STRENGTH, MUSCULAR ENDURANCE, AND CARDIORESPIRATORY ENDURANCE CHANGES IN COLLEGE MALES AND FEMALES AS A FUNCTION OF TRAINING

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Bruce Michael Scotland
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ABSTRACT

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Brockport, New York Institutional Representative

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The strength, muscular endurance, and cardiorespiratory trainability of men and women were investigated. The subjects, twelve male and ten females, engaged in a six week training program in which they were required to perform progressive resistance exercises using DeLorme's technique in order to increase their strength and muscular endurance. In addition, the subjects took part in a six week interval running program for the purpose of developing cardiorespiratory endurance. Prior to training each subject was tested for elbow flexion strength with Clarke's cable tensiometer. Muscular endurance was measured using Shaver's arm-lever ergometer method, and cardiorespiratory endurance according to the Astrand-Rhyming bicycle ergometer technique. Following the training program the subjects were re-tested in a manner patterned after the initial test.

While both men and women increased significantly in strength, muscular endurance, and cardiorespiratory endurance following the six weeks of training there were no significant differences between the sexes in terms of their strength, muscular endurance, and cardiorespiratory trainability. However, absolute strength gains were found to be significantly greater in men than women. This difference was attributed to the predominantly male

hormone testosterone which enables men to develop greater amounts of muscle mass and achieve greater strength levels than women.

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A special expression of appreciation must be given to Dr. Larry G. Shaver for his time and consideration throughout each phase of the thesis.

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CHAPTER I

INTRODUCTION

The effects of training on muscular strength, and endurance as well as on cardiorespiratory endurance have received a great deal of study in recent years in pursuit of solutions to numerous problems. Much research has been conducted with both men and women involving a variety of training techniques, methods, and research methodology. However, a review of the literature has failed to disclose any research comparing the training response of both men and women to a muscular endurance conditioning program. At the same time, only one study has been found comparing the strength as well as the cardiorespiratory endurance differences of boys and girls taking part in the same type of training program simultaneously.

THE STATEMENT OF THE PROBLEM

The purpose of this study was to investigate the differences in strength, muscular endurance, and cardiorespiratory endurance training response of both men and women who underwent relatively identical training programs simultaneously.

SIGNIFICANCE OF THE PROBLEM

In athletics, there are few sports in which strength, muscular endurance, and cardiorespiratory endurance are not factors, and in many sports the entire training and conditioning programs are directed toward these ends. A variety of studies have been undertaken in the past using either men or women to determine the effects of training and conditioning upon strength,[1] muscular endurance,[2] and cardiorespiratory endurance.[3] In addition, there has also been a considerable amount of information[4] published on comparing men and women on selected physiological responses. In general, the literature has indicated that past the age of 12, males not only become considerably stronger than females, but they also obtain greater muscular and cardiorespiratory

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[1] R. A. Berger, "Comparison of the Effects of Various Weight Training Loads on Strength," Research Quarterly, 36: 141-146, May, 1965; C. H. Brown and J. H. Wilmore, "The Effects of Maximal Resistance Training on the Strength and Body Composition of Women Athletes," Medicine and Science in Sports, 6:174-177, Spring, 1974; C. K. Capen, J. A. Bright and P. A. Line, "The Effects of Weight Training on Strength, Power, Muscular Endurance, and Anthropometric Measurements on a Selected Group of College Women," Journal of the Association for Physical and Mental Rehabilitation, 15:169-173, 180, November - December, 1961.

[2] Ibid.; L. G. Shaver, "Effects of Training on Relative Muscular Endurance in Ipsilateral and Contralateral Arms," Medicine and Science in Sports, 2:165-171, Fall, 1970.

[3] J. L. Ardisson and others, "Cardio-Respiratory Effects of Interval Training," The Journal of Sports Medicine and Physical Fitness, 13:74-89, June, 1973; W. E. Sinning and M. J. Adrian, "Cardiorespiratory Changes in College Women Due to a Season of Competitive Basketball," Journal of Applied Physiology, 25:720-724, December, 1968; C. X. Witten and W. Witten, "The Effects of Frequency Interval Training Upon Cardiovascular Fitness Among College Females," The Journal of Sports Medicine and Physical Fitness, 13:183-186, September, 1973.

[4] P. O. Astrand, "Human Physical Fitness With Special Reference to Sex and Age," Physiological Reviews, 36:307-335, July, Journal of Sports Medicine and Physical Fitness, 6:100-105, June, 1966; C. Ulrich "Women and Sports," Science and Medicine of Exercise and Sports, ed. W. R. Johnson (New York: Harper Brothers, 1960), pp. 511-513.

endurance. It appears that these differences increase in magnitude through full maturity, after which they become relatively constant.[5]

The review of literature has indicated that there are no studies that specifically compared the training response of both men and women to a muscular endurance conditioning program simultaneously. Also, only one investigation has been found comparing the conditioning response of both men and women to a strength[6] as well as a cardiorespiratory[7] type training program simultaneously. In essence, these studies found that women experience as much, if not more, relative increases in strength than men, while there was no significant differences between sexes in cardiorespiratory endurance improvements.

It has been suggested that structural and physiological differences between men and women have a direct bearing on the amount of improvement that occurs in strength, muscular endurance, and cardiorespiratory endurance. For example, deVries[8] states that

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[5] J. H. Wilmore, "Exploding the Myth of Female Inferiorty," The Physician and Sports Medicine, 2:54-58, May, 1974.

[6] J. H. Wilmore, "Alterations in Strength, Body Composition, and Anthropometric Measurements Consequent to a 10 - Week Weight Training Program," Medicine and Science in Sports, 6:133-138, Spring, 1974.

[7] H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," Canadian Medical Association Journal, 96:895-899, March, 1967.

[8] H. deVries, Physiology of Exercise for Physical Education and Athletics (Dubuque, Iowa: Wm. C. Brown, 1974), p. 402.

strength in terms of physical performance, is one of the most important sex difference, which after puberty is generally much greater in the male. Asmussen[9] reports that adult women have about 65% of the strength of adult men. Part of this is attributed to the difference in average height, however, even when this factor is eliminated women have only 80% the strength of men. In accordance with this, Klafs and Arnheim[10] indicate that muscle tissue in men constitutes approximately 43% of the total body mass, whereas in women muscle tissue only accounts for approximately 36% of the total body mass. The difference in the relative amount of muscle tissue in men and women has been attributed to the male hormone testosterone which increases the weight of muscle tissue and enlargement of the muscle fibers. Ikai, as reported by Brown and Wilmore,[11] indicates there is little if any qualitative difference between male and female muscular strength when related to cross sectional area, the only difference being greater muscle mass in males.

The literature also reveals that the ratio of heart weight to body weight is different in males and females. Burger, as cited by deVries,[12] states that from the age of 10 to the age of 60, the average value for women is only 85-90% of

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[9] E. Asmussen, "The Neuromuscular System and Exercise," ed. H. B. Falls (New York: Academic Press, 1968), P. 33.

[10] C. E. Klafs and D. Arnhiem, Modern Principles of Athletic Training (St. Louis, Missouri: C. V. Mosby Co., 1974), p. 146.

[11] Brown, and Wilmore, op. cit., p. 177.

[12] deVries, op. cit., p. 403.

the value for men. Ulrich[13] indicates that this difference in heart size causes women to have a faster heart rate. In fact, the adult females resting heart rate averages between 5 and 10 beats per minute faster than the adult male under any given set of conditions.[14] It has also been found that the oxygen pulse, which measures the efficiency of the heart as a respiratory organ, and is calculated as the oxygen consumption per milliliter per heart beat, is higher in the male. In comparing the oxygen pulse of men and women 31-35 years of age Nocher and Bohlau, as reported by deVries[15] found that the oxygen pulse for the male is about three times higher than the female.

In addition, the male has been found to have a greater total volume of blood than the female.[16] In fact, in regards to blood components, Astrand[17] reports that the average number of red blood cells at rest in females is 4,800,000 per cu. mm. as compared to 5,700,000 per cu. mm. in the male. Astrand further reported that the females hemoglobin content of the blood averages 13.9 gm/100cc.; whereas males average 15.8 gm/100cc. Therefore, there is approximately 12% less hemoglobin per 100cc. of blood in women

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[13]Ulrich, op. cit., pp. 511, 512.

