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PHYSIOLOGICAL RESPONSES TO WEIGHT REDUCTION IN HIGH SCHOOL WRESTLERS

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PHYSIOLOGICAL RESPONSES TO WEIGHT REDUCTION

IN HIGH SCHOOL WRESTLERS

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ABSTRACT

PHYSIOLOGICAL RESPONSES TO WEIGHT REDUCTION
IN HIGH SCHOOL WRESTLERS

by John Paalzow Farr

The purpose of this study was to evaluate the physiological changes affecting a high school wrestling team and its weight reduction program during a competitive season.

Eighteen subjects formed the experimental group and sixteen subjects served as the control group. The experimental group followed a normal training routine and underwent a rapid weight reduction. The control group followed a normal training routine; however, they did not reduce their body weight.

Data was collected during five testing periods throughout a thirteen-week wrestling season. Test items were selected to assess anthropometrical data, body composition, body circumference, muscular strength, muscular endurance, cardiovascular endurance, urine composition, and blood composition.

The tests were administered at the beginning of training cycle one, before the pre-season conditioning period; at training cycle two, at the end of the pre-season

conditioning period; at training cycle three at the beginning of the weight reduction interval; at training cycle four, at the end of the weight reduction interval; and at training cycle five, at the conclusion of the competitive season.

A two-way analysis of variance with repeated measures was used to determine significant differences. Duncan's Multiple Range Test was used to locate the significant differences among the means.

There were significant differences in the following variables: (1) body diameters including bitrochanteric diameter, wrist diameters, and ankle diameters; (2) body composition including triceps skinfold, chest skinfold, suprailiac skinfold, abdominal skinfold, and thigh skinfold; (3) body circumferences including gluteal circumference and thigh circumference; (4) muscular strength including grip strength, elbow flexion strength, elbow extension strength, and knee extension strength; (5) muscular endurance including pull-up endurance and dip endurance; (6) cardiovascular endurance including physical work capacity utilizing the heart rate for the fifth-minute of exercise and the heart rate for the sixth-minute of exercise; (7) urine composition including specific gravity, sodium, and potassium; and (8) blood composition including hemoglobin, mean corpuscular hemoglobin concentration, polymorphonuclear neutrophils, lymphocytes, monocytes, and sodium.

There were no significant differences in the following variables: (1) anthropometrical data including weight; (2) body diameters including biacromial diameter, chest diameter, chest depth, and bi-iliac diameter; (3) body composition including scapula skinfold; (4) muscular strength including knee flexion; and (5) blood composition including white blood count, red blood count, hematocrit, mean corpuscular hemoglobin, eosinophils, potassium, and chloride.

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

"Making weight" and its ramifications present one of the thorniest problems in the conditioning of athletes,[1] especially for the high school wrestler. The practice of making weight has become an essential procedure in amateur wrestling, possibly ranking only behind ability and strength in importance. In 1951, Gallagher and Peery stated, "Weight control presents one of the major problems in the life of a wrestler whether he is the greenest amateur or the most experienced professional."[2]

Health practices associated with "making weight" by interscholastic wrestlers have been a problem to coaches, physicians, educators and parents since weight classes were established.[3] These practices suggested that weight loss

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[1]Philip J. Rasch and Walter Kroll, What Research Tells the Coach About Wrestling, (Washington, D. C.: American Association for Health, Physical Education, and Recreation, 1964), p. 41.

[2]E. C. Gallagher and Rex Peery, Wrestling. Revised edition: (New York: A. P. Barnes and Company, 1951), p. 18.

[3]Tse-Kia Tcheng and Charles M. Tipton, "Iowa Wrestling Study: Anthropometric Measurements and the Prediction of a 'Minimal' Body Weight for High School Wrestlers," Medicine and Science in Sports, V (March, 1973), 1.

was detrimental to the athlete's ability to perform. It is one thing to be slim and trim, but quite another to be gaunt and starved.

To alleviate this problem, recommendations were made by physicians, physiologists, coaches, parents, and organizations such as the American Medical Association; The American Alliance for Health, Physical Education, and Recreation; and the National Federation of State High School Associations. These recommendations include intricate weight control programs; terminating high school wrestling programs; information programs directed to parents, coaches, and wrestling fans; education of youth as to the importance of medical examinations and a year-around conditioning program; intensive pre-season conditioning programs for wrestlers; and determining minimal effective weight by scientific methods.[4] A statement by the American Medical Association's Committee on the Medical Aspects of Sports was representative of the position these individuals and groups have taken. The committee stated: "that the good name of the sport has been tainted by charges that ill-advised practices of weight control are being employed. . . Professional judgment would best be exercised if coach and physician take, as their objective, the boy's effective

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[4]"Weight Loss Has Limits," Scholastic Wrestling News, IV (April 26, 1969), 16.

weight level (the weight at which the boy will perform best) instead of a minimal weight figure which invariably invites trouble."[5]

By the fall of 1969, a group of medical doctors in Muscatine, Iowa, recommended that the sport of wrestling be banned because of what they claimed were "excessive weight losses among many of the area high school wrestlers."[6] The city's school board did not accept their recommendation; however, they brought the matter of excessive weight reduction into the open. Further investigation by the Iowa High School Athletic Association revealed that the individual wrestlers and their parents had not been informed of the hazards of excessive weight loss.[7]

In spite of continuing concern and the application of protective measures, excessive weight loss frequently persists stirring considerable controversy. Thus there is a need for additional research and investigation into the matter. The unique feature of this inquiry was to compare the physiological changes taking place during the

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[5]Committee on the Medical Aspects of Sports, "Wrestling and Weight Control," The Journal of the American Medical Association, CCI (August 14, 1967), 131.

[6]"Weight Loss Has Limits," p. 16.

[7]"Weight Loss Has Limits," p. 16.

pre-season conditioning period, during the competitive season, and during a one-week weight reduction interval.

STATEMENT OF THE PROBLEM

The study was designed to investigate the physiological changes occurring in high school wrestlers over a prolonged training cycle and a one-week weight reduction period.

PURPOSE OF THE STUDY

M. G. Maetozo, Jr., found, in a nationwide survey of six high school sports, that only track surpassed wrestling in the number of coaches who did not have an undergraduate degree in physical education.[8] Therefore, the need existed for wrestling coaches to acquire knowledge and information about weight loss and its accompanying physiological changes.

This study was developed to scientifically evaluate the physiological changes affecting a high school wrestling team throughout a competitive season, and was designed to provide an objective evaluation of the practice of making weight. The results of the study were developed into a

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[8] John Jesse, Wrestling Physical Conditioning Encyclopedia, (Pasadena, California: The Athletic Press, 1974), p. 374.

unit of instruction and were made available to the Department of Health, Physical Education, Recreation, and Safety at Middle Tennessee State University and appropriate individuals.

DELIMITATIONS OF THE STUDY

In early October, 1974, the administrators and coaches of East Ridge Junior and Senior High Schools were asked to consider participation in a scientific study. After thoroughly discussing the project, approval was granted on October 14, 1974. The wrestling teams of these schools were selected because of their excellent wrestling performance in recent years, because they had the appropriate number of participants necessary for the study, and because they were accessible to the researcher.

Thirty-six subjects were selected for the study of certain physiological changes resulting from weight loss over a prolonged training period. Anthropometric measures, strength, muscular endurance, cardiovascular endurance, urine composition, and blood composition were measured to evaluate physiological changes appearing during the preseason conditioning period, the competitive season and a one-week weight reduction interval.

IMPLICATIONS FOR TEACHING

The growing problem of excessive weight loss in various athletic activities suggested the need for additional information and knowledge. Many activities including 150 pound football, lightweight sculling crew, boxing, and wrestling have instituted the requirement of weight reduction.[9] Thus, the physical education instructor and the coach were frequently required to assist individuals in making weight.

A unit of instruction was prepared from the findings which utilized the significant physiological information as revealed in the research of literature, the statistical analysis of the data and the findings of this study. The material was developed to assist physical education instructors and coaches in teaching others to recognize the physiological changes associated with weight loss as they affect the high school athlete.

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[9]Warren K. Palmer, "Selected Physiological Responses of Normal Young Men Following Dehydration and Rehydration," Research Quarterly, XXXIX (December, 1968), 1054; see also American Association for Health, Physical Education, and Recreation, Nutrition for Athletes: A Handbook for Coaches (Washington: American Association for Health, Physical Education, and Recreation, 1971), p. 36.

DEFINITION OF TERMS

Anthropometric Measures--Anthropometric measures are the processes used in measuring the human body to determine the differences between individuals.[10]

Cardiovascular Endurance--Cardiovascular endurance is the proper functioning of the lungs, heart, and blood vessels resulting in an efficient exchange of oxygen and carbon dioxide.[11]

Competitive Season--Competitive season was the period extending from two weeks before the first wrestling match through the end of the last competitive match.

Excessive Weight Reduction--Excessive weight reduction is the process of losing an unsafe amount of weight.[12]

Making Weight--Making weight is the process of reducing weight to a prescribed level.

Pre-Season Period--The pre-season period was the period of time that began with the opening of practice and ended two weeks before the first dual meet.

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[10]Norman L. Hoerr and Arthur Osol (eds.), Balkiston's New Gould Medical Dictionary 2nd edition; (New York: The Balkiston Division, McGraw-Hill Book Company, Incorporated, 1949), p. 86.

[11]Donald K. Mathews, Measurement in Physical Education 4th edition; (Philadelphia: W. B. Saunders Company, 1973), p. 6.

[12]Committee on Medical Aspects of Sports, "Wrestling and Weight Control," 131.

Rapid Weight Reduction--Rapid weight reduction is the process of losing weight during a period of between twenty-four and forty-eight hours.

Training Cycle--Training cycle was considered to be the interval of time from one testing period to another, and it was repeated on four consecutive occasions under different conditions.

Weight Classification--Weight classification is the division into weight classes for purposes of competition in interscholastic wrestling.[13]

Weigh-in--Weigh-in is the period of time in which wrestlers are certified for a particular weight class. Weigh-in was usually held one hour before the contest.

Weight Loss--Weight loss is the amount of weight lost during any particular time.

Weight Reduction Period--Weight reduction period is considered as the period of time in which weight is lost for the purpose of qualifying for a prescribed weight classification at a specific weigh-in.

Weight Reduction Program--A weight reduction program is a regulated program of exercise, diet, and dehydration designed to assist an athlete in making his most efficient weight.

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[13]National Federation of State High School Associations, Wrestling Rule Book, (Elgin, Illinois: National Federation of State High School Associations, 1975), 13.

Physiological Measures--Physiological measures are defined to include anthropometric measures, cardiovascular endurance measures, circulatory measures, and excretory measures.

LIMITATIONS

Research is invariably conducted on the basis of a sample from which inferences concerning the population can be made. For a sample to serve as a basis for inferences concerning the population, it is essential that it be representative of the population in question.

The sample for this study consisted of thirty-six wrestlers from East Ridge Junior High School and East Ridge High School who were randomly assigned to experimental and control conditions. Although not readily apparent, the inclusion of physically immature ninth grade wrestlers as part of the sample may have affected the results of the study.

Other unforeseen factors may have influenced the results as well. These were as follows: first, the results of the study may have been influenced by the early morning trip to Murfreesboro for the first testing session. Second, the results of the study may have been influenced by a Tennessee Secondary School Athletic Association rule which requires a wrestler to have wrestled at least half of his individual bouts in the lowest weight class he would wrestle during the district tournament. This requirement forced early placement of team members into weight classes. Third, the results of the study may have been influenced by the coaches' demands that testing not be performed on the day before difficult meets or on meet days. Fourth, the results of the study may have been influenced by a decline in interest as the season progressed. The decline in interest was a result of the extensive testing routine and the realization that individual team members, ranking third or fourth in their respective weight classes, would not wrestle on the varsity squad.

HYPOTHESES

The researcher postulated the following hypotheses:

1. In the experimental group there will be no significant change in the physiological measures beginning with the pre-season conditioning period and ending with the competitive season.
2. In the control group there will be no significant change in the physiological measures beginning with the pre-season conditioning period and ending with the competitive season.
3. In the experimental group there will be no significant difference in the physiological

measures between the pre-season conditioning period and the weight reduction period.

4. In the experimental group there will be no significant difference in the physiological measures between the pre-season conditioning period and the competitive season.
5. In the experimental group there will be no significant difference in the physiological measures between the competitive season and the weight reduction period.
6. In the experimental group there will be no significant difference in the physiological measures between the pre-season conditioning period, the competitive season, and the end of the competitive season.
7. In the experimental group there will be no significant difference in the physiological measures between the weight reduction period, the pre-season conditioning period, and the end of the competitive season.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Wrestling, as an activity designed to match men of equal weight, has often been criticized for the practice of rapid and extreme weight loss. Quite frequently, the criticism was justified because the intention of the athlete was not to attain his most desirable competitive weight, but to compete with an advantage against those who really belonged in a lower weight classification. The common practice has been for the individual to lose from ten to twelve pounds within a four or five day period to qualify for a lower weight class. Some of this weight has been lost on the day of the contest. The greater part of this reduction has occurred through dehydration and crash dieting. "Empirically, it is known that many wrestlers cut the majority of their weight in the forty-eight hour period preceeding weigh-in . . . ,"[1] contrary to the warning of medical doctors as to possible health hazards.

The effects of rapid weight loss upon the working efficiency of athletes has been equivocal. Rasch and Kroll

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[1]Paul M. Ribisl and William G. Herbert, "Effects of Rapid Weight Reduction and Subsequent Rehydration Upon the Physical Working Capacity of Wrestlers," Research Quarterly, XLI (December, 1970), 537.

found convincing scientific evidence that the harmful effects of making weight to the extent customary among interscholastic and intercollegiate wrestlers was rare, although the medical literature contained at least one report of a case of acute pancreatitis developing as a result of this procedure.[2] Kroll stated before the National Conference on the Medical Aspects of Sports that even proponents of sound health practices must agree that the effects of short-term weight loss were not carefully researched as they pertain to conditioned athletes, adolescents, or adults.[3]

Weight loss can be either gradual or rapid, either slight or great. Harold Nichols Jr., in his study of weight loss, found four conditions occurring in a weight reduction program: (1) the withholding of food; (2) the withholding of water; (3) exercise; and (4) the removal of water from the body through perspiration.[4] Usually, weight loss has been accomplished by using one, all, or a

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[2]Philip J. Rasch and Walter Kroll, What Research Tells the Coach About Wrestling (Washington, D. C.: American Association for Health, Physical Education, and Recreation, 1964), p. 42.

[3]Warren K. Palmer, "Selected Physiological Responses of Normal Young Men Following Dehydration and Rehydration," Research Quarterly, XXXIX (December, 1968), 1055.

[4]Harold J. Nichols, "The Effect of Rapid Weight Loss on Selected Physiologic Responses of Wrestlers," (Unpublished Doctoral dissertation, University of Michigan, Ann Arbor, 1956), p. 80.

combination of these methods, depending upon the amount of weight to be lost and the time allowed for losing it. Dr. Stanley W. Henson recognized two sources of weight which could be removed from the human body--body fat and body fluid.[5] Body fat was reduced slowly by a semistarvation diet in combination with exercise. Body fluid was not considered as excess weight; however, it was reduced by rapid dehydration caused by exercise, steam baths, hot boxes, rubberized apparel, diuretics, or induced vomiting.

A conclusive trend in research has established an objective evaluation of weight loss by dieting. Several studies have indicated extensive dieting had deleterious effects. Thompson, Buskirk, and Goldman determined body weights and skinfold measurements of ten varsity and four freshmen basketball players and twelve hockey players before and after a season of play in their respective sports. They found that the basketball players reflected a before-season mean weight of 81.13 kilograms and an end-of-season mean weight of 80.19 kilograms. The hockey players reflected a before-season mean weight of 71.63 kilograms and an end-of-season mean weight of 71.22 kilograms.[6]

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[5]Stanley W. Henson, "The Problem of Losing Weight," Scholastic Wrestling News, V (February 1, 1970), 13.

[6]C. W. Thompson, E. R. Buskirk, and R. F. Goldman, "Changes in Body Fat,Estimated from Skinfold Measurement of College Basketball and Hockey Players During a Season," Research Quarterly, XXVII (December, 1956), 423.

The skinfold measures of the basketball players showed, for the chest, a mean of 7.0 millimeters before the season and a mean of 6.0 millimeters at the end of the season. The abdomen measures showed a mean of 10.0 millimeters before the season and a mean of 7.0 millimeters at the end of the season. The upper arm measure showed a mean of 13.0 millimeters before the season and a mean of 10.3 millimeters at the end of the season. The hockey players' skinfold measures for the chest showed a before-the-season mean of 7.0 millimeters and an end-of-season mean of 5.0 millimeters. The abdomen measures showed a before-season mean of 8.0 millimeters and an end-of-season mean of 7.0 millimeters. The upper arm measures showed a before-season mean of 11.0 millimeters and an end-of-season mean of 9.0 millimeters.[7]

A comparison of the mean body weight indicated there had been a change in body weight; however, these changes were insignificant. A comparison of the skinfold measures clearly indicated that a redistribution of weight had occurred. Presumably, subcutaneous fat had been utilized and muscle mass had increased. The greatest changes were found in the abdominal and upper arm skinfolds, although all three skinfolds were consistently smaller at the end of the season.[8]

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[7]Thompson, Buskirk, and Goldman, p. 423.

[8]Thompson, Buskirk, and Goldman, pp. 421-423.

In a study of thirty-four varsity college football players, Thompson found similar results. He observed a mean weight loss of 1.49 kilograms (3.3 pounds), which was not significant. Twenty-seven of the thirty-four players lost weight ranging from .2 kilograms (less than one-half pound) to 6.7 kilograms (approximately 15 pounds). Two players had no weight change and five others gained weight.[9]

A comparison of skinfold measurements indicated that a redistribution of weight had occurred. Subcutaneous fat had been utilized and presumably muscle mass and/or other bodily components had increased. The most pronounced change occurred in the abdominal skinfold. The mean decrease was 5.76 millimeters which was significant at the one percent level of probability. The chest and upper arm skinfolds were significantly smaller at the end of the season: chest--4.94 millimeters and upper arm--1.44 millimeters. The decreases at all three skinfold sites were significant at the one percent level of probability.[10]

Johnson, Burke, and Mayer studied Boston school girls of similiar height, age, and grade level to compare physical maturation, food intake, and activity. Girls in

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[9]Clem W. Thompson, "Changes in Body Fat, Estimated from Skinfold Measurements of Varsity College Football Players During a Season," Research Quarterly, XXX (March, 1959), 90.

[10]Thompson, p. 90.

grades ten, eleven, and twelve were divided into two matched groups of twenty-eight obese girls and twenty-eight nonobese girls. The subjects were extensively interviewed to secure information about their dietary habits and their physical activities. The data was then compared for the two groups. It was found that the mean caloric intake of the obese girls was 1,965 calories, while the mean caloric intake of the nonobese controls was 2,706 calories.[11] The study suggested that the caloric intake of the obese girls was not higher and, in most cases, was lower than that of the nonobese controls. The study also showed that the obese girls had significantly lower activity indices than the nonobese control girls. The mean daily activity index for the obese girls was 96, while the mean daily activity index for the nonobese control girls was 122.[12] The marked inactivity of the obese group accounted for the caloric surplus in these adolescents. The study further suggested that strenuous activity was important as a weight control measure and caloric intake and output must be considered simultaneously when studying obesity.[13]

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[11] Mary Louise Johnson, Bertha S. Burke, and J. Mayer, "Relative Importance of Inactivity and Overeating in the Energy Balance of Obese High School Girls," American Journal of Clinical Nutrition, IV (April, 1956), 40.

[12] Johnson, Burke, and Mayer, p. 41.

[13] Johnson, Burke, and Mayer, p. 41.

Kroll conducted a study of the anthropometric measures of Big Ten varsity wrestlers. He utilized thirty-five varsity wrestlers from four Big Ten schools, testing the wrestlers as their teams came to the University of Illinois for dual wrestling meets. Kroll used a battery of forty-five tests including somatotyping; vital capacity; bone, muscle, and fat analyses; measurements of body proportions and ratios taken from photographs and extra measurements taken in the bone, muscle, fat analysis; and a four-item strength test. Some of the means recorded were chest breadth, 11.36 inches; chest depth, 7.96 inches; hip width, 11.2 inches; shoulder width, 15.85 inches; thigh girth, 19.86 inches; abdomen, 14.46 mm.; front thigh, 17.29 mm.; and right grip, 122.6 pounds. An analysis of the data concluded that the body type of the wrestler was sufficiently different by being slightly below average in ectomorphy. The average wrestler was not characterized by a wide hip measure, but he was fully one-half of an inch or ten standard scores below the mean. The fat measures indicated the average Big Ten wrestler was low in all the fat measures taken, therefore agreeing with the subjective endomorphic component rating. On the basis of chest depth, chest breadth, and normal chest girth measurements, the average Big Ten wrestler was not characterized by huge chest measurements, since normal groups of young men exceeded most of these measurements. In comparing the strength measures, it was found that the average Big Ten wrestler was below average in his left grip and right grip, almost average in leg lift, and above average in the back lift. These strength measures agree with the subjective mesomorphic component rating. The average Big Ten wrestler in Kroll's study was more superbly built for all-round performance than the best athletic group studied by Cureton in the 1948 Olympics.[14]

Katch and McArdle used anthropometric measurements to predict body density. They measured fifty-three college men and sixty-nine college women taking five skinfold measures, thirteen circumferences, and eight bone diameters. Among the measurements taken, they reported the following means: biacromial diameter, 40.9 mm.; chest diameter, 29.0 mm.; bi-iliac diameter, 28.2 mm.; bitrochanteric diameter, 32.1 mm.; ankle diameter, 5.1 mm.; and wrist diameter, 5.1 mm. When the bone diameters were used to predict density, the multiple correlation value of the body diameters to body density did not exceed .55.[15]

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[14]Walter Kroll, "An Anthropometrical Study of Some Big Ten Wrestlers," Research Quarterly, XXV (May, 1954), 309-311.

[15]Frank I. Katch and William D. McArdle, "Prediction of Body Density from Simple Anthropometric Measurements in College-Age Men and Women," Human Biology, XLV (September, 1973), 449.

Twenty-three male college students were examined utilizing a battery of pre-conditioning, cardiovascular, and fitness measures developed by Frank. Test items included the Harvard Step Test and the sit-ups, pull-ups, shuttle run, and broad jump sections of the American Association of Health, Physical Education, and Recreation Youth Fitness Test. Frank recorded the means for each variable in a pre-test condition and a post-test condition. The Harvard Step Test recorded a pre-test mean of 68.09 and a post-test mean of 81.83, while the Sit-up Test reflected a pre-test mean of 56.96 and a post-test mean of 67.83. The Pull-up Test and Shuttle Run Test reported pre-test means of 6.39 and 9.9, and post-test means of 8.52 and 9.2 respectively. The pre-test and post-test means for the Broad Jump were 91.96 and 93.78. T-test comparisons indicated that the amount of conditioning attained in the fitness factors was significant at the .01 level.[16]

A study by Hakes and Rosemier examined the time allotments for a typical physical education class. Seventy male volunteers from a general college physical education program were divided into three groups of twenty-four, twenty-five, and twenty-one students. Next, they were organized into conditioning classes which met for thirty

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[16]James H. Frank, "Comparison of Pre- and Post-Fitness Scores in a Conditioning Experiment," <u>Research Quarterly</u>, XXXVIII (October, 1967), 510-512.

minutes three times a week for four weeks. Class activities were divided between circuit training and active games with a 5 and 25 minute, a 10 and 20 minute, or a 15 and 15 minute distribution of time. The students were tested on the bench step, push-ups, leg-exchanges, squat-thrusts, sit-ups, and pull-ups. Pretest and post-test means were recorded for pull-ups as follows: Class I, 3.25 and 4.58; Class II, 3.08 and 5.24; and Class III, 3.38 and 5.19. The pull-up test was significant at the .05 level.[17]

Rogers, and later McCloy, utilized chins and dips in predicting strength. More recently Johnson and Nelson found chins and dip strength tests had high correlation values (r=.99 and r=.98) when compared to the scores made on separate days of testing.[18] Utilizing fifty-nine subjects, Berger determined that maximum chinning and dipping strength could be predicted with high accuracy from the number of chins and dips performed at body weight. He recorded ranges in chins from 11 to 30 at 130 pounds,

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[17] Richard R. Hakes and Robert A. Rosemier, "Circuit Training Time Allotments in a Typical Physical Education Class Period," Research Quarterly, XXXVIII (December, 1967), 580-582.

[18] Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis, Minnesota: Burgess Publishing Company, 1969), pp. 243-247.

from 6 to 21 at 150 pounds, from 4 to 18 at 170 pounds, and from 1 to 13 at 190 pounds of body weight. Also, he found the difference between actual and predicted dipping strength ranged from 0 to 22 pounds with a mean of 6.9 pounds. Seven of the fifty-nine subjects varied by 8.5 percent or more than 11 pounds, and thirty-two of the fifty-nine subjects varied by 54.2 percent or less than 5 pounds between actual and predicted dipping strength. A correlation coefficient of .95 was reported between actual and predicted dipping strength.[19] Ruffer analyzed the results of entering freshmen at the University of Vermont on the Cozens Test. The data had been compiled over a thirteen-year period and reflected an increase in dip strength. The mean dip strength reported was 6.5 dips.[20]

Henschel, Taylor and Keys studied the capacity to perform hard work while in a state of acute starvation. Twelve male subjects were studied as they fasted for five days. The men were allowed no food, but they were allowed to drink water liberally. The subjects were required to

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[19] Richard A. Berger, "Determination of a Method to Predict 1-RM Chin and Dip from Repetitive Chins and Dips," Research Quarterly, XXXVIII (October, 1967), 333-335.

[20] William A. Ruffer, "Summary of a Thirteen-year Study of the Cozens Test of General Athletic Ability in College Freshmen Men," Research Quarterly, XXXIX (October, 1968), 820.

remain entirely within the laboratory under supervision during the experiment.

The men were required to walk at 3.5 miles per hour on a motor-driven treadmill at a ten percent grade in an air-conditioned room at 78° Fahrenheit and 50% relative humidity. Each subject was required to walk three periods of one hour each, and to perform a bout of anaerobic work daily for four days. On the fifth day, the subjects were required to walk one hour and perform an anaerobic run. A complete set of observations was taken daily on oxygen consumption, pulse rate, and blood sugar during work. The Harvard Fitness Test was administered during the pre-fasting control period, on the second and fourth days of fasting, and during the refeeding period. Postural adjustment tests were routinely made.[21]

The pulse rate during walking was counted three times using a stethoscope over the apex of the heart and a fifteen-second count between the fifty-fifth minute and the sixtieth minute of the one-hour walk on the treadmill. The pulse rate was also counted at one and at two minutes after cessation of walking and the average was recorded as the "recovery pulse".[22]

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[21]Austin Henschel, Henry Longstreet Taylor, and Ancel Keys, "Performance Capacity in Acute Starvation with Hard Work," Journal of Applied Physiology, VI (April, 1954), 625.

[22]Henschel, Taylor, and Keys, p. 625.

The oxygen consumption during walking was measured from the fiftieth to the fifty-fifth minute by collecting the expired air in a balanced gasometer with subsequent gas analysis using the Haldane method. All respiratory volumes were calculated in terms of standard temperature and pressure. An antecubital venipuncture, made immediately after collections of the expired air during continued walking, provided a blood sample to characterize the better part of this exercise. Another blood sample was taken exactly five minutes after the end of the walk to provide information about the blood composition before the "anaerobic" work which started ten minutes later, i.e., fifteen minutes from the end of the walk.[23]

The blood samples were taken and delivered into cold trichloracetic acid within three minutes for measurement of lactate by Edwards' method and for pyruvate by the method of Friedemann and Haugen. Blood sugar was measured by Nelson's modification of Somogyi's method.[24]

Maximal oxygen intake was measured from one minute forty-five seconds to two minutes forty-five seconds of running on the treadmill at seven miles per hour on a grade adjusted to the capacity of the individual subject.

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[23]Henschel, Taylor, and Keys, p. 625.

[24]Henschel, Taylor, and Keys, p. 626.

During the pre-starvation period, a number of trials, on separate days, were made with each subject for whom two treadmill grades, 2.5% apart, were established at which the oxygen intake was essentially constant. The effects of starvation and subsequent refeeding were studied by running the test at the lower of the two grades. This ensured that the workload would be large enough to produce the maximal oxygen intake but provided a condition which would not often be beyond the capacity of the subject in the deteriorated state. Postural adjustment was studied on a tilt table equipped with a footboard. After the pulse and blood pressure were stabilized in the horizontal supine position, the table was tilted to 68° and the pulse and blood pressure were followed for fifteen minutes. Postural adjustment scores were calculated with the scoring system of Crampton. Maximal performance capacity was followed by the use of the treadmill version of the Harvard Fatigue Laboratory Fitness Test.[25]

Observations made during the testing procedure reflected the following data. Both the work and recovery pulse rates showed only small increases during the first day. On the morning of the second day, the work pulse had risen from 130 to 145. It remained between 140 and 151

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[25]Henschel, Taylor, and Keys, p. 626.

for the duration of the fasting period. The recovery pulse rate followed a similar course. The work blood sugar was characterized by a marked drop which occurred on the morning of the second day and a slow rise until roughly one-half of the decline had been recovered on the morning of the fourth day. The ability of the cardiovascular system to adjust to upright posture reflected Crampton scores of 52.1 for the first day of starvation, 38.8 for the second day of starvation, and 24.1 for the fourth day of starvation. This data showed a marked decrease on the second day with a further decline on the fourth day. The capacity of the men to perform exhausting work, as indicated by the Harvard Fitness Test, reflected a decline in capacity on the second day and a smaller loss of capacity between the second and fourth days. The mean values from the maximal oxygen intake procedure were recorded utilizing a control period, the fifth day of starvation, and the fifth day of refeeding. The recorded means are found in Table I.

The maximal oxygen intake decreased 266 cc./min. (7.7%), while the maximal oxygen intake per unit of body weight remained constant. Respiratory ventilation did not show any change after five days of fasting. There was, however, a relative hyperventilation as indicated by the 9.3% decrease in the respiratory efficiency. The standard rest blood lactate concentration increased 8.9 mg./100 cc. of

TABLE I

MEAN VALUES FOR DATA OBTAINED FROM THE MAXIMAL OXYGEN INTAKE PROCEDURE

ITEM	CONTROL	S5	R5
Max. O_2 intake cc/min.	3455	3189	3383
Max. O_2 intake cc/kg/min.	49.5	49.5	48.3
Ventilation, 1/min.	85.5	86.6	87.5
Respiratory efficiency, work	40.9	37.1	39.2
O_2 debt (10 min.)	5.77	6.71	5.76
O_2 debt, respiratory efficiency	33.0	32.1	32.7
Standard lactate, mg. %	6.19	14.2	7.5
12 min. lactate, mg. %	28.0	36.6	25.9
Standard pyruvate, mg. %	1.09	1.06	1.27
12 min. pyruvate, mg. %	3.07	3.11	3.14
Body weight, kg.	70.5	65.0	70.6[26]

[26]Henschel, Taylor, and Keys, p. 627.

blood (198%), and the lactate concentration increases twelve minutes after the run to 8.6 mg./100 cc., (31%). There were no significant changes from the control levels in pyruvate concentration. The changes in the lactate concentration were accompanied by an increase in the ten-minute post-exercise oxygen consumption of 400 cc. for the period or 7%. This increase was found to be significant at the 5% level of probability.[27]

To summarize, the study showed that in a five-day starvation period, the mean weight loss was 5.5 kg., (7.8%). The ability to perform exhausting "anaerobic" work was impaired after the first day of starvation. On the second day of starvation, the score of the Harvard Fitness Test was decreased to 70% of the control value; and on the fourth day, the score had dropped to 40%. The oxidative energy available during anaerobic work was well-maintained as shown by the fact that there was no change in the maximal oxygen intake per kilogram of body weight during the course of the five-day fast. The physiological response to a fixed anaerobic task showed no deterioration at the end of the first day as measured by the blood lactate concentration. However, there was a definite increase in blood lactate concentration and in the ten-minute oxygen debt on the fifth day of the fast.

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[27]Henschel, Taylor, and Keys, pp. 627-628.

Recovery of performance showed that after four and five days of refeeding, the body weight had returned to normal. The ability to perform anaerobic work was completely recovered by the fourth day. On the fifth day, the pulse rate during the walk was four beats less than that of the control period. The ten-minute oxygen debt and the blood lactate concentration, twelve minutes after a fixed task of anaerobic work, had returned to normal levels. The maximal oxygen intake was 2% less than the control value and there was a small amount of over-ventilation present during both work and recovery. It was concluded that the physical deterioration under these conditions is repaired within 3-5 days of refeeding.[28]

In another study, Blyth and Lovingood found that adverse effects associated with acute and semistarvation or crash diets included hypoglycemia, ketosis, a reduction in maximal oxygen intake, reduction in cardiovascular efficiency, liver damage, and increased susceptibility to infection. Also, the capacity for anaerobic work was reduced along with a loss of physical fitness.[29]

By 1963, research had not established a conclusive trend for weight loss by rapid dehydration, Tuttle, in

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[28]Henschel, Taylor, and Keys, p. 633.

[29]Carl S. Blyth and W. Lovingood, "Harmful Effects of Crash Dieting," Athletic Journal, XLIII (May, 1963), 30.

experimenting with wrestlers weighing from 145 to 217 pounds, found a loss of 5 percent body weight had no deleterious effect on strength or vital body functions.[30] Nichols, in his study of a group of Iowa State College wrestlers, found they lost varied amounts of weight ranging from three to eighteen pounds, an overall loss of 10.29 pounds, or 6,78 percent of their body weight with a maximum weight loss of 11.11 percent. He concluded that weight losses within these limits did not materially affect a wrestler's strength, slow his reaction time, affect his balance in motion, reduce his endurance, or hinder his development of power.[31] James found no significant differences in pulse rate, systolic blood pressure, diastolic blood pressure, or scores on the Carlson Fatigue Curve Test when high school wrestlers who lost 4.4 percent to 6.9 percent of their body weight (mean seven pounds) were compared with those who did not make weight.[32]

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[30] W. W. Tuttle, "The Effect of Weight Loss by Dehydration and the Withholding of Food on the Physiologic Responses of Wrestlers," Research Quarterly, XIV (May, 1943), 165.

[31] Nichols, "The Effect of Rapid Weight Loss on Selected Physiologic Responses. . . ," p. 78.

[32] Byron D. James, "The Effect of Weight Reduction on the Physical Condition of High School Wrestlers," (Unpublished Master's thesis, State University of Iowa, Cedar Falls, 1960), p. 8.

Singer and Weiss studied the effects of weight reduction on selected anthropometric, physical and performance measures in college wrestlers. Their study utilized ten members of the Illinois State University wrestling team, with each subject being tested for five consecutive days during the wrestling season. A total of eighteen anthropometric, physical, and performance measures were taken as the subjects used traditional methods in reducing their body weight in preparation for a forthcoming meet. The anthropometric measures included body weight; girth measures of the upper arm, chest, abdomen, thigh, and calf; and skinfold measures of the cheek, chest, triceps, subscapula, abdomen, suprailiac, and front thigh. The physical measures included elbow flexion, elbow extension, knee flexion, and hip flexion; and the Harvard Step Test was used to measure cardiovascular endurance. The performance measure consisted of a sit-out maneuver. The mean scores were recorded on the eighteen measures during the weight reduction period. These scores are reported in Table II.

No significant differences were obtained on data collected during the experimental period on the following measures: upper arm girth, chest girth, and calf girth. A significant F of 24.47 was found when analyzing the waist girth data. Thigh girth yielded a significant F of 8.55. All differences in skinfold measurements

TABLE II

MEAN SCORES OBTAINED ON MEASURES DURING WEIGHT REDUCTION

MEASURE	MONDAY	FRIDAY
Upper Arm Girth (cm.)	13.01	12.76
Chest Girth (cm.)	36.57	36.34
Waist Girth (cm.)	30.78	29.22
Thigh Girth (cm.)	21.16	20.47
Calf Girth (cm.)	14.17	13.91
Triceps Skinfold (mm.)	5.90	4.50
Cheek Skinfold (mm.)	7.66	7.00
Front Thigh Skinfold (mm.)	9.70	7.96
Suprailiac Skinfold (mm.)	9.93	7.77
Abdomen Skinfold (mm.)	8.00	6.37
Subscapular Skinfold (mm.)	8.19	6.81
Chest Skinfold (mm.)	5.08	3.92
Response Time	52.13	48.51
Pulse Rate	95.00	92.00
Elbow Flexion (pounds)	137.60	125.70
Elbow Extension (pounds)	114.30	109.40
Knee Flexion (pounds)	138.60	140.20
Hip Flexion (pounds)	117.60	116.70[33]

[33] Robert N. Singer and Stephen A. Weiss, "Effects of Weight Reduction on Selected Anthropometric, Physical, and Performance Measures of Wrestlers," <u>Research Quarterly</u>, XXXIX (May, 1968), 366.

(triceps, cheek, front thigh, suprailiac, abdomen, subscapular, and chest) were found to be significant. A rejection value of 2.63 was surpassed in all cases, with the F's ranging from 5.37 for the suprailiac skinfold to 15.17 for the subscapular skinfold. The response time taken to react to a stimulus in doing the sit-out reflected a significant F of 3.42. An application of the Newman-Keuls statistic to the data determined a significantly faster wrestlers' response on Friday than on Monday. Although there was a downward trend of mean pulse rate scores from day to day following the Harvard Step Test, a nonsignificant F of .20 indicated no effect on this measure due to weight loss. None of the strength measures, including elbow flexion, elbow extension, knee flexion and hip extension, were statistically significant. Therefore, no loss of strength in the muscles involved in these measurements coincided with the loss in weight. The mean body weight decreased from 153.28 pounds on Monday to 142.43 pounds on Friday. The mean percent loss ranged from 1.64 on Tuesday to 7.10 on Friday. The mean weight loss ranged from 2.52 pounds on Tuesday to 10.95 pounds on Friday. An extremely high significant F of 80.65 was found when analyzing daily weight loss.[34]

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[34]Singer and Weiss, pp. 364-368.

It may be concluded from this study and for the ten subjects observed that a wrestler may lose up to seven percent of his body weight without adversely affecting the measured factors which were apparently related to wrestling performance. Rapid weight reduction did not appear to have a significant effect on strength or cardiovascular endurance. Also, the response times of the subjects became significantly faster.

These studies dealing with rapid weight loss by dehydration indicated wrestlers may lose between 4.4 percent and 11.11 percent of their weight. These percentages reflected mean weight losses of from seven to ten and one-quarter pounds. Yet, these weight losses did not adversely affect pulse rate, systolic blood pressure, diastolic blood pressure, or endurance. Neither did they affect strength, reaction time, nor the development of power.

Other studies reflected the opposite. Saltin found there was a marked decrease in the ability of men to perform extended heavy work (anaerobic) of two to six minutes duration on a stationary bicycle (bicycle ergometer) after dehydration.[35] Blyth and Burt studied the effects of dehydration upon the duration of all-out runs on the treadmill, with an ambient temperature of 120° F. They found dehydration lowered endurance while superhydration

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[35]Bengt Saltin, "Aerobic and Anaerobic Work Capacity after Dehydration," Journal of Applied Physiology, XIX (November, 1964), 1118.

increased endurance in the athletes and decreased it in nonathletes.[36] Craig and Cummings found maximum oxygen intake and endurance on a treadmill test were significantly impaired after dehydration amounting to 4.3 percent of body weight.[37] Bock, Fox, and Bowers studied the performance of ten Ohio State freshmen wrestlers after they dehydrated for a period of forty hours. The investigators found considerable changes from normal in core temperature, maximum oxygen intake, sweat loss, and heart rate after a bicycle ergometer test when compared to the same results before water loss.[38] Ribisl and Herbert simulated, as closely as possible, the weigh-in conditions for collegiate wrestlers and found the athletes lost an average of five percent of their body weight. They found a significant reduction in working capacity on a bicycle ergometer after dehydration, even though it increased again after rehydration.[39]

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[36] Carl S. Blyth and John J. Burt, "Effects of Water Balance on Ability to Perform in High Ambient Temperatures," Research Quarterly, XXXII (October, 1961), 306-307.

[37] E. N. Craig and E. G. Cummings, "Dehydration and Muscular Work," Journal of Applied Physiology, XXI (March, 1966), 673.

[38] William Bock, Edward L. Fox, and Richard Bowers, "The Effects of Acute Dehydration Upon Cardio-respiratory Endurance," Journal of Sports Medicine and Physical Fitness, VII (June, 1967), 71-72.

[39] Paul M. Ribisl and William G. Herbert, "Effects of Rapid Weight Reduction and Subsequent Rehydration Upon the Physical Working Capacity of Wrestlers. . . ," p. 540.

These studies disclosed that weight loss by dehydration reduced endurance in performing extended heavy work. Also, there were increases in core temperature, oxygen intake, sweating, and heart rate. These changes appeared to be a result of the disturbance to the fluid volume in the body.

Water was an important factor in the weight-making process, and its impact was tremendous. About seventy percent of the adult body is composed of water found in the blood plasma, in the interstitial fluid, and in the intercellular fluid. The arterial blood carries oxygen and food particles to the interstitial fluid, where they pass through the capillaries to the tissue cells. As the oxygen and food particles are metabolized, waste products pass through the capillaries and interstitial fluid into the venous blood. Carbon dioxide and other waste products are expelled through the lungs and the kidneys. Near constant conditions are maintained by the circulation of the blood.[40]

During exercise, the blood receives glucose from the liver and delivers it to the muscles where it is mixed with oxygen and forms fuel for the muscles. By

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[40]Laurence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise 6th edition; (St. Louis: C. V. Mosby Company, 1971), p. 167.

extension and contraction of the muscles, glucose and oxygen are burned, giving off carbon dioxide and lactic acid. These products are returned to the blood where they are transported to the lungs and kidneys for elimination. As exercise becomes more intense and the acidity of the blood increases, bicarbonate buffers are released to neutralize the acids. These buffers are eventually reduced, and the acid level in the blood begins to increase rapidly causing exhaustion.[41]

Another effect of exercise is an increase in cardiac output which increases the volume of circulating blood. Most of the increased blood flow is shunted to the muscles. As blood flow increases, the number of red blood cells increases, probably as a result of simple hemoconcentration. During prolonged exercise, fluid passes into the blood, and the resulting dilution lowers the red cell count. Strenuous exertion may cause an increase in the rate of destruction of red blood cells by compressing the capillaries with muscular contraction and the velocity of the blood flow.[42]

Another effect of exercise is an increase in the white blood cell count. This increase is caused by an

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[41]Morehouse and Miller, pp. 167-168.

[42]Morehouse and Miller, p. 168.

increase in the number of lymphocytes which, during rest, are attached to the walls of the blood vessels; as the blood flow increases in volume and velocity, the white blood cells are washed into the circulating stream. If exercise is prolonged and strenuous, a further increase in white blood cell count results from the neutrophils. The number of neutrophils increases as a result of hormone secretions from the adrenal cortex. These secretions cause a reduction of the eosinophils in the blood. As the eosinophils decrease, there is a comparable decrease in the number of lymphocytes and an increase in the neutrophils.[43]

In addition to the transportation function of body fluid, it is responsible for maintaining constant body temperature. Body temperature is stabilized within narrow limits by balancing heat production with heat loss. When heat is produced in the body through strenuous exercise. the rate of heat loss increases proportionately to maintain a constant body temperature. The excess heat is dissipated by the elimination of water in the form of sweat. Wastes such as sodium, potassium, and other products are excreted. As sweating increases, the hypothalamic "thermostat" attempts to restore balance by reducing the excretion of water through the kidneys and activating the thirst mechanism.

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[43]Morehouse and Miller, p. 169.

When food and water are ingested, electrolytes are added to the body fluid. These electrolytes are responsible for carrying electrical charges when they combine with chemicals in the tissue cells. The electrolytes contain ions capable of carrying electrical charges used in muscular contractions. Excess electrolytes are excreted through the kidneys, compensating for the changes made by the regulating mechanism as it battles to restrain or correct the tendency of the blood to lose water during exercise. As this regulating action is effected, electrolytes and water are balanced by osmosis.[44]

When the waste products carried by the blood reach the kidneys, they are filtered out as the blood flows through two sets of capillaries arranged in a series. The first set of capillaries, called the glomeruli, filter the water and dissolve materials in the lumen of the renal tubules. As the blood leaves the glomeruli, it traverses a second set of capillaries surrounding the renal tubules. Here the water is reabsorbed from the tubular fluid and is transferred back into the blood. The various dissolved substances are either reabsorbed into the blood from the tubular fluid or they are secreted into the tubular fluid where they are eliminated in the form of urine.

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[44]Morehouse and Miller, pp. 169-170, 131-133.

The volume of urine depends upon the rate of filtration of fluid in the glomeruli and the amount of the filtered fluid reabsorbed by the blood as it passes down the renal tubules. The amount of water reabsorbed by the blood depends upon the antidiuretic hormone, ADH. This hormone increases the reabsorption of water from the fluid in the renal tubules and, hence, diminishes the rate of urine formation during exercise. The kidneys eliminate the excess acid, glucose, and albumin produced by the contracting muscles during strenuous exertion.[45]

The preceeding discussion of the physiological aspects of body fluid and exercise reflects the most widely accepted information on these topics. Cade, Free, DeQuesada, Shires and Roby studied the changes in body fluid composition and volume during vigorous exercise. They studied two subjects each day for a five-day period. Observations were made with the subjects at rest, before, and immediately after vigorous two-hour football practice sessions in the late afternoon in early September. The results of their study showed each athlete lost weight during the exercise period, with an average weight loss of 2.9 percent for the group as a whole. The extracellular fluid volume decreased an average of 11 percent, and the

[45]Morehouse and Miller, pp. 136-137.

plasma volume decreased 7 percent. The sweat concentration varied between 37 and 114 mEq/L., while sweat potassium ranged from 10 to 65 mEq/L. In all instances, sweat sodium was much lower than the plasma sodium concentration. The plasma sodium concentration increased in all subjects as a result of severe sweating. The average increase in sodium concentration was 3.4 mEq/L. Large amounts of potassium were lost in sweat; however, no significant change in plasma potassium concentration occurred. Serum osmolarity increased by 8 mosm/kg. Largely a result of the increased sodium concentration, the remainder resulted from the rise in the lactate and pyruvate content of the serum. Plasma protein concentration increased from 7.8 to 8.1 Gm/100 ml., a finding reflected by the loss of salt and water from the vascular space. Plasma phosphate fell in all seven subjects in whom it was measured. Since no phosphate was found in the sweat, the only likely explanations were entry of phosphate into cells or deposition on bone as a result of physical stress. Water loss ranged from 0.93 to 3.55 liters with an average loss of 2.4 L., while the loss of sodium varied from 34 to 370 mEq., and the loss of potassium varied from 27 to 187 mEq. The sweat sodium concentration was highest in the subjects whose weight loss was the greatest. Changes in blood glucose and serum lipids were taken from four subjects who exercised to exhaustion peddling a bicycle against a fixed resistance for thirty minutes. Blood samples for glucose and lipids were obtained before the exercise period. They showed an initial increase, then a progressive fall throughout the exercise period. The serum lipids and blood glucose both returned toward control values during the recovery period.[46]

In a study of aerobic and anaerobic work capacity after dehydration, Saltin found there was a marked increase in heart rate and a decrease in blood lactate at the submaximal loads, but the oxygen intake did not change. When comparing the nine subjects dehydrated by exercise or work in heat at about the same degree of dehydration, the effect of heart rate was about the same. In most cases, the respiratory quotients were somewhat lower in the afternoon experiment. The largest decrease was found after exercise dehydration when the respiratory quotient was reduced from 0.90 and 0.94 to 0.86 and 0.88 at the first and the second submaximal loads, respectively. In none of the three conditions--dehydration by thermal heat, metabolic heat, or a combination of thermal and metabolic

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[46]J. R. Cade, H. J. Free, A. M. DeQuesada, D. L. Shires and L. Roby, "Changes in Body Fluid Composition and Volume During Vigorous Exercise by Athletes," _Journal of Sports Medicine and Physical Fitness_, XI (September, 1971), 173-175.

heat load for 2.5 to 4 hrs.--was the pulmonary ventilation per liter of oxygen consumed (VE/VO_2) significantly changed. The average values for this ratio were higher in the afternoon, but this had no effect. After dehydration at maximal load, no significant changes were found in the maximal values for oxygen uptake and heart rate. There was a large reduction in both work time and blood lactate. Neither the ventilation per liter oxygen consumed (VE/VO_2) nor the respiratory quotient measured in the afternoon experiment was significantly different from the values under normal conditions. The maximal isometric strength in the muscle groups studied showed no differences from normal values.[47]

In another study, Saltin used four subjects to study the circulatory response to submaximal and maximal exercise after thermal dehydration. The results of his study showed that during a stay in a sauna, a high sweat rate caused a total decrease in body weight of 0.8-4.2 kg., (1.0-5.2%). The rectal temperature was elevated to 39° C. during the first hour of exposure to the hot environment; then there was a slight decrease during the following hours when the subjects had to rest outside the sauna for longer periods due to discomfort. A decrease in body weight of

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[47]Saltin, "Aerobic and Anaerobic Work Capacity After Dehydration. . . ," pp. 1115-1116.

about 3.5 percent corresponded to a reduction in plasma volume of 10-20 percent. The variations in hematocrit and hemoglobin concentration in fingertip blood did not exactly follow the changes in plasma volume. In submaximal work, the oxygen intake was not significantly affected by dehydration. After the heat exposure, the arteriovenous oxygen difference was, on the average, 3.8 m./liter (3.2%) higher than before. These changes were not correlated to the degree of reduction in body weight. During submaximal exercise, the calculated cardiac output was lower after dehydration than before. When the decrease in body weight was 1.0-3.4 percent, the mean reduction in cardiac output was 0.2 liters/min. With a 3.5-5.2 percent reduction in body weight, the mean decrease in cardiac output was 0.4 liters/min. The heart rate was higher after dehydration and the increase was more marked as the reduction in body weight became larger. The average heart rate was 6.2 beats/min. at the 45 percent load and 7.1 beats at the heavier load, at an average weight reduction of 2.3 kg.,(2.9%).

When the subjects worked in supine position, the difference in heart rate was negligible as compared with the standard test. There was hardly any difference in oxygen intake. Immediately after the supine work, the same workload was again applied in a sitting position. The difference in heart rate was then 9.7 beats/min. On the

45% load, the stroke volume was 10.2 ml., and on the 77 percent load, 8.0 ml., below normal. The correlation between the decrease in body weight and the change in stroke volume was 0.65, but there was a difference between the two maximal loads. The blood lactate concentration measured after the 77 percent load was 4.9 mmole/liter lower after dehydration, but there was no correlation to the decrease in body weight.

During maximal work, the measurements of oxygen intake, arteriovenous oxygen difference, heart rate, and therefore cardiac output and stroke volume, under normal conditions and after dehydration, gave almost identical results. Only one determination of maximal oxygen intake and one arteriovenous oxygen difference were just outside two standard deviations of the method used. Work time was shorter in all experiments with maximal work except one. The decrease in body weight and work time was not significant. The peak blood lactate value was lower after dehydration but there was no correlation to either decrease in body weight or work time.[48]

In a similar study, Kozlowski and Saltin studied the effect of sweat loss on body fluid in six healthy men.

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[48]Bengt Saltin, "Circulatory Response to Submaximal and Maximal Exercise After Thermal Dehydration," Journal of Applied Physiology, XIX (November, 1964), 1128-1129.

The subjects were studied under normal conditions and after dehydration caused by sweating produced in a sauna at 80° C., by hard muscular work at 18° C., and by mild exercise at room temperature, 38° C. The dehydration period lasted for 2.5-3.5 hours.

After thermal and exercise dehydration, the reduction in body weight was 3.11 kg., (4.1%) and 3.14 kg., (4.1%). The difference was not significant. After the dehydration caused by work in a hot environment, the reduction in body weight was 3.51 kg., (4.7%). Water loss from extracellular fluids showed that in all three conditions apparent extracellular space was diminished, though there was a marked difference between the three kinds of dehydration. After thermal heat stress, the decrease was 1.4 liters compared with 0.2 liter after the exercise dehydration and 1.35 liters after the exercise in the hot environment. The same tendency was found in the plasma volume with a decrease of 0.7, 0.4, and 0.1 liter after each testing condition. The electrolytes were almost completely eliminated by sweat. The voluntarily voided urine volume was no higher than 84, 82, and 50 ml. during the dehydration periods. During thermal dehydration there was a somewhat higher loss of sodium chloride than during the other two conditions. Comparing the loss of electrolytes in sweat, a significantly high loss of potassium occurred during exercise. However, the difference in total loss was small. In the sodium and chloride concentrations, there were only small changes. The smallest deviation from resting value was always found during and after the thermal heat stress. There was a large increase in potassium concentration during exercise, with the highest figure, 5.6 mlq/liter, at the termination of work. Changes in osmolarity of plasma followed the same pattern as the electrolyte changes, with the highest value at the end of the dehydration period. The decrease in the osmolarity in plasma during the recovery period was small, and the largest difference was 9 moemoles/liter. In the collected sweat and urine, there were no significant differences between the three kinds of dehydration. Nonprotein excretion of nitrogen in urine during and after exercise-dehydration showed the same values as during the control period. During the first hour of the dehydration period, body temperature increased to about 38.5° C. and remained on that level throughout the period. During exercise in a hot environment, the body temperature was usually about 39.0° C. The sweating rate was varied. It was about the same for each subject in exercise and in the sauna, but somewhat higher during exercise in the hot room. Four subjects, having the same body surface and exposed to the same thermal heat, reflected a difference in body weight decrease from 3.8 to 2.0 kg. The decrease in sweating rate at the end of the dehydration period was probably due to the subject's intoleration of longer periods in the sauna.[49]

In a study conducted by Cook, Gualtiere, and Galla, it was found there was no difference in plasma or blood volumes between groups of fourteen trackmen, ten wrestlers, and nine non-athletes. The athletes had higher extra-cellular fluid volumes and total body water than the non-athletes, but the trackmen did not differ from the wrestlers in these same parameters. In all three groups, the ratio of extracellular water to total body water was similar.[50]

Bock, Fox, and Bowers observed the effects of acute dehydration on cardio-respiratory endurance. They studied ten subjects who were members of the Ohio State University Freshman Wrestling Team and reached the following conclusions:

1. The 40-hour dehydration period was shown to have no statistically significant effect upon maximal oxygen intake. However, seven of ten subjects had a reduced maximal oxygen uptake following dehydration, and this was viewed as a trend toward a reduced maximal oxygen uptake. The rehydration procedure had no apparent effect upon maximal oxygen intake.

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[49]Stanislaw Kozlowski and Bengt Saltin, "Effect of Sweat Loss on Body Fluids," Journal of Applied Physiology, XIX (November, 1964), 1120-1122.

[50]David R. Cook, William S. Gualtiere, and Stephen J. Galla, "Body Fluid Volumes of College Athletes and Non-Athletes," Medicine and Science in Sports, I (December, 1969), 219.

2. Heart rate was not significantly affected by the dehydration period. Heart rates were not significantly affected by eating and drinking following the dehydration period. However, slightly higher heart rates were observed following the rehydration procedure which was perhaps due to metabolic heat production as a result of eating and drinking together with the stress of the exhaustive exercise bouts.

3. Core temperature was not significantly affected by the dehydration period. Core temperature was significantly affected by the eating and drinking condition which followed the dehydration period. It was suggested that the higher temperature following the rehydration was perhaps due partially to the specific dynamic action of food and water consumed by Sub-Group II before being tested.

4. Exercise weight loss was significantly affected by the condition of dehydration. In both sub-groups, significantly more water was lost in the pre-dehydrated condition than in the post-dehydrated condition. The rehydration procedure had no apparent effect upon sweat loss. The significant sweat loss differences following dehydration were concluded to be due to the effects of prior dehydration.[51]

To summarize briefly, the above studies tended to support the general conclusions reached by Morehouse and Miller, as well as other prominent physiologists of today. These studies showed that athletes had a higher extra-cellular fluid volume and total body water than nonathletes. During dehydration, exercise weight loss was significantly affected and the reduction in body weight was comparable to a reduction in plasma volume. Most of this weight was

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[51]Bock, Fox, and Bowers, "The Effects of Acute Dehydration Upon Cardio-respiratory Endurance. . . ," pp. 71-72.

lost in the form of water from the extracellular fluid under three conditions of dehydration: in a sauna, by exercise, and in a hot room performing maximal work. The ratio of extracellular water to body water was similar in all three conditions of dehydration. The water loss averaged 2.4 liters or 2.9 percent of the body weight. By using the Evans Blue Dye Method, it was determined that most of the lost water came from the inulin space, and, thereby, the inulin space was diminished. It was also found that more water was lost in a condition of pre-dehydration rather than in a condition of post-dehydration.

Heart rate increased after dehydration and it was found to be proportional to the amount of weight lost. Once the body had reached a stabilized condition, there was no additional increase when a maximal workload was included in the dehydrated condition. Heart rate was not affected by eating or drinking immediately before exercise, but it increased as the body became rehydrated.

Cardiac output was lower after dehydration. When the body became stabilized in a dehydrated condition, there was no additional increase when a workload was applied either in a lying position or a sitting position. Neither was there a significant difference between stroke volume and weight loss.

During each of the three conditions of dehydration, plasma volume decreased, while the highest plasma osmolarity came after dehydration. Plasma sodium concentration and plasma protein concentration increased, while plasma potassium concentration did not significantly change until a condition of excessive dehydration was reached. Plasma phosphate concentration decreased. Blood glucose increased initially then fell during dehydration. Blood lactate decreased with dehydration under a condition of maximum work. During the rehydration period, blood glucose returned toward control values. Hematocrit and hemoglobin did not follow the changes in plasma volume.

During all three conditions of dehydration, it was found that the sweating rate was variable. It was highest during exercise in a dry hot room, but was not affected by rehydration. Sweat sodium concentration was lower than plasma sodium concentration; the sweat sodium concentration was highest in the subjects who lost the greatest amount of weight.

There was no significant change in maximum oxygen intake during the three conditions of dehydration. During submaximal work there was no significant change between control values and dehydrated values; however, when the workload was increased to maximal level, maximal oxygen intake changed, but the change was not significant. This reflected a trend toward reduced maximum oxygen consumption following dehydration. Maximum oxygen consumption was not significantly changed by rehydration.

There was no significant change in pulmonary ventilation during the three conditions of dehydration. The arteriovenous oxygen increased after heat exposure, but the increase was not significantly different from normal conditions. As maximum work was added during the state of dehydration, the arteriovenous oxygen changed, but it was not significant.

Maximum isometric strength showed no significant difference from normal. Meanwhile, work time was reduced during each condition of dehydration, and showed the largest decrease while subjects were working under maximum load.

The review of literature on urinary excretion substantially supported the physiological information regarding excretion as noted by Morehouse and Miller in The Physiology of Exercise. Rasch, Faires, and Hunt studied the effects of amateur wrestling on the kidneys. Sixteen wrestlers on a major university wrestling squad gave samples of urine before and after participation in a wrestling tournament, and forty-hours after competition. Their findings showed an increase in acidity following competition by eight subjects (50%). By the end of the forty-hour, post-competition period, alkalinity had increased, and in most instances, slightly exceeded the pre-exercise level.

Immediately after competition, albumin was present or increased in eleven subjects (69%). These included two whose tests showed albumin (1 plus) before competition and a like amount (1 plus) in the paired samples examined at the end of the forty-hour, post-competition period. The exception was the two who were positive for albumin before and immediately after competition.

Urinalyses showed casts in the specimens obtained from three wrestlers (19 percent) following competition. In all three instances, the casts disappeared in the specimens obtained after the post-competition period. In only one instance did sugar appear in the urine following wrestling competition. Only random changes were observed in the number of red blood cells present in the urine following strenuous competition.[52]

In another study on the urinary profiles of state finalists, Zambraski, Tipton, and Tcheng took approximately 500 urine samples from wrestlers at the state wrestling tournament. These samples were taken immediately before weigh-in and immediately before competition. Forty-five

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[52] Philip J. Rasch, Lucius B. Faires and M. Briggs Hunt, "Effects of a Combative Sport (Amateur Wrestling) on the Kidneys," Research Quarterly, XXIX (March, 1958), 57-59.

samples were taken under similar conditions from non-wrestlers of approximately the same age and weight as the finalists.

The results showed specific gravity for the wrestlers was much higher than it was for the non-wrestlers before both the weigh-in and competition. The hydrogen-ion concentration value for the wrestlers was lower before the weigh-in and higher before the match. The hydrogen-ion concentration for the non-wrestlers was higher before the weigh-in and only slightly less than the finalists before competition. Both specific gravity and hydrogen-ion concentration for the wrestlers at weigh-in was significant at the .05 level. Specific gravity did not change from the time of weigh-in to the first match, whereas, the hydrogen-ion concentration returned to a normal level. Urinalyses showed that osmolarity was higher for the wrestlers before weigh-in than before competition. The non-wrestlers were lower in osmolarity than the wrestlers before weigh-in and before competition. Sodium concentration was lower for the wrestlers before weigh-in than before competition. The non-wrestlers' sodium concentration was higher than both the weigh-in and the pre-competition measures of the wrestlers. The potassium concentration was higher for the wrestlers before weigh-in than before competition. The potassium concentration was lower in the non-wrestlers than in the wrestlers before the weigh-in and before competition. All groups and condition differences were statistically significant at the .05 level.[53]

These two studies showed that competition tended to produce the following changes in urine: an increase in acidity, the appearance of protein, an increase in the number of casts, the appearance of red blood cells, and the appearance of sugar. There was also an increase is osmolarity, specific gravity, potassium and creatinine, and markedly lower hydrogen-ion concentration and sodium values.

The foregoing review of literature from the past quarter-century reflects various results regarding weight reduction by dieting and dehydration. These studies suggested there has been considerable interest in this matter; however, the results in many cases were inconclusive, The most recent study dealing with excessive weight reduction was conducted by Zambraski, Tipton, and Tcheng. They found that:

1. Many wrestlers lost a considerable amount of body weight in a relatively short period of time before weigh-in or certification.

2. The non-finalists are "lean" rather than "fat" before the season starts.

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[53]Edward J. Zambraski, Charles M. Tipton, and Tse-Kia Tcheng, "Iowa Wrestling Study: Urinary Profiles of State Finalists," <u>The Predicament</u> IV (December 13, 1973), 5.

3. The advice on how to make weight was provided more by the coach than by the physician or the parent.

4. Wrestlers lost weight by methods that included fluid restriction, food deprivation and dehydration by thermal or exercise means.

5. The lowest body weight an individual should possess for competitive wrestling was one that had approximately 5% fat.[54]

Thus, it has been suggested that many high school students do lose an excessive amount of weight in a brief span of time by a variety of questionable health procedures known to diminish performance levels.

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[54] Zambraski, Tipton, and Tcheng, p. 5.

CHAPTER 3

SELECTION OF SUBJECTS

Several wrestling teams in the Chattanooga, Tennessee, area were considered as possible subjects for this study. The wrestling teams at East Ridge High School and East Ridge Junior High School were selected following careful consideration of the project by the respective school administrators and wrestling coaches. The selection of these teams was based on their wrestling success in recent years, the required number of participants to serve as subjects, and their accessibility to the researcher.

A meeting was held with the members of both teams informing them that they were to be participants in a research study. The nature of the study was explained, and their role as subjects was reviewed. At the conclusion of the meeting, the team members in grades nine through twelve were given the opportunity to volunteer for the project. At that time, thirty-nine individuals volunteered. Each volunteer was then given a letter explaining the nature of the project and a parental permission form. (Appendix A). Thirty-six parental permission forms were returned. Upon return of the permission slips, each individual was advised that he must complete a medical examination prior to October 25, 1974, and that he must plan for a trip to Murfreesboro, Tennessee, on October 26, 1974, for the first series of testing. Seven parents of the junior high school boys and four parents of the high school boys contacted the coaches regarding the weight reduction program and the trip to Murfreesboro, Tennessee. Their questions focused on the length of the weight reduction period, the kind of training program involved, and the amount of money the boys would require for the trip to Murfreesboro. These questions were answered satisfactorily and all eleven individuals were permitted to participate in the study. On October 26, 1974, thirty-six boys went to Murfreesboro for testing.

During the training cycles, the subjects in the experimental group were required to follow the standard practice routine from the onset of practice until the beginning of the weight reduction period. Upon entering the weight reduction period, the experimental group followed a one-week weight reduction program consisting of the standard practice routine, dieting, and dehydration. At the conclusion of the weight reduction period, the experimental group returned to the standard practice routine. The subjects in the control group followed the standard practice routine throughout the study.

COLLECTION OF DATA

Data were collected on the following five occasions:

Tc_1 Training Cycle One October 26, 1974
Prior to the beginning of practice.

Tc_2 Training Cycle Two November 29, 1974
Prior to the beginning of the competitive season.

Tc_3 Training Cycle Three January 2, 1975
Prior to the beginning of the weight reducing period.

Tc_4 Training Cycle Four January 12, 1975
At the conclusion of the weight reduction period.

Tc_5 Training Cycle Five January 26, 1975
At the conclusion of the competitive season.

Training cycle one was conducted in the Human Performance Laboratory, Middle Tennessee State University, Murfreesboro, Tennessee, because of the availability of the testing equipment. Subsequent testing was performed at East Ridge High School in Chattanooga, Tennessee, with equipment on loan from the Human Performance Laboratory, Middle Tennessee State University.

A Latin Square was developed utilizing six groups of subjects. Each group was composed of three experimental subjects and three control subjects and was rotated to prevent testing at the same time during any two testing sessions. A test-retest procedure was utilized to insure accuracy in data collection. All measures were taken in accordance with the standard procedures outlined by the

International Committee for Standardization of Physical Fitness Tests.[1]

TIMES OF TESTS

	Tc_1 OCTOBER 26 1974		Tc_2 NOVEMBER 29 1974		Tc_3 JANUARY 2 1975		Tc_4 JANUARY 12 1975		Tc_5 JANUARY 26 1975	
9:00					C	F				
10:00	A	D			B	E				
11:00	B	E			D	A				
12:00	C	F								
1:00							D	A		
2:00							E	B		
3:00							F	C	D	A
4:00			B	E					F	C
5:00			C	F					E	B
6:00			D	A						

ANTHROPOMETRIC MEASUREMENTS

Age, Height and Weight. The age of each subject was recorded in years and months. Height was recorded to the nearest one-fourth inch using a stadiometer. The nude

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[1]Leonard A. Larson (ed.), Fitness, Health and Work Capacity: International Standards for Assessment (New York: Macmillan Publishing Co., Inc., 1974), pp. 1-532.

weight was taken using a balance beam health scales and was recorded to the nearest one-fourth pound.

Body Diameters

The wooden shoulder calipers[2] were used to measure all body diameters applying standard techniques and procedures as described by Wilmore and Behnke.[3] The following body diameters were taken and the data were recorded to the nearest tenth of a centimeter:

Biacromial Diameter. Biacromial diameter was measured with the subject in a standing position, the elbows next to the body, and the hands resting on the thighs. The distance was measured between the lateral projections of the acromial processes.

Chest Diameter. Chest diameter was measured with the subject standing with the hands on the crests of the ilium. The calipers were then placed in the axillary region, the ends being placed on the second or third rib. The distance was measured at nipple level, and was obtained at the end of expiration.

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[2]J. A. Preston Corporation, 71 Fifth Avenue, New York, New York, 10013.

[3]Jack H. Wilmore and Albert R. Behnke, "Predictability of Lean Body Weight Through Anthropometric Assessment in College Men," Journal of Applied Physiology, XXV (October, 1968), 349.

Chest Depth. Chest depth was measured with the subject in the standing position, the right arm raised to shoulder level. The distance was measured at nipple level from the sternum to the fifth vertebra. The measurement was taken at the end of expiration.

Bi-iliac Diameter. Bi-iliac diameter was measured with the subject standing with arms slightly extended from the sides. The distance was measured from the most lateral projections of the crests of the ilium.

Bitrochanteric Diameter. Bitrochanteric diameter was measured with the subject in a standing position, the arms slightly extended from the sides. The distance was measured from the most lateral projections of the greater trochanters.

Wrist Diameters. Wrist diameter was measured with the subject seated, the arm extended to the front. The distance was measured from the styloid processes of the radius and ulna. The right wrist was measured first; then the left wrist was measured. The measures of both wrists were summed.

Ankle Diameters. Ankle diameter was measured with the subject seated, the lower leg extended to the front. The distance was measured between the malleoli with the wooden calipers pointed upward at a 45° angle. The right ankle was measured first, then the left ankle was measured The measures of both ankles were summed.

BODY COMPOSITION MEASUREMENTS

Skinfolds

The Lange Skin Calipers[4] were used to measure all skinfolds applying standard techniques and procedures as described by Keys and Brozek.[5] The following skinfold measures were taken on the right side and the data was recorded to the nearest millimeter:

Scapula Skinfold. Scapula skinfold was measured with the subject in a standing position, the elbows next to the body, and the hands resting on the thighs. The scapula skinfold measure was made with the fold running parallel to the axillary border. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the vertical plane with the blades of the calipers held horizontally.

Triceps Skinfold. Triceps skinfold was measured with the subject in a standing position, the arm raised to

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[4]Cambridge Scientific Industries, 527 Poplar Street, Cambridge, Maryland, 21613.

[5]Ancel Keys and Josef Brozek, "Body Fat in Adult Man," Physiological Review, XXXIII (July, 1953), 245.

shoulder height and slightly flexed in a position of supination. The triceps skinfold was measured at the point midway between the acromion and olecranon processes on the posterior aspect of the arm with the fold running parallel to the upper arm. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the horizontal plane with the blades of the calipers held vertically.

Chest Skinfold. Chest skinfold was measured with the subject standing, the elbows next to the body, and hands on the thighs. The chest skinfold was measured at the level oblique to the midclavicular line over the pectoralis major muscle medial to the anterior axillary line with the fold running parallel to the midaxillary line. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the vertical plane with the blades of the calipers held horizontally.

Suprailiac Skinfold. Suprailiac skinfold was measured with the subject standing, the arms extended laterally from the sides. The suprailiac skinfold was measured at a site midway between the crest of the ilium and the twelfth rib at the midaxillary line. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the vertical plane with the blades of the calipers held horizontally.

Abdomen Skinfold. Abdomen skinfold was measured with the subject standing, elbows next to the body, and hands resting on the thighs. The abdominal skinfold was measured to the right of the umbilicus at the midaxillary line at waist level. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the vertical plane with the blades of the calipers held horizontally.

Thigh Skinfold. Thigh skinfold was measured with the subject standing, feet comfortably apart at shoulder width, weight equally distributed on both feet, and the hands on the crests of the ilium. The thigh skinfold was measured at a point midway between the anterior superior spine of the pelvis and the patellar tendon. The examiner grasped two thicknesses of skin and subcutaneous fat between the thumb and index finger along the vertical plane with the blades of the calipers held horizontally.

BODY CIRCUMFERENCE MEASURES

Circumferences

The Gulick Cloth Tape[6] was used to measure all circumferences by applying standard techniques and

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[6] J. A. Preston Corporation, 71 Fifth Avenue, New York, New York, 10013.

procedures as described by Wilmore and Behnke.[7] The following circumferences were taken and the data were recorded to the nearest tenth of a centimeter:

Gluteal Circumference. The gluteal circumference was measured with the subject standing, feet together. The gluteal circumference was measured at the outermost region of the gluteal muscles and the tape was pulled "taut" before the measurement was taken.

Thigh Circumference. Thigh circumference was measured with the subject standing, feet comfortably apart at shoulder width, weight equally distributed on both feet. The right thigh circumference was measured at a point approximately 10 centimeters below the crotch and the tape was pulled "taut" before the measurement was taken.

STRENGTH MEASURES

Muscular Strength

The Aircraft Tensiometer[8] with chain and cable, twelve-inch strap, goniometer, and grip device was used

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[7]Jack H. Wilmore and Albert R. Behnke, "An Anthropometric Estimation of Body Density and Lean Body Weight in Young Men," Journal of Applied Physiology, XXVI (February, 1969), 25-31.

[8]Pacific Scientific Company, 1346 South State College Boulevard, Anaheim, California, 93803.

to measure the strength of various muscle groups by applying standard techniques and procedures as described by Clarke.[9] The Aircraft Tensiometer was calibrated by the Bureau of Standards in Nashville. The following measures were taken on the right side of the body, and the data was recorded to the nearest pound:

Grip Strength. Grip strength was measured by using the grip device with an attached Aircraft Tensiometer. Grip strength was measured on three successive tries. The subject was allowed to move as he chose during the test.

Elbow Flexion. Elbow flexion was measured with the subject lying in the supine position with hips and knees flexed, feet resting on the table. The arm was adducted at the shoulder to 180°, the arm extended at the shoulder to 180°, and the forearm in vertical plane. The elbow was in 115° flexion with the forearm in mid-prone-supine position. The hand of the free arm rested on the chest. The attachment of the strap was placed around the forearm midway between the wrist and the elbow joints. The cable was attached to a vertical runner at the subject's feet. The direction of pull was parallel with the median line.

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[9] H. Harrison Clarke, "Improvement of Objective Strength Tests of Muscle Groups by Cable-Tension Methods," Research Quarterly, XXI (October, 1950), 399-419.

<u>Elbow Extension</u>. Elbow extension was measured with the subject lying in the supine position, hips and knees flexed, and feet resting on the table. The arm was adducted at the shoulder to 180°, with the arm extended at the shoulder to 180°, and the forearm in the vertical plane. The elbow was in 45° flexion with the forearm in mid-prone-supine position. The hand of the free arm rested on the chest. The attachment of the strap was placed around the forearm midway between the wrist and the elbow joints. The cable was attached to a vertical runner at the subject's head. The direction of pull was parallel with the median line.

<u>Knee Flexion</u>. Knee flexion was measured with the subject lying in the prone position, with the patellae at the edge of the table, the head resting on folded arms, and the knee flexed to 165°. The attachment of the strap was placed around the leg midway between the knee and ankle joint. The cable was attached to a hook affixed to the base of the table at the floor level. The direction of pull was parallel with the vertical planes.

<u>Knee Extension</u>. Knee extension was measured with the subject sitting in a backward-leaning position, with the legs hanging free, and the arms extended to the rear with the hands grasping the sides of the table. The thigh

was adducted at the hip joint to 180° with the knee in 115° extension. The attachment of the strap was placed around the leg midway between the knee and ankle joint. The cable was attached to the rear-most hook at the lower end of the table. The direction of pull was parallel with the median line.

MUSCULAR ENDURANCE MEASURES

Muscular Endurance

Two parallel bars[10] and a horizontal bar, one and a half inches in diameter, were used to measure muscular endurance as described by Johnson and Nelson.[11] The parallel bars were raised to a height so that all subjects were supported freely above the ground in a lowered bent arm support; the horizontal bar was placed at a height so that the tallest subject could not touch the ground from the hanging position.

Pull-ups. Pull-ups were measured by having each subject take a position of complete extension on a chinning bar using the palms-toward-body grip. Each subject was

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[10] Nissen, 930-27th Avenue Southwest, Cedar Rapids, Iowa, 52406.

[11] Barry L. Johnson and Jack K. Nelson, Practical Measurements for Evaluation in Physical Education (Minneapolis, Minnesota: Burgess Publishing Company, 1969), pp. 273, 288.

required to enter complete flexion by raising the chin to hand level, then returning to complete extension. Only complete pull-ups were counted.

Dips. Dips were measured by having each subject take a position of complete extension on parallel bars. Each subject was required to dip to a point where the elbow formed a right angle, then return to complete extension. Only complete dips were counted.

CARDIOVASCULAR ENDURANCE MEASURES

Physical Work Capacity

The Monark bicycle ergometer[12] was used to measure the physical work capacity applying standard techniques and procedures as described by Astrand and Rhyming.[13]

Bicycle Ergometer Test. The bicycle ergometer was used to measure the amount of work accomplished by each subject. The subject was required to pedal the bicycle ergometer in cadence with an electric metronome for a period of six minutes. The metronome was set at a cadence

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[12]Quinton Instruments, 3051-44th Avenue West, Seattle, Washington, 98199.

[13]P. O. Astrand and Irma Rhyming, "A Nomogram for Correlation of Aerobic Capacity from Pulse Rate During Submaximal Work," Journal of Applied Physiology, VII (September, 1954), 218.

of 100 beats per minute. The workload for the ergometer was set at 900 kilo pounds per minute. Each subject was required to pedal for five minutes at a steady rate of fifty revolutions per minute; then at the conclusion of the fifth minute, the heart rate was measured for five seconds. The five-second count was multiplied by twelve to determine the total heart rate. Immediately after the five-second count was completed, the subject was required to continue pedaling for one additional minute. Upon the completion of this pedaling time, another five-second count was taken; this five-second count was multiplied by twelve to attain the second heart rate. Both heart rates were recorded for each subject. Maximum oxygen consumption was predicted from the formula developed by Astrand.

URINALYSIS

Urinalysis

Labstix,[14] a Total Solids Meter,[15] microscope[16] and Flame Photometer[17] were used to analyze the urine samples. Standard laboratory techniques and required controls as described by Free and Frankel[18] and Van Fossan[19] were applied. A urine sample was taken from each subject at the conclusion of each training cycle. Each sample was tested for the following: color, clarity, protein, glucose, acidity, acetone, occult blood, specific gravity, white blood cells, red blood cells, casts, parasites, crystals, bacteria, epithelial cells, sodium and potassium.

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[14] Ames Company, 1127 Myrtle Street, Elkhart, Indiana, 46514.

[15] Scientific Products, Division of American Hospital Supply Corporation, 1210 Leon Place, Evanston, Illinois, 60601.

[16] Bausch and Lomb Optical Company, Division of Bausch and Lomb, Incorporated, 77468 Bausch Street, Rochester, New York, 14602.

[17] Scientific Products, Division of American Hospital Supply Corporation, 1210 Leon Place, Evanston, Illinois, 60601.

[18] Alfred H. Free and Sam Frankel, "Rapid Tests," Gradwohl's Clinical Laboratory Method and Diagnosis, eds. Sam Frankel, Stanley Reitman, and Alex C. Sonnenwirth, II, (7th edition: St. Louis: C. V. Mosby Company, 1970), pp. 1876-1883.

[19] D. D. Van Fossan, "Microanalytic Chemistry," Laboratory Medicine, ed. George J. Race, I (Hagerstown, Maryland: Medical Department, Harper and Row Publishers, 1975), pp. 20-22.

<u>Color and Clarity</u>. Each sample of urine was examined for color and clarity by observation.

<u>Specific Gravity</u>. Specific gravity was measured using a Total Solids Meter. The ratio between the weight of 10 cc. of urine and an equal weight of distilled water was determined.

<u>Labstix Test</u>. Protein, glucose, acidity, occult blood and acetones were measured using a Labstix. The Labstix is a firm, plastic strip to which are attached five impregnated reagent areas. The Labstix was placed in fresh, well-mixed uncentrifuged urine. The Labstix was removed from the urine and compared with corresponding color charts. The pH and protein tests were compared before the timed tests. Glucose was compared to the color chart at ten seconds, acetone at fifteen seconds, and occult blood at thirty seconds.

<u>Microscopic Examination</u>. Microscopic examination was performed using a microscope to examine the following urinary sediments: casts, epithelical cells, leukocytes, erythrocytes, parasites, and crystals. Ten milliliters of well-mixed urine was poured into a fifteen milliliter conical centrifuge tube. The urine was then centrifuged at fifteen-hundred revolutions per minute for five minutes. Next the supernatant fluid was poured off; while still

inverted, the tubes were pressed twice onto two thicknesses of paper towels. Sufficient urine remained in the tube to suspend the sediment. A drop of the remaining material was placed on a slide and a cover glass was placed over the specimen. Care was taken to prevent the specimen from over-running the cover glass, and care was taken to prevent the introduction of air bubbles into the specimen since both tend to alter results. The specimens were examined and the particles were identified and counted.

Flame Photometer Test. The internal standard flame photometer was used to measure sodium and potassium. The serum was diluted in a standardized dilute solution of lithium nitrate. This solution was aspirated into the burner where it was evenly burned by a propane flame. Every element in the dilution was subjected to heat excitation. Under heat excitation, each cationic element emitted light at several wavelengths characteristic of the element. The higher the concentration of the element being excited, the more intense the light. Two monochromatons permitted only the light to be measured to pass from the chamber. The intensity of this light was measured by a photosensitive system, and the resultant electrical output difference activated a computer which registered the results on a readout device. Sodium and potassium were analysed simultaneously, each using a separate channel and photosensitive system.

BLOOD ANALYSIS

Blood Analysis

The Model S Coulter Counter,[20] blood smears using the slide technique,[21] flame photometer,[22] and Cotlove Chloridometer[23] were used to analyze the blood samples. Standard techniques and required controls as described by Cross and Parker,[24] Van Fossan,[25] and Spear, Roberts, and Kension[26] were applied. A venous blood sample was taken from each subject at the conclusion of each training cycle. Each sample was tested for the following: white blood count, red blood count, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean

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[20]Coulter Electronics, Incorporated, Hialeah, Florida.

[21]Gwendolyn Cross and Dora Mae Parker, "Hematology and Blood Banking," Laboratory Medicine, ed. George J. Race, II (Hagerstown, Maryland: Medical Department, Harper and Row Publishers, 1975), p. 19.

[22]Scientific Products, Division of American Hospital Supply Corporation, 1210 Leon Place, Evanston, Illinois, 60601.

[23]Buchler Instruments, Incorporated, Fort Lee, New Jersey.

[24]Gwendolyn Cross and Dora Mae Parker, pp. 16-19.

[25]D. D. Van Fossan, Laboratory Medicine, ed. George J. Race, I, pp. 20-22.

[26]Robert J. Spear, Joan Roberts, and Susan Kension, "Manual Procedures for Routine Chemistry," Laboratory Medicine, ed. George J. Race, I (Hagerstown, Maryland: Medical Department, Harper and Row Publishers, 1975), pp. 31-32.

corpuscular hematocrit, neutrophils, lymphocytes, monocytes, eosinophils, red blood cells, platelets, sodium, potassium and chloride.

The Model S Coulter Counter. White blood count, red blood count, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hematocrit were measured using the Model S Coulter Counter. The dilution was made by adding 44.7 microliters of blood to 10 cc. of Isoton. One cubic centimeter of this original dilution was transferred back through the diluter and 44.7 microliters of this was diluted further to make a 1:50,000 dilution for the red count. One cubic centimeter of lysing-Hgb reagent was added to the remaining 9 cc. sample to make a 1:250 dilution for the white blood count and hemoglobin readings. The lysing reagent both lyses the red cells and converts the hemoglobin to cyanmethemoglobin, with ninety-eight percent conversion in thirteen seconds. Triplicate counts were made of both red and white cells and an average reading was reported. The mean corpuscular volume was electronically determined on the red count side and the hematocrit was computed from the mean corpuscular volume and red count. The mean corpuscular hemoglobin and the mean corpuscular hematocrit were computed.

The operation of the Model S Coulter Counter begins with a priming of the unit by cycling Isoton a few times. It is important for an adequate amount of lysing reagent to come into the lysing chamber before running the test. The Isoton supply must be checked at this point. Next 4 C. must be run and the necessary calibrations made. The machine is never calibrated on the first run of 4 C., since there will be some dilution due to Isoton in the system. Next, a whole blood sample is aspirated through the center aspirator. This sample of whole blood must be rinsed out before switching to dilutions. Next a print-out card is put into the printer unit with care so that the red light comes on; this indicates the printer is activated. The diluted sample is run by switching the aspirator switch to 224/1 "dilution" position. This procedure will run a diluted sample to rinse Isoton out before starting the test run. Finally, a tube containing a diluted sample is placed under the right aspirator and the activator bar is pushed to begin the test. All 10 cc.'s of the sample must be aspirated. A card is placed in the printer and the results are printed.

Microscopic Examination. A blood smear using the slide technique was accomplished for each subject. A drop of blood from the venous blood sample was placed 0.5 inch from the end of the slide. The slide was then placed on a flat surface and a second slide was held between the fingers at an angle of 30°. This slide was placed on the first slide in front of the drop of blood, and pulled back into the blood. The blood was spread to each side of the slide to approximately two-thirds of the width of the slide. The spreader slide was then moved forward with a rapid, steady motion. The smear was thick or thin according to the speed of the movement and the angle at which the spreader slide was held. The blood smear was then air-dried and stained within one hour. The stains used were prepared by taking 10 milliliters of neutral absolute ethyl alcohol, and adding 1.1 milliliters of red stock solution. Then to three milliliters of this solution were added two or three drops of stock solution of Janus green. The stained cells appeared as follows: mitochondria, brilliant green; basophilic granules, brick red; neutrophilic granules, faint pink; and eosinophilic granules, bright yellow.

Platelets were counted by the following procedure. Blood was emptied from a syringe into a siliconized test tube. It was then drawn to the .05 mark in two red cell pipets and diluted with a diluting fluid of ammonium oxalate, 1%, in distilled water. The pipets were diluted to the 101 mark. They were then placed in a pipet rotor and vibrated for three minutes. Following the shaking procedure, four drops of the fluid were expelled. The remainder of the fluid was used to fill both chambers of a hemacytometer where it was covered with a number one cover. The hemacytometer was placed in a closed Petri dish kept humid with moist filter paper in the top half and allowed to stand for fifteen minutes. The platelets were then counted by phase microscopy in the central $mm.^2$ of each chamber. One hundred of these cells were counted to obtain the values for each subject.

Flame Photometer Test. The internal standard flame photometer was used to measure sodium and potassium. The serum was diluted in a standardized dilute solution of lithium nitrate. This solution was aspirated into the burner where it was evenly burned by a propane flame. Every element in the dilution was subjected to heat excitation. Under heat excitation, each cationic element emitted light at several wavelengths characteristic of the element. The higher the concentration of the element being excited, the more intense the light. Two monochromatons permitted only the light to be measured to pass from the chamber. The intensity of this light was measured by a photosensitive system, and the resultant electrical output difference activated a computer which registered the results on a readout device. Sodium and potassium were analyzed simultaneously, each using a separate channel and photosensitive system.

<u>Cotlove Chloridometer Test</u>. The Cotlove Chloridometer Test was used to measure chloride. Two pairs of electrodes were dipped in an electrolyte solution of the analytic sample. An electrical current involving one pair of electrodes produced silver ions which combined with the chloride ions of the sample. When there was a minute excess of silver ions present, the electrical potential of the second pair of electrodes was influenced in such a manner as to turn off a switch that stopped the flow of current in the first circuit and stopped an automatic timer. The time lapse multiplied by the generating current in amperes was expressed directly in coulombs, which in turn were identical with the number of equivalents of silver (and chloride) ions that were reacting.

The chloride was analyzed as follows: a titration vial containing chloride standard (0.1 ml.), acid reagent (4 ml.), and gelatin (4 drops), was placed in position. The titration switch was turned to "adjust," the timer was reset to zero, and the adjustable needle of the milliamp meter was set 10 scale divisions above the observed reading. The titration switch was then turned to the "titrate" position. Once the timer had stopped, the time was recorded to the nearest 0.1 second. The vial was removed and the electrodes were rinsed. The above procedures were repeated and the results recorded. The above procedures were repeated a second time using 0.1 milliliter of deionized water in lieu of the serum. The results of the blank sample were recorded. The above procedures were repeated for a third time using 0.1 milliliter of serum instead of standard chloride solution. The procedure was repeated a fourth time to duplicate results. The results were calculated: chloride (mEq/liter) = sample time in seconds - blank time in seconds. The duplicate results were averaged.

ANALYSIS OF DATA

The collected data were analyzed applying a two-way analysis of variance utilizing the Bio-medical Statistical Packet developed at the University of Southern California at Los Angeles and presently being employed by Middle Tennessee State University. A separate analysis applying repeated measures was computed for each dependent variable. When a significant F-ratio was obtained, Duncan's Multiple Range Test was used to locate the significant difference. The .05 level was used to determine significance, and all relationships were resolved by the Pearson Product-Moment Correlation Coefficient. All statistical computations were made utilizing Middle Tennessee State University's Honeywell 6000 computer.

CHAPTER 4

ANALYSIS AND DISCUSSION

A comparison of the pre-season conditioning period, the competitive season, and a one-week weight reduction interval was utilized to test the seven hypotheses related to significant changes occurring in selected physiological measurements. Variables utilized were the anthropometrical measures of age, height, weight, and body diameters; body composition; body circumferences; strength; muscular endurance; cardiovascular endurance; urine composition; and blood composition. The data were collected prior to, during, and following the wrestling season and were analyzed using a two-way analysis of variance with repeated measures. Means and standard deviations for all measures and the data for two-way analysis of variance were reported. The significant differences were located utilizing Duncan's Multiple Range Test.

ANTHROPOMETRIC MEASURES

Age, Height, and Weight

Age, height, and weight were measured during the initial testing session for both the experimental and control groups. These measures were used to identify the physical characteristics of the subjects used in this study. The means and standard deviations for age, height, and weight are reported in Table III.

TABLE III

AGE, HEIGHT, AND WEIGHT MEANS AND STANDARD DEVIATION VALUES

Group	Age yrs.	Height ins.	Weight lbs.
Exp.	15.81 ± 1.23	67.90 ± 3.51	139.98 ± 13.66
Con.	16.35 ± 0.94	67.81 ± 6.42	142.09 ± 28.01

The body weight of the wrestlers revealed no statistically significant differences throughout the wrestling season. The group means and standard deviations for high school varsity and "B" team wrestlers, and for junior high school varsity and "B" team wrestlers are reported in Table IV. Analysis of variance for weight is reported in Table V.

<u>Body Diameters</u>

Eleven body diameters were measured on five occasions for both the experimental and control groups. Some variability was noted among these measures and may have been the result of experimental errors of measurement or dehydration of the subjects. Group means and standard deviations for all body diameters are presented in Table VI.

TABLE IV

TEAM BODY WEIGHT MEAN AND STANDARD DEVIATION VALUES*

TEAM	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
High School Varsity					
Exp.	146.25 ± 16.73	147.20 ± 18.16	146.60 ± 16.89	144.75 ± 17.31	146.20 ± 15.45
Con.	153.33 ± 31.60	151.08 ± 36.16	150.00 ± 36.82	150.50 ± 36.02	150.50 ± 35.85
High School "B" Team					
Exp.	141.57 ± 8.38	140.43 ± 8.33	138.50 ± 10.53	139.64 ± 9.82	141.21 ± 10.36
Con.	134.96 ± 21.52	133.50 ± 20.20	135.67 ± 21.81	134.50 ± 22.55	134.00 ± 22.46
Junior High School Varsity					
Exp.	134.00 ± 21.43	130.67 ± 21.83	131.83 ± 21.95	130.33 ± 22.37	130.83 ± 22.81
Con.	147.92 ± 29.95	148.50 ± 30.78	146.00 ± 31.43	151.17 ± 30.93	150.83 ± 35.61
Junior High School "B" Team					
Exp.	135.25 ± 18.76	135.42 ± 15.64	136.67 ± 19.30	138.50 ± 16.26	139.17 ± 18.33
Con.	111.75 ± 0.00	112.00 ± 0.00	112.00 ± 0.00	114.00 ± 0.00	118.00 ± 0.00

*All values are in pounds

TABLE V

ANALYSIS OF VARIANCE FOR WEIGHT RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	79582.97	2411.61	
Control and Experimental Groups	1	244.88	244.88	0.10
Error (b)	32	79338.09	2479.32	
Within--Ss	136	2020.75	14.86	
Testing Periods Tc_1 - Tc_5	4	57.44	14.36	0.94
Interaction	4	7.81	1.95	0.13
Error (w)	128	1955.50	15.28	
Total	169	81603.72	482.86	

F-ratio needed for significance at .05 level, 2.45.

Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Biacromial Diameter. Analysis of the biacromial diameters revealed no significant changes during the training cycles or between the experimental group and control group. This data is presented in Table VII. The means and standard deviations for all chest diameters are presented in Table VI.

Chest Diameter. The analysis of chest diameter revealed no significant differences during the training cycles or between the experimental group and control group. This data is presented in Table VIII. The means and standard deviations for all chest diameters are reported in Table VI.

Chest Depth. There were no significant changes in chest depth during the training cycles or between the experimental group and control group. These data are presented in Table IX. The means and standard deviations for all chest depth measurements are presented in Table VI.

Bi-iliac Diameter. The analysis of bi-iliac diameters showed no significant change during the training cycles or between the experimental group and control group. These data are reported in Table X. The means and standard deviations for all bi-iliac diameters are reported in Table VI.

TABLE VI

GROUP BODY DIAMETER MEAN AND STANDARD DEVIATION VALUES*

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Biacromial					
Exp.	40.93 ± 2.10	41.66 ± 1.99	40.69 ± 5.13	41.80 ± 2.50	41.83 ± 2.58
Con.	40.95 ± 2.18	41.57 ± 2.80	41.73 ± 2.51	41.40 ± 2.75	41.70 ± 2.94
Chest					
Exp.	28.32 ± 1.80	28.85 ± 2.02	28.16 ± 2.85	29.13 ± 1.96	28.05 ± 4.24
Con.	28.55 ± 2.52	29.28 ± 2.48	28.74 ± 2.65	29.33 ± 2.31	29.68 ± 2.44
Chest Depth					
Exp.	19.93 ± 2.10	19.05 ± 1.42	20.61 ± 2.64	19.79 ± 1.46	19.66 ± 1.30
Con.	19.76 ± 2.44	19.27 ± 2.05	20.71 ± 3.44	20.19 ± 2.20	20.33 ± 2.08
Bi-iliac					
Exp.	26.88 ± 1.45	26.88 ± 1.25	27.25 ± 2.30	26.52 ± 1.35	26.46 ± 1.70
Con.	27.24 ± 2.82	27.22 ± 2.65	27.18 ± 2.41	26.95 ± 2.76	26.94 ± 2.45
Bitrochanteric					
Exp.	31.63 ± 1.59	30.77 ± 1.70	28.06 ± 8.47	30.91 ± 1.56	31.27 ± 1.43
Con.	32.39 ± 2.28	31.01 ± 2.32	31.69 ± 2.30	30.97 ± 2.03	31.45 ± 2.11
Wrist					
Exp.	11.42 ± 0.46	11.13 ± 0.55	10.46 ± 1.62	11.02 ± 0.51	11.01 ± 0.55
Con.	11.29 ± 0.67	11.12 ± 0.56	10.50 ± 1.75	10.98 ± 0.53	11.04 ± 0.66
Ankle					
Exp.	13.98 ± 0.68	13.28 ± 0.72	13.05 ± 0.68	13.29 ± 0.76	13.11 ± 0.43
Con.	14.22 ± 0.78	13.41 ± 0.71	13.23 ± 0.77	13.38 ± 0.68	13.41 ± 0.72

*All values are in centimeters

TABLE VII

ANALYSIS OF VARIANCE FOR BIACROMIAL DIAMETER RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	1316.91	39.91	
Control and Experimental Groups	1	24.61	24.61	0.61
Error (b)	32	1292.30	40.38	
Within--Ss	136	1432.25	10.53	
Testing Periods Tc_1 - Tc_5	4	59.05	14.76	1.43
Interaction	4	50.79	12.70	1.23
Error (w)	128	1322.41	10.33	
Total	169	2749.16	16.27	

F-ratio needed for significance at .05 level, 2.45.

TABLE VIII

ANALYSIS OF VARIANCE FOR CHEST DIAMETER RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	938.69	28.45	
Control and Experimental Groups	1	0.25	0.25	0.01
Error (b)	32	938.44	29.33	
Within--Ss	136	989.60	7.28	
Testing Periods Tc_1 - Tc_5	4	16.53	4.13	0.57
Interaction	4	47.05	11.76	1.63
Error (w)	128	926.02	7.23	
Total	169	1928.29	11.41	

F-ratio needed for significance at .05 level, 2.45.

TABLE IX

ANALYSIS OF VARIANCE FOR CHEST DEPTH RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	623.43	18.89	
Control and Experimental Groups	1	0.93	0.93	0.05
Error (b)	32	622.50	19.45	
<u>Within--Ss</u>	136	487.61	3.59	
Testing Periods Tc_1 - Tc_5	4	23.96	5.99	1.72
Interaction	4	18.08	4.52	1.30
Error (w)	128	445.57	3.48	
Total	169	1111.04	6.57	

F-ratio needed for significance at .05 level, 2.45.

TABLE X

ANALYSIS OF VARIANCE FOR BI-ILIAC RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	755.85	22.90	
Control and Experimental Groups	1	0.48	0.48	0.02
Error (b)	32	755.38	23.61	
Within--Ss	136	680.63	5.00	
Testing Periods Tc_1 - Tc_5	4	30.05	7.51	1.52
Interaction	4	19.66	4.92	1.00
Error (w)	128	630.92	4.93	
Total	169	1436.49	8.50	

F-ratio needed for significance at .05 level, 2.45.

<u>Bitrochanteric Diameter</u>. The changes in the bitrochanteric diameters were significantly different among the training cycles ($F=2.84$, $dF=4/136$, $p<.05$). The data are presented in Table XI. The results of the Duncan Multiple Range Test indicated the differences were located in the control group between training cycle one and training cycles two, three, four, and five. Changes were also evident between the experimental group and control group during training cycle three. The means and standard deviations for bitrochanteric diameters are presented in Table VI.

<u>Wrist Diameters</u>. Analysis of wrist diameters revealed there were significant differences among the training cycles ($F=5.63$, $dF=4/136$, $p<.05$). These data are presented in Table XII. The results of Duncan's Multiple Range Test revealed the differences for both wrist diameters to be located between training cycle one and training cycle five; training cycle two and training cycle five; and training cycle three and training cycle five for the experimental group. Also, there were differences located between training cycle one and training cycles two, three, four and five; and training cycle two and training cycle five for the control group. Changes were evident between the experimental group and the control group during

TABLE XI

ANALYSIS OF VARIANCE FOR BITROCHANTERIC DIAMETER RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	790.24	23.95	
Control and Experimental Groups	1	0.01	0.01	0.00
Error (b)	32	790.24	24.69	
<u>Within--Ss</u>	136	798.44	5.87	
Testing Periods Tc_1 - Tc_5	4	62.19	15.55	2.84**
Interaction	4	34.66	8.67	1.58
Error (w)	128	701.58	5.48	
Total	169	1588.68	9.40	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XII

ANALYSIS OF VARIANCE FOR TOTAL WRIST DIAMETER RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	49.34	1.50	
Control and Experimental Groups	1	0.55	0.55	0.36
Error (b)	32	48.79	1.52	
Within--Ss	136	53.86	0.40	
Testing Periods Tc_1 - Tc_5	4	7.88	1.97	5.63**
Interaction	4	1.17	0.29	0.84
Error (w)	128	44.81	0.35	
Total	169	103.20	0.61	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

training cycle four. The means and standard deviations for wrist diameters are reported in Table VI.

Ankle Diameters. Analysis of ankle diameters revealed there were significant changes among the training cycles for total ankle diameters ($F=60.29$, $dF=4/136$, $p<.05$). These data are presented in Table XIII. The results of the Duncan's Multiple Range Test showed the differences for the diameters of both ankles to be located between training cycle one and training cycles four and five; between training cycle two and training cycle five; between training cycle three and training cycle five; and between training cycle four and training cycle five for the experimental group. Differences were located between training cycle one and training cycle five; between training cycle two and training cycle five; between training cycle three and training cycle five; and between training cycle four and training cycle five for the control group. There were no significant differences located between the experimental group and the control group during the training cycles. The means and standard deviations for ankle diameters are reported in Table VI.

Summary

To summarize, age, height, and weight were used to identify the physical characteristics of the subjects

TABLE XIII

ANALYSIS OF VARIANCE FOR TOTAL ANKLE DIAMETER RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	75.48	2.29	
Control and Experimental Groups	1	1.53	1.53	0.66
Error (b)	32	73.95	2.31	
Within--Ss	136	30.15	0.22	
Testing Periods Tc_1 - Tc_5	4	19.53	4.88	60.29**
Interaction	4	0.26	0.06	0.79
Error (w)	128	10.37	0.08	
Total	169	105.63	0.63	

**$p<.05$ F-ratio needed for significance at .05 level, 2.45.

utilized in this study. The results showed there were no significant differences during the training cycles or between the experimental group and control group for weight, biacromial diameter, chest diameter, chest depth, and bi-iliac diameter. The results also showed there were significant changes during the training cycles and between the experimental group and control group for bitrochanteric diameter, wrist diameter, and ankle diameter.

BODY COMPOSITION MEASUREMENTS

Skinfolds

A total of six skinfolds were measured during five testing cycles for both the experimental and control groups. Considerable variability was noted among these measures. Skinfolds by their nature are difficult to reproduce. Possible reasons for these variations may have been experimental errors of measurement, dehydration of the subjects, or calibration of the skinfold calipers. These results should be viewed with the perspective limitations mentioned above. Group means and standard deviations for all skinfold measures are presented in Table XIV. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Scapulae Skinfold. Analysis of the scapulae skinfold measures showed no significant changes during the training cycles or between the experimental and control groups.

TABLE XIV

GROUP SKINFOLD MEAN AND STANDARD DEVIATION VALUES*

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Scapulae					
Exp.	10.17 ± 3.59	9.44 ± 2.94	9.95 ± 1.99	10.22 ± 2.34	10.17 ± 2.28
Con.	11.39 ± 5.23	11.39 ± 5.46	11.06 ± 5.90	12.63 ± 5.83	11.13 ± 5.70
Triceps					
Exp.	9.00 ± 3.29	11.56 ± 3.18	9.00 ± 3.66	11.11 ± 2.49	13.17 ± 3.97
Con.	10.89 ± 3.18	12.00 ± 4.45	10.94 ± 4.60	11.94 ± 3.64	13.25 ± 5.00
Chest					
Exp.	3.89 ± 0.83	5.00 ± 1.68	5.39 ± 3.57	4.44 ± 0.92	4.33 ± 0.91
Con.	3.78 ± 0.94	4.61 ± 1.79	4.81 ± 1.64	5.13 ± 1.41	4.25 ± 0.93
Suprailiac					
Exp.	8.72 ± 2.52	14.17 ± 4.66	13.33 ± 3.66	13.78 ± 4.11	15.33 ± 3.29
Con.	9.44 ± 4.96	14.39 ± 6.43	15.31 ± 7.10	15.94 ± 8.70	15.81 ± 7.58
Abdomen					
Exp.	13.94 ± 5.83	14.33 ± 4.60	12.22 ± 4.14	12.89 ± 4.39	13.56 ± 4.71
Con.	15.61 ± 7.92	14.89 ± 8.23	13.63 ± 6.64	14.94 ± 8.53	14.44 ± 7.75
Thigh					
Exp.	13.28 ± 4.44	15.22 ± 3.81	16.50 ± 9.77	15.17 ± 3.71	15.28 ± 3.25
Con.	15.33 ± 4.74	15.78 ± 5.72	14.38 ± 4.24	17.31 ± 6.99	16.44 ± 5.40

*All values are in millimeters

These data are presented in Table XV. The means and standard deviations for scapulae skinfold measures are presented in Table XIV.

Triceps Skinfold. The changes in the triceps skinfold measures were significantly different among the training cycles ($F=7.91$, $dF=4/136$, $p<.05$). The data are presented in Table XVI. The results of Duncan's Multiple Range Test for the experimental group indicated the differences were located between training cycle one and training cycles three, four, and five; between training cycle two and training cycles four and five; and between training cycle four and training cycle five. Differences were found in the control group between training cycle one and training cycle five, and between training cycle two and training cycle five. Changes were also evident between the experimental group and the control group during training cycle one and training cycle three. The means and standard deviations for triceps skinfolds are presented in Table XIV.

Chest Skinfold. Analysis of chest skinfold measures revealed there was a significant change among the training cycles ($F=6.27$, $dF=4/136$, $p<.05$). These data are presented in Table XVII. The results of Duncan's Multiple Range Test showed the differences for the chest skinfolds for the

TABLE XV

ANALYSIS OF VARIANCE FOR SCAPULAE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	2680.62	81.23	
Control and Experimental Groups	1	95.70	95.70	1.18
Error (b)	32	2584.92	80.78	
Within--Ss	136	408.15	3.00	
Testing Periods Tc_1 - Tc_5	4	18.60	4.65	1.64
Interaction	4	26.39	6.60	2.33
Error (w)	128	363.16	2.84	
Total	169	3088.78	18.28	

F-ratio needed for significance at .05 level, 2.45.

TABLE XVI

ANALYSIS OF VARIANCE FOR TRICEPS SKINFOLD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	1404.49	42.56	
Control and Experimental Groups	1	32.28	32.28	0.75
Error (b)	32	1372.21	42.88	
Within--Ss	136	1208.21	8.88	
Testing Periods Tc_1 - Tc_5	4	237.03	59.26	7.91**
Interaction	4	12.85	3.21	0.43
Error (w)	128	958.33	7.49	
Total	169	2612.70	15.46	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XVII

ANALYSIS OF VARIANCE FOR CHEST SKINFOLD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	120.82	3.66	
Control and Experimental Groups	1	1.11	1.11	0.29
Error (b)	32	119.71	3.74	
Within--Ss	136	160.27	1.18	
Testing Periods $Tc_1 - Tc_5$	4	25.14	6.29	6.27**
Interaction	4	6.79	1.70	1.69
Error (w)	128	128.34	1.00	
Total	169	281.09	1.66	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

experimental group were located between training cycle one and training cycles three, four, and five; between training cycle two and training cycle five; between training cycle three and training cycle five; and between training cycle four and training cycle five. Differences for the control group were located between training cycle one and training cycles three, four, and five; between training cycle two and training cycles four and five; and between training cycle three and training cycle five. Differences were also evident between the experimental group and the control group during training cycle four. The means and standard deviations for chest skinfold measures are reported in Table XIV.

Suprailiac Skinfold. The changes in the suprailiac skinfolds were significantly different among the training cycles ($F=35.82$, $dF=4/136$, $p<.05$). The data are presented in Table XVIII. The results of Duncan's Multiple Range Test located the differences in the experimental group between training cycle one and training cycles two, three, four, and five; and between training cycle two and training cycle five. In the control group differences were found between training cycle one and training cycles two, three, four, and five in the control group. Differences also appeared between the experimental group and the control group during

TABLE XVIII

ANALYSIS OF VARIANCE FOR SUPRAILIAC SKINFOLD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	4304.99	130.45	
Control and Experimental Groups	1	50.99	50.99	0.38
Error (b)	32	4254.01	132.94	
<u>Within--Ss</u>	136	1840.00	13.53	
Testing Periods Tc_1 - Tc_5	4	962.55	240.64	35.82**
Interaction	4	17.45	4.36	0.65
Error (w)	128	859.99	6.72	
Total	169	6144.99	36.36	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

training cycle four. The means and standard deviations for suprailiac skinfold measures are presented in Table XIV.

Abdomen Skinfold. The changes in the abdominal skinfold measures were significantly different among the training cycles ($F=4.06$, $dF=4/136$, $p<.05$). The data are presented in Table XIX. The results of Duncan's Multiple Range Test showed the differences to be located between training cycle one and training cycles three, four, and five; and between training cycle two and training cycle five for the experimental group. In the control group, differences were located between training cycle one and training cycle five; between training cycle two and training cycle five; and between training cycle three and training cycle five. Differences were also noted between the experimental group and the control group during training cycles one, three, and four. The means and standard deviations for abdominal skinfold measures are reported in Table XIV.

Thigh Skinfold. The changes in the thigh skinfold measures were significantly different among the training cycles ($F=3.87$, $dF=4/136$, $p<.05$). The data are presented in Table XX. The results of Duncan's Multiple Range Test indicated the differences in the experimental group were located between training cycle one and training cycles

TABLE XIX

ANALYSIS OF VARIANCE FOR ABDOMEN SKINFOLD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	5963.69	180.72	
Control and Experimental Groups	1	60.28	60.28	0.33
Error (b)	32	5903.41	184.48	
Within--Ss	136	796.80	5.86	
Testing Periods Tc_1 - Tc_5	4	88.85	22.21	4.06**
Interaction	4	7.13	1.78	0.33
Error (w)	128	700.82	5.84	
Total	169	6760.49	40.00	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XX

ANALYSIS OF VARIANCE FOR THIGH SKINFOLD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	2642.12	80.06	
Control and Experimental Groups	1	56.45	56.15	0.69
Error (b)	32	2585.98	80.81	
<u>Within--Ss</u>	136	1310.40	9.64	
Testing Periods Tc_1 - Tc_5	4	140.91	35.23	3.87**
Interaction	4	3.05	0.76	0.08
Error (w)	128	1166.45	9.11	
Total	169	3952.52	23.39	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

three, four and five; and between training cycle two and training cycles three, four and five. In the control group, differences were located between training cycle one and training cycles three, four and five; and between training cycle two and training cycles three, four, and five in the control group. Differences were also found between the experimental group and the control group during training cycles one, three, and four. The means and standard deviations for thigh skinfold measures are reported in Table XIV.

Summary

A review of skinfold measurements for the experimental group exhibited significant changes in triceps, chest, suprailiac, abdomen, and thigh skinfold measures while scapulae skinfold measures did not change significantly. These changes appeared during the training cycles and between the experimental group and control group.

BODY CIRCUMFERENCE MEASURES

Body Circumferences

Two body circumference measures were taken during the five testing cycles for both the experimental and control groups. Group means and standard deviations for all body circumferences are presented in Table XXI. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

TABLE XXI

GROUP BODY CIRCUMFERENCE MEAN AND STANDARD DEVIATION VALUES*

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Gleuteal Cir.					
Exp.	89.88 ± 4.22	87.16 ± 3.48	86.55 ± 4.27	86.19 ± 5.10	86.78 ± 4.16
Con.	91.66 ± 7.83	87.99 ± 8.07	86.61 ± 7.42	86.34 ± 8.10	86.83 ± 7.72
Thigh Cir.					
Exp.	48.47 ± 3.26	49.31 ± 2.90	47.87 ± 3.46	48.23 ± 3.21	47.82 ± 3.33
Con.	49.23 ± 4.20	49.53 ± 6.26	48.57 ± 5.57	47.99 ± 5.66	48.20 ± 4.81

***All values are in centimeters**

<u>Gluteal Circumference</u>. The changes in the gluteal circumference were significantly different among the training cycles ($F=4.94$, $dF=4/136$, $p<.05$). These data are presented in Table XXII. The results of Duncan's Multiple Range Test established the differences in the experimental group between training cycle one and training cycles two, three, four and five; between training cycle two and training cycle five; and between training cycle three and training cycle five. Differences were found in the control group between training cycle one and training cycle five; between training cycle two and training cycle five; and between training cycle three and training cycle five. Changes were not evident between the experimental group and the control group during any of the training cycles. The means and standard deviations for gluteal circumference measurements are presented in Table XXI.

<u>Thigh Circumference</u>. Analysis of thigh circumference revealed there were significant changes among the training cycles ($F=3.60$, $dF=4/136$, $p<.05$). These data are presented in Table XXIII. The results of Duncan's Multiple Range Test indicate the differences in the experimental group were located between training cycle one and training cycle five; between training cycle two and training cycle five; and and between training cycle three and training cycle five.

TABLE XXII

ANALYSIS OF VARIANCE FOR GLUTEAL CIRCUMFERENCE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	7487.86	226.90	
Control and Experimental Groups	1	65.02	65.02	0.28
Error (b)	32	7422.84	231.96	
Within--Ss	136	5229.59	38.45	
Testing Periods Tc_1 - Tc_5	4	686.28	171.57	4.94**
Interaction	4	97.33	24.33	0.70
Error (w)	128	4445.98	34.73	
Total	169	12717.45	75.25	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XXIII

ANALYSIS OF VARIANCE FOR THIGH CIRCUMFERENCE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	2602.14	78.85	
Control and Experimental Groups	1	2.83	2.83	0.03
Error (b)	32	2599.30	81.23	
Within--Ss	136	446.62	3.28	
Testing Periods Tc_1 - Tc_5	4	44.79	11.20	3.60**
Interaction	4	3.95	0.99	0.32
Error (w)	128	379.88	3.11	
Total	169	3048.76	18.04	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

Differences in the control group were located between training cycle one and training cycle five; between training cycle two and training cycle five; and between training cycle three and training cycle five. No apparent differences were found between the experimental group and the control group during any of the training cycles. The means and standard deviations for thigh circumference measures are presented in Table XXI.

Summary

Body circumference measures for the experimental group showed significant changes in both gluteal and thigh circumferences. These changes were evident during the training cycles; however, there were no apparent changes between the experimental group and control group during the training cycles.

STRENGTH MEASURES

Muscular Strength

A total of five strength measures were taken during all testing cycles for both the experimental and control groups. Some variability was noted among the strength measures which may have been caused by experimental errors, or calibration of the cable tensiometer. These measures should be viewed with the perspective of the limitations mentioned above. Group means and standard deviations are presented in Table XXIV. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Grip Strength. Analysis of grip strength revealed there were significant changes among the training cycles ($F=23.05$, $dF=4/136$, $p<.05$). These data are presented in Table XXV. The results of Duncan's Multiple Range Test revealed the differences for grip strength to be located between training cycle one and training cycles two, three, four, and five in the experimental group. Differences were located between training cycle one and training cycles two, three, four, and five in the control group. Differences were also found to exist between the experimental group and the control group during training cycles one, two, three, four, and five. The means and standard deviations for grip strength are reported in Table XXIV.

Elbow Flexion. The changes in elbow extension strength were significantly different among the training cycles ($F=3.10$, $dF=4/136$, $p<.05$). These data are presented in Table XXVI. The results of Duncan's Multiple Range Test indicated the differences were located between training cycle one and training cycles four and five; between training cycle two and training cycle five; and between training cycle three and training cycle five for the experimental group. Differences were found between training

TABLE XXIV

GROUP MUSCULAR STRENGTH MEAN AND STANDARD DEVIATION VALUES*

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Grip Strength					
Exp.	67.78 ± 10.01	85.57 ± 6.37	89.43 ± 6.26	88.70 ± 6.22	93.20 ± 6.68
Con.	74.70 ± 10.15	91.40 ± 7.62	93.28 ± 7.07	91.88 ± 6.83	96.25 ± 8.21
Elbow Flexion					
Exp.	78.90 ± 7.76	74.45 ± 6.15	66.80 ± 5.59	62.93 ± 5.31	64.18 ± 5.49
Con.	76.65 ± 7.51	48.90 ± 4.59	69.85 ± 5.71	64.70 ± 5.10	66.25 ± 4.89
Elbow Extension					
Exp.	54.07 ± 9.52	55.55 ± 7.05	59.58 ± 6.16	63.05 ± 5.61	63.33 ± 5.30
Con.	54.88 ± 8.10	62.65 ± 5.58	59.85 ± 5.26	64.85 ± 5.46	66.40 ± 5.15
Knee Flexion					
Exp.	72.20 ± 5.84	65.28 ± 4.93	67.78 ± 4.36	69.85 ± 6.71	65.55 ± 5.21
Con.	70.55 ± 8.90	64.08 ± 6.10	65.78 ± 5.55	63.28 ± 5.08	63.28 ± 4.45
Knee Extension					
Exp.	99.45 ± 9.88	92.20 ± 8.26	104.85 ± 8.61	108.90 ± 8.23	108.90 ± 8.22
Con.	100.00 ± 7.86	104.08 ± 8.08	107.20 ± 9.27	106.58 ± 9.47	110.65 ± 7.29

*All values are in pounds

TABLE XXV

ANALYSIS OF VARIANCE FOR GRIP STRENGTH RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	7120.80	215.78	
Control and Experimental Groups	1	99.76	99.76	0.45
Error (b)	32	7021.04	219.41	
Within--Ss	136	3911.20	28.76	
Testing Periods $Tc_1 - Tc_5$	4	1636.35	409.09	23.05**
Interaction	4	3.52	0.88	0.05
Error (w)	128	2271.32	17.74	
Total	169	11032.00	65.28	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XXVI

ANALYSIS OF VARIANCE FOR ELBOW FLEXION RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	3467.01	105.06	
Control and Experimental Groups	1	15.80	15.80	0.15
Error (b)	32	3451.21	107.85	
Within--Ss	136	3805.07	27.98	
Testing Periods Tc_1 - Tc_5	4	329.19	82.30	3.10**
Interaction	4	77.57	19.39	0.73
Error (w)	128	3398.31	26.55	
Total	169	7272.09	43.03	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

cycle one and training cycle five for the control group. Additional differences were located between the experimental group and the control group for training cycles two and three. The means and standard deviations for elbow flexion are presented in Table XXIV.

Elbow Extension. The analysis of elbow extension strength revealed there were significant changes among the training cycles ($F=4.43$, $dF=4/136$, $p<.05$). The data are presented in Table XXVII. The results of Duncan's Multiple Range Test indicated the differences were located between training cycle one and training cycles four and five; between training cycle two and training cycle five; and between training cycle three and training cycle five for the experimental group. Differences were observed between training cycle one and training cycles three, four and five in the control group. Other differences were noted between the experimental group and the control group for training cycle two. The means and standard deviations for elbow extension are reported in Table XXIV.

Knee Flexion. Analysis of knee flexion strength measures showed no significant changes during the training cycles or between the experimental and control groups. Group means and standard deviations for knee flexion

TABLE XXVII

ANALYSIS OF VARIANCE FOR ELBOW EXTENSION RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	4070.13	123.34	
Control and Experimental Groups	1	6.28	6.28	0.05
Error (b)	32	4063.85	127.00	
Within--Ss	136	5801.91	42.66	
Testing Periods $Tc_1 - Tc_5$	4	694.58	173.65	4.43**
Interaction	4	85.28	21.32	0.54
Error (w)	128	5022.05	39.23	
Total	169	9872.04	58.41	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

strength measures are reported in Table XXVIII. The means and standard deviations for knee flexion are reported in Table XXIV.

Knee Extension. The changes in knee extension strength measures were significantly different among the training cycles ($F=4.86$, $dF=4/136$, $p<.05$). The data are presented in Table XXIX. The results of Duncan's Multiple Range Test placed the differences between training cycle one and training cycles three, four, and five; and between training cycle two and training cycles four and five for the experimental group. Differences were discovered between training cycle one and training cycles three, four, and five in the control group. Differences also appeared between the experimental group and control group for training cycle two. The means and standard deviations for knee extension are reported in Table XXIV.

Summary

Muscular strength of the experimental group changed significantly in the areas of grip strength, elbow flexion, elbow extension, and knee extension. These changes occurred during the training cycles and between the experimental group and control group. There were no significant changes in knee flexion.

TABLE XXVIII

ANALYSIS OF VARIANCE FOR KNEE FLEXION RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	3480.38	105.47	
Control and Experimental Groups	1	63.99	63.99	0.60
Error (b)	32	3416.39	106.76	
Within--Ss	136	2056.80	15.12	
Testing Periods Tc_1 - Tc_5	4	91.47	22.87	1.51
Interaction	4	23.85	5.96	0.39
Error (w)	128	1941.48	15.17	
Total	169	5537.18	32.76	

F-ratio needed for significance at .05 level, 2.45.

TABLE XXIX

ANALYSIS OF VARIANCE FOR KNEE EXTENSION RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	8693.80	263.45	
Control and Experimental Groups	1	16.54	16.54	0.06
Error (b)	32	8677.25	271.16	
<u>Within--Ss</u>	136	3826.00	28.13	
Testing Periods Tc_1 - Tc_5	4	493.06	123.26	4.86**
Interaction	4	87.83	21.96	0.87
Error (w)	128	3245.11	25.35	
Total	169	12519.79	74.08	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

MUSCULAR ENDURANCE MEASURES

Muscular Endurance

Two muscular endurance measures were recorded on five occasions for both the experimental and control groups. Group means and standard deviations are presented in Table XXX. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Pull-ups. The changes in the pull-up measures were significantly different among the training cycles ($F=14.53$, $dF=4/136$, $p<.05$). These data are presented in Table XXXI. The results of Duncan's Multiple Range Test show the differences to be located between training cycle one and training cycles two, three, four, and five; between training cycle two and training cycles four and five; and between training cycle three and training cycle five for the experimental group. Differences were located between training cycle one and training cycles two, three, four and five in the control group. Differences also appeared between the experimental group and control group for training cycles four and five. The means and standard deviations for pull-ups are reported in Table XXX.

Dips. The changes in the dip measures were significantly different among the training cycles ($F=5.57$, $dF=4/136$, $p<.05$). The data are presented in Table XXXII.

TABLE XXX

GROUP MUSCULAR ENDURANCE MEAN AND STANDARD DEVIATION VALUES

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Pull-ups					
Exp.	9.17 ± 4.81	11.56 ± 4.12	12.72 ± 4.42	13.78 ± 4.24	14.56 ± 4.59
Con.	9.38 ± 4.98	11.86 ± 4.91	12.25 ± 5.13	12.06 ± 5.03	12.69 ± 5.43
Dips					
Exp.	11.89 ± 7.25	15.39 ± 6.94	14.44 ± 7.53	16.56 ± 7.14	17.28 ± 8.15
Con.	12.50 ± 7.27	15.25 ± 6.55	14.50 ± 5.92	14.88 ± 7.28	14.19 ± 7.42

TABLE XXXI

ANALYSIS OF VARIANCE FOR PULL-UPS RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	2756.01	83.51	
Control and Experimental Groups	1	21.08	21.08	0.25
Error (b)	32	2734.82	85.46	
Within--Ss	136	1296.00	9.53	
Testing Periods $Tc_1 - Tc_5$	4	393.32	98.33	14.53**
Interaction	4	36.52	9.13	1.35
Error (w)	128	866.16	6.77	
Total	169	4051.91	23.98	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XXXII

ANALYSIS OF VARIANCE FOR DIPS RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	6557.28	198.71	
Control and Experimental Groups	1	30.50	30.50	0.15
Error (b)	32	6526.78	203.96	
<u>Within--Ss</u>	136	2187.60	16.09	
Testing Periods Tc_1 - Tc_5	4	312.96	78.24	5.57**
Interaction	4	77.67	19.42	1.38
Error (w)	128	1796.97	14.04	
Total	169	8744.88	51.74	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

The results of Duncan's Multiple Range Test indicated the differences were located between training cycle one and training cycles two, three, four, and five; and between training cycle two and training cycles four and five in the experimental group. Differences were located between training cycle one and training cycles three, four, and five in the control group. Differences also appeared between the experimental group and control group for training cycle five. The means and standard deviations for dips are reported in Table XXX.

Summary

Pull-ups and dips were measured to determine muscular endurance. Both of these measures changed significantly for the experimental group during the training cycles and between the experimental group and control group.

CARDIOVASCULAR ENDURANCE MEASURE

Physical Work Capacity

Two measures of physical work capacity were taken during each testing period for both the experimental and control groups. Group means and standard deviations are presented in Table XXXIII. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Heart Rate--Fifth Minute. The changes in the heart rate for the fifth-minute measure were significantly

TABLE XXXIII

GROUP CARDIOVASCULAR ENDURANCE MEAN AND STANDARD DEVIATION VALUES*

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Heart Rate Fifth-Minute					
Exp.	163.28 ± 21.23	160.00 ± 13.02	166.67 ± 5.66	166.00 ± 4.60	168.00 ± 7.13
Con.	154.63 ± 15.17	157.50 ± 11.49	163.88 ± 6.47	164.25 ± 5.74	166.50 ± 4.10
Heart Rate Sixth-Minute					
Exp.	172.33 ± 20.46	180.33 ± 9.76	179.33 ± 6.47	178.00 ± 4.60	180.00 ± 7.13
Con.	163.69 ± 15.79	171.75 ± 8.45	177.00 ± 6.93	176.25 ± 5.74	178.50 ± 4.10

*All values are in beats per minute

different between the experimental and control groups, as well as between the training cycles ($F=4.80$, $dF=4/136$, $p<.05$). The data are presented in Table XXXIV. Duncan's Multiple Range Test revealed the differences were located between training cycle one and training cycles three, four, and five in the experimental group. Differences were observed between training cycle one and training cycles three, four, and five; and between training cycle two and training cycles three, four, and five in the control group. Differences were located between the experimental group and control group during training cycle one. The means and standard deviations for fifth-minute heart rate are found in Table XXXIII,

Heart Rate--Sixth Minute. The analysis of heart rate at the end of the sixth-minute revealed there were significant changes between the experimental and control groups and between the training cycles ($F=6.96$, $dF=4/136$, $p<.05$). These data are presented in Table XXXV. The results of Duncan's Multiple Range Test indicate the differences were located between training cycle one and training cycles two, three, four, and five for the experimental group. Differences were located between training cycle one and training cycles two, three, four, and five; and between training cycle two and training cycles

TABLE XXXIV

ANALYSIS OF VARIANCE FOR HEART RATE FIFTH-MINUTE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	5416.88	164.15	
Control and Experimental Groups	1	500.88	500.88	3.26**
Error (b)	32	4916.00	153.63	
Within--Ss	136	16023.19	117.82	
Testing Periods Tc_1 - Tc_5	4	2053.81	513.45	4.80**
Interaction	4	297.25	74.31	0.70
Error (w)	128	13672.13	106.81	
Total	169	21440.06	126.86	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XXXV

ANALYSIS OF VARIANCE FOR HEART RATE SIXTH-MINUTE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	5214.88	158.03	
Control and Experimental Groups	1	881.63	881.63	6.51**
Errow (b)	32	4333.25	135.41	
Within--Ss	136	15130.44	111.25	
Testing Periods Tc_1 - Tc_5	4	2619.56	654.89	6.96**
Interaction	4	466.69	116.67	1.24
Error (w)	128	12044.19	94.10	
Total	169	20345.31	120.39	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

four and five for the control group. Additional changes were located between the experimental group and control group during training cycle one and training cycle two. The means and standard deviations for sixth-minute heart rate are presented in Table XXXIII.

Summary

The fifth and sixth-minute heart rates changed significantly for the experimental group. These changes appeared during the training cycles, and between the experimental group and control group.

URINE COMPOSITION

Urine composition was measured by evaluating seventeen elements on five occasions for both the experimental and control groups. Group means and standard deviations are presented in Table XXXVI. Only when a significant F-ratio was computed were Analysis of Variance Tables presented. Duncan's Multiple Range Test was used to locate the significant differences. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

Color and Clarity. Each urine sample was observed for both color and clarity. All the samples were yellow or straw-colored and were clear for training cycle one in both the experimental and control groups. By the time the subjects had completed training cycle two, several

TABLE XXXVI

GROUP URINE MEAN AND STANDARD DEVIATION VALUES

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Specific Gravity					
Exp.	1.028 ± 0.0028	1.026 ± 0.0068	1.025 ± 0.0046	1.028 ± 0.0035	1.028 ± 0.0038
Con.	1.025 ± 0.0051	1.028 ± 0.0045	1.026 ± 0.0054	1.030 ± 0.0036	1.027 ± 0.0034
Potassium (mEq/liter)					
Exp.	198.56 ± 76.82	213.56 ± 75.60	142.28 ± 51.90	173.17 ± 60.46	164.11 ± 58.49
Con.	184.50 ± 48.18	130.00 ± 75.11	132.06 ± 52.81	139.13 ± 62.00	159.56 ± 62.01
Sodium (mEq/liter)					
Exp.	111.59 ± 29.46	113.28 ± 30.88	92.97 ± 30.31	91.67 ± 31.49	101.23 ± 26.71
Con.	110.80 ± 25.88	105.09 ± 40.58	102.17 ± 55.16	109.33 ± 32.61	122.71 ± 34.18

individuals began to have slightly cloudy urine; however, evidence was inconclusive as to a possible cause for this phenomenon. This condition continued throughout the remainder of the competitive season.

Protein. The urine samples were examined by the Clinistix Method[1] and reflected only traces of protein for three individuals during the pre-conditioning period. By the end of training cycle two, the protein count had increased from a trace (5-20 mg./100 ml.) to a +1 mg. (30 mg. % protein) level for those who were repeatedly making weight for meets. These levels were above the normal level of zero. Similar effects were noted during the weight reduction period. By the end of the competitive season, the protein level had receded to a slight trace level for most of the wrestlers; only three individuals in the control group remained at the +1 mg. level.

Glucose. Glucose was measured using the Labstix Method[2] and the analysis showed all the urine samples to have a value of zero in glucose for both the experimental

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[1]Sam Frankel, Stanley Reitman, and Alex C. Sonnenwirth, eds., Gradwohl's Clincial Laboratory Method and Diagnosis (7th edition.; St. Louis: C. V. Mosby Company, 1970), p. 1877.

[2]Frankel, Reitman, and Sonnenwirth, pp. 1875-1876.

and control groups during the five training cycles. These values reflect the healthy status of the subjects.

Hydrogen-ion Concentration. The Labstix Method[3] was used to determine pH. Examination of the urine samples showed only a slight change in the hydrogen-ion concentration or pH during the training cycles and between the experimental and control groups. The pH level of the urine samples of the experimental group varied slightly, ranging from 5.69 for training cycle one to a low of 5.22 for training cycle three. There was a slight rise in pH level during the weight reduction interval. Finally, there was another slight rise in pH near the end of the season.

Acetone. The acetone bodies were measured using the Labstix Method.[4] Only two individuals registered acetone bodies. The first case registered a 2+ rating during training cycle two. The subject was in the experimental group. The other case showed a trace of acetone bodies during training cycle three. The subject was in the control group.

Specific Gravity. Specific gravity changed significantly among the training cycles for both the experimental

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[3] Frankel, Reitman, and Sonnenwirth, pp. 1875-1876.

[4] Frankel, Reitman, and Sonnenwirth, pp. 1875-1876.

and control groups ($F=3.33$, $dF=4/136$, $p<.05$). The data are presented in Table XXXVII. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles two, three, four, and five in the experimental group. Differences were found between training cycle one and training cycles two, three, four, and five; and between training cycle three and training cycle five for the control group. Additional differences were found between the experimental group and control group during training cycle one. The means and standard deviations for specific gravity of the urine are presented in Table XXXVI.

White Blood Cells. The white blood cells appearing in the urine were highly unstable during the various training cycles. The white blood cell count ranged from rare to as high as 15 and appeared to increase whenever there were variations in weight, increases in exercise workload, or increases in stress associated with upcoming competition.

Red Blood Cells. Red blood cells rarely appeared in the urine. Four different subjects in the study reflected an increase in red blood cell count during the course of the study. In the experimental group, one individual showed an increase of 0-2, mg./100 ml. during training cycle

TABLE XXXVII

ANALYSIS OF VARIANCE FOR SPECIFIC GRAVITY RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	0.0017	0.00005	
Control and Experimental Groups	1	0.0002	0.00002	0.29
Error (b)	32	0.0017	0.00005	
Within--Ss	136	0.0032	0.00002	
Testing Periods Tc_1 - Tc_5	4	0.0003	0.00007	3.33**
Interaction	4	0.0003	0.00006	3.13
Error (w)	128	0.0026	0.00002	
Total	169	0.0049	0.00003	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

one, and another individual showed a similar increase during training cycle two. In the control group, one individual showed an increase of 3-4 mg./100 ml. in training cycle one, and another individual showed an increase of 2-3 mg./100 ml. in training cycle three.

Casts. Casts appeared in the urine of 35 percent of the wrestlers following the pre-conditioning period (28 percent for the experimental group and 44 percent for the control group); in 56 percent of the wrestlers during the early season (61 percent for the experimental group and 50 percent for the control group); in 47 percent of the wrestlers during the weight reduction interval (44 percent for the experimental group and 50 percent for the control group); and in 26 percent of the wrestlers by the end of the season (27 percent for the experimental group and 25 percent for the control group).

Parasites. Parasites did not appear in the urine of any of the wrestlers in this study. This supports the fact that these young men were normal, well-conditioned, physically-fit individuals.

Crystals. Crystals appeared in the urine of both the experimental and control groups. Two kinds of crystals were observed: amorphous and calcium oxalate. The appearance of crystals was irregular and was observed occasionally during single training cycles for approximately 7 percent of the wrestlers. They appeared to be unrelated to any other items in the urinalyses.

Bacteria. Bacteria was present in one individual each, in training cycles one and two. Both individuals were members of the control group and showed 2+ and 1+ cocci bacteria respectively. By the end of the early competitive season, 56 percent of the wrestlers evidenced cocci bacteria. By the end of the weight reduction period, 68 percent of the wrestlers had cocci bacteria. By the end of the season, 50 percent of the wrestlers had cocci bacteria. It is also interesting to note that one individual in the control group during training cycles four and five showed bacillus bacteria in addition to the cocci bacteria previously noted. Also interesting is the fact that when the cocci bacteria reached a 3+ level, the white blood cell count also rose. The normal bacteria count in the urine is zero.

Epithelial Cell Count. An epithelial cell count appeared in the urine samples of 26 percent of the wrestlers during the pre-season conditioning period, a decrease of 9 percent below the base established during training cycle one. By the end of the early season, the epithelial cell count had decreased to 18 percent or 17 percent below the base established during training cycle one. During the weight reduction interval, the epithelial cell count had increased by 8 percent to a level of 26 percent. By the end of the season, the level of the epithelial cell count had increased an additional 18 percent to a total count of 44 percent. This was 9 percent above the base established in training cycle one. The normal epithelial cell count is zero.

Mucous Cell Count. Mucous appeared in the urine samples of 29 percent of the wrestlers during the pre-season conditioning period, a decrease of 24 percent from the base established in training cycle one. By the end of the early season, mucous cells had increased an additional 18 percent, to 44 percent. By the end of the weight reduction interval, mucous cells had increased an additional 21 percent to 65 percent. By the end of the season, the mucous count had stabilized and remained at the 65 percent level. The normal mucous cell count is zero.

Sodium. The sodium content of the urine changed significantly among the training cycles ($F=2.49$, $dF=4/136$, $p<.05$). The data are presented in Table XXXVIII. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles three, four, and five; and between training cycle two and

TABLE XXXVIII

ANALYSIS OF VARIANCE FOR SODIUM RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	84331.50	2555.50	
Control and Experimental Groups	1	4651.52	4651.52	1.87
Error (b)	32	79679.98	2489.99	
<u>Within--Ss</u>	136	124917.88	918.51	
Testing Periods Tc_1 - Tc_5	4	8534.69	2133.67	2.49**
Interaction	4	6678.45	1669.61	1.95
Error (w)	128	109704.73	857.07	
Total	169	209249.38	1238.16	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

training cycles four and five in the experimental group. There were also differences between training cycle one and training cycle five; and between training cycle two and training cycle five in the control group. Differences appeared between the experimental group and the control group during training cycle two and training cycle four. The means and standard deviations for sodium content found in the urine are reported in Table XXXVI.

Potassium. The potassium concentration in the urine changed significantly among the training cycles and between the experimental and control groups ($F=4.75$, $dF=4/136$, $p<.05$). The data are presented in Table XXXIX. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles three, four, and five; between training cycle two and training cycles three, four, and five; and between training cycle three and training cycle five in the experimental group. There were also differences between training cycle one and training cycles four and five; between training cycle two and training cycle five; and between training cycle three and training cycle five in the control group. There were no differences located between the experimental group and the control group during any of the training cycles. The means and standard deviations for potassium content of the urine are reported in Table XXXVI.

TABLE XXXIX

ANALYSIS OF VARIANCE FOR POTASSIUM RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	319190.50	9672.44	
Control and Experimental Groups	1	31629.50	31629.50	3.52**
Error (b)	32	287561.00	8986.28	
Within--Ss	136	437047.94	3213.59	
Testing Periods Tc_1 - Tc_5	4	53041.00	13260.25	4.75**
Interaction	4	27025.88	6756.47	2.42
Error (w)	128	356981.06	2788.91	
Total	169	756238.44	4474.78	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

Summary

Seventeen measures were evaluated to determine significant changes in urine composition. The urine samples were either yellow or straw-colored and were either clear or slightly cloudy. The protein level increased from a trace to as much as 3+ mg./24 hrs., in those who were repeatedly making weight. The hydrogen-ion concentration or pH varied slightly from training cycle to training cycle. Acetone bodies appeared in two individuals after they had eaten considerable quantities of sugar a few hours before the urine samples were taken. Specific gravity decreased during the pre-season conditioning period and the early season, returned to normal during the weight reduction interval, and decreased again by the end of the competitive season, White blood cells appeared during the various training cycles. These cells ranged from rare to 15 mg./100 ml., and they appeared to increase whenever there was a variation in weight, an increase in exercise workload, or an increase in stress associated with competition. Red blood cells rarely appeared in the urine. Only four individuals displayed an increase in red blood cell count ranging from 0-2 mg./100 ml. Casts increased during the pre-seasoning conditioning period and the early season; however, they declined during the weight reduction interval and then declined further during the remainder of the

competitive season. Crystals appeared infrequently and were either amorphous or calcium oxalate. They were observed only during single cycles, and they appeared to be unrelated to the other items of the urinalysis. Bacteria appeared in the urine during the early season as a consequence of the body's reduced resistance to disease. Two types of bacteria were identified: cocci and bacillus bacteria. When the cocci bacteria reached the 3+ level, the white blood cell count rose. The epithelial cell count decreased during the pre-season conditioning period and the early season. The count then increased during the weight reduction interval, and increased again by the end of the competitive season. Mucous cell count decreased during the pre-season conditioning period, increased during the early season, increased during the weight reduction interval, and became stabilized by the end of the competitive season. The mucous cell count did not appear to be related to any other microscopic particles of the urine. Sodium content declined during the pre-season conditioning period, the early season, and the weight reduction interval, and finally increased by the end of the season. The potassium concentration increased during the pre-season conditioning period, declined during the early season, increased during the weight reduction interval, and finally decreased at the end of the competitive season.

BLOOD ANALYSIS

Blood Composition

Fourteen blood composition measures were taken on each of the five testing occasions for both the experimental and control groups. Means and standard deviations for this data are presented in Table XL. Analysis of Variance Tables are presented for all measures. Critical values for Duncan's Multiple Range Test are presented in Appendix D.

White Blood Count. The analysis of variance for the white blood count was neither significant between the experimental and control groups nor among the training cycles as can be observed in Table XLI. The means and standard deviations for white blood count are presented in Table XL. Although not significant, there was a slight increase in the white blood count during the weight reduction period for the experimental group, whereas the white blood count decreased slightly for the control group during the same period.

Red Blood Count. The red blood count did not change significantly between the experimental and control groups nor among the training cycles. Analysis of variance for red blood count is presented in Table XLII. The means and standard deviations for the red blood count are presented in Table XL.

TABLE XL

GROUP BLOOD MEASURES MEAN AND STANDARD DEVIATION VALUES

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
White Blood Count (cu. mm.)					
Exp.	7.48 ± 1.05	7.35 ± 1.65	6.63 ± 1.42	7.09 ± 0.93	6.94 ± 0.97
Con.	6.44 ± 2.93	6.92 ± 2.31	7.61 ± 1.53	7.34 ± 2.14	6.77 ± 1.00
Red Blood Count (cu. mm.)					
Exp.	4.89 ± 0.36	5.02 ± 0.31	5.01 ± 0.36	4.94 ± 0.33	4.94 ± 0.29
Con.	5.03 ± 0.31	5.07 ± 0.31	5.10 ± 0.34	4.94 ± 0.34	4.86 ± 0.79
Hemoglobin (gm./100 ml.)					
Exp.	14.69 ± 1.02	14.48 ± 0.92	14.36 ± 1.06	14.20 ± 0.86	14.25 ± 0.96
Con.	15.10 ± 1.01	14.65 ± 0.70	14.53 ± 1.04	14.18 ± 0.99	13.51 ± 3.73
Hematocrit (ml./100 ml.)					
Exp.	42.27 ± 2.60	41.66 ± 2.44	41.91 ± 2.99	41.68 ± 2.71	41.63 ± 2.51
Con.	43.31 ± 2.28	42.04 ± 1.99	42.39 ± 2.51	41.36 ± 2.48	39.63 ± 10.51
Mean Corpuscular Volume (cu. micra.)					
Exp.	84.33 ± 3.61	84.33 ± 3.44	84.56 ± 3.73	85.28 ± 3.29	85.24 ± 3.46
Con.	84.19 ± 2.74	84.0[illegible] ± 2.90	84.06 ± 2.32	84.56 ± 2.68	79.38 ± 21.34

TABLE XL

(continued)

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Mean Corpuscular Hemoglobin (picogm.)					
Exp.	27.62 ± 5.07	28.98 ± 1.38	28.83 ± 1.24	28.94 ± 1.37	29.01 ± 1.38
Con.	29.23 ± 1.27	29.06 ± 1.12	28.76 ± 0.96	28.86 ± 1.11	27.34 ± 5.80
Mean Corpuscular Hemoglobin Concentration (percent)					
Exp.	34.74 ± 0.59	34.58 ± 1.28	34.12 ± 0.48	33.92 ± 0.74	34.06 ± 0.60
Con.	34.71 ± 0.80	34.60 ± 0.92	33.46 ± 2.70	34.15 ± 0.77	33.98 ± 0.82
Polymorphonuclear Neutrophils (percent)					
Exp.	63.06 ± 9.06	60.00 ± 8.36	64.56 ± 9.98	57.67 ± 7.75	59.83 ± 7.44
Con.	57.00 ± 9.14	61.31 ± 11.03	61.25 ± 11.87	54.63 ± 10.42	54.69 ± 7.95
Lymphocytes (percent)					
Exp.	33.11 ± 8.36	31.83 ± 8.75	27.61 ± 7.55	31.67 ± 7.45	33.88 ± 6.96
Con.	37.69 ± 8.77	29.75 ± 9.57	31.13 ± 8.82	34.81 ± 9.46	40.31 ± 7.74
Monocytes (percent)					
Exp.	2.22 ± 1.80	4.28 ± 3.04	4.83 ± 2.43	6.67 ± 2.43	3.94 ± 2.41
Con.	2.94 ± 2.79	5.31 ± 3.48	4.88 ± 2.92	6.63 ± 2.99	3.44 ± 2.76

TABLE XL

(continued)

Variable	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5
Eosinophils (percent)					
Exp.	1.67 ± 2.06	1.72 ± 1.56	2.83 ± 3.13	1.94 ± 1.43	1.29 ± 1.21
Con.	2.25 ± 1.95	2.06 ± 2.54	2.13 ± 2.47	2.63 ± 1.41	1.25 ± 1.48
Sodium (mEq/liter)					
Exp.	140.44 ± 1.58	141.44 ± 2.83	141.22 ± 2.98	141.22 ± 2.98	140.06 ± 2.79
Con.	138.75 ± 2.72	141.06 ± 2.05	141.50 ± 3.31	141.94 ± 2.41	140.25 ± 2.33
Potassium (mEq/liter)					
Exp.	4.59 ± 0.43	4.42 ± 0.50	4.24 ± 0.56	4.43 ± 0.51	4.42 ± 0.43
Con.	4.48 ± 0.40	4.49 ± 0.47	4.61 ± 0.57	4.55 ± 0.39	4.63 ± 0.78
Chloride (mEq/liter)					
Exp.	102.11 ± 1.94	100.94 ± 3.35	102.11 ± 2.59	99.78 ± 2.71	101.78 ± 3.02
Con.	101.06 ± 1.81	100.12 ± 3.34	101.62 ± 2.42	101.19 ± 2.66	100.87 ± 2.19

TABLE XLI

ANALYSIS OF VARIANCE FOR WHITE BLOOD COUNT RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	141.30	4.28	
Control and Experimental Groups	1	0.25	0.25	0.06
Error (b)	32	141.05	4.41	
Within--Ss	136	338.26	2.49	
Testing Periods Tc_1 - Tc_5	4	2.80	0.70	0.28
Interaction	4	19.49	4.87	1.97
Error (w)	128	315.97	2.47	
Total	169	479.56	2.84	

F-ratio needed for significance at .05 level, 2.45.

TABLE XLII

ANALYSIS OF VARIANCE FOR RED BLOOD COUNT RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	17.33	0.53	
Control and Experimental Groups	1	0.07	0.07	0.13
Error (b)	32	17.26	0.54	
Within--Ss	136	8.61	0.06	
Testing Periods Tc_1 - Tc_5	4	0.57	0.14	2.33
Interaction	4	0.26	0.07	1.08
Error (w)	128	7.78	0.06	
Total	169	25.94	0.15	

F-ratio needed for significance at .05 level, 2.45.

Hemoglobin. The changes in hemoglobin were significantly different among the training cycles ($F=3.39$, $dF=4/136$, $p<.05$). The data are presented in Table XLIII. The results of Duncan's Multiple Range Test placed the differences between training cycle one and training cycles three, four, and five; and between training cycle two and training cycle five only in the control group. Differences were located between the experimental group and the control group during training cycle five. The means and standard deviations for hemoglobin are presented in Table XL.

Hematocrit. Hematocrit did not significantly change between the experimental and control groups or among the training cycles. Analysis of variance for hematocrit is presented in Table XLIV. The means and standard deviations for hematocrit is reported in Table XL.

Mean Corpuscular Volume. Mean corpuscular volume did not significantly change between the experimental and control groups or among the training cycles. Analysis of variance for mean corpuscular volume is presented in Table XLV. The means and standard deviations for mean corpuscular volume are reported in Table XL.

Mean Corpuscular Hemoglobin. Mean corpuscular hemoglobin did not change significantly between the

TABLE XLIII

ANALYSIS OF VARIANCE FOR HEMOGLOBIN RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	168.48	5.11	
Control and Experimental Groups	1	0.00	0.00	0.00
Error (b)	32	168.48	5.26	
Within--Ss	136	197.99	1.46	
Testing Periods $Tc_1 - Tc_5$	4	18.29	4.57	3.39**
Interaction	4	7.04	1.76	1.30
Error (w)	128	172.66	1.35	
Total	169	366.47	2.17	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XLIV

ANALYSIS OF VARIANCE FOR HEMATOCRIT RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	1164.38	35.28	
Control and Experimental Groups	1	0.50	0.50	0.01
Error (b)	32	1163.88	36.37	
Within--Ss	136	1543.29	11.35	
Testing Periods Tc_1 - Tc_5	4	74.89	18.72	1.70
Interaction	4	51.38	12.84	1.16
Error (w)	128	1417.02	11.07	
Total	169	2707.66	16.02	

F-ratio needed for significance at .05 level, 2.45.

TABLE XLV

ANALYSIS OF VARIANCE FOR MEAN CORPUSCULAR VOLUME
RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	2741.13	83.06	
Control and Experimental Groups	1	97.61	97.61	1.18
Error (b)	32	2643.52	82.61	
<u>Within--Ss</u>	136	5967.59	43.88	
Testing Periods $Tc_1 - Tc_5$	4	113.34	28.34	0.64
Interaction	4	205.03	51.26	1.16
Error (w)	128	5649.22	44.13	
Total	169	8708.72	51.53	

F-ratio needed for significance at .05 level, 2.45.

experimental and control groups or among the training cycles. Analysis of variance for mean corpuscular hemoglobin is presented in Table XLVI. The means and standard deviations for mean corpuscular hemoglobin are reported in Table XL.

Mean Corpuscular Hemoglobin Concentration. Mean corpuscular hemoglobin concentration changed significantly among the training cycles ($F=4.96$, $dF=4/136$, $p<.05$). The data are presented in Table XLVII. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles four and five; between training cycle two and training cycle five; and between training cycle three and training cycle five in the experimental group. There were also differences between training cycle one and training cycles three, four, and five; between training cycle two and training cycles four and five; and between training cycle three and training cycle five in the control group. Differences were found between the experimental group and control group during training cycle three. The means and standard deviations for mean corpuscular hemoglobin concentration are reported in Table XL.

Polymorphonuclear Neutrophils. The polymorphonuclear neutrophils changed significantly among the training cycles and between the experimental and control groups

TABLE XLVI

ANALYSIS OF VARIANCE FOR MEAN CORPUSCULAR HEMOGLOBIN RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	340.99	10.33	
Control and Experimental Groups	1	0.04	0.04	0.00
Error (b)	32	340.94	10.65	
<u>Within--Ss</u>	136	858.35	6.31	
Testing Periods Tc_1 - Tc_5	4	16.65	4.16	0.67
Interaction	4	45.42	11.36	1.83
Error (w)	128	796.27	6.22	
Total	169	1199.33	7.10	

F-ratio needed for significance at .05 level, 2.45.

TABLE XLVII

ANALYSIS OF VARIANCE FOR MEAN CORPUSCULAR HEMOGLOBIN CONCENTRATION RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	66.16	2.00	
Control and Experimental Groups	1	0.33	0.33	0.16
Error (b)	32	65.83	2.06	
<u>Within--Ss</u>	136	161.58	1.19	
Testing Periods Tc_1 - Tc_5	4	21.17	5.29	4.96**
Interaction	4	3.88	0.97	0.91
Error (w)	128	136.53	1.07	
Total	169	227.74	1.35	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

(F=3.46, dF=4/136, $p < .05$). The data are presented in Table XLVIII. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles four and five for the experimental group. Differences were located between training cycle one and training cycles four and five; and between training cycle two and training cycles four and five for the control group. Differences were also located between the experimental group and control group during training cycle one and training cycle five. The means and standard deviations for polymorphonuclear neutrophils are reported in Table XL.

Lymphocytes. Lymphocytes changed significantly between the experimental and control groups and among the training cycles (F=6.50, dF=4/136, $p < .05$). The data are presented in Table XLIX. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles two, three, four and five in the experimental group. There were also differences between training cycle one and training cycles three, four, and five; between training cycle two and training cycles four and five; and between training cycle three and training cycle four in the control group. Differences were found between the experimental group and the control group during training cycle one and training cycle five. The means and standard deviations for lymphocytes are presented in Table XL.

TABLE XLVIII

ANALYSIS OF VARIANCE FOR POLYMORPHONUCLEAR NEUTROPHIL RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	5268.09	159.64	
Control and Experimental Groups	1	446.59	446.59	2.96**
Error (b)	32	4821.51	150.67	
Within--Ss	136	10390.40	76.40	
Testing Periods Tc_1 - Tc_5	4	986.55	246.64	3.46**
Interaction	4	273.84	68.46	0.96
Error (w)	128	9130.01	71.33	
Total	169	15658.49	92.65	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE XLIX

ANALYSIS OF VARIANCE FOR LYMPHOCYTE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	4922.10	149.15	
Control and Experimental Groups	1	405.19	405.19	2.87**
Error (b)	32	4516.91	151.15	
<u>Within--Ss</u>	136	8273.20	60.83	
Testing Periods Tc_1 - Tc_5	4	1340.56	335.14	6.50**
Interaction	4	334.93	83.73	1.62
Error (w)	128	6597.71	51.54	
Total	169	13195.30	78.08	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

Monocytes. The monocytes were significantly changed among the training cycles ($F=10.18$, $dF=4/136$, $p<.05$). The data are presented in Table L. The results of Duncan's Multiple Range Test located the differences between training cycle one and training cycles two, three, four, and five; between training cycle two and training cycle five; between training cycle three and training cycle five; and between training cycle four and training cycle five in the experimental group. There were also differences between training cycle one and training cycles three, four, and five; between training cycle two and training cycles four and five; and between training cycle three and training cycle five in the control group. There were no differences located between the experimental group and control group during any of the training cycles. The means and standard deviations for monocytes are presented in Table XL.

Eosinophils. Eosinophils did not significantly change between the experimental and control groups or among the training cycles. Analysis of variance for eosinophils is presented in Table LI. The group means and standard deviations for all blood measures are reported in Table XL.

Sodium. The sodium serum measures were significantly changed among the training cycles ($F=3.03$, $dF=4/136$, $p<.05$). These data are presented in Table LII. The results of

TABLE L

ANALYSIS OF VARIANCE FOR MONOCYTE RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	192.50	5.83	
Control and Experimental Groups	1	2.86	2.86	0.48
Error (b)	32	189.64	5.93	
Within--Ss	136	1316.00	9.68	
Testing Periods $Tc_1 - Tc_5$	4	314.53	78.6	10.18**
Interaction	4	12.30	3.08	0.40
Error (w)	128	989.17	7.73	
Total	169	1508.50	8.93	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

TABLE LI

ANALYSIS OF VARIANCE FOR EOSINOPHILS RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	158.45	4.80	
Control and Experimental Groups	1	1.28	1.28	0.30
Error (b)	32	157.18	4.91	
Within--Ss	136	530.40	3.90	
Testing Periods Tc_1 - Tc_5	4	29.71	7.43	1.94
Interaction	4	10.77	2.69	0.70
Error (w)	128	489.93	3.83	
Total	169	688.85	4.08	

F-ratio needed for significance at .05 level, 2.45.

TABLE LII

ANALYSIS OF VARIANCE FOR SODIUM RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	218.78	6.63	
Control and Experimental Groups	1	1.50	1.50	0.22
Error (b)	32	217.28	6.79	
<u>Within--Ss</u>	136	1086.41	7.99	
Testing Periods $Tc_1 - Tc_5$	4	91.59	22.90	3.03**
Interaction	4	28.41	7.10	0.94
Error (w)	128	966.41	7.55	
Total	169	1305.19	7.72	

**$p < .05$ F-ratio needed for significance at .05 level, 2.45.

Duncan's Multiple Range Test located the differences between training cycle one and training cycles two, three, four, and five; and between training cycle two and training cycle five for the control group. Differences were found between the experimental group and control group during training cycle one. The means and standard deviations for sodium content in the blood are reported in Table XL.

Potassium. The analysis of variance for potassium was neither significant between the experimental and control groups nor among the training cycles. Analysis of variance for potassium is presented in Table LIII. Group means and standard deviations for potassium content of the blood are presented in Table XL.

Chloride. Chloride did not significantly change between the experimental and control groups or among the training cycles. Analysis of variance for chloride is presented in Table LIV. The means and standard deviations for chloride content of the blood are reported in Table XL.

Summary

Fourteen measures were evaluated to determine significant changes in blood composition. The blood samples of the experimental group reflected significant changes in hemoglobin, mean corpuscular hemoglobin concentration,

TABLE LIII

ANALYSIS OF VARIANCE FOR POTASSIUM BLOOD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
Between--Ss	33	19.88	0.60	
Control and Experimental Groups	1	0.96	0.96	1.62
Error (b)	32	18.92	0.59	
Within--Ss	136	24.76	0.18	
Testing Periods Tc_1 - Tc_5	4	0.34	0.09	0.48
Interaction	4	1.11	0.28	1.55
Error (w)	128	23.30	0.18	
Total	169	44.63	0.26	

F-ratio needed for significance at .05 level, 2.45.

TABLE LIV

ANALYSIS OF VARIANCE FOR CHLORIDE BLOOD RESPONSE TO TRAINING REGIMENS

Source	dF	SS	MS	F
<u>Between--Ss</u>	33	240.44	7.29	
Control and Experimental Groups	1	5.78	5.78	0.79
Error (b)	32	234.66	7.33	
<u>Within--Ss</u>	136	1001.61	7.36	
Testing Periods Tc_1 - Tc_5	4	55.95	13.99	1.96
Interaction	4	34.96	8.74	1.22
Error (w)	128	910.68	7.11	
Total	169	1242.04	7.35	

F-ratio needed for significance at .05 level, 2.45.

polymorphonuclear neutrophils, lymphocytes, monocytes, and sodium. There were no significant changes in white blood count, red blood count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, eosinophils, potassium, or chloride. Hemoglobin decreased during the pre-season conditioning period, the early season and the weight reduction interval; and then increased gradually near the end of the season. The mean corpuscular hemoglobin concentration decreased during the pre-season conditioning period, the early season, and the weight reduction interval; and finally increased toward the end of the competitive season.

The polymorphonuclear neutrophils decreased during the pre-season conditioning period, increased during the early season, decreased sharply during the weight reduction period, and finally, increased near the end of the competitive season. The lymphocytes declined in the pre-season conditioning period and the early season as a consequence of improved conditioning through increasing physical activity. Lymphocytes increased from the weight reduction interval to the end of the competitive season, as a reduced immunity to diseased developed during the weight reduction interval.

Monocytes increased during the pre-season conditioning period, early season, and the weight reduction interval as the body became more susceptible to disease. The monocytes decreased near the end of the season as the threat of disease dissipated with rehydration and the return to normal body weight. The sodium level increased during the pre-season conditioning period as a possible consequence of the body's reabsorption of sodium in the renal tubules from increased physical activity. The decrease in sodium level during the early season was a consequence of the weight loss sustained throughout that period. The sodium level stabilized during the weight reduction interval and compensated for the added decrease in weight by dehydration. The sodium level decreased further near the end of the season as a consequence of acclimatization and rehydration.

DISCUSSION

ANTHROPOMETRIC MEASURES

Age, Height, and Weight

The age, height, and weight of the subjects utilized in this study were comparable to the subjects used by Tcheng and Tipton[5] in Iowa and Kroll in Illinois.[6] These results

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[5]Tse-Kia Tcheng and Charles M. Tipton, "Iowa Wrestling Study: Anthropometric Measurements and the Prediction of a 'Minimal' Body Weight for High School Wrestlers," Medicine and Science in Sports, V (March, 1973), 4.

[6]Walter Kroll, "Selected Factors Associated with Wrestling Success," Research Quarterly, XXIX (December, 1958), 401.

are presented in Table LV. Kroll established a criteria for determining success in wrestling by dividing his subjects into successful and unsuccessful groupings based upon their placement of first or second in a sectional tournament and their placement of first, second, third, or fourth in the state tournament. For comparison purposes, the present researcher utilized a similar criteria of placing first or second in a regional tournament, and placing first, second, third or fourth in the state tournament. When making a comparison between either the Iowa study or the Illinois study it must be kept in mind that the Iowa study utilized 582 subjects and the Illinois study used one hundred subjects. The current study used thirty-four subjects. The variations in age, height, and weight between the experimental and control groups may be attributed to sampling errors.

Age. The mean age of the wrestlers used in this study were 15.81 years for the experimental group and 16.35 years for the control group. The subjects utilized in the current study were generally younger than the subjects used by Tcheng and Tipton in their study of Iowa wrestlers. The unsuccessful subjects of the current study were slightly younger than the unsuccessful subjects of Kroll's study; however, the successful subjects of the current study were slightly older than the successful subjects of Kroll's study.

TABLE LV

A COMPARISON OF RESULTS OF THE PRESENT STUDY WITH THOSE OF TCHENG AND TIPTON AND KROLL

STUDIES	AGE	HEIGHT	WEIGHT
Present Study			
Average	15.41 yrs.	68.02 ins.	141.75 lbs.
Championship Finalist	17.24 yrs.	68.15 ins.	142.90 lbs.
Tcheng and Tipton (Study of Iowa wrestlers)			
Average	15.95 yrs.	67.43 ins.	142.66 lbs.
Championship Finalist	17.77 yrs.	67.64 ins.	142.00 lbs.
Present Study			
Unsuccessful	15.79 yrs.	67.87 ins.	140.88 lbs.
Successful	17.13 yrs.	68.40 ins.	137.30 lbs.
Kroll (Study of Illinois wrestlers)			
Unsuccessful	16.05 yrs.	67.70 ins.	140.07 lbs.
Successful	16.75 yrs.	67.79 ins.	149.05 lbs.

Height. The height of the subjects used in the current study showed a mean of 67.90 inches for the experimental group, and a mean height of 67.81 inches for the control group. The subjects of the current study were taller than the average and championship finalists identified by Tcheng and Tipton; however, the subjects of the current study who won championships were shorter than the championship finalists in Iowa. Both the unsuccessful and successful wrestlers of the current study were, on the average, taller than either the unsuccessful or successful wrestlers of Kroll's study.

Weight. The weight of the subjects utilized in the current study reflected a mean weight of 139.98 pounds for the experimental group and a mean weight of 142.09 pounds for the control group. A comparison of body weights shows the average subjects of the current study to be lighter than the average Iowa subjects, while the championship finalists of the current study were slightly heavier than their Iowa counterparts. When compared with the unsuccessful subjects of Kroll's study, the unsuccessful subjects of the current study were found to be slightly heavier, while the successful subjects of Kroll's study were considerably heavier than the subjects of the current study.

A comparison of the current study with studies by Nichols[7] and Singer and Weiss[8] may be made. Nichols observed a mean weight loss of 10.29 pounds in a ten-week competitive season. A study by Singer and Weiss reported a mean weight loss of 10.95 pounds in a five-day period. The current study showed a mean weight loss of .36 pounds for the experimental group in the thirteen-week competitive season, while a mean weight loss of .01 pounds occurred during the one-week weight reduction interval as shown in Table LVI. This mean reflected weight losses of 1.85 pounds and 1.50 pounds respectively for the high school and junior high school varsity wrestlers. The mean also reflected weight gains of 1.14 pounds and 1.83 pounds respectively for the high school and junior high school "B" team wrestlers. The percent of weight loss during each training cycle for the experimental group is reported in Table LVII. Probable reasons for the low weight loss in the current study are: (1) The Tennessee Secondary School Athletic Association rule requiring an individual participant to have at least one-half of his individual bouts at the lowest weight class

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[7]Harold J. Nichols, "The Effect of Rapid Weight Loss on Selected Physiologic Responses of Wrestlers," (Unpublished Doctoral dissertation, University of Michigan, 1956), p. 78.

[8]Robert N. Singer and Steven A. Weiss, "Effects of Weight Reduction on Selected Anthropometric, Physical, and Performance Measures of Wrestlers," Research Quarterly, XXXIX (May, 1968), 368.

TABLE LVI

BODY WEIGHTS FOR THE EXPERIMENTAL GROUP*
DURING EACH TESTING CYCLE

SUBJECT	TEAM	Tc_1	Tc_2	Tc_3	Tc_4	Tc_5	SEASONAL WEIGHT CHANGES
1	(HSV)	130.25	125.50	122.00	119.25	125.00	-5.25
2	(HSB)	146.75	147.00	143.00	143.00	146.00	-0.75
3	(HSV)	170.75	169.50	167.00	165.00	167.00	-3.75
4	(JRB)	149.50	148.25	152.00	150.50	149.50	0.00
5	(HSV)	133.25	150.00	149.00	144.00	147.00	+7.75
6	(HSB)	141.75	143.00	138.00	140.00	143.00	+1.25
7	(JRV)	146.25	142.00	145.00	143.50	144.00	-2.25
8	(HSB)	132.75	130.00	120.50	124.50	127.00	-5.75
9	(JRB)	142.25	140.00	143.00	145.00	150.00	+7.75
10	(JRV)	109.25	105.50	106.50	104.50	104.50	-4.75
11	(HSV)	142.00	132.50	140.00	140.00	140.00	-2.00
12	(JRB)	114.00	118.00	115.00	120.00	118.00	+4.00
13	(HSB)	143.00	142.00	143.00	142.00	145.00	+2.00
14	(HSB)	151.50	151.50	150.50	153.00	154.50	+3.00
15	(HSV)	155.00	158.50	155.00	155.50	152.00	-3.00
16	(HSB)	147.25	140.00	146.00	146.00	146.00	-1.25
17	(JRV)	146.50	144.50	144.00	143.00	144.00	-2.50
18	(HSB)	128.00	129.00	128.50	129.00	127.00	-1.00
TOTAL		2530.00	2516.75	2508.00	2507.75	2529.50	-6.50
MEAN		140.56	139.81	139.33	139.32	140.53	-0.36

*All values are in pounds

TABLE LVII

PERCENTAGE OF BODY WEIGHT FOR THE EXPERIMENTAL GROUP DURING EACH TESTING CYCLE*

SUBJECT	TEAM	BOUTS	Tc_1-Tc_2	Tc_2-Tc_3	Tc_3-Tc_4	Tc_4-Tc_5	AVERAGE WEIGHT
1	(HSV)	15	-3.65	-2.79	-2.25	+4.82	-0.97
2	(HSB)	0	+0.17	-2.72	0.00	+2.10	-0.11
3	(HSV)	32	-0.73	-1.47	-1.20	+1.21	-0.55
4	(JRB)	0	-0.84	+2.19	-0.97	-0.66	-0.07
5	(HSV)	32	+12.57	-0.67	-3.35	+2.08	+2.66
6	(HSB)	0	+0.88	-3.50	+1.45	+2.14	+0.24
7	(JRV)	8	-2.91	+2.11	-1.03	+0.35	-0.37
8	(HSB)	7	-2.07	-7.30	+3.32	+2.01	-1.01
9	(JRB)	2	-1.58	+2.14	+1.40	+3.45	+1.35
10	(JRV)	14	-3.43	+0.95	-1.88	+0.24	-1.03
11	(HSV)	0	-6.69	+5.66	0.00	0.00	0.26
12	(JRB)	0	+3.51	-2.54	+4.34	-1.67	+0.91
13	(HSB)	2	-0.70	+0.70	-0.70	+2.11	+0.35
14	(HSB)	2	0.00	-0.66	+1.66	+0.98	+0.50
15	(HSV)	5	+2.26	-2.20	+0.32	-2.25	-0.47
16	(HSB)	13	-4.92	+4.28	0.00	0.00	-0.16
17	(JRV)	0	-1.37	-0.35	-0.69	+0.70	-0.43
18	(HSB)	13	+0.78	-0.39	+0.39	-1.55	-0.19
TOTAL			-8.72	-6.56	+10.81	+16.06	+0.02
MEAN			-0.484	-0.364	+0.045	+0.892	+.005

*All values are in percentages

in which he will compete during the district tournament; (2) the lack of motivation on the part of those individuals who were not successful in making the varsity teams; and (3) the lack of mental toughness to endure the suffering of making weight when the rewards were slight or nonexistent.

Body Diameters

The body diameters of the subjects utilized in this study were comparable to those of the subjects used by Tcheng and Tipton,[9] Kroll,[10] Katch and McArdle,[11] and Laubach and McConville.[12] These results are presented in Table LVIII.

Biacromial diameter, chest diameter, chest depth, and bi-iliac diameters were not statistically significant, however, as the following trends were noted. The subjects used by Tcheng and Tipton were smaller in biacromial diameter, chest diameter, and chest depth; however, the subjects used in the current study were smaller in bi-iliac

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[9]Tcheng and Tipton, p. 4.

[10]Walter Kroll, "An Anthropometrical Study of Some Big Ten Varsity Wrestlers," Research Quarterly, XXV (May, 1954), 310.

[11]Frank I. Katch and William D. McArdle, "Prediction of Body Density from Simple Anthropometric Measurements in College-Age Men and Women," Human Biology, XLV (September, 1973), 449.

[12]Lloyd L. Laubach and John T. McConville, "Muscle Strength, Flexibility, and Body Size of Adult Males," Research Quarterly, XXXVII (October, 1966), 387.

TABLE LVIII

A COMPARISON OF RESULTS OF THE PRESENT STUDY WITH THOSE OF TCHENG AND TIPTON, KROLL, KATCH AND McARDLE, AND LAUBACH AND McCONVILLE*

Body Diameter Measures	Present Study	Tcheng and Tipton		Kroll	Katch and McArdle	Laubach and McConville
		Average	Champions			
Biacromial	40.91	33.6	35.1	40.26	40.4	——
Chest	28.78	26.8	27.7	28.85	29.0	30.29
Chest Depth	19.79	19.1	19.2	20.22	——	23.46
Bi-iliac	26.79	26.8	27.0	——	28.2	29.60
Bitrochanteric	31.14	31.0	31.1	28.45	32.1	33.25
Wrist	10.99	11.0	11.2	——	——	——
Ankle	13.53	14.3	14.0	——	——	——

*All measures are in centimeters

diameter. The subjects of the present study were larger in biacromial diameter than the subjects of either Kroll or Katch and McArdle. Also, the subjects of the present study were smaller in chest diameter, chest depth, and bi-iliac diameter than the subjects utilized by Kroll, Katch and McArdle, and Laubach and McConville. The above trends suggest there was good shoulder width and hip width which is indicative of all-around athletic ability. The wrestlers were not characterized by huge chest measurements since normal groups of young men as studied by Laubach and McConville exceeded most of these measures. It may be suggested from the Tcheng and Tipton study that championship finalists had greater chest diameters. A possible reason for the above trends was that the subjects from each of the studies were older and more mature than those of the present study. This is especially true since the subjects of Kroll, Katch and McArdle, and Laubach and McConville were all mature college students.

Bitrochanteric diameter, wrist diameters, and ankle diameters were statistically significant. These findings suggest that the subjects of the present study were comparable to the subjects of Tcheng and Tipton in bitrochanteric diameters and wrist diameters, however, the subjects of the present study were considerably less in ankle diameters. A possible reason for the differences in ankle diameters may be the fact that Tcheng and Tipton's subjects were somewhat older and more mature than the subjects of the present study. There was a decrease in bitrochanteric diameter, wrist diameter, and ankle diameter measurements during the pre-season conditioning period, the early competitive season, and the weight reduction interval. There was an increase in these diameters near the end of the competitive season. These changes suggest weight was redistributed during the early season, with a weight loss occurring during the weight reduction interval, and finally a weight gain near the end of the competitive season.

Body Composition

The body skinfolds of the subjects utilized in this study were comparable to the skinfold measures of subjects used by Tcheng and Tipton,[13] Kroll,[14] Katch and McArdle,[15] Laubach and McConville,[16] and Singer and Weiss.[17] This data is presented in Table LIX.

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[13]Tcheng and Tipton, p. 4.

[14]Kroll, "An Anthropometrical Study of Some Big Ten Varsity Wrestlers," p. 310.

[15]Katch and McArdle, p. 449.

[16]Laubach and McConville, p. 387.

[17]Robert N. Singer and Steven A. Weiss, "Effects of Weight Reduction on Selected Anthropometric, Physical, and Performance Measures of Wrestlers," p. 366.

TABLE LIX

A COMPARISON OF RESULTS OF THE PRESENT STUDY WITH THOSE OF TCHENG AND TIPTON, KROLL, KATCH AND McARDLE, LAUBACH AND McCONVILLE, AND SINGER AND WEISS*

Skinfold Measures	Present Study	Tcheng and Tipton		Kroll	Katch and McArdle	Laubach and McConville	Singer and Weiss	
		Average	Champions				Monday	Friday
Scapulae	9.96	8.9	6.4	——	13.6	9.90	8.19	6.81
Triceps	10.94	9.1	7.7	——	13.1	9.10	5.90	4.50
Chest	4.42	6.6	4.5	——	——	8.60	5.08	3.92
Suprailiac	13.08	14.4	9.1	14.91	21.7	11.40	9.93	7.77
Abdomen	13.34	14.4	8.6	14.46	20.0	——	8.00	6.37
Thigh	14.51	11.6	7.7	17.29	16.4	——	9.70	8.96

*All measures are in millimeters

Scapulae skinfold measures were not statistically significant. From Table LIX it will be noted that the scapulae skinfold measures of the present study were greater than the scapulae skinfold measures of the subjects of either Tcheng and Tipton, Laubach and McConville, or Singer and Weiss; however, the skinfold measures of the subjects used in the current study were lower than those of Katch and McArdle. This indicates all the wrestlers used as subjects in the above studies were considerably lower in scapulae skinfold measures than were the normal college men used as subjects by Katch and McArdle. This also suggests that the wrestlers were lean and trim when compared to normal college men.

Triceps, chest, suprailiac, abdomen, and thigh skinfold measures were statistically significant. The triceps skinfold measures for the subjects of the current study were greater than the skinfold measures reported by either Tcheng and Tipton, Laubach and McConville, or Singer and Weiss. The skinfold measures reported by Katch and McArdle were greater than those reported in the current study. Changes were reported by the current study during the training cycles and between the experimental group and control group. These changes suggest triceps skinfold measures increased during the pre-season conditioning period thus indicating a redistribution of weight. A decrease in triceps skinfold measures appeared during the early competitive season suggesting a slight weight loss. Finally, there was an increase in triceps skinfold measures near the end of the competitive season suggesting a weight increase by rehydration following the weight reduction interval.

Chest skinfold measures for the subjects in the present study were lower than those reported by Tcheng and Tipton and Laubach and McConville. Chest skinfold measures reported by Singer and Weiss were lower on the final day of their weight reduction period than those reported in the current study.

Significant changes were detected during the training cycles and between the experimental group and control group. These observations suggest that the wrestlers used in the current study were lean and trim throughout the wrestling season. They also suggest chest skinfold measures increased during the pre-season conditioning period and the early season. This indicates a redistribution of weight during these periods. Finally, there was a decrease in chest skinfold measures during the weight reduction interval and extending to the end of the competitive season. This suggests an additional weight redistribution during the weight reduction interval. There was a return to a normal distribution of weight as the wrestling season drew to a close and rehydration occurred.

The suprailiac skinfold measures for the subjects of the current study indicated these wrestlers were lower in suprailiac skinfold measures than the average wrestlers identified by Tcheng and Tipton or the subjects studied by Kroll. The suprailiac skinfold measures for championship finalists as observed by Tcheng and Tipton and the subjects observed by Laubach and McConville and Singer and Weiss indicated they were considerably lower in suprailiac skinfold measures than were the subjects of the present study.

Significant changes were noted during the training cycles and between the experimental group and control group. These observations suggest the wrestlers utilized in the present study were lean and trim at the beginning of the season. They also indicate there was an increase in suprailiac skinfold measures during the pre-season conditioning period which reflected a weight redistribution during this period. There was a decrease in suprailiac skinfold measures during the early season which indicated a weight redistribution as the wrestlers made their competitive weight. Finally, there was a gradual increase in suprailiac skinfold measures until the end of the competitive season suggesting that body weight was being lost by dehydration and then followed a weight redistribution as body weight returned to its normal level.

Abdominal skinfold measures for the subjects of the current study were less than the abdominal skinfold measures of average wrestlers observed by Tcheng and Tipton or the subjects observed by Kroll and Katch and McArdle. The abdominal skinfold measures for championship finalists recorded by Tcheng and Tipton, and the abdominal skinfold measures reported by Singer and Weiss were lower than the abdominal skinfold measures of the present study.

Significant changes were detected during the training cycles and between the experimental group and control group. These observations indicate the subjects of the current study were lean and trim throughout the wrestling season; however, they had not lost as much weight as the championship finalists observed by Tcheng and Tipton or the subjects observed by Singer and Weiss. These findings also suggest there was slight increase in abdominal skinfold measures during the pre-season conditioning period indicating a redistribution of body weight had occurred. This was followed by a sharp decrease in abdominal skinfold measures as weight was made for meets during the early competitive season. Finally, there was a gradual increase in abdominal skinfold measures for the remainder of the competitive season indicating that body weight was being lost through exercise and dehydration. An additional weight redistribution occurred as the body returned to normal.

Thigh skinfold measures for the subjects of the present study were greater than the thigh skinfold measures of the subjects studied by Tcheng and Tipton and Singer and Weiss. The thigh skinfold measures for the current study were less than the thigh skinfold measures reported by either Kroll or Katch and McArdle.

Significant changes were detected during the training cycles and between the experimental group and the control group. These observations suggest the subjects of the present study were lean and trim; however, they were larger in the thighs indicating some weight had been redistributed before the wrestling season began. These observations also suggest there was considerable weight redistribution during the pre-season conditioning period and the early competitive season as fat was lost and muscle mass increased. There was a slight decrease in thigh skinfold measures as fat was redistributed to compensate for dehydration during the weight reduction interval. Finally, there was a slight increase in thigh skinfold measures as the season drew to a close indicating that body weight was returning to its normal level.

BODY CIRCUMFERENCE MEASURES

Body Circumferences

The body circumferences of the subjects in this study were comparable to those used by Tcheng and Tipton,[18]

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[18]Tcheng and Tipton, p. 4.

Kroll,[19] Katch and McArdle,[20] and Laubach and McConville.[21] These comparisons are presented in Table LX.

Both gluteal and thigh circumferences were statistically significant during the training cycles, however, they were not statistically significant between the experimental group and control group. These results indicate there was a redistribution of weight during the pre-season conditioning period. There was a decrease in both gluteal and thigh circumference during the early season indicating an additional redistribution of weight as well as a weight loss during that period. There was a decrease in gluteal circumference and an increase in thigh circumference during the weight reduction period. These changes suggest an additional weight loss. The gluteal circumference decreased because of the loss of weight from dehydration, while the thigh circumference increased because of the added exercise workload of running and wrestling on the feet. Both the gluteal and thigh circumferences returned to normal near the end of the competitive season as a consequence of rehydration.

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[19]Kroll, "An Anthropometrical Study of Some Big Ten Varsity Wrestlers," p. 310.

[20]Katch and McArdle, p. 449.

[21]Laubach and McConville, p. 387.

TABLE LX

A COMPARISON OF RESULTS OF THE PRESENT STUDY WITH THOSE OF TCHENG AND TIPTON, KROLL, KATCH AND McARDLE AND LAUBACH AND McCONVILLE*

Circumference Measures	Present Study	Tcheng and Tipton		Kroll	Katch and McArdle	Laubach and McConville
		Average	Champions			
Gluteal Cir.	86.51	88.2	85.7	87.76	94.1	94.10
Thigh Cir.	48.34	51.5	49.2	50.44	55.4	56.16

*All measures are in centimeters

STRENGTH MEASURES

Muscular Strength

The muscular strength of the subjects used in this study was comparable to those used by Kroll,[22] Singer and Weiss,[23] and Saltin.[24] These comparisons are presented in Table LXI.

Muscular strength was statistically significant for grip strength, elbow flexion, elbow extension, and knee extension; however, knee flexion was not statistically significant. Grip strength and elbow extension increased while elbow flexion and knee extension decreased in the pre-season conditioning period. These changes were probably the outcome of a redistribution of weight and the strengthening of muscle mass. Some of this change may also be a result of the increase in physical conditioning activities during this period. During the early season, grip strength and elbow extension increased, while elbow flexion decreased. These changes were most likely caused by making weight for competition and the attendant weight loss and redistribution of weight. Grip strength and elbow flexion decrease while

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[22]Kroll, "An Anthropometrical Study of Some Big Ten Varsity Wrestlers," p. 310.

[23]Singer and Weiss, p. 366.

[24]Bengt Saltin, "Aerobic and Anaerobic Work Capacity After Dehydration," Journal of Applied Physiology, XIX (November, 1964), 1117.

TABLE LXI

A COMPARISON OF RESULTS OF THE PRESENT STUDY WITH THOSE OF KROLL, SINGER AND WEISS, AND SALTIN*

Strength Measures	Present Study	Kroll	Singer and Weiss		Saltin
			Monday	Friday	
Right Grip	84.26	122.6	—	—	—
Right Elbow Flexion	69.45	—	137.60	126.90	65.70
Right Elbow Extension	60.38	—	114.30	109.40	—
Right Knee Flexion	67.93	—	138.60	140.29	—
Right Knee Extension	103.75	—	—	—	122.36

*All measures are in pounds

elbow extension increased during the weight reduction interval. These changes were probably caused by the added weight loss from starvation and dehydration. It appears that only the larger muscle groups were affected and showed a decrease in efficiency during this period. Grip strength, elbow flexion, and elbow extension all showed an increase near the end of the competitive season. These changes seemed to be a consequence of rehydration and a restoration of body weight to normal. The increased workload accompanying tournament preparations may have been a contributing factor as well.

Knee extension strength decreased during the pre-season conditioning period, probably as a result of the redistribution of fat and the strengthening of muscle tissue. Knee extension strength increased during the early season, the weight reduction interval, and the remainder of the competitive season, This increase was probably a result of the reduction of excess fat and the associated physiological adjustments necessary to balance the weight loss. The increase in knee extension strength may have resulted as a consequence of the physical conditioning program. These means of the subjects in the current study were quite low when compared with the subjects used in the other studies. This was probably a consequence of the maturity of the subjects used by Kroll and Singer and Weiss.

They were all college wrestlers. Saltin's subjects were mature men between the ages of twenty-one to thirty-two years.

MUSCULAR ENDURANCE MEASURES

Muscular Endurance

Muscular endurance of the subjects in this study were comparable to those used by Frank,[25] Hakes and Rosemier,[26] and Ruffer.[27] These comparisons are presented in Table LXII.

Pull-ups and dips were statistically significant during the training cycles and between the experimental group and the control group. These results indicate pull-up and dip endurance increased during the pre-season conditioning period. This was probably a result of the training program and its accompanying exercises. Pull-up endurance increased while dip endurance decreased during the early season. These changes may have been a consequence of the physical training program and the weight loss which

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[25]James H. Frank, "Comparison of Pre- and Post-Fitness Scores in a Conditioning Experiment," Research Quarterly, XXXVIII (October, 1967), 511.

[26]Richard R. Hakes and Robert A. Rosemier, "Circuit Training Time Allotments in a Typical Physical Education Class Period," Research Quarterly, XXXVIII (December, 1967), 580.

[27]William A. Ruffer, "Summary of a Thirteen-year Study of Cozens Test of General Athletic Ability in College Freshman Men," Research Quarterly, XXXIX (October, 1968), 820.

TABLE LXII

A COMPARISON OF THE RESULTS OF THE PRESENT STUDY WITH THOSE OF FRANK, HAKES AND ROSEMIER AND RUFFER*

Endurance Measures	Present Study	Frank		Hakes and Rosemier		Ruffer
		Pre-test	Post-test	Pre-test	Post-test	
Pull-ups	12.36	6.39	8.52	3.25	4.58	——
Dips	15.11	——	——	——	——	6.5

*All measures are the recorded means

occurred as the wrestlers reached their competitive weight classes. Both pull-up and dip endurance increased during the weight reduction interval. This phenomenon was probably an outcome of the improved physiological condition attained as the body compensated for the additional weight reduction during this period. Finally, there was a slight increase in both pull-up and dip endurance. This may have been an effect of the return to normal in body weight. The pull-up and dip endurance levels may have resulted from the daily rope climbing activity included in the physical conditioning program.

CARDIOVASCULAR ENDURANCE MEASURE

Physical Work Capacity

Both the fifth-minute and the sixth-minute heart rates were statistically significant during the training cycles and between the experimental group and control group.

Heart Rate--Fifth Minute. These results indicate there was a decrease in the fifth-minute heart rate during the pre-season conditioning period. This decrease was probably caused by improved conditioning resulting from the pre-season conditioning program. There was an increase in fifth-minute heart rate during the early season. This was probably a result of increased workload and small amounts of weight loss as preparation for weekly wrestling meets was undertaken. There was a decrease in the fifth-minute heart rate during the weigh reduction interval. This change was probably a consequence of the added weight loss by dehydration. Saltin recorded a mean heart rate of 192.4 beats per minute under normal conditions without dehydration and a mean heart rate of 192.0 beats per minute under a condition of dehydration during hard work.[28] Blyth and Burt recorded a mean increase in heart rate of 8.96 beats per minute under normal conditions and a mean heart rate of 11.52 beats per minute under dehydrated conditions.[29] Bock, Fox and Bowers found a mean heart rate of 180.5 beats per minute in a pre-test for non-eaters and a mean heart rate of 180.3 beats per minute in a post-test for non-eaters after a period of dehydration.[30] Finally there was an increase in the fifth-minute of heart rate near the end of the competitive season. This elevation in heart rate was probably a result of the increase in conditioning activity in preparation for tournament competition and a return to normal weight. Bock, Fox and

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[28] Saltin, p. 1116.

[29] Carl S. Blyth and John J. Burt, "Effect of Water Balance on Ability to Perform in High Ambient Temperatures," Research Quarterly, XXXII (October, 1961), 305.

[30] William Bock, Edward Fox, and Richard Bowers, "The Effects of Acute Dehydration Upon Cardio-respiratory Endurance," Journal of Sports Medicine and Fitness, VII (March, 1967), 69.

Bowers reported a slightly elevated heart rate following rehydration.[31] The current study recorded a mean of 164.79 beats per minute for the experimental group and a mean of 161.35 for the control group. These heart rate means indicate that the wrestlers used in the current study had a lower heart rate than Saltin's subjects who were mature men. The wrestlers used in the present study had a lower heart rate than the subjects of Bock, Fox, and Bowers since they did not starve extensively to make weight.

Heart Rate--Sixth Minute. These results indicate there was a sharp increase in the heart rate for the sixth-minute. A probable cause for this increase was poor conditioning for endurance activities. There was a slight decrease in the sixth-minute heart rate during the early season. This was possibly a consequence of increased physical conditioning and the making of weight for the early season. There was a continuing decrease in sixth-minute heart rate during the weight reduction interval. This additional decrease in heart rate was probably caused by the added weight loss from starvation and dehydration. Finally, there was an increase in the sixth-minute heart rate. This was probably a consequence of rehydration the

[31] Bock, Fox, and Bowers, pp. 73-74.

return to normal in weight, and the increased physical activity in preparation for tournament competition. The current study recorded a mean of 178.00 beats per minute for the experimental group and a mean of 173.44 for the control group.

URINE COMPOSITION

Three urine measures were statistically significant. These were specific gravity, sodium, and potassium. The other measures used required comparisons with color charts or comparisons through microscopic study. The nature of these results were inadequate for statistical analysis.

The urine samples changed from yellow or straw-colored to slightly cloudy. These changes were only slight and did not appear to be related to the training program or to weight reduction.

An increase in the protein level occurred in those continually making weight. This was probably the consequence of a restricted diet containing large quantities of proteins.

The hydrogen-ion concentration or pH varied from training cycle to training cycle. The pH decreased during the pre-season conditiong period and the early season, then it increased during the weight reduction interval and declined again near the end of the season. The decreases in pH seem to be a consequence of increased acidity caused by physical conditioning activities.[32] The increase in pH seemed to be a result of the physiological balancing of the internal processes as body weight returned to normal.

Acetone bodies appeared in two individuals after they had eaten considerable quantities of sugar a short time before urine samples were drawn. None of the other subjects reflected any acetone bodies throughout the study.

Specific gravity was statistically significant and showed changes during the training cycles and between the experimental group and the control group. These changes suggest considerable amounts of excess acid were excreted during the pre-season conditioning period and the early season as physical activity increased and a weight loss occurred. Acid excretion increased slightly during the weight reduction interval as a consequence of dehydration and its attendant effects upon the circulatory system, thereby causing a reduction in acid production. There was a slight decrease in specific gravity near the end of the season. This was a result of rehydration and the increased tempo in physical activity in preparation for tournament competition. It was also a consequence of the return to normal for body weight.

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[32]Laurence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise 6th edition; (St. Louis: C. V. Mosby Company, 1971), p. 168.

White blood cells appeared during the various training cycles. These cells appeared to increase whenever there was a variation in weight, an increase in exercise workload, or an increase in stress associated with competition. Morehouse and Miller indicate exercise of any kind or stress associated with exercise will cause a rise in white blood count.[33]

Red blood cells rarely appeared in the urine. The increase in red blood cells was probably a consequence of new blood cells being released from the bone marrow to compensate for the old blood cells which were being destroyed by muscular activity.[34]

Casts changed with each training cycle. They appear to be a consequence of the increased intensity of exercise.[35] It is also possible they were a result of an irritation of the glomerui and the renal tubules resulting from an increase in filtration by the kidneys. The casts decreased as the body weight returned to normal.

Crystals appeared infrequently. They were observed during single cycles and they appeared to be unrelated to

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[33]Morehouse and Miller, pp. 168-169.

[34]Morehouse and Miller, p. 168.

[35]Philip J. Rasch, Lucian B. Faires, and M. Briggs Hunt, "Effects of a Combative Sport (Amateur Wrestling) on the Kidneys," <u>Research Quarterly</u>, XXIX (March, 1958), 57.

the other items in the urinalysis. Parasites did not appear in the urine samples, however, bacteria was present in the urine during the early season. Bacteria was evident as a consequence of the reduced resistance to disease when the wrestlers made their competitive weights. They were probably related to inadequate food, loss of sleep, or fatigue.

Epithelial cell count changed throughout the wrestling season. These cells appear to have been a result of the increased filtration process occurring in the tubules. These cells may have been released from the tubule linings and were later filtered into the urine.

Mucous cell count changed during the various training cycles. These changes were probably a result of the metabolic changes occurring in the kidneys. It is possible some of the mucous cells may have been absorbed from the stomach lining or were the result of a respiratory infection.

Sodium content of the urine was statistically significant during each training cycle and between the experimental group and control group. These changes were caused by fluctuation in the extracellular fluid volume and the filtration and reabsorption rates in the kidneys. This was a consequence of an increased exercise workload and sweating rates. The sodium level returned to normal as rehydration and body weight returned to normal.

These findings are in agreement with those of Harvey, Cuff, Johns, Owens, Rabinowitz and Ross who found a correlation existing between plasma sodium concentration and the rate of sodium excretion. Sodium excretion also responds to changes in extracellular fluid volume. Changes in both the rate of filtration and the rate of reabsorption affect sodium excretion. Relatively small increases in the glomerular filtration rate may be associated with striking increases and, conversely, virtually unmeasurable drops in glomerular filtration rate, causing a marked diminution in sodium excretion.[36] Guyton suggests that when the absorptive ability of the tubules is exceeded, the glomerular filtration rate increases higher and higher; and when the maximum glomerular filtration is reached, the substances begin to spill into the urine thus increasing the volume of the urine.[37]

Potassium content was statistically significant during the various training cycles and between the experimental group and control group. These changes indicate

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[36]A. McGehee Harvey, Leighton E. Cuff, Richard J. Johns, Albert H. Owens, Jr., David Rabinowitz and Richard S. Ross, The Principles and Practice of Medicine 17th edition; (New York: Appleton-Century-Crofts, Meredith Corporation, 1968), pp. 122-123.

[37]Arthur C. Guyton, Textbook of Medical Physiology, 4th edition; (Philadelphia: W. B. Saunders Company, 1971), p. 410.

that the excretion of potassium increased as a consequence of the exercise workload during the pre-season conditioning period. Potassium decreased again during the early season as the exercise workload increased and weight loss occurred. The increase in potassium excretion during the weight reduction period reflected a decrease in the extracellular fluid volume caused by extensive sweating, dehydration, and sodium loss. The decrease in potassium excretion near the end of the competitive season reflected a condition of rehydration, a decrease in sweating rate, and a decrease in sodium loss during extended physical activity. Potassium fluctuations were balanced by sodium fluctuations. When the potassium level increased, the sodium level decreased and when the sodium level increased, the potassium level decreased.

These results agree with the views of Harvey, Cuff, Johns, Owens, Rabinowitz, and Ross who indicate potassium always appears in the urine. All plasma potassium is filterable and potassium concentration of the glomerular filtrate is in Donnan equilibrium with plasma potassium concentration. All, or nearly all, filtered potassium is reabsorbed so that little or no potassium reaches the distal tubule. In the distal tubule, intracellular potassium is exchanged with sodium in the tubular urine and all, or nearly all, potassium finally excreted in the urine arrives there by tubular excretion produced by an ion exchange process.[38] Guyton indicates that when sodium is reabsorbed in the distal tubules and collecting ducts, large quantities of positive ions transfer from the tubules into the peritubular fluids. As a result, strong electronegativity develops in the tubules, -40 to -120 millivolts, and pulls positive potassium ions from the tubular cells into the tubules, thereby causing passive secretion of potassium into the urine.[39]

BLOOD COMPOSITION

Six blood measures were statistically significant. These measures included hemoglobin, mean corpuscular hemoglobin concentration, polymorphonuclear neutrophils, lymphocytes, monocytes, and sodium. These measures changed significantly during the training cycles and between the experimental group and control group. The following measures showed no significant differences: white blood count, red blood count, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, eosinophils, potassium, and chloride.

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[38]Harvey, Cuff, Johns, Owens, Rabinowitz and Ross, p. 79.

[39]Guyton, p. 418.

White blood count did not significantly change; however, there was a slight increase in white blood count during the weight reduction period. This suggests an attempt by the body to compensate for the possibility of infection or injury during a period of increased vulnerability. Since the weight reduction period was characterized by an increased exercise workload, an increase in white blood count is a natural consequence. Karpovich indicated there was a relationship between the amount and intensity of work on the one hand and the character of the change on the other.[40]

Red blood count did not change significantly during the training cycles or between the experimental group and control group. This reaction was probably a result of an adjustment of physiological functions to the training regimen, and/or the training regimen was not of the required duration, intensity, or frequency to cause significant alterations in this parameter.

Hemoglobin changed significantly during the training cycles and between the experimental group and control group. There was a gradual decrease in hemoglobin during the pre-season conditioning period, the early season, and the weight reduction interval, with a slight

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[40]Peter V. Karpovich, "The Effect of Basketball, Wrestling, and Swimming Upon the White Blood Corpuscles," p. 43.

increase near the end of the season. These findings confirm those of Morehouse and Miller who indicated that, during prolonged exercise, the red blood cell count is lowered, as the red blood cells are destroyed by heavy muscular contractions and the increased velocity of blood flow.[41] The hemoglobin level also remains relatively constant.[42]

Hematocrit did not change significantly during the training cycles or between the experimental group or among the training cycles. These results agree with those of Morehouse and Miller who reported that evidence is not convincing that hematocrit increases with training.[43] Saltin found hematocrit increased when plasma volume decreased in a state of dehydration; however, this change was not significant.[44]

Mean corpuscular volume did not significantly change during the training cycles or between the experimental group and control group. Beeson and McDermott indicated that an abnormal hemoglobin content may appear in red blood cell size and is indicative of disorders of anemia. They suggest that the degree of anemia and the

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[41]Morehouse and Miller, p. 168.

[42]Morehouse and Miller, p. 158.

[43]Morehouse and Miller, p. 168.

[44]Saltin, p. 1128.

abnormal appearance of the red blood cells are the consequences of the effects of both the primary cause and the erythropoietic response by the bone marrow.[45]

Mean corpuscular hemoglobin did not change significantly between the experimental group and the control groups or among the training cycles. Beeson and McDermott indicated that an abnormal hemoglobin content may appear in the red blood cells and is indicative of disorders of anemia. They suggest that the degree of anemia and the abnormal appearance of the red blood cells are the consequences of the effects of the primary cause and the erythropoietic response by the bone marrow.[46] Guyton indicated that in anemia, blood viscosity decreases allowing a greater than normal quantity of blood to be returned to the heart causing an increase of cardiac output.[47]

Mean corpuscular hemoglobin concentration changed significantly during the training cycles and between the experimental group and the control group. These results suggest mean corpuscular hemoglobin concentration decreased during the pre-season conditioning period, the early season, and the weight reduction period, and finally increased toward

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[45]Paul B. Beeson and Walsh McDermott, eds., Textbook of Medicine (14th edition; Philadelphia: W. B. Saunders Company, 1975), II, p. 1884.

[46]Beeson and McDermott, p. 1403.

[47]Guyton, p. 106.

the end of the competitive season. This was caused by a decrease in plasma volume as the osmotic balance between extracellular fluid and interstitial fluid was maintained during weight redistribution and weight reduction. The mean corpuscular hemoglobin concentration increased near the end of the season as plasma volume increased and subsequent rehydration returned the weight to normal.

Polymorphonuclear neutrophils changed significantly among the training cycles and between the experimental group and control group. These results reflect a decrease in polymorphonuclear neutrophils during the pre-season conditioning period and an increase during the early season. There was a sharp decline during the weight reduction interval, and a slight increase near the end of the competitive season. This reaction during the pre-season conditioning period can best be attributed to an increase in leukocytes which entered the blood stream from the lymph nodes. During the early season as physical conditioning improved, increased neutrophils were washed from the storage spaces by the circulating blood. The neutrophils then decreased during the weight reduction interval as the plasma volume decreased during dehydration. Finally, the neutrophils increased near the end of the season as the plasma volume increased with rehydration and the subsequent return to normal body weight. Morehouse and

Miller indicate that during brief periods of strenuous exercise, the white blood cells increase in number by lymphocytic action; however, when exercise is prolonged, the additional rise in white cell count is caused almost entirely by an increase of neutrophils.[48] Karpovich found that short periods of wrestling produce a lymphocytic phase while long periods result in a neutrophilic phase. These blood changes indicate there is a relationship between the amount and intensity of work, on the one hand, and the character of the change, on the other hand.[49]

Lymphocytes changed significantly between the experimental group and control group and among the training cycles. The results of the current study show a decline in lymphocytes during the pre-season conditioning period and early competitive season which may in part by explained by the improvement in conditioning; while the increase in lymphocytes during the weight reduction period and later competitive season may be indicative of the physiological disturbances caused by disease producing bacteria. The anxiety of approaching tournament competition may also have been a factor.

Monocytes significantly changed between the experimental group and the control group and among the training

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[48]Morehouse and Miller, p. 169.

[49]Karpovich, p. 45.

cycles. These results show a rapid increase in monocytes during the pre-season conditioning period, early season, and the weight reduction interval. This condition is probably a result of the body's preparation to fight disease producing bacteria during the physiological disturbance brought on by heavy exercise, the conditioning program, and weight loss during these periods. The decline in monocytes during the latter stages of the competitive season is, most likely, a result of rehydration and a decrease in the susceptability of the body to disease from the exercise workload and conditioning activities of the wrestlers as they approached the end of the season. Karpovich concluded that the duration and the intensity of exercise were partly responsible for the changes occurring in the white blood cells.[50]

Eosinophils did not significantly change between the experimental group and control group and among the training cycles. These findings are supported by Guyton who pointed out that the function of the eosinophils is almost totally unkown; however, they are found in the blood in large numbers after foreign protein injections. They are also present in the mucosa of the intestinal tract and in the tissues of the lungs, where foreign proteins

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[50]Karpovich, p. 43.

normally enter the body.[51] It has been suggested that the function of the eosinophils is to detoxify the proteins before they can cause damage to the body, and they are possibly important for the dissolution of old blood clots. The eosinophils react to toxic products released from the tissues, thus increasing the number of eosinophils in the blood. Guyton indicates that infection by parasites is the most common cause of extremely large numbers of eosinophils in the blood.[52]

Sodium serum measures were significantly different between the experimental group and control group and among the training cycles. The current study reflected a gradual increase in the sodium serum level during the pre-season conditioning period, possibly as a result of the reabsorption of sodium in the renal tubules as a consequence of increased physical activity. There was a gradual decline in the sodium serum level during the early season, possibly a consequence of the acclimatization of the wrestlers to the heat conditions of the practice area, the intensity of wrestling activity, and the making of weight during the early season. There was a stabilization of the sodium serum level during the weight reduction interval as a possible consequence of the continued reduction in fluid

[51]Guyton, p. 115.

[52]Guyton, p. 115.

from the extracellular space by dehydration. There was a further decrease in the sodium level near the end of the season, possibly a consequence of the acclimatization of the physiological functions within the body to post-dehydration conditions. These results are supported by Cade, Free, DeQuesada, Shires, and Roby who reported that sodium serum concentration increased in all their subjects as a result of severe sweating.[53] Kozlowski and Saltin attained similar results noting a higher sodium serum loss during thermal heat stress with a greater portion of this loss coming from the extracellular space during exercise dehydration.[54]

The sodium serum level of the blood is responsible for maintaining the equilibrium between the extracellular fluid and the intracellular fluid. Sodium causes water to be expelled in the form of sweat which cools the body thus stabilizing the core temperature and varying the extracellular fluid level. The sodium serum which is extracted from the intracellular fluid is carred to the kidneys and filtered.

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[53]J. R. Cade, H. J. Free, A. M. DeQuesada, D. L. Shires, and L. Roby, "Changes in Body Fluid Composition and Volume During Vigorous Exercise by Athletes," Journal of Sports Medicine and Physical Fitness, XI (September, 1971), 174.

[54]Stanislaw Kozlowski and Bengt Saltin, "Effects of Sweat Loss on Body Fluids," Journal of Applied Physiology, XIX (November, 1964), 1123.

This fluid is then returned to the blood plasma in the form of sodium chloride for additional use. When an over-abundance of sodium is present it is passed off in the form of sweat or in the urine.

Potassium serum showed no significant difference between the experimental group and the control group or among the training cycles. The potassium level increased slightly during the weight reduction period. This effect was a consequence of the physiological balancing process to compensate for sodium losses through the dehydration process, and through the increased exercise workload.

Potassium serum of the blood is in equilibrium with the sodium serum of the blood. When the sodium level decreases, the potassium level increases, when the sodium level increases, the potassium level decreases, thus maintaining a balanced internal environment. When the potassium level becomes excessive potassium is excreted. When the potassium level is inadequate, it is filtered by the kidneys and returned to the blood plasma for additional use.

Chloride did not significantly change between the experimental group and the control group or among the training cycles. These findings are in agreement with those of Guyton who indicated the function of chloride is to assist in buffering the blood during heavy exercise. As the extracellular fluid becomes acid, the renal tubules reabsorb large quantities of bicarbonate ions. The chloride ion reabsorption diminishes during the reabsorption process.[55] The quantity of chloride found in the extracellular fluid is a consequence of the volume of extracellular fluid and is not the result of an increase in the chloride concentration. In fact, as extracellular fluid volume increases, the chloride concentration decreases a proportional amount. Chloride also works in conjunction with sodium to maintain balance within the blood plasma. The sodium and chloride work to balance the extracellular fluid level and the intracellular fluid level in conjunction with potassium and other substances.

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[55]Arthur C. Guyton, Basic Human Physiology: Normal Function and Mechanisms of Disease (Philadelphia: W. B. Saunders, 1971), p. 291.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

In recent years, there has been increasing concern regarding the problem of excessive weight reduction of high school wrestlers. The practice of "making weight" has been questioned by parents, teachers, school administrators, physicians, and national organizations, especially the American Medical Association and the National Federation of State High School Associations.

This study was undertaken to investigate the physiological changes affecting a high school wrestling team during the various phases of a competitive season. The physiological changes resulting from making weight were evaluated by comparing the pre-season conditioning period, the early season, the weight reduction interval, and the end of the competitive season.

Thirty-six high school athletes between fourteen and eighteen years of age were selected from thirty-nine prospective participants in the wrestling programs at East Ridge High School and East Ridge Junior High School in Chattanooga, Tennessee. Of the thirty-nine wrestlers who expressed interest in the project initially, thirty-four completed all experimental requirements. Two individuals were unable to complete the program. One individual received a knee injury in the final football game of the season, and another individual moved away.

The thirty-four subjects were randomly assigned to an experimental group or to a control group for study during the training regimen. The experimental group followed a normal training program during the pre-season conditioning period and the early season. Next, they entered a weight reduction interval in which weight was reduced by increased exercise, dieting, and dehydration. Following the weight reduction interval, the experimental group returned to the normal practice routine. The control group followed a normal training routine without weight reduction throughout the entire season. The wrestling season began on October 28, 1974, and ended on January 27, 1975, and did not include the tournament series.

The data were obtained on five occasions over a period of thirteen weeks from tests given to the subjects in both groups. These items were selected to measure the more important physiological attributes of high school wrestlers. Data were collected and analyzed for sixty-two variables including fourteen anthropometric measures, six body composition skin-fold measures, two body circumference measures, five strength measures, two muscular endurance measures, two cardiovascular endurance measures, seventeen urine composition measures, and fourteen blood composition measures.

Weight reduction was limited to the methods and conditions used by high school wrestlers in reducing their body weight. No attempt was made to govern the techniques used; however, advice was given regarding diet and dieting practices. The amount of weight reduced was limited to that normally lost by the wrestlers for a specific weight classification. This resulted in a difference in the amounts of weight lost by the wrestlers which varied from 1.50 to 5.00 pounds.

Analysis of the data obtained from these tests was made as follows:

1. Computation and comparison of the means and standard deviations for each test administered during each training cycle for the experimental and control groups. Means and standard deviations were reported for all measures.
2. Computation of a two-way analysis of variance with repeated measures for each dependent variable, utilizing the .05 level to determine significance. Two-way analysis of variance was reported for all measures.
3. Computation of Duncan's Multiple Range Test to locate significant difference when a significant F-ratio was obtained.

CONCLUSIONS

Within the limitations of this study and the sample used, the following conclusions were drawn:

1. The null hypothesis that in the experimental group there would be no significant change in the physiological measures beginning with the pre-season conditioning period and ending with the competitive season was rejected.
2. The null hypothesis that in the control group there would be no significant change in the physiological measures beginning with the pre-season conditioning period and ending with the competitive season was rejected.
3. The null hypothesis that in the experimental group there would be no significant differences in the physiological measures between the pre-season conditioning period and the weight reduction period was rejected.
4. The null hypothesis that in the experimental group there would be no significant difference in the physiological measures between the pre-season conditioning period and the competitive season was rejected.

5. The null hypothesis that in the experimental group there would be no significant difference in the physiological measures between the competitive season and the weight reduction period was rejected.
6. The null hypothesis that in the experimental group there would be no significant difference in the physiological measures between the pre-season conditioning period, the competitive season, and the end of the competitive season was rejected.
7. The null hypothesis that in the experimental group there would be no significant difference in the physiological measures between the weight reduction period, the pre-season conditioning period, and the end of the competitive season was rejected.

RECOMMENDATIONS

1. High school wrestlers are growing rapidly and are not physically mature. The wrestling coach should evaluate age, height, weight, body diameters, body composition, and body circumference before initiating a weight reduction program.

2. The wrestling coach should evaluate body circumferences periodically during the wrestling season to identify weight redistribution as fat is displaced by an increase in muscle mass.
3. High school wrestlers are not physically strong, therefore, the coach should adopt techniques and wrestling skills to the maturity level of his wrestlers.
4. High school wrestlers have lower muscular endurance than college wrestlers, therefore, the length of wrestling bouts should be tailored to the abilities of high school wrestlers.
5. Cardiovascular endurance levels are lower for high school wrestlers than for college wrestlers, therefore, the high school wrestling coach should modify his conditioning program to the maturity level of high school wrestlers.
6. Urine samples should be analyzed periodically to identify degenerative effects of dehydration on the kidneys.
7. Administrators should discipline their coaches who dehydrate their wrestlers.
8. Blood samples should be analyzed periodically to identify infections, deseases, or anemias.

Additional data and information are necessary to provide an answer to the criticisms leveled at high school wrestling. Such investigation might take the following approaches:

1. A similar study deleting the body diameter measures and increasing the body circumference measures. The body diameter measures were difficult to reproduce, therefore, resulting in some variability. The body circumference measures should give a better perspective of weight redistribution and weight loss.
2. A similar study utilizing either high school wrestlers or junior high school wrestlers exclusively.
3. A study of high school wrestlers to determine oxygen affinity and its relationship to changes in blood composition during a competitive wrestling season.
4. A comparative study of the different methods of weight reduction utilized by high school wrestlers.
5. A study of the changes in mineral and phosphate composition of the blood and urine occurring during a competitive wrestling season.

6. A study of the wrestling weight control program of the Tennessee Secondary School Athletic Association and its impact on the high school wrestler in Tennessee.
7. A study of Tennessee schools to determine the extent of making weight among high school or junior high school wrestlers.

IMPLICATIONS FOR TEACHING

With the growing problem of excessive weight loss in athletic activities, the need for additional training and information persists. A unit of instruction has been prepared from the findings of this study and incorporated as Appendix C. This material has been prepared to assist physical education instructors and coaches in teaching others about weight loss and its attendant effects on the high school athlete.

APPENDICES

APPENDIX A

LETTER TO PARENTS

John P. Farr
211 Browntown Road
Chattanooga, Tennessee 37415
Telephone: 875-9282

October 15, 1974

Memorandum To: Parents, East Ridge High School and East Ridge Junior High School wrestlers.

From: John P. Farr

RE: High School Wrestling Study

This letter is being sent to you, the parents of East Ridge High School and East Ridge Junior High School wrestlers. The purpose of this letter is to familiarize you with the high school wrestling study.

A study of physiological factors will be undertaken to determine the physiological changes accompanying a season of competitive high school wrestling. Measures will be taken and evaluated for the following items:

1. Age, height, and weight--health scales with a stadiometer will be used.

2. Body diameters--wooden shoulder calipers will be used.

3. Skinfolds--Lange skinfold calipers will be used.

4. Strength--cable tensiometer and hand dynometer will be used.

5. Body circumferences--cloth measuring tape will be used.

6. Muscular endurance--chin bar and parallel bars will be used.

7. Cardiovascular endurance--Bicycle Ergometer will be used.

8. Urinalysis--urine samples will be analyzed by East Ridge Community Hospital Laboratory.

9. Blood analysis--blood analyses will be performed by East Ridge Community Hospital Laboratory.

The specific testing procedures will be reviewed on October 18, 1974, after parental permission forms have been returned.

Physical examinations will be required of all participants and must be completed prior to October 25, 1974. The normal physical examination for athletics as required by the schools will suffice for this purpose. Physical examinations will be accepted if completed after August 25, 1974.

Each parent must sign a permission form granting permission for your son(s) to participate in the wrestling study. Permission must also be granted for your son(s) to make a trip to Middle Tennessee State University at Murfreesboro, Tennessee, on or about October 26, 1974, to undergo the first series of testing. Expenses for the trip will be furnished by Mr. Farr. Transportation will be provided by Mr. Hall, a bus driver for East Ridge High School and employed by Hamilton County Department of Education.

Additional information may be obtained by contacting Coach Mike Parker, East Ridge High School; Coach Paul Smith, East Ridge Junior High School; or Mr. Farr, Sale Creek School, at 875-9282.

Respectfully yours,

John P. Farr

APPENDIX B

CONSENT FORM

DEPARTMENT OF HEALTH, PHYSICAL EDUCATION
RECREATION AND SAFETY
MIDDLE TENNESSEE STATE UNIVERSITY
MURFREESBORO, TENNESSEE

EXPERIMENTAL STUDY CONSENT FORM

Project Title: High School Wrestling Study

Study Collaborators: Dr. Powell D. McClellan, Faculty Advisor

John P. Farr, DA Candidate

This is to certify that I, ______________________, hereby agree to participate in an experimental study under the direction of the above. I am ______ years of age.

This study will include:

1. Various physiological tests
2. Trip to Murfreesboro, Tennessee

A detailed explanation of this study has been given to me and I understand the procedures to be followed. I have been informed of all inconvenience and risks reasonably to be expected from the procedures, and possible beneficial effects thereof. All of my inquiries have been answered, and I choose freely and voluntarily to participate.

______________________________ ______________
Volunteer's Signature Date

I hereby grant permission for my son to participate in the study outlined above.

______________________________ ______________
Parent or Guardian's Signature Date

I have defined and fully explained the extensiveness of this study to the above volunteer.

______________________________ ______________
Investigator's Signature Date

APPENDIX C

COURSE OF STUDY

PRINCIPLES OF WEIGHT REDUCTION
PHYSIOLOGY OF EXERCISE

Hours Required: Class 3

Prequisites: None

Text: Morehouse, L. E. and Miller, A. T., Jr. Physiology of Exercise, 6th edition. St. Louis: The C. V. Mosby Company, 1971.

Course Description:

This course is designed to introduce the prospective physical education major and/or coach to the field of physiology and to provide a firm basis for understanding weight loss and its implications as an additional responsibility in teaching or coaching. Information is provided to help the study understand the overall functioning of the body during weight loss by athletes. Fundamental knowledge of the physical and functional properties, composition, mechanisms, and effects of weight loss will be emphasized.

Behavioral Objectives:

At the completion of this course the student will be able to:

1. properly recognize the various bodily systems and their importance in weight loss.

2. state the rationale for correctly following effective weight control procedures.

3. relate the principles of basic physiology to those associated with losing weight.

In addition, the student should be able to demonstrate comprehension of the physical aspects of weight loss.

Coordination:

A coordinated approach will best integrate this material into the health science courses. The following will aid in more effective coordination: a common textbook, common syllabus, list of outside readings, annotated card file on films, and slide collections. Periodical meetings of the Health Science Staff are necessary to effectively coordinate efforts.

I. Introduction to weight reduction

- A. What is weight reduction
  1. Definition of weight reduction
  2. Comparison of weight reduction with aspects of healthful living
- B. Criticisms of weight reduction
  1. Relevance: understanding how attitudes have developed as they have, and how change has affected these attitudes
  2. Aesthetics: appreciation of human accomplishments
  3. Judgment: provides a broad sense of perspective
  4. Objectives: reasons for studying weight reduction

II. Methods of weight reduction

A. Dieting

B. Dehydration

1. Excessive sweat production by heat

2. Excessive sweat production by exercise

3. Reduction of fluid levels in the body

C. Combination of methods

III. The Ill Effects of Excessive Weight Reduction

A. Acute starvation

B. Dehydration

C. Physical Effects

1. Reduction in strength

2. Decreased muscular endurance

3. Decreased oxygen consumption

4. Deficient circulation

5. Changes in heart rate

6. Changes in cardiac output

7. Reduction in blood volume

8. Deficient excretion

9. Reduction in body fluids

IV. Physiology of Exercise

A. Bodily conditions during weight reduction

1. Body water and fluids

2. Electrolytes

3. Temperature

4. Sweat glands
5. Cardiovascular efficiency
6. Circulation
7. Excretion
8. Acclimatization
9. Rehydration

B. Measures utilized to determine weight reduction

1. Anthropometrical measures
    a. Age, height, and weight
    b. Body diameters
2. Body composition
3. Body circumferences
4. Muscular strength
5. Muscular endurance
6. Cardiovascular endurance
7. Urine composition
8. Blood composition

C. Limits of weight loss

1. Above ten percent
2. Seven to ten percent
3. Less than seven percent

V. The Ideal Athlete

A. Physical Qualities

1. Age, height, and weight
2. Body structure

B. Minimal body weight

VI. Recommendations for coaching

A. Maturity of high school wrestlers

B. Ideal body weight

C. Adjustment of the wrestling program to the needs and capabilities of the high school student

D. Degenerative effects of weight reduction

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APPENDIX D

THE CRITICAL VALUES

FOR

DUNCAN'S MULTIPLE RANGE TEST

TABLE LXIII

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR BODY DIAMETERS AS SHOWN IN TABLE VI

VARIABLE	K	2	3	4	5
Bitrochanters	0.4155	1.3254	1.3005	1.2590	1.2008
Wrists	0.1079	0.3442	0.3377	0.3266	0.3115
Ankles	0.0808	0.2578	0.2529	0.2448	0.2335

TABLE LXIV

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR BODY SKINFOLDS AS SHOWN IN TABLE XIV

VARIABLE	K	2	3	4	5
Triceps	0.5112	1.6307	1.6001	1.5489	1.4774
Chest	0.1862	0.5940	0.5828	0.5642	0.5381
Suprailiac	0.6308	2.0123	1.9744	1.9113	1.8230
Abdomen	0.4151	1.3242	1.2993	1.2578	1.1996
Thigh	0.5323	1.6980	1.6661	1.6129	1.5383

TABLE LXV

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR BODY CIRCUMFERENCES AS SHOWN IN TABLE XXI

VARIABLE	K	2	3	4	5
Gluteal Circumference	1.0635	3.3926	3.3288	3.2224	3.0735
Thigh Circumference	0.3108	0.9915	0.9728	0.9417	0.8982

TABLE LXVI

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR MUSCULAR STRENGTH AS SHOWN IN TABLE XXIV

VARIABLE	K	2	3	4	5
Grip Strength	0.9197	2.9338	2.8787	2.7867	2.6579
Elbow Flexion	0.9071	2.8936	2.8392	2.7485	2.6215
Elbow Extension	1.1202	3.5734	3.5062	3.3942	3.2374
Knee Extension	0.9096	2.9016	2.8470	2.7561	2.6287

TABLE LXVII

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR MUSCULAR ENDURANCE AS SHOWN IN TABLE XXX

VARIABLE	K	2	3	4	5
Pull-ups	0.5294	1.6888	1.6570	1.6041	1.5300
Dips	0.6878	2.1941	2.1528	2.0840	1.9877

TABLE LXVIII

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR CARDIOVASCULAR ENDURANCE AS SHOWN IN TABLE XXXIII

VARIABLE	K	2	3	4	5
Heart Rate Fifth-Minute	1.8615	5.9382	5.8265	5.6403	5.3797
Heart Rate Sixth-Minute	1.8089	5.7704	5.6619	5.4810	5.2277

TABLE LXIX

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR URINE COMPOSITION AS SHOWN IN TABLE XXXVI

VARIABLE	K	2	3	4	5
Specific Gravity	0.000777	0.00248	0.00243	0.00235	0.00225
Potassium	9.722	31.0132	30.4299	29.4577	28.0966
Sodium	5.1976	16.5803	16.2685	15.7487	15.0211

TABLE LXX

THE CRITICAL VALUES FOR DUNCAN'S MULTIPLE RANGE TEST FOR BLOOD COMPOSITION AS SHOWN IN TABLE XL

VARIABLE	K	2	3	4	5
Hemoglobin	0.2069	0.6600	0.6476	0.6269	0.5979
M.C.H.C.	0.1869	0.5962	0.5850	0.5663	0.5401
Neutrophils	1.4990	4.7818	4.6919	4.5420	4.3321
Lymphocytes	1.3376	4.2669	4.1867	4.0529	3.8657
Monocytes	0.5335	1.7019	1.6699	1.6165	1.5418
Sodium	0.4847	1.5462	1.5171	1.4686	1.4008

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