Dietary influences on selected physiological parameters in collegiate wrestlers during the pre-competitive training period
by Don Wayne Jensen

A thesis submitted in partial fulfillment of the requirements for the degree of . Master of Science in Physical Education
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Abstract:
The purpose of this investigation was to examine the relationship between the presence and absence of specific nutritional control for purposes of attaining a pre-selected weight loss and 31 physiological parameters in 18 collegiate wrestlers during the pre-competitive training period utilizing a pre- and post-test design.

The subjects were divided into two groups. An experimental group (EG) was placed on a high carbohydrate-hypocaloric diet. The second group (CG) served as controls and received no dietary directions to aid in reducing body weight.

As a result of following a hypocaloric diet, the EG experienced a significantly larger ($P<0.05$) reduction in total body weight in comparison to the CG. The composition of the weight loss for the EG was made up of a decrease in both fat weight and lean body weight. The CG had an overall decrease in total body weight due to a decrease in fat weight partly offset by an increase in lean body weight, however, the two groups for body composition were not significant. No significant differences were observed for muscular endurance, power, and aerobic endurance, although results indicate that the EG made slightly larger improvements for nearly every variable measured over the pre-competitive training period. Also, at both weigh-in periods just prior to competition, the differences found in the urinary profiles (dehydration/ rehydration) between the two groups were not significant.

The results of this study indicate that there may be an individual optimal body composition for each wrestler and that attempts at weight reduction beyond that level would be at the expense of lean body weight as well as fat weight. Gains in performance related variables appear to be slight as a result of following a hypocaloric diet."

DIETARY INFLUENCES ON SELECTED PHYSIOLOGICAL PARAMETERS IN COLLEGIATE WRESTLERS DURING THE PRE-COMPETITIVE TRAINING PERIOD

by

Don Wayne Jensen

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Don Wayne Jensen

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The purpose of this investigation was to examine the relationship between the presence and absence of specific nutritional control for purposes of attaining a pre-selected weight loss and 31 physiological parameters in 18 collegiate wrestlers during the pre-competitive training period utilizing a pre- and post-test design.

The subjects were divided into two groups. An experimental group (EG) was placed on a high carbohydrate-hypocaloric diet. The second group (CG) served as controls and received no dietary directions to aid in reducing body weight.

As a result of following a hypocaloric diet, the EG experienced a significantly larger ($P<0.05$) reduction in total body weight in comparison to the CG. The composition of the weight loss for the EG was made up of a decrease in both fat weight and lean body weight. The CG had an overall decrease in total body weight due to a decrease in fat weight partly offset by an increase in lean body weight, however, the two groups for body composition were not significant. No significant differences were observed for muscular endurance, power, and aerobic endurance, although results indicate that the EG made slightly larger improvements for nearly every variable measured over the pre-competitive training period. Also, at both weigh-in periods just prior to competition, the differences found in the urinary profiles (dehydration/rehydration) between the two groups were not significant.

The results of this study indicate that there may be an individual optimal body composition for each wrestler and that attempts at weight reduction beyond that level would be at the expense of lean body weight as well as fat weight. Gains in performance related variables appear to be slight as a result of following a hypocaloric diet.

CHAPTER I

THE PROBLEM

Introduction

In the sport of wrestling, contestants are grouped into weight classes to allow them to compete with others of a similar body weight. In an effort to maximize performance potential, wrestlers often attempt to minimize the amount of body fat, as fat does not contribute to performance. By reducing to their lowest functional body weight the wrestler hopes to gain an advantage over opponents having more body fat and less muscle mass.

Mental attitude, technique, muscular strength, cardiovascular endurance, body composition, and energy levels are among the many factors which influence the overall performance of wrestlers. In addition, semi-starvation plus dehydration are often used to attain an artificially low body weight to qualify for a lower weight class. Whenever possible, the negative effects of "making weight" prior to each contest through dieting and dehydration should be kept to a minimum because an artificially low body weight may significantly curtail the progress of wrestlers as they can neither train nor compete at their optimal level (4, 5, 6, 27, 53). To minimize the stresses caused by chronic caloric restriction and dehydration, any major changes in body weight to achieve an "optimal" body composition would most appropriately take place during the base- and pre-competitive training periods. A need exists for research to determine if a high carbohydrate-hypocaloric diet will assist wrestlers attain their optimal body composition during the pre-competitive training period.