[14]deVries, op. cit., p. 71.

[15]deVries, op. cit., p. 404.

[16]Ulrich, op. cit., p. 512.

[17]P. O. Astrand, Textbook of Work Physiology (New York: McGraw-Hill, Inc., 1970), p. 106.

than men. In regard to blood pressure, the systolic and diastolic pressures are both generally about 5 to 10 mm. Hg. lower in women.[18]

After the age of 12, the maximum aerobic power of the female is 25 to 30% less than the male. However, when body weight is taken into consideration the difference is only about 15 to 20%.[19] The vital capacity of the female when compared to her male counterpart of the same size and age, is approximately 10% less, and because of the smaller thorax, women respire more rapidly and breathe shallower than men.[20]

With regard to weight and body fat, it has been reported that the adult male is about 20 to 25% heavier than the female; however, the average adult female has about seven more pounds of subcutaneous fat than the average man.[21] Thus, the average adult male has a lower ratio of fat to lean body weight, and a higher specific gravity than his female counterpart.

Although there certainly appears to be structural and physiological sex differences, the variations between men and women in terms of physical performance and training response may be due to social or cultural restrictions that have been imposed on the female. For example, it was only in the mid-sixties and

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[18]Ulrich, loc. cit.

[19]Astrand, op. cit., p. 313.

[20]F. A. Hellebrandt and S. J. Houtz, "Mechanisms of Muscle Training in Man: Experimental Demonstrations of the Overload Principle," Physical Therapy Review, 36:371-383, June, 1956.

[21]Ulrich, op. cit., p. 511.

early seventies that social and cultural attitudes regarding the sterotype model of feminity actually changed. Now, it is well known and accepted that the female can be athletically skilled without necessarily losing her feminity.[22]

Due to the lack of evidence in the literature, it was hoped that this research would contribute to the knowledge of what training differences occur between men and women who undergo relatively identical strength, muscular endurance, and cardio-respiratory endurance conditioning programs simultaneously.

SCOPE OF THE STUDY

The subjects were 12 male and 10 female volunteers, all in good health, between the ages of 18 and 25, and enlisted from both the graduate and undergraduate population. The research was conducted during the spring semester of 1975 in the Research Laboratories at the State University College of Brockport.

LIMITATIONS OF THE STUDY

The measures of strength, muscular endurance, and cardio-respiratory endurance depended on the motivation and will of each subject to perform an all-out effort. The investigator had no means of determining whether or not the subjects were actually unable to persist at the activity once a certain point of fatigue was reached. It was also beyond the ability of the investigator to control the activities of the subjects outside the actual testing situation.

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[22] C. E. Klafs and M. J. Lyon, The Female Athlete: Conditioning, Competition and Culture (St. Louis: C. V. Mosby Co., 1974), p. 38.

Therefore, there was always the possibility that the subjects may have exercised the muscles and organs being trained even though verbal agreement to the contrary had been secured by the investigator.

DEFINITIONS OF TERMS

Cardiorespiratory endurance: "Moderate contractions of large muscle groups for relatively long periods of time, which require the adjustment of the circulatory - respiratory systems to the activity."[23]

Muscular endurance: The ability to continue muscular exertions of submaximal magnitude.[24]

Strength: Maximum strength applied in a single muscular contraction.[25]

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[23] H. H. Clarke, Application of Measurement to Health and Physical Education, (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1967), p. 203.

[24] Ibid.

[25] Ibid.

CHAPTER II

REVIEW OF LITERATURE

Since there is a limited amount of research that is directly related to this topic, this section has been divided into three parts. The first contains the presentation of studies specifically related to strength, muscular endurance, and cardiorespiratory endurance development in both men and women engaged in relatively identical training programs simultaneously. The second section includes selected studies related to the development of strength, and muscular endurance as a result of progressive - resistance overload training. The third section contains selected research related to the development of cardiorespiratory endurance as a result of interval training.

STRENGTH, MUSCULAR ENDURANCE, AND CARDIORESPIRATORY ENDURANCE DEVELOPMENT IN BOTH MEN AND WOMEN ENGAGED IN RELATIVELY IDENTICAL TRAINING PROGRAMS SIMULTANEOUSLY

Prior to Wilmore's[1] study, no research has been conducted comparing strength training responses of both men and women simultaneously. In this study although it was found that men

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[1] J. H. Wilmore, "Alterations in Strength, Body Composition, and Anthropometric Measurements Consequent to a 10-Week Weight Training Program," Medicine and Science in Sports, 6:133-138, Spring, 1974.

had higher absolute strength values for all measures, women exhibited the greatest relative increases in leg (mean of 29.5%), bench press (mean 28.6%), and grip (mean of 12.8%), strength as compared to men (leg = mean of 26.0%; bench press = mean of 16.5%; and grip = mean of 5.0%). The men, on the other hand, had a greater relative increase in forearm flexion (mean of 18.9%) as compared to women (mean of 10.6%). Summarizing this study, it appears that the female has perhaps the same potential for relative strength development as the male.

These results appear to be contradictory to those of Hettinger.[2] He reports that between the ages of 20 and 30 years, women are approximately 50% less responsive to strength training than men. It should be pointed out, however, that Hettinger's results did not specifically compare men and women taking part in identical type testing and training as did Wilmore's. Thus, the difference in the two studies may be explained, in part, by the two unequal states of training and testing as found in Hettinger's report.

McDonald[3] has stated that there is some evidence to indicate that the musculature of women respond less to training than men. He bases his statement on the research conducted by

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[2]T. Hettinger, Physiology of Strength (Springfield, Illinois: Charles C. Thomas, 1961), p. 10.

[3]A. McDonald, "Strength and The Female," Physical Education, 156:33-37, 1960. Cited by H. Olson, Index and Abstracts of Foreign Physical Education Literature, VI p. 49.

Knoll which found that the forearm muscles of male tennis players increased in size and strength through practice, but this was not true in women tennis players.

The research by Roskamm[4] has been the only investigation comparing improvements in cardiorespiratory endurance in women and men who simultaneously participated in identical-type training. This investigation concluded that there was no difference in the trainability of six young women as compared to six men of approximately the same age, since men and women obtained equal increases in maximum watt pulse (work done per pulse beat). Kilbom[5] indicates that the results of Roskamm's study confirms the theory that there is no sexual difference in the aerobic trainability of men and women. However, it should be pointed out that the basis for this theory is that both sexes have about the same maximal aerobic power per kilogram (kg) of body weight, if the individuals fat content is disregarded. Therefore, improvement of aerobic capacity through training should be identical in men and women. On the other hand, if aerobic capacity is expressed per kilogram of total body weight, improvement should be less in women.

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[4]H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," Canadian Medical Association Journal, 96:895-898, March, 1967.

[5]A. Kilbom, "Physical Training in Women," Scandanavian Journal of Clinical Laboratory Investigations Supplement, 119:1-34, October, 1971.

A recent study by Hanson and Nedde[6] investigated the long term physical training effect in sedentary females. This study concluded that "the trainability of non-athletic females and their oxygen transport system do not differ from that of their male counterparts."

Finally, the literature indicates that if the strength factor is eliminated, there is no significant difference in terms of muscular endurance.[7] However, no research could be found comparing the effects of identical training of men and women on muscular endurance.

STRENGTH AND MUSCULAR ENDURANCE

Shaver[8] used DeLorme's progressive resistance weight training technique to investigate the effects of a high-intensity, low repetition, isotonic training program on maximum static strength and relative muscular endurance of 40 male subjects. The experimental subjects trained three times weekly for six weeks. Following the six weeks of training a post-test patterned

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[6]J. J. Hanson and W. H. Nedde, "Long Term Physical Training Effects in Sedentary Females," Journal of Applied Physiology, 37:112-116, July, 1974.

[7]H. deVries, Physiology of Exercise For Physical Education and Athletics (Dubuque, Iowa: Wm. C. Brown, 1974), p. 327; M. Ikai, "Work Capacity of Japanese Related to Age and Sex," Journal of Sports Medicine and Physical Fitness, 6:100-105, June, 1966.

[8]L. G. Shaver, "Effects of Training on Relative Muscular Endurance in Ipsilateral and Contralateral Arms," Medicine and Science in Sports, 2:165-171, Fall, 1970.

after the pre-test was administered to all subjects in both arms. The results indicated that the traditional method of progressive resistance weight training will increase static elbow strength and muscular endurance in the unexercised limb as well as the exercised limb.

Hansen[9] conducted a study dealing with the effects of three different weight training programs on muscular strength, endurance, girth, and cardiorespiratory endurance. In this study, 30 varsity football players were randomly divided into three weight training groups. One group used a modification of DeLorme's progressive resistance weight training technique, the second group followed a traditional strength training method, while the third group followed a circuit training program. The training program covered a period of seven weeks, three times a week. Tests were given for muscular strength, endurance, and girth before the program began and at the conclusion of the training program. The results of the test showed that all parameters improved significantly as a result of all three weight training programs. There was no significant difference between the groups.

Berger[10] reported that Faulkner, in comparing DeLorme's and McCloy's programs of progressive resistance exercises,

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[9] L. Hansen, "The Effects of Three Selected Weight Training Programs on Muscular Strength, Endurance, Girth, and Cardiorespiratory Endurance," (unpublished Master's thesis, South Dakota State University, Brookings, 1969), p. 47.

[10] R. A. Berger, "The effects of Varied Weight Training Programs on Strength and Endurance" (unpublished Doctor's dissertation, University of Illinois, Urbana, 1960), p. 21.

inferred that DeLorme's program appeared to be superior for developing strength and McCloy's program for developing endurance. However, in Faulkner's study only one subject was used and he trained the right arm and left leg according to McCloy's method, and the left arm and right leg were trained according to DeLorme's method. The subject trained for a period of eight weeks, five times a week.

Berger[11] sought to compare the strength and endurance improvements resulting from nine programs of progressive resistance exercises over a twelve week period. Berger concluded from his investigation that progressive resistance exercises involving all possible repetitions per set; improved strength significantly after three weeks of training and continued to improve significantly from three to six, six to nine, and nine to twelve weeks. In addition, Berger found that by increasing strength from progressive resistance training, muscular endurance also improved.

With regard to progressive resistance exercises and its effect on strength and muscular endurance, Yessis[12] concluded from his investigation on the relationship between varying combinations of resistance and repetitions on the strength

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[11] Berger, op. cit., p. 68, 69.

[12] M. Yessis, "Relationships Between Varying Combinations of Resistance and Repetitions in the Strength-Endurance Continuum." (unpublished Doctor's dissertation, University of Southern California, Los Angeles, 1963), p. 203.

endurance continuum that: "exercise in progressive resistive programs which employ varying resistances and number of repetitions leads to the development of significant gains in strength and endurance."

CARDIORESPIRATORY ENDURANCE DEVELOPMENT STUDIES

Knuttgen[13] conducted a study on the effects of interval training on the physical fitness of young adult males. The researchers used three programs of interval training. Group one (N=20) exercised for 15 seconds and rested 15 seconds three days a week for two months. Group two (N=9) exercised for three minutes and rested for three minutes three days a week for two months. Group three (N=8) had no formal program for one month, then for the next month they exercised for three minutes, and rested for three minutes. After one and two months, significant increases in maximal oxygen consumption were observed. Groups one, two, and three improved 7, 10, and 11 milliliters per kilogram of body weight, respectively. It was also found that improvement was inversely related to fitness; that is, the lower the level of fitness at the start of the program, the greater the increase relative to this value. It was concluded from this study that aerobic capacity in young male adults can be markedly and rapidly improved by interval training.

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[13]H. G. Knuttgen, "Interval Training and Physical Fitness of Young Male Adults," Medicine and Science in Sports, 4:59,60, Spring, 1972.

Peterson and Kelley[14] sought to determine the chronic effects of cigarette smoking upon the acquisition of physical fitness during an interval type training program. The interval training program consisted of having the smokers and non-smokers run a series of 440-yard runs at a pace of 88 seconds. The training program was initiated with four runs, three times a week. Every two weeks an additional 440-yard run was added. Using this interval-type training method, Peterson and Kelley found that smokers and non-smokers increased aerobic capacity throughout the entire program. The total increases in mean aerobic capacity for smokers and non-smokers were .42 liters per minute and .38 liters per minute, respectively.

Witten and Witten[15] studied the effects of interval training frequency upon cardiorespiratory fitness among college females. This study employed an interval training program consisting of three sets of 3 X 220 in 47 to 49 seconds and a 220-yard jog in two minutes with a five minute rest interval between sets. However, when an individuals heart rate dropped to 172 beats per minute the time allowed for the set was shortened. Twelve girls were equally divided into three

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[14] F. S. Peterson and D. L. Kelley, "The Effects of Cigarette Smoking Upon the Acquisition of Physical Fitness During Training as Measured by Aerobic Capacity," Journal of the American College Health Association, 17:250-254, February, 1969.

[15] C. X. Witten and W. Witten, "The Effects of Frequency Interval Training Upon Cardiovascular Fitenss Among College Females," The Journal of Sports Medicine and Physical Fitness, 13:183-185, September, 1973.

groups. Group one trained five days a week, and group two trained three days a week. Both groups trained according to the interval program stated above and group three was a control group. The investigators found that at the end of the seven weeks of training groups one and two improved significantly over group three, but there was no significant difference between groups one and two. Therefore, three days a week of interval training improved cardiovascular endurance as significantly as five days a week training in female subjects.

Harper and others[16] compared the effects of two physical conditioning programs on cardiovascular fitness in men. One training program was a modified army program consisting of calisthenics and marching. The second conditioning program involved interval training. The 25 male subjects in the study were placed into three matched groups based on maximum oxygen consumption. Group one participated in the army program, group two the interval training program and group three served as a control and only participated in recreational activities. The groups met five times a week for seven weeks. Before and after the seven weeks of conditioning the maximal oxygen consumption test and Harvard Step Test were given to evaluate differences in cardiovascular improvements. The

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[16]D. D. Harper and others, "Comparison of Two Physical Conditioning Programs on Cardiovascular Fitness in Man," Research Quarterly, 40:293-298, May, 1969.

results showed that the interval trained group improved significantly on the two tests of fitness. The army trained group showed no significant differences in maximal oxygen consumption, but did significantly improve on the Harvard Step test. Therefore, it is believed that an interval training program can improve physical fitness more than a program of calisthenics and marching.

Fox and others[17] investigated the relative importance of training intensity and training distance using interval training programs on the development of maximal aerobic power. In conducting this study three programs were used (1) high-intensity, short distance sprints; (2) low-intensity, long distance runs; (3) a combination of both. Following, 7 1/2 weeks of training, five days a week, the researchers found significant increases in maximal oxygen consumption in liters per minute, and significant decreases in maximal and submaximal heart rates within each group. Among the three groups there was no significant difference in maximal aerobic power either before or after training. However, a significant relationship was found between the change in maximal oxygen consumption and training intensity; thus, indicating that intensity is more important than distance in improving maximum oxygen consumption.

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[17] E. L. Fox and others, "Intensity and Distance of Interval Training Programs and Changes in Aerobic Power," Medicine and Science in Sports, 5:18-22, Spring, 1973.

CHAPTER III

PROCEDURES AND METHODS

It was the purpose of this investigation to examine strength, muscular endurance, and cardiorespiratory endurance responses of both men and women who took part in relatively identical training programs simultaneously. The subjects were 12 male and 10 female volunteers, all in good health, and between the ages of 18 and 25 years. Members of varsity or freshmen athletic teams were restricted from this study. Each subject was given an initial testing period which was utilized for orientation, explanation of the basic experimental procedures and several practice trials. The purpose of the practice trials was to avoid any learning factors from entering into the study. The remaining part of this chapter presents a detailed description of the seven testing procedures and have been divided into the following sections: (1) strength testing; (2) muscular endurance testing; (3) cardiorespiratory endurance testing; (4) strength and muscular endurance training; (5) analysis of data; (6) cardiorespiratory endurance training; (7) post-testing.

I. Strength testing:

Each subject was given a cable tensiometer strength test for elbow flexion using Clarke's[1] procedures for this instrument. The subject was in a supine position, hips and knees flexed with

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[1]H. H. Clarke, and D. H. Clarke, Developmental and Adapted Physical Education (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1963), p. 81.

the free hand resting on the chest. The subjects upper arm on the side tested was close to the side; elbow in 115 degrees flexion; and forearm in the mid-prone-supine position. A regulation strap was placed around the forearm midway between the wrist and elbow joint. The pulling assembly was secured at right angles to the subjects forearm. Three trials were given to each subject with the average being recorded as maximum strength. The strength trials were separated from the endurance test by a 10-minute rest period.

II. Muscular endurance testing:

A modified arm-lever ergometer, previously described by Shaver[2] was used for testing muscular endurance. The workload was determined from the average response of the three strength trials. Each subject performed with one-fourth of his or her maximum strength at a cadence of 30 repetitions per minute. The previous literature indicated that the best cadence for use in development of muscular endurance was one of relatively quick rate as long as the rate did not hamper the subject from completing the full range of motion on each repetition of the exercise. With this information in mind and with specific reference to the studies by Clarke and his associates[3] and Shaver,[4] the cadence of 30 repetitions per

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[2] L. G. Shaver, "Effects of Training on Relative Muscular Endurance in Ipsilateral and Contralateral Arms," Medicine and Science in Sports, 2:165-171, Fall, 1970.

[3] H. H. Clarke and others, "Conditions for Optimum Work Output in Elbow Flexion, Shoulder Flexion, and Grip Erography," Archives of Physical Medicine and Rehabilitation, 39:475-481, August, 1958.

[4] L. G. Shaver, "Muscular Endurance in Ipsilateral and Contralateral Arms: Influence of Training and Inactivity," Archives of Physical Medicine and Rehabilitation, 54:505-510, November, 1973; Shaver, loc. cit.

minute was selected as the exercise rate. The rate was maintained with the help of a metronome, and each subject continued to exercise until he or she fell behind the cadence by four beats or failed to go through the full range of movement on two successive repetitions. In order to motivate the subjects and obtain an all-out effort, the subjects were encouraged to continue regardless of fatigue in an attempt to better their previous score. The criterion score for muscular endurance was the total time, in seconds, that the subjects performed within the guidelines stated above.

III. Cardiorespiratory endurance testing:

The Astrand-Rhyming test and nomogram[5] was used to determine cardiorespiratory endurance. The workload ranged from 600 to 900 kilopond-meters per minute for the males and 450 to 600 kilopond-meters for the females and was administered on a Crescent Monarck bicycle ergometer. In order to assure that a steady state was obtained, each subject exercised for a period of six minutes at a rate of 50 revolutions per minute. Heart rate was measured during the last 30 seconds of each minute with the use of a 4-channel Narco Bio Physiograph Recorder. If the difference in heart rate for the fifth and sixth minutes was more than six beats the test was continued until a heart rate for two consecutive minutes was within six beats. In addition, the heart rate had to be between

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[5] P. O. Astrand, Textbook of Work Physiology (New York: McGraw-Hill, Inc., 1970), pp. 617-622.

120-170 beats per minute, since this is the specified range designated by Astrand to insure reliability. If the workload did not allow the heart rate to level off within this range the workload was adjusted accordingly. The criterion score for cardiorespiratory endurance was maximal oxygen intake (ml/kg/min), as predicted from heart rate.

IV. Strength and muscular endurance training:

It has been well documented that simultaneous development of strength and muscular endurance are greatest when work has been performed in overload.[6] For this reason, the experimental group trained three times weekly in right elbow flexion curls for six weeks according to DeLorme's[7] progressive resistance weight training technique. Training was done using an arm-lever ergometer. The training program consisted of:

(1) One set of ten repetitions, with 1/2 10 R.M.

(2) One set of ten repetitions, with 3/4 10 R.M.

(3) One set of ten repetitions, with 10 R.M.

A two minute rest interval was given between each set.

The resistance was determined by the amount of weight each subject could raise 10 times and 10 times only when performing elbow flexion curls on the arm-lever ergometer. This was the

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[6]F. A. Hellebrandt, "Applications of the Overload Principle to Muscle Training in Man," American Journal of Physical Medicine, 37:278-283, October, 1958; F. A. Hellebrandt and S. J. Houtz, "Mechanisms of Muscle Training in Man," Physical Therapy Review, 36:371-383, June, 1956; S. J. Houtz, A. M. Parrish and F. A. Hellebrandt, "The Influence of Heavy Resistance Exercise on Strength," Physiotherapy Review, 26:299-304, November - December, 1946.

[7]T. L. DeLorme and A. L. Watkins, "Techniques of Progressive Resistance Exercise," Archives of Physical Medicine and Rehabilitation, 29:263-273, May, 1948.

subjects 10 repetitions maximum - 10 R.M. Once the 10 repetitions maximum was found the subjects workload for three sets of 10 repetitions was determined. The resistance for the first set was 1/2 the subjects 10 R.M.; the resistance for the second set was 3/4 the subjects 10 R.M.; the resistance for the final set was the 10 R.M. On Monday of each week training consisted of determining each subjects 10 R.M. On the basis of this each subject's workload for that particular week was determined.

V. Cardiorespiratory endurance:

The training program used in this study was a slight modification of the one devised by Mole[8] and used by Peterson and Kelley.[9] For developing cardiorespiratory endurance a program of interval running over a period of six weeks was employed. During the six weeks the subjects attempted to run a series of 440-yard dashes at a pace that was one to four seconds less than 1/4 the time required to run a mile. This was in accordance with the interval training times recommended by Wilt, as reported by Mathews and Fox.[10] However, due to the inexperience of the subjects in pacing themselves, intervals sometimes ran up to four seconds faster than the target time. A two minute rest interval was given

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[8] P. A. Mole, "The Influence of Interval Running on the Aerobic Metabolism and Endurance Performance of Four Young Men," (unpublished Master's thesis, University of Illinois, Urbana, 1962), p. 17.

[9] F. S. Peterson and D. L. Kelley, "The Effects of Cigarette Smoking upon the Acquisition of Physical Fitness During Training as Measured by Aerobic Capacity," Journal of The American College Health Association, 17:250-254, February, 1969.

[10] D. K. Mathews and E. L. Fox, The Physiological Basis of Physical Education and Athletics, (Philadelphia: W. B. Saunders Co., 1971), p. 85.

between runs. The training program was initiated with a mile run every Monday, followed by a series of four 440-yard runs, three times per week. At the end of six weeks of training the subjects were running six 440-yard runs, three times per week.

VI. Post-testing:

Following the six weeks of training, all subjects were retested for strength, muscular endurance, and cardiorespiratory endurance in a manner patterned after the initial examination period.

VII. Analysis of data:

Various statistical analyses were computed on the data gathered from the pre-test, and post-test scores. Most of the analyses were executed by PDP-8/E computer at the psychology computer center of the State University College at Brockport. Mean scores and standard deviations were used to represent central tendency and variability. Using pre-test scores as the covariate, a one-way analysis of covariance was performed to compare the strength post-test scores of both men and women. A two factor analysis of variance with repetition on one factor was used to determine if men and women improved significantly in the three parameters being tested.

To test the reliability, cardiorespiratory and muscular endurance, post-testing was readministered to five males and five females. The two sets of post-test scores were then correlated using intra-class correlation. In addition, the scores obtained in the second and third strength trials were used to determine the reliability of the strength measures. Graphic analyses (on a week to week basis) were performed on the strength and cardiorespiratory endurance mean training scores. The .05 level of significance was applied to all statistical analyses.

CHAPTER IV

PRESENTATION AND DISCUSSION OF RESULTS

The purpose of the present study was to examine and compare the training responses of men and women who took part in relatively identical strength, muscular endurance and cardiorespiratory endurance training programs simultaneously. Twelve male and ten female subjects participated in the study. As specified in Chapter III, each subject participated in a six week training program for improving strength, muscular endurance, and cardiorespiratory endurance. Immediately prior to and after training the subjects were tested on each of the three parameters.

Various statistical analyses were conducted on the data that was gathered. Using the pre-test score as a covariate, an analysis of covariance was used to evaluate the post-training differences between men and women on strength. In addition, evaluation of the absolute changes in strength, muscular endurance, and cardiorespiratory endurance was based upon a two factor analysis of variance with repetition on one factor (pre-test and post-test scores). Intra-class correlation coefficients were calculated to determine the reliability of the post-training measures. Graphic representations were also used in analyzing the weekly improvements for both men and women.

There are four main sections to be found in this chapter. The first section pertains to strength results, the second section is concerned with muscular endurance results, and the third section contains the cardiorespiratory endurance results. In the fourth section, the results of the present investigation are discussed in relation to previous investigations concerning the effect of conditioning on the training responses of both men and women on strength, muscular endurance, and cardio-respiratory endurance.

I. STRENGTH

As a result of an analysis of covariance it was revealed that the strength trainability of men and women was not significantly different following a regime of progressive resistance exercises (Table 1).

Table 1

Strength Analysis of Covariance

Source	S.S.	df	M.S.	F
Treatment	29.85	1	29.86	2.35
Error	241.45	19	12.71	
Total	271.30	20		

F-ratio = 4.3896 required for significance at the .05 level.

The descriptive data contained in Table 2 shows that the mean improvement of 12.29 lbs. for the men represent an 11.86% improvement whereas the mean improvement of 6.76 for the women represent an 11.95% improvement. The intra-class correlation coefficient of .99 revealed that the raw strength scores summarized in Table 2 were reliable.

Table 2

Descriptive Strength Data

Groups	X (lbs.)	S.D.	S.E.	$\overline{X}$ Improvement (lbs.)	% Improvement
Male (n=12)					
Pre-test	103.69	17.59	5.08	12.29	11.86
Post-test	115.98	19.05	5.50		
Female (n=10)					
Pre-test	56.55	8.72	2.76	6.76	11.95
Post-test	63.31	7.38	2.33		

Absolute strength scores were analyzed to determine if, after six weeks of training, there was any significant difference between men and women in strength gains, and whether or not the sexes achieved significant improvements in their strength. From the analysis of variance (Table 3), it was determined that the men in this study were significantly stronger than the women. Furthermore, the analysis revealed that both the men and women achieved significant increases in absolute elbow flexion strength as a result of the progressive resistance training program.

Table 3

2 X 2 Analysis of Variance of Absolute Strength Scores

Source	DF	M.S.	F
<u>Between Subjects</u>			
Sex (A)	1	27167.38	64.32*
Subjects	20	422.40	
<u>Within Subjects</u>			
Pre/Post (B)	1	989.04	162.95*
AB	1	83.19	13.71*
Within Subjects error	20	6.07	

*F-ratio = 4.35 required for significance at the .05 level.

Due to a significant interaction of the main effects a test for simple effects was conducted (Table 4). The results of the test indicated that the men were significantly stronger than the women in absolute elbow flexion strength prior to as well as after the progressive resistance training program. This means, therefore, that any post-training differences found between the two sexes in terms of absolute strength increases cannot necessarily be attributed to the training program itself. Instead, the strength differences may be due, in part, to the fact that the two groups were actually different before the training program began. The results of the simple effects test supports the analysis of covariance which found no difference in the strength trainability of men and women once initial strength differences between the sexes were accounted for.

Table 4

Sample Effects of Absolute Strength Scores

Source	SS	df	M.S.	F
A at b_1 (Pre-test)	10755.96	1	10755.96	25.46*
A at b_2 (Post-test)	13419.06	1	13419.06	31.77*
Error		20	422.40	

*F-ratio = 4.35 required for significance at the .05 level.

Table 5 shows and Figure 1 illustrates that during the course of the six weeks of training, the total mean improvement for men was 8.75 lbs. whereas the total mean improvement for women was 5.25 lbs. It was interesting to note that both groups achieved their greatest increases during the first week of training and the pattern of strength increment was very similar for both sexes.

Table 5

Weekly Strength Training Increases* (lbs.)

Males					
1-2 week	2-3 week	3-4 week	4-5 week	5-6 week	total
3.05	2.08	1.75	1.00	0.87	8.75
Females					
1-2 week	2-3 week	3-4 week	4-5 week	5-6 week	total
1.90	1.00	0.95	0.75	0.65	5.25

*one set of 10 maximum repetitions as determined by the arm-lever ergometer.

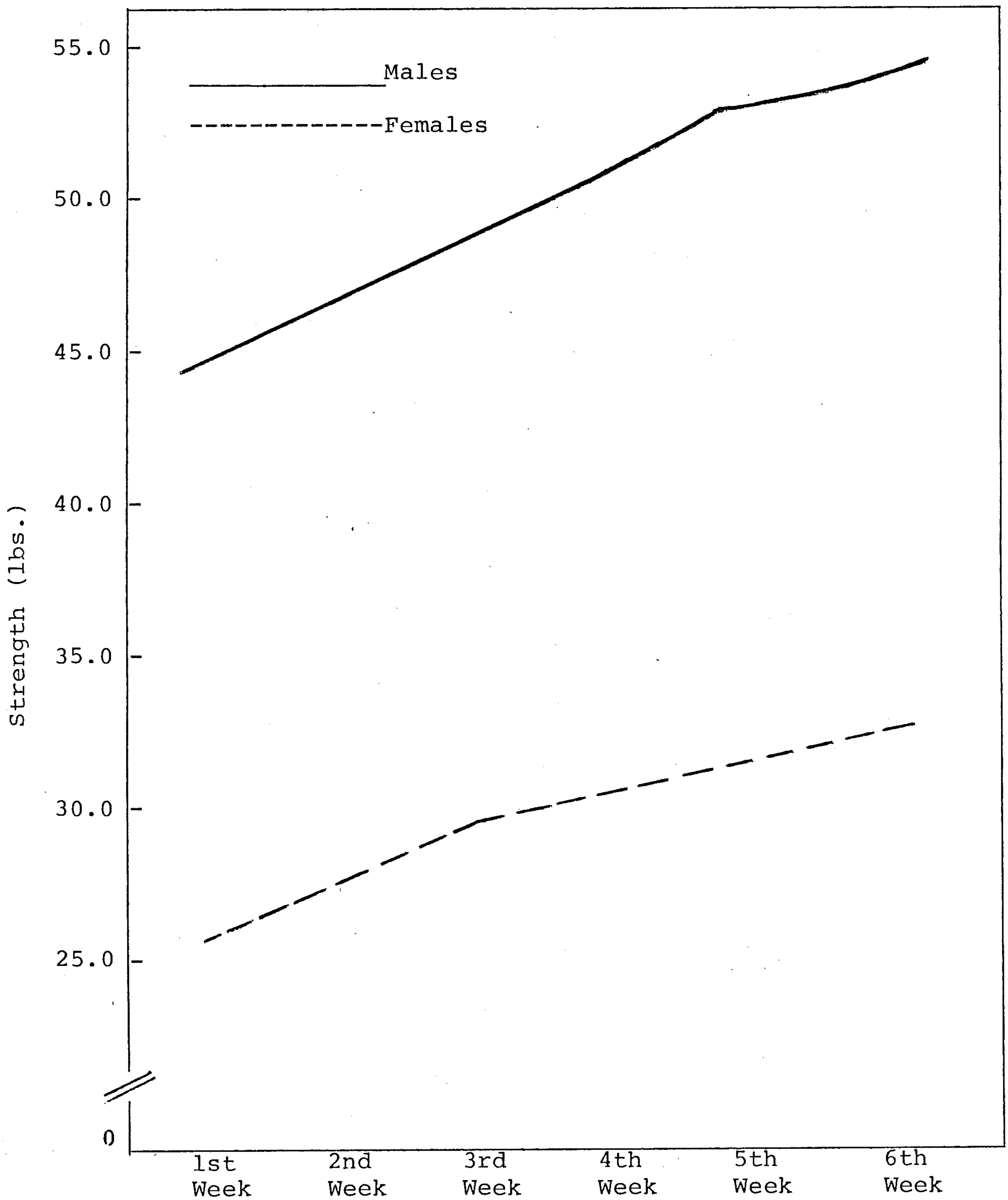

Figure 1.

Weekly Performance Scores for Males and Females

II. MUSCULAR ENDURANCE

The muscular endurance data in table 6 shows that following six weeks of training the men on the average had an endurance improvement of 14.68 secs. or a 45.05% as compared to a mean improvement of 17.50 secs. or a 50.87% improvement for the women. An intra-class correlation of .94 was found for the muscular endurance scores, thus indicating a high reliability.

Table 6

Descriptive Muscular Endurance Data

Groups	X (secs.)	S.D.	S.E.	$\bar{X}$ Improvement (secs.)	% Improvement
Male (n=12)					
Pre-test	32.56	7.81	2.25	14.68	45.05
Post-test	47.24	9.60	2.77		
Female (n=10)					
Pre-test	34.40	9.34	2.95	17.50	50.87
Post-test	51.90	13.29	4.20		

An analysis of muscular endurance scores for men and women are presented in Table 7. The data shows that there is no significant difference between men and women in this study in terms of muscular endurance trainability. This analysis also indicates that both men and women improved significantly in muscular endurance following six weeks of progressive resistance training.

Table 7

2 X 2 Analysis of Variance of Muscular Endurance Scores

Source	DF	M.S.	F
Between subjects			
Sex (A)	1	116.71	0.75
Subjects	20	155.11	
Within Subjects			
Pre/Post (B)	1	2814.59	130.88*
AB	1	22.54	1.05
Within Subjects Error	20	21.51	

*F-Ratio = 4.35 required for significance at the .05 level.

III. CARDIORESPIRATORY ENDURANCE

The descriptive statistics in Table 8 indicates that following six weeks of training, the men increased an average of 6.66 ml/kg/min per person (or a 19.51% improvement), while the women increased an average of 6.26 ml/kg/min per person (or an 18.11% improvement). The reliability of the aerobic measures taken for men and women was .93 as indicated by the intra-class correlation.

Table 8

Descriptive Cardiorespiratory Data

Groups	X Max O_2 (ml/kg/min)	S.D.	S.E.	$\overline{X}$ Improvement (ml/kg/min)	% Improvement
Male (n=12)					
Pre-test	34.07	7.00	2.02	6.66	19.51
Post-test	40.73	6.12	1.76		
Female (n=9)					
Pre-test	34.06	4.73	1.58	6.26	18.11
Post-test	40.32	4.26	1.42		

The analysis in Table 9 indicates that there were no differences in aerobic capacity between men and women. In addition, the analysis snows that both men and women achieved significant increases in their maximal oxygen intake.

Table 9

2 X 2 Analysis of Variance of Cardiorespiratory Scores

Source	DF	M.S.	F
Between Subjects			
Sex (A)	1	0.67	0.01
Subjects	19	62.87	
Within Subjects			
Pre/Post (B)	1	423.30	98.61*
AB	1	0.60	0.60
Within Subjects Error	19	4.29	

*F-Ratio = 4.3896 required for significance at the .05 level.

Table 10 shows that after six weeks of training, the men reduced their mean mile time by 60 secs. while the women improved their mean times by 79 secs. The women improved the most during the first week of training (38 secs.) whereas the men improved the most during the second week of training (32 secs.). These results are illustrated in Figure 2.

Table 10

Weekly Improvements in Running the Mile (secs.)

Males					
1-2 week	2-3 week	3-4 week	4-5 week	5-6 week	total
13	32	10	5	0	60
Females					
1-2 week	2-3 week	3-4 week	4-5 week	5-6 week	total
38	9	16	5	11	79

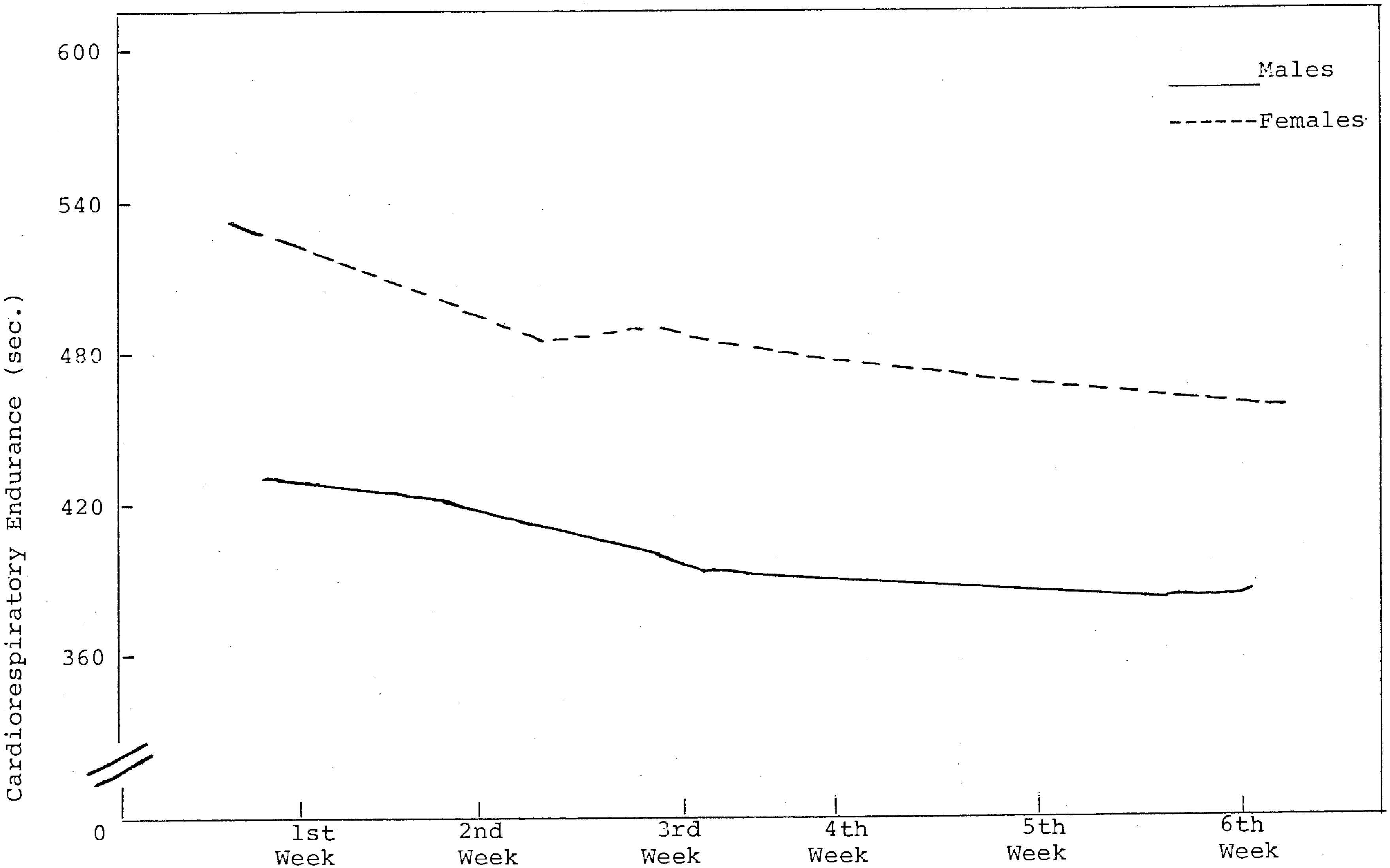

Figure 2.

Weekly Performance Scores for Males and Females

IV DISCUSSION

In the section dealing with the significance of the study it was indicated that men have a greater muscle mass than women. However, by using analysis of covariance one can statistically adjust the strength gains obtained by men and women so that initial differences in muscle mass between the sexes, as exhibited by their initial strength level, does not play a significant role when comparing strength increases in both men and women as a result of their participating in the same type of training program. The results obtained from the analysis of covariance in the present investigation revealed that there were no significant differences between the sexes in terms of strength trainability if muscle bulk, as indicated by their initial strength level, was accounted for. This finding is contrary to that of Hettinger[1] who reported that the strength trainability in men is greater than it is in women during an identical training program. Mathews and Fox[2] have also suggested that females will respond less from a strenuous type activity such as weight training than their male counterpart. It should be pointed out, however, that these two reports did not take into account initial strength differences which may, in fact, effect the strength training response. The only study this investigator could find that compared the strength training response

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[1]T. Hettinger, Physiology of Strength (Springfield, Illinois: Charles C. Thomas, 1961), pp. 9,10.

[2]D. K. Mathews and E. L. Fox, The Physiological Basis of Physical Education and Athletics (Philadelphia: W.B. Saunders Co., 1971), p. 74.

of both men and women (mean age of 20), after taking into account initial strength differences was that of Wilmore[3]. In this study Wilmore tested and trained the muscles involved in the leg press, bench press, forearm curl, and grip. Wilmore trained each muscle group twice a week and assessed leg strength with a leg dynamometer; grip strength with a Stoelting hand grip dynamometer, and the 1-REM technique described by Clarke was used to determine curl and bench press strength. From his investigation Wilmore concluded that there was no difference in the percentage of strength improvement between college age men and women following eight weeks of training. Thus, the present findings are in complete accord with Wilmore's results. It is interesting to note that the literature indicates that if the testosterone levels found in men and women produces equal amounts of muscle mass, then the strength trainability is identical between the sexes since the quality of the muscle (that is, the contractile properties and the ability to exert force are identical) and the mechanisms for developing strength are the same in both sexes.[4,5]

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[3]J. H. Wilmore, "Alternations in Strength, Body Composition, and Anthropometric Measurements Consequent to a 10-week Weight Training Program," Medicine and Science in Sports, 6:133-138, Spring, 1974.

[4]Ibid.

[5]S. Vandersteop and N. Goodhartz, "Physiological Fallacies Regarding the Female Athlete," in Women and Sports Symposium held at the University of Rochester, New York, May 15, 1974. p. 48.

From the analysis of variance it was found that the men in this study had greater absolute elbow flexion strength than the women. In accordance with this, Astrand[6] reported that women are only capable of developing 53% to 80% the elbow flexion strength of men. Jensen and Fisher[7] state the strength difference between the sexes can be accounted for primarily by the greater amounts of muscle mass found in men than women. The greater muscle mass men possess is attributed to the hormone testosterone which increases the weight of the muscle tissue and enlargement of the muscle fiber, and is found in greater quantities in men than women[8]. At the same time, Klafs and Lyon[9] indicate that the social and cultural mores may play an even greater part in the regulation of females to prescribed roles than any particular physiological limitations. Astrand[10] believes that the difference in strength found between men and women in some of the reported studies may be the result of sampling error instead of training. That is, highly-trained men too often being compared to less-trained women.

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[6] P. O. Astrand, "Human Physical Fitness with Special Reference to Age and Sex," Physiological Reviews, 36:307-335, July, 1956.

[7] C. E. Jensen and A. G. Fisher, Scientific Basis of Athletic Conditioning (Philadelphia: Lea and Febiger, 1972), p. 80.

[8] C. H. Brown and J. H. Wilmore, "The Effects of Maximal Resistance Training on the Strength and Body Composition of Women Athletes," Medicine and Science in Sports, 6:174-177, Spring, 1974.

[9] C. E. Klafs and M. J. Lyon, The Female Athlete: Conditioning, Competition, and Culture (St. Louis: C. V. Mosby Co., 1974), p. 38.

[10] Astrand, loc. cit.

Significant gains in strength and muscular endurance were attained in both men and women following six weeks of progressive resistance training. These results extend the findings of Shaver[11] and Yessis[12] since they conducted their research using only male subjects. Shaver, in accordance with this study, found significant increases in static elbow flexion strength and muscular endurance following six weeks of progressive resistance exercises, whereas Yessis concluded from his investigation that resistance-type programs which employ varying resistances and numbers of repetitions leads to the development of significant gains in both strength and muscular endurance.

The literature states that if the factor of strength is eliminated (by testing relative endurance as was done in the present study and not absolute endurance) there should be no difference between sexes in muscular endurance[13,14]. After

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[11] L. G. Shaver, "Effects of Training on Relative Muscular Endurance in Ipsilateral and Contralateral Arms," Medicine and Science in Sports, 2:165-171, Fall, 1970.

[12] M. Yessis, "Relationships Between Varying Combinations of Resistance and Repetitions in the Strength Endurance Continuum," (Unpublished Doctor's dissertation, University of Southern California, Los Angeles, 1963), p. 203.

[13] M. Ikai, "Work Capacity of Japanese Related to Age and Sex," Journal of Sports Medicine and Physical Fitness, 6:100-105, June, 1966.

[14] H. deVries, Physiology of Exercise for Physical Education and Athletes (Dubuque, Iowa: Wm. C. Brown, 1974), p. 327.

eliminating the strength factor in the testing of muscular endurance an analysis of variance revealed that there was no significant difference in the muscular endurance trainability of men and women. In general, the findings of this study indicate that one should expect the trainability of muscular endurance to be about the same in both men and women if initial differences in muscular strength are accounted for.

Significant improvements in cardiorespiratory endurance (ml/kg/min) were found in both men and women as a result of the six weeks of interval training. In comparing the cardiorespiratory training response, it was found that there was no difference between the sexes. These results agree with the findings and conclusions of Hanson and Nedde[15]. They concluded from their research that there was no oxygen transport trainability differences between non-athletic females and males. Roskamm's[16] results also support these findings. Kilbom[17], on the other hand, feels that if the aerobic capacity is expressed per kilogram of total body weight, improvement should be lower in women due to the greater percentage of fat normally found in women. Drinkwater[18], who reported that there is a 15-20% maximal aerobic capacity difference (favoring men)

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[15] J. J. Hanson and W. H. Nedde, "Long Term Physical Training Effects in Sedentary Females," Journal of Applied Physiology, 37:112-116, July, 1974.

[16] H. Roskamm, "Optimum Patterns of Exercise for Healthy Adults," Canadian Medical Association Journal, 96:895-898, March, 1967.

[17] A. Kilbom, "Physical Training in Women," Scandanavian Journal of Clinical Laboratory Investigations Supplement, 119:1-34, October, 1971.

[18] B. Drinkwater, "Physiological Responses of Women to Exercise," in Scientific Reviews, ed. J. H. Wilmore (New York: Academic Press, 1973), pp. 126, 127.

between sexes suggests that this difference may disappear if the percentage of the body fat found in men and women are about the same. While this may have been the case in the present study, it is rather difficult to draw any significant relationship from Kilbom's and Drinkwater's comments to the present findings since body fat was not determined in this particular study.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

The purpose of this study was to investigate the differences in strength, muscular endurance, and cardiorespiratory endurance training response of both men and women who underwent relatively identical training programs simultaneously. Twelve males and ten females served as subjects. Each subject was pre-tested, trained, and post-tested in each of the three parameters.

Immediately before and after the six week training period, the average of three strength trials for elbow flexion was obtained for each subject. Subjects were tested for elbow flexion strength according to Clarke's cable tensiometer method. Using a modified arm-lever ergometer a muscular endurance test was performed with the arm which underwent training; the workload for each subject was 25% of the average response of the initial three strength trials. Each subject was pre- and post-tested with that workload at a cadence of 30 repetitions per minute. Cardiorespiratory endurance was determined by the Astrand-Rhyming submaximal bicycle ergometer test for predicting maximal oxygen consumption.

For developing strength and muscular endurance each subject underwent DeLorme's progressive resistance training program three times weekly for six weeks. An interval training program was used for developing cardiorespiratory endurance. The interval training program consisted of running 440-yard dashes at a pace 1/4 the time required to run a mile. The mile was run every Monday, followed by a series of four 440-yard runs, three times per week. An additional

440-yard run was added after each two weeks. This resulted in the subjects running six 440-yard runs, three times per week for the last two weeks of the six-week training program.

The statistical analyses of the data obtained revealed that while both men and women increased their strength levels significantly as a result of six weeks of progressive resistance training, there was no difference in their trainability. However, due to the greater muscle bulk found in males, the men obtained significantly greater absolute strength gains than women. In addition, following six weeks of progressive resistance training while both men and women achieved significant increases in muscular endurance, there was no significant differences in their trainability.

CONCLUSIONS

The findings of this investigation form the basis for the following conclusions:

1. There are no sex differences in the strength trainability if absolute strength gains found in both men and women are statistically adjusted so that the greater muscle mass in men, as indicated by initial strength levels, are accounted for.

2. Absolute strength increases are greater in men than women.

3. The muscular endurance (25% of maximum strength) response of men and women to six weeks of progressive resistance exercises are not significantly different.

4. Six weeks of progressive resistance training caused significant strength and muscular endurance increases in men and women.

5. The aerobic trainability of college men and women did not differ significantly following identical training.

6. Six weeks of interval training caused significant increases in the maximal oxygen uptake (ml/kg/min) of men and women.

RECOMMENDATIONS

During the course of this investigation, several suggestions arose which seem to warrant further study.

1. Since this study was one of the few studies which examined the training response of non-athletic men and women, more research using non-athletes needs to be conducted.

2. Since this investigation only dealt with the training response of men and women under normal environmental conditions, it would be interesting to conduct a similar type of study and compare the physiological conditions under extreme environmental conditions (such as at high altitude or in hot, humid weather).

3. This study was limited to a six-week training program. Further research of a longitudinal nature comparing the training responses of men and women would be beneficial to the literature.

4. Further research using training programs consisting of varying resistances and repetitions in comparing the strength and muscular endurance training response of men and women would be beneficial to the literature.

5. A study that takes into account body fat when comparing the aerobic trainability of men and women should be conducted.

APPENDIX A

STRENGTH SCORES

Table 11

Strength Scores for Males*

Subject	Pre-test	Post-test
T.M.	123.3	139.3
J.L.	93.8	114.3
J.S.	85.0	100.0
J.O.	122.0	132.3
J.M.	87.0	98.5
E.C.	90.6	101.0
E.G.	87.0	90.8
E.F.	106.0	115.0
D.N.	115.0	126.0
B.P.	113.3	128.3
E.L.	135.0	149.6
T.F.	86.3	96.6

*The strength score represents the average, in pounds, that the subject persisted on the tensiometer for three successive trials prior to and immediately following the training period.

Table 12

Strength Scores for Females*

Subject	Pre-test	Post-test
M.M.	67.5	72.3
J.B.	46.6	54.2
P.S.	62.5	67.5
M.S.	46.6	54.2
G.W.	64.6	73.3
J.C.	47.3	56.7
J.R.	55.6	63.3
K.W.	58.3	62.5
C.R.	67.5	70.8
M.C.	49.0	58.3

*The strength score represents the average, in pounds, that the subject persisted on the tensiometer for three successive trials prior to and immediately following the training period.

Table 13

Weekly Strength Training Scores for Males*

Subject	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
B.P.	38.0	42.5	45.0	46.5	47.5	48.5
E.C.	41.5	44.0	45.5	46.5	48.0	48.0
T.M.	49.0	52.0	54.0	56.5	57.0	58.0
J.O.	49.0	50.5	52.5	54.5	55.5	56.5
J.M.	39.0	44.0	46.0	48.0	48.0	48.5
J.L.	46.5	50.0	52.0	53.0	54.0	55.0
J.S.	39.0	42.5	44.5	45.0	46.0	46.5
E.G.	36.0	39.0	41.0	43.0	43.5	44.5
D.N.	49.0	51.5	53.5	56.0	57.5	58.5
T.F.	44.0	44.5	46.5	49.0	50.5	51.5
E.F.	44.5	48.0	50.0	52.0	52.5	53.5
E.L.	49.0	52.5	55.5	57.0	59.0	60.5

*The strength score represents the maximal weight, in pounds, the subject was able to lift the arm-lever ergometer ten times.

Table 14

Weekly Strength Training Scores for Females*

Subject	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
M.E.	26.5	29.0	30.0	31.5	31.5	32.5
P.S.	29.0	31.0	32.5	33.0	34.0	34.5
K.W.	26.5	29.0	30.0	31.0	31.5	32.0
M.C.	21.5	22.0	23.5	24.5	24.5	25.5
J.B.	20.5	23.5	23.5	24.5	25.0	26.0
G.W.	22.5	24.0	26.5	27.0	28.0	39.0
M.M.	26.5	27.5	28.5	30.5	31.0	31.0
C.R.	26.0	28.0	28.5	29.5	30.5	31.5
J.C.	24.5	27.0	27.0	27.5	28.5	29.0
J.R.	27.5	29.0	30.0	30.5	32.5	32.5

*The strength score represents the maximal weight, in pounds, the subject was able to lift the arm-lever ergometer 10 times.

APPENDIX B

MUSCULAR ENDURANCE SCORES

Table 15

Muscular Endurance Scores for Males*

Subject	Pre-test	Post-test
T.M.	29.8	43.0
J.L.	38.5	50.8
J.F.	29.0	49.3
J.O.	23.7	48.6
J.M.	45.4	57.8
E.C.	37.8	46.7
E.G.	26.4	39.7
E.F.	27.6	40.1
D.N.	38.5	51.1
B.P.	23.8	41.6
E.L.	26.3	39.9
T.F.	44.0	58.3

*The endurance score represents the amount of time, in seconds, that the subject persisted in elbow flexion curls on the arm-lever ergometer at one-fourth their initial strength level.

Table 16

Muscular Endurance Scores for Females*

Subject	Pre-test	Post-test
M.M.	19.9	32.8
J.B.	45.5	75.9
P.S.	40.3	45.3
M.S.	44.7	61.1
G.W.	21.2	50.1
J.C.	41.4	66.1
J.R.	30.0	46.2
K.W.	29.4	45.4
C.R.	31.4	37.8
M.C.	40.2	58.3

*The endurance score represented the amount of time, in seconds, that the subjects persisted in elbow flexion curls on the arm-lever ergometer at one-fourth their initial strength level.

APPENDIX C

CARDIORESPIRATORY ENDURANCE SCORES

Table 17

Cardiorespiratory Endurance Scores for Males*

Subject	Pre-test	Post-test
T.M.	38.67	49.65
J.L.	31.72	37.86
J.S.	37.68	40.58
J.O.	35.71	39.47
J.M.	36.23	38.46
E.C.	47.48	52.17
E.G.	39.16	45.16
E.F.	36.98	41.25
D.N.	21.21	28.69
B.P.	27.03	37.68
E.L.	27.67	37.25
T.F.	29.33	40.54

*The cardiorespiratory endurance score represents the maximal oxygen consumption of the subject in milliliters per kilogram of body weight per minute (ml/kg/min) prior to and immediately following the training period.

Table 18

Cardiorespiratory Endurance Scores for Females*

Subject	Pre-test	Post-test
M.M.	27.44	32.01
J.B.	40.82	47.71
P.S.	38.24	42.65
M.S.	38.98	43.14
G.W.	35.84	38.46
J.C.	30.77	39.37
J.R.	34.42	40.52
K.W.	29.36	38.33
C.R.	30.65	39.90

*The cardiorespiratory endurance score represents the maximal oxygen consumption of the subject in milliliters per kilogram of body weight per minute (ml/kg/min) prior to and immediately following the training period.

APPENDIX D

WEEKLY MILE TIMES

Table 19

Males

Subject	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
B.P.	7:36	7:17	6:48	6:37	6:30	6:22
E.C.	6:43	5:41	5:17	5:14	5:08	5:06
T.M.	7:20	6:47	6:52	6:22	6:19	6:19
J.O.	6:30	6:08	5:52	5:49	5:44	5:41
J.M.	6:48	6:08	5:57	5:55	5:51	5:59
J.L.	7:48	6:57	7:04	6:35	6:44	6:31
J.S.	6:24	6:05	6:12	6:14	6:00	5:59
E.G.	6:19	6:19	6:23	6:09	5:57	6:08
D.N.	10:31	9:05	8:20	8:06	7:56	7:59
T.F.	6:54	6:15	6:04	5:50	5:44	5:49
E.F.	6:21	5:55	6:02	5:51	5:46	5:50
E.L.	6:57	6:27	6:26	6:25	6:28	6:27

Table 20

Females

Subject	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
M.E.	7:36	7:34	7:04	6:54	6:49	6:49
P.S.	8:37	7:51	7:20	7:13	7:14	7:03
K.W.	8:36	8:24	8:16	7:51	7:35	7:31
J.B.	7:52	7:29	7:29	7:31	7:26	7:24
G.W.	8:42	7:44	7:52	7:15	7:39	7:20
M.M.	10:01	9:10	9:24	8:29	8:27	8:35
C.R.	10:11	9:34	9:20	9:19	8:36	8:14
J.C.	9:24	8:40	8:34	8:30	8:28	8:01
J.R.	8:35	7:20	7:11	7:01	6:51	6:46

APPENDIX E

VOLUNTEER ACCEPTANCE FORM

VOLUNTEER ACCEPTANCE FORM*

I acknowledge my services as a subject in an investigation comparing the strength, cardiorespiratory and muscular endurance response of men and women as a function of training. This study is to be conducted at Brockport State University College during the Spring semester 1975. I am aware of the general importance of this study and will strive to be reliable and prompt. I also understand the training and testing procedures to be conducted.

SIGNATURE________________________________

DATE____________________

*This form was administered to each subject prior to taking part in the study.

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