	410	905	990	922
Pearce, J.	121	109	127	112	112	120	351*	320	380	880	750	860
Smith, D.L.	110	131	130	92	123	120	397	438	408	875	922	1050
Stafford, M.	142	142	144	124	131	136	422	475	480	917	1112	920
Walker, R.	123	128	114	121	130	118	400	370	338	1200	1175	1045

APPENDIX E

APPENDIX F

FITNESS RESULTS - DYNAMOMETER STRENGTH (LBS.)

NAME	TOTAL LIFT			STRENGTH PER POUND OF BODY WEIGHT		
	T1	T2	T3	T1	T2	T3
Auld, G.	1428	1701	1472	8.87	10.70	9.11
Baker, G.	1693	1689	1681	11.21	11.11	10.92
Conroy, P.	1392	1454	1512	10.01	10.06	10.36
Frewer, C.	1411	1504	1380	10.85	11.48	10.49
Gillespie, G. W.	1397	1458	1752	8.62	9.06	10.65
Griffiths, B.	1718	1485	1538	9.82	8.23	8.40
Mansell, R.	1765	1843	1684	11.10	11.41	10.36
Marks, E.	1595	1633	1555	9.33	9.84	9.56
Pearce, J.	1464	1291	1487	8.93	7.87	9.12
Smith, D. L.	1474	1614	1708	10.10	11.05	11.62
Stafford, M.	1605	1860	1680	9.17	10.85	9.66
Walker, R.	1844	1803	1615	11.67	11.34	10.22

APPENDIX G

FITNESS RESULTS - BREATHING CAPACITY, REACTION TIME

NAME	BREATHING CAPACITY (CU. IN.)			VERTICAL JUMP REACTION TIME (SEC.)		
	T1	T2	T3	T1	T2	T3
Auld, G.	336	331	342	.308	.300	.295
Baker, G.	275	265	275	.327	.317	.308
Conroy, P.	340	331	343	.321	.285	.290
Frewer, C.	306	333	325	.306	.308	.292
Gillespie, G. W.	367	370	372	.330	.333	.298
Griffiths, B.	334	323	327	.314	.328	.332
Mansell, R.	357	357	364	.344	.362	.323
Marks, E.	384	382	387	.299	.278	.265
Pearce, J.	360	342	347	.283	.280	.270
Smith, D. L.	295	290	299	.285	.298	.320
Stafford, M.	402	428	425	.294	.282	.273
Walker, R.	340	345	339	.266	.237	.240

APPENDIX H

FITNESS RESULTS - HARVARD STEP TEST

NAME	TOTAL RECOVERY PULSE			RATING		
	T1	T2	T3	T1	T2	T3
Auld, G.	195	182	175	77	82	86
Baker, G.	157	158	147	96	95	102
Conroy, P.	168	146	137	89	103	109
Frewer, C.	165	155	178	91	97	84
Gillespie, G. W.	131	155	153	115	97	98
Griffiths, B.	187	186	180	80	81	83
Mansell, R.	164	151	156	91	99	96
Marks, E.	174	185	158	86	81	95
Pearce, J.	168	160	152	89	94	99
Smith, D. L.	137	137	124	109	109	121
Stafford, M.	165	153	165	91	98	91
Walker, R.	155	163	137	97	92	114

APPENDIX I

FITNESS RESULTS - ANKLE FLEXIBILITY (DEGREES)

NAME	T1		T2		T3	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
Auld, G.	66	69	70	70	70	67
Baker, G.	59	50	70	66	54	71
Conroy, P.	56	64	68	70	75	74
Frewer, C.	69	71	71	70	66	79
Gillespie, G. W.	50	65	63	59	72	72
Griffiths, B.	58	62	66	57	62	63
Mansell, R.	68	70	68	68	69	69
Marks, E.	50	47	52	53	51	50
Pearce, J. D.	42	51	57	63	62	68
Smith, D. L.	64	63	71	66	63	63
Stafford, M.	60	58	60	59	58	58
Walker, R.	55	56	62	65	64	64

APPENDIX J

FITNESS DATA SHEET

Swimmers 1964-65

NAME ________________________ DATE ______________

FACULTY ________________________ AGE ______ YEARS

LOCAL ADDRESS ________________ LOCAL PHONE NO. ______

HOME ADDRESS ________________ HOME PHONE NO. ______

HEIGHT _____ (Ft.) _____ (Ins.) WEIGHT _____ (Lbs.)

1. Bone Muscle Fat Analysis. _____ (Check)

2. Larson's Muscular Strength Test.

   Chins _____ (No.)
   Dips _____ (No.)
   Vertical Jump _____ (Ins.)
   Composite _____

3. Dynamometer Strength (Lbs.)

   Right Grip 1-___ 2___ 3___
   Left Grip 1___ 2___ 3___
   Back Lift 1___ 2___
   Leg Lift 1___ 3___
   Total ______ Pounds
   Strength per pound of body weight = _____

4. Breathing Capacity (Cubic Inches)

   Room Temperature = _____ F.
   Trials 1____ 2____ 3____

5. Vertical Jump Reaction Time (Seconds)

   Trials:

   1. _____ 6. _____
   2. _____ 7. _____
   3. _____ 8. _____
   4. _____ 9. _____
   5. _____ 10. _____

   Test Time = _____

6. Harvard Step Test

   Resting Pulse Rate (30") = _____
   Recovery Pulse:
   1 - 1:30 = _____
   2 - 2:30 = _____
   3 - 3:30 = _____
   Total = _____

7. Ankle Flexibility (Degrees)

   Right Ankle _____
   Left Ankle _____

APPENDIX K

STATISTICAL CALCULATION FORM

Item.......................................

SUBJECT	T	T	d	d^2
G. A.				
G. B.				
P. C.				
C. F.				
W. G.				
B. G.				
R. M.				
E. M.				
J. P.				
D. S.				
M. S.				
R. W.				
$N = 12$ $N - 1 = 11$	$\bar{X} =$	$\bar{X} =$	$\sum d =$	$\sum d^2 =$

$$t = \frac{\sum d}{\sqrt{\frac{N\sum d^2 - (\sum d)^2}{N - 1}}} =$$