Statement of the Problem

The purpose of this investigation is to examine changes in body composition, total body weight, girths, muscular endurance, power, and aerobic endurance that occur during a collegiate wrestling pre-competitive training period in wrestlers following a program of prescribed dietary controls versus a free or uncontrolled dietary program.

Specific Objectives

1. To analyze the composition of foods consumed from food items and portion size for each subject during the pre-competitive training period.

2. To measure the changes in body composition, total body weight, and girths for each subject during the pre-competitive training period.

3. To measure the changes in muscular endurance, power, and aerobic endurance for each subject during the pre-competitive training period.

4. To measure the specific gravity of urine samples from each of the subjects the morning of the first competition (weigh-ins) and again five hours later.

Hypothesis

Null Hypothesis. It was hypothesized that there would be no significant difference between the experimental and control groups in body composition, total body weight, girths, muscular endurance, power, and aerobic endurance during the pre-competitive training period as a result of dietary controls.

Alternate Hypothesis. It was hypothesized that there would be a significant difference between the experimental and control groups in body composition, total body weight, girths, muscular endurance, power, and aerobic endurance during the pre-competitive training period as a result of dietary controls.

Delimitations

This study was delimited to twenty-five members of the Montana State University (MSU) wrestling team, 1983-84.

Limitations

1. The selection of the subjects for the experimental and control groups were based on their campus living arrangements.

2. The degree of weight reduction was limited to the amount required for each subject to reach a specified weight classification (pre-determined by each subject) for competition.

3. The experimental group's dietary intake and food selection was not completely controlled, as the subjects could not be continuously observed during the investigation.

4. Records of food intake (i.e., portion size, ingredients) by both groups were assumed to be accurate.

5. The ability of the investigator to accurately analyze the recorded food intake of the subjects was assumed to be accurate.

6. The analysis of the subjects' diets was performed on an N-Squared Nutritionist computer program, which had a limited number of listings in the food code.

7. All of the test results are assumed to represent maximal efforts on the part of the subjects.

8. The training and testing of the subjects may be affected by injury and/or illness.

General Terms and Definitions

1. Aerobic Endurance. Aerobic endurance refers to cardiovascular fitness, which is a more general total body endurance and is not localized to any specific muscle group (63).

2. Aerobic Training. Aerobic training refers to training which can be performed with a sufficient supply of oxygen available to meet the activities' energy demands (63).

3. Anaerobic Training. Anaerobic training refers to training involving intense periods of exercise such as wrestling or interval training (63).

4. Base-Training Period. During the base-training period emphasis is placed upon building overall strength, increasing aerobic endurance, rehabilitating injuries, promoting general flexibility, and gradually

reducing total body weight nearer to competitive weight. This period extends from April 15 to September 29.

5. Carbohydrate. Carbohydrate refers to a food substance that includes various sugars and starches and is found in the body in the form of glucose and glycogen (63).

6. Competitive Training Period. During the competitive training period the emphasis is upon maintaining the strength and aerobic endurance levels built during the base- and pre-competitive training periods, progressively increasing the intensity of wrestling, and adding interval training (fartleks, sprints, and stair running). This period extends from November 18 to March 15.

7. Dehydration. Dehydration refers to an extreme decrease of the intake of fluids in an attempt to rapidly reduce body weight.

8. Diet. Diet refers to foods consumed to meet nutritional needs. It is also used to describe the pattern of foods selected to meet these needs, as well as a program to lose, maintain, or gain weight (63).

9. Fat. Fat refers to a food substance that is composed of glycerol and fatty acids (63).

10. Memory Recall. Memory recall refers to an interview with a subject to determine food intake and portion sizes for a given time period (36).

11. Muscular Endurance. Muscular endurance refers to the muscles' ability to resist fatigue and perform physical work (repetitious) with a given percentage of the subject's body weight.

12. Power. For the purposes of this investigation, power refers to the maximal amount of work which can be performed for a given resistance

and time period. This is a reflection of anaerobic power as well as anaerobic metabolism (31).

13. Pre-Competitive Training Period. During the pre-competitive training period the emphasis is to continue building the aerobic base, change from a general strength training program to one designed specifically for wrestling, progressively add more wrestling time and reduce body weight nearer to competitive weight. This period extends from October 1 to November 17.

14. Protein. Protein refers to a food substance formed from amino acids (63).

15. Semi-Starvation. Semi-starvation refers to the practice of severely restricting caloric intake in an attempt to induce a reduction in body weight.

16. Specific Gravity. Specific gravity is the weight of a substance compared with the weight of an equal amount of some other substance taken as a standard. The standard for liquids is usually water, which has a specific gravity of 1.000. If a urine sample shows a specific gravity of 1.020, this means the urine is 1.020 times heavier than an equal volume of water. Normal urine has a range of 1.006 to 1.025 (41).

CHAPTER II

REVIEW OF RELATED LITERATURE

The focal point of this investigation is directed towards the physiological effects of weight reduction in collegiate wrestlers as a result of dietary controls. Though a great deal of information is available which relates to performance in the sport of wrestling, relatively little research has examined performance changes as a function of dietary restriction (26, 62). This chapter attempts to provide a brief summary of such research and will be structured in the following manner:

1. Physical Characteristics of Wrestlers
2. Dietary Controls on Weight Loss in Wrestlers
3. Dehydration in Wrestlers
4. Dehydration/Rehydration in Wrestlers
5. Acute and Chronic Semi-Starvation

Physical Characteristics of Wrestlers

Regardless of variations in anatomic structure, successful wrestlers are characterized by low levels of body fat, except for those participating in the heavyweight division. Excessive body fat acts as deadweight and reduces performance potential (63). Of greater concern is the fact that wrestlers are grouped into weight classes, consequently they may have to compete against others having a larger percentage of their body weight as muscle if the individual wrestler is overly fat. Having more lean tissue can be viewed as a definite advantage in a combative sport such as wrestling where strength is major determinant in the outcome.

Gayle and Flynn (24) studied nineteen wrestlers participating in the 1974 U.S. Olympic Trials to determine the maximal oxygen consumption and the relative body fat of high-ability wrestlers. The subjects ranged from 17 to 36 years old and weighed from 52 to 135 kg. Results indicated the mean estimated body fat was 9.8 percent for all but the heavyweight wrestlers (27.5%) who attempt to gain as much weight as possible.

Di Prampero and co-workers (21) investigated 116 athletes participating in the 1968 Olympic Games in Mexico City. They reported pentathletes as having the lowest percentage of body fat (10%), followed by long distance runners (11%), middle distance runners (11.5%), cyclists (11.5%), boxers (12%), wrestlers (12.5%), swimmers (12.%), sprint runners (12.5%), rowers (14%), soccer players (14%), fencers (14.5%), and rifle shooters (24.5%).

Tcheng and Tipton (57) undertook the assessment of anthropometric data on 582 state finalists and 835 "average" Iowa high school wrestlers to develop a multiple regression equation to predict minimal wrestling weight (MWW). Measurements were taken for height, weight, diameters, girths, and skinfolds. As a result of their findings, the recommended minimal level of body fat without prior medical approval was estimated at five percent.

Table 1 presents a summary of selected body composition studies performed on wrestlers and non-athletes (normals). From these studies it is apparent that, as a group, wrestlers tend to be lean. It appears that the optimal level of relative body fat for wrestlers is approximately six to nine percent, with five percent the recommended minimum. Some individuals may be able to safely maintain health when reducing below a level of five percent body fat (62).

Dietary Control on Weight Loss in Wrestlers

An in-depth case study was performed by Widerman and Hagan (62) on one wrestler (54.9 kg) preparing for the 1981 Maccabiah Games Trials and the National AAU Championships. The subject remained on a high carbohydrate-low calorie diet for the duration of the study (Feb. 23-Apr. 13, 1981). The total amount of Kcal/week was recorded and averaged to determine the Kcal consumed per day. From February 23 to March 17, the average caloric intake was approximately 2006 Kcal/day, with the proportion of foodstuffs being approximately 61 percent carbohydrate, 19 percent fat, and 20 percent protein. From March 23 to April 13, his average caloric consumption was 1152 Kcal/day, with a resultant change in the proportion of foodstuffs to 63 percent carbohydrate, 12 percent fat, and 25 percent protein.

Anthropometric measurements, muscular strength, maximal aerobic capacity, pulmonary function, and blood tests were performed during three testing sessions (Feb. 23, Mar. 16, and Apr. 13). A summary of results found: (a) maximal aerobic capacity (VO_2 max), as determined using the Balke treadmill test, increased by 2.0 percent when expressed

Table 1. Body Composition of Male Normals and Athletes.

Investigator	No. of Subjects	Age	Subjects	% Fat	Skinfolds*					
					TR	TH	CH	AB	SU	SI
Katch and Michael (33)	94	15-18	High school wrestlers	6.9	9.0	--	7.1	12.9	10.5	12.9
Tcheng and Tipton (57)	582	15-18	High school wrestlers	--	7.7	7.7	4.5	8.6	6.5	9.1
Kelly et al. (34)	13	18-22	Collegiate wrestlers	10.4	6.8	10.5	8.1	12.7	10.5	12.2
Sinning (50)	35	18-22	Collegiate wrestlers	8.8	8.9	--	--	9.4	9.5	--
Wilmore and Behnke (64)	135	--	College-aged male normals	14.6	7.9	14.9	--	16.0	14.1	19.3
Jackson and Pollock (30)	95	18-22	College-aged male normals	13.4	13.6	17.4	11.4	20.6	13.9	15.2

in oxygen consumption per minute per kilogram of body weight; (b) $\dot{V}O_2$ max, when expressed in terms of oxygen consumption per minute, decreased by 5.8 percent; (c) total skinfolds (seven sites) were observed to decrease from 43mm to 30mm, with a concomitant reduction in body fat from 4.8 to 1.1 percent; (d) total body weight decreased from 54.9 to 50.6 kg; (e) isotonic muscular strength was maintained for both the bench and leg press; however, when expressed in relation to body weight, there was an 8.7 and 8.6 percent increase, respectively. Explosive power increased by 25 percent on the isokinetic bench press and 5.6 percent on the isokinetic leg press; (f) blood test results indicated that all plasma constituents remained in the normal range; (g) electrolyte balance remained unchanged; (h) triglyceride levels remained constant, though as body weight decreased, the ratio of LDL-to-HDL was observed to decrease, and cholesterol-to-HDL ratio also decreased due to increased HDL values. Within the limitations of this investigation, results indicate that a highly trained wrestler was able to drop two weight classifications by reducing his weight through semi-starvation and dehydration methods while maintaining or even improving his fitness level.

In a similar study, Hansen (26) investigated the effects of dietary controls on four wrestlers and four non-wrestlers over a three-week period. The subjects reduced approximately 5.3 to 8.8 percent of their body weight during the course of the investigation. The caloric content of the reduction diet equaled 10 Kcal per pound of the desired weight (i.e., a subject reducing to 142 pounds consumed approximately 1420 Kcal per day). Test batteries of physiologic variables were performed prior to the initiation of the diet (control period) and each week thereafter. Measurements of oxygen consumption, blood lactic acid levels, heart rate and rectal temperatures were recorded at each testing session. The results indicated that: (a) $\dot{V}O_2$ max, as measured on a bicycle ergometer at an established workload, showed no significant decrease when expressed in oxygen consumption per minute per kilogram of body weight ($ml \cdot min^{-1} \cdot kg^{-1}$); (b) $\dot{V}O_2$ max expressed in liters per minute ($1\ min^{-1}$) decreased; (c) anaerobic work, determined from blood lactate levels, was observed to increase in concentration by the end of the study (though work performance was not impaired), indicating that the work was becoming more anaerobic; (d) heart rate and body temperature during exercise were not significantly elevated as a result of the weight reduction. From the results it was concluded that gradual weight reduction through dietary means does not significantly impair performance for the variables measured.

Dehydration in Wrestlers

Empirical evidence, as well as the findings of various investigators, indicates the practice of rapid weight reduction (RWR) is widespread through all levels of amateur wrestling (25, 34, 57-59, 66, 67). Bock (11) estimated that perhaps as high as ninety percent of all wrestlers use some form of RWR in order to qualify for a specific weight classification. Up to ten pounds of body weight may be lost to "make weight" (34). Repeated use of the regimen may take place as many as twenty-five times a season (66). RWR is most commonly brought about through semi-starvation, exercise and/or dehydration, with dehydration being responsible for the largest weight loss. Layered clothings, nylon or rubber sweat suits, sauna and steam baths are the primary methods of thermal dehydration. The use of dehydration generally occurs within a forty-eight hour period prior to weigh-ins (34, 62, 67).

Tipton and Tcheng (59) studied 747 high school wrestlers from Iowa and found that most wrestlers lost approximately five percent of their body weight in preparation for weight certification.* Changes in body weight were measured over a seventeen-day period with most of the changes taking place in the final ten days. It was concluded that weight reduction was brought about primarily through dehydration and semi-starvation.

A longitudinal study was conducted by Zambreski and co-workers (67) on eleven members of the 1974-75 NCAA championship team from the University of Iowa to determine if the practice of RWR was used as extensively as had been found at the high school level. Results indicated that dehydration was the principal method by which wrestlers reduced weight. As a group, they regularly lost approximately six percent of their total body weight at periodic intervals (competition) throughout the season.)

The effects of RWR upon the physical working capacity (PWC) of wrestlers is a controversial subject. Both the American Medical Association (4, 5) and the American College of Sports Medicine (6) have taken the position that the practice of RWR is a potential health

* High school wrestlers are required to be certified by a physician at the beginning of the wrestling season to determine the minimum weight classification in which they can participate.

hazard and that measures must be taken to eliminate the abuses associated with "making weight." The respective position statements of the AMA and ACSM are based upon the research of Adolph (1), Saltin (45) and others, whose findings have indicated that not only is PWC significantly impaired but as the extent of dehydration increases so does the risk to one's health (Table 2). Adolph (1) stated the following in regards to the relative effects of dehydration on man:

> "We know that man tolerates water deficits of up to 3 to 4 percent of body weight with moderate impairment of efficiency; at 5 to 8 percent deficits, the average man in the desert is fatigued, spiritless, prone to complain about his situation, and predisposed to physical collapse. Cooperation among men dehydrated more than 10 percent of their weights is not to be expected. Even after man's working or fighting abilities have succumbed to dehydration, he can survive some additional loss of body water, and recovery is still possible. Accurate observations on man do not extend to deficits greater than 11 percent of body weight. . . . Our best estimate of the rapid dehydration which is limiting for man is 20 percent loss of body weight."

Dehydration/Rehydration in Wrestlers

Since most of the criticism of weight reduction practices is directed towards performance in the dehydrated state, such a position may not be entirely justified if, for a given recovery period, rehydration takes place and PWC is restored. A substantial amount of research supports the viewpoint that weight losses of up to seven percent do not significantly impair performance if followed by rehydration prior to performance.

Tuttle (60) investigated the effects of withholding food and water and inducing weight loss through RWR methods on the physiologic responses of thirteen college wrestlers. The subjects were tested at

Table 2. Dehydration in Man (Adolph, 1950).

Water Loss (%)	
0	
	Thirst.
2	Stronger thirst, vague discomfort and sense of oppression, loss of appetite.
	Increasing hemoconcentration.
4	Economy of movement.
	Lagging pace, flushed skin, impatience; in some, weariness and sleepiness, apathy; nausea, emotional instability.
6	Tingling in arms, hands, and feet; heat oppression, stumbling, headache; fit men suffer heat exhaustion; increase in body temperature, pulse rate and respiratory rate.
	Labored breathing, dizziness, cyanosis.
8	Indistinct speech.
	Increasing weakness, mental confusion.
10	Spastic muscles; positive Romberg sign (inability to balance with eyes closed); general incapacity.
	Delirium and wakefulness; swollen tongue.
	Circulatory insufficiency; marked hemoconcentration and decreased blood volume; failed renal function.
	Shriveled skin; inability to swallow.
15	Dim vision.
	Sunken eyes, painful urination.
	Deafness; numb skin; shriveled tongue.
	Stiffened eyelids.
	Cracked skin; cessation of urine formation.
20	Bare survival limit.
	Death

five different times in the dehydrated state and then retested following rehydration. Of the initial test group, only five subjects completed the entire experiment. Eighteen measurements of neuromuscular, cardiovascular and respiratory functioning were determined. The degree of weight loss observed varied from six to ten pounds, representing a decrease in total body weight of 3.6 to 4.9 percent. No statistically significant differences between the testing periods were found for any of the physiologic responses tested, except for a slight increase in heart rate, and a slight decrease in vital capacity in the dehydrated state. It was concluded that a weight reduction of up to five percent of total body weight through RWR had no significant effect on the physiologic responses tested.

An investigation was undertaken by Edwards (23) to determine the effects of short-term semi-starvation and dehydration on the physiologic responses of three college wrestlers. A fourth subject served as the control and was not required to lose weight. Muscular strength was determined by pushups, pullups, and a hand dynamometer. Cardiovascular endurance was tested on a motor-driven treadmill. Measurements for heart rates, blood pressure, blood lactate, and basal metabolism were also made. The subjects were tested prior to initiating rapid weight reduction, again four days later, and the final tests were performed at the end of the seven-day test period. The three subjects had a mean weight loss of approximately six percent of total body weight. The authors concluded that, for the subjects who reduced weight, endurance was the only factor which was significantly negatively affected by the week of semi-starvation and dehydration.

Bowers (16) attempted to discern the effects of RWR on the physiologic responses of high school wrestlers. The subjects were divided into two groups of sixteen. The experimental group was required to use RWR methods in order to compete. The second group served as controls and were not required to lose weight. Five physical efficiency tests were administered to the subjects in each group over a thirteen-week period. Strength was determined by a hand dynamometer; a vertical "chalk jump" was used as a measure of power; endurance was determined using the Pulse Rate Index; the Stepping Stone Test was used as a measure of dynamic balance; and reaction time was determined by an electronic device using a visual signal. Testing was performed each Monday and again the day prior to an interscholastic wrestling meet. No statistically significant differences between the two groups were found for any of the variables measured. This was also the case when a comparison was made using only the experimental group before and after dehydration procedures (prior to competition). It was concluded that a wrestler may safely lose three to four percent of total body weight through RWR methods without adversely affecting physiologic responses.

In a longitudinal study performed by James (32), twenty high school wrestlers were divided into two groups. Ten of the subjects composed the experimental group and were required to periodically (prior to competition) lose weight using RWR methods throughout the wrestling season. The second group served as controls and were not required to lose weight in order to compete. Cardiovascular endurance was determined using the Carlson Fatigue-Curve Test. Testing was performed each week on Mondays (initial practice) and again on Fridays, after the final practice of the week. Comparisons were made for pulse rate, systolic and diastolic blood pressure after interscholastic wrestling matches. The experimental group lost an average of 4.4 to 6.9 percent of their total body weight each week. No significant differences between the two groups were found for any of the variables measured.

Bock (10) tested ten subjects on a university freshman wrestling team to determine the effects of a forty-hour dehydration period on cardiovascular endurance. Maximal oxygen consumption, heart rate, core temperature and exercise weight loss were measured before and after the dehydration period. Fluids were not allowed during the dehydration process. Before final testing the subjects were divided into subgroups of five each. The first group was tested immediately after the dehydration period and the second group was permitted to consume foods and fluids prior to being tested. A statistical analysis comparing the results before and after dehydration indicated that the dehydration process had no significant effect on maximal oxygen consumption. Heart rate and core temperature were not significantly affected by dehydration for the immediately tested group but were elevated following the rehydration period for the group consuming food. Elevated heart rates and core temperatures were partially explained as the result of metabolic action from digestion. Exercise weight loss was significantly affected by the dehydration process; both groups lost significantly more water in the pre-dehydrated condition than in the post-dehydrated condition.

Schuster (47) investigated the effects of RWR on muscular and cardiovascular endurance using twenty college wrestlers divided into experimental and control groups. Each subject in the experimental group was required to lose approximately ten pounds over a seven-day period through semi-starvation and dehydration. The control group was not required to lose weight. Muscular endurance was determined by the number of pushups and squat thrusts the subjects could perform, and cardiovascular endurance was determined by the number of miles they could ride on a bicycle ergometer. In addition, the number of points scored in actual competition were recorded. No significant differences between the two groups were observed for any of the variables measured. It was concluded that conditioned wrestlers can safely lose up to seven percent of their total body weight using RWR methods without adversely affecting performance.

Palmer (38) carried out an investigation on seven men to measure the differences between normal physiologic functioning when performing submaximal work following rapid dehydration and rehydration (five-hour recovery period). The first test was conducted in the evening with the subjects at their normal body weight. The following morning after breakfast, the subjects attempted to lose five percent of their total body weight. Dehydration was brought about by utilizing a steam heated cabinet. The subjects attained a weight reduction of 4.75 percent. Measurements of rectal temperature, exercise and recovery rates, ventilatory rates, ventilatory volume, oxygen consumption, respiratory quotient, oxygen pulse, and ventilatory efficiency were made on the subjects. On the basis of the data collected it was found that: (a) mean temperature changes during and following exercise were not significantly affected between the control period and dehydration/rehydration; (b) ventilatory volumes, oxygen consumption, respiratory quotient, and respiratory efficiency exhibited no significant changes as a result of dehydration/rehydration; (c) mean exercise heart rate was significantly elevated as a result of dehydration, but returned to normal following rehydration; (d) recovery heart rate increased and was not completely restored following the rehydration period. It was concluded that following a RWR of 4.75 percent of total body weight an impairment in performance will result. If during the rehydration period (five hours) the total amount of water lost is replaced, normal functioning during exercise will occur.

Ribisl and Herbert (44) used eight college wrestlers to determine the effects of dehydration and rehydration upon PWC-170. The test consisted of two consecutive rides on a bicycle ergometer of six minutes duration at submaximal workloads of 450 and 900 kpm/min. The average heart rate during the last two minutes of each ride represented the heart rate for those workloads. PWC-170 was predicted by plotting heart rates against the respective workloads which would result in a heart rate of 170 beats per minute. The subjects were allowed 48 hours in which to reduce their body weight by five percent. The methods employed by the subjects were not reported. A repeat test in the dehydrated state was performed a week later to determine the reliability of the results. From the data collected, it was concluded that PWC-170 decreased significantly but was restored following a five-hour rehydration period.

Kelly and co-workers (34) studied the effects of a competitive wrestling season on the body composition, cardiovascular fitness, muscular strength and endurance in collegiate wrestlers. At the end of the regular season (prior to Nationals), four national qualifiers were asked to simulate preparations for competition by rapidly dehydrating to their respective weight classes for a morning weigh-in, followed by running to exhaustion on a treadmill after a five-hour recovery period (uncontrolled food and fluid intake). The subjects lost approximately 3.7 to 9.5 percent of their total body weight without causing a significant change in aerobic power as measured after recovery.

Although collegiate wrestlers are allowed up to five hours in which to rehydrate following weigh-ins, interscholastic wrestlers in some states are only allowed up to one hour after weigh-ins in which to replace body fluids. Allen and co-workers (3) looked into this situation to determine the extent to which normalization of body water could be reestablished when an unlimited fluid intake was permitted for one hour. Over a 48-hour RWR period, an average weight loss of 4.3 percent with an accompanying decrease in plasma volume of 3.4 percent was observed in the sixteen high school wrestlers studied. After a one-hour rehydration period, body weight was still 2.6 percent below initial body weight, indicating the wrestlers would be entering competition in a state of dehydration. Nevertheless, heart rate and stroke volume were restored to normal levels and the authors concluded that PWC was significantly restored.

Acute and Chronic Semi-Starvation

Under conditions of restricted food intake a caloric deficit will result in using energy reserves in the body in the form of fat, carbohydrate, and protein. A decrease in the capacity to perform physical work is directly associated with a long-term reduction in available fuel. The Minnesota Experiment (35) was conducted to determine the effects of long term semi-starvation and rehabilitation in man. The semi-starvation period lasted 24 weeks and involved 34 men of varying fitness levels. The controlled diet was designed to bring about a 24 percent weight reduction during the course of the investigation. The actual average weight loss was 24.2 percent. Most of the weight loss occurred in the first few weeks although a steady decline took place throughout the study. The average body fat lost amounted to 83.3 percent of the estimated initial values. Basal metabolism was observed to decrease by 19.5 percent. Submaximal aerobic work capacity as determined by a treadmill decreased by 28.3 percent. Anaerobic work capacity measured with a treadmill version of the Harvard Step Test resulted in a severe decline; 71.6 percent. Associated decreases in maximal oxygen consumption, respiratory efficiency, a reduced oxygen debt and lactate concentration were found after running to exhaustion. A reduction in strength, as measured by a standard hand and back dynamometer decreased by 25.6 and 26.2 percent, respectively. It was concluded that long-term semi-starvation results in significant impairment for the variables measured.

In studying the effects of acute and semi-starvation on PWC, Henschel and co-workers (27) performed two experiments. Four men were placed on a 2½-day fast (acute starvation), and twelve men were placed on a five-day fast (semi-starvation). The subjects in the 2½-day fast recorded an average total caloric deficit of 9,000 Kcal and a decrease in total body weight by 6.7 percent. The subjects in the five-day fast had an average total caloric deficit of 10,000 Kcal and a decrease in total body weight by 7.8 percent. The subjects walked on a treadmill at a 10 percent grade and at 3.5 m.p.h. pace for four hours each day in the 2½-day fast and for three hours per day in the five-day fast. No changes were observed in performance until the morning of the second day, at which time work pulse rates increased by 10-15 beats/min. Blood glucose levels decreased during work by 25 mg/100 ml, and anaerobic capacity as measured by the Harvard Step Test decreased 30 percent by the second day and another 30 percent by the fourth day.

In a similar study, Taylor and co-workers (55) studied the effects of dietary controls on PWC under conditions of semi-starvation. The experimental group was divided into two subgroups. One group had 13 subjects and consumed 1010 Kcal/day for 24 days, and the second group had six subjects and consumed 580 Kcal/day for 12 days. The experimental subjects consumed daily diets of pure carbohydrate and ingested 4.5 mg of NaCl and a multivitamin preparation. A control group of six men consumed a mixed diet consisting of 3100 Kcal/day. The weight losses of the subjects were not provided. Work was performed by walking on a treadmill at a 10 percent grade and 3.5 m.p.h. for one hour and a 1½-hour walk outside each day. Anaerobic capacity was determined from the Harvard Step Test. Results indicated that: (a) blood glucose levels during work were not maintained on the 580 Kcal/day diet; (b) both experimental diets prevented the occurrence of the debilitating effects of ketosis, which are often associated with acute starvation; (c) strength measurements were unchanged for weight losses less than 10 percent; and (d) maximal oxygen consumption declined slowly, but when expressed per kilogram of body weight, no significant decrease occurred until weight loss exceeded 10 percent. From the data collected it was concluded that when at least 580 Kcal/day and supplements are provided, ketosis, dehydration and hypoglycemia are prevented under conditions of moderate energy expenditure, and PWC is maintained for weight losses of up to 10 percent.

An investigation into the effects of successive fasts on PWC was performed by Taylor and co-workers (56). The protocol consisted of placing four men on five 2½-day fasts. Each fast was separated by five- to six-week intervals. Caloric expenditure on the first day was approximately 4,500 Kcal, 4,000 Kcal on the second, and 2,000 Kcal on the third day. Weight lost during each fast was not provided. Work was carried out on a treadmill at a 10 percent grade and at a 3.5 m.p.h. pace. "Anaerobic" work was performed by running for 1¼ minutes at 9 m.p.h. at a 10 percent grade. Psychomotor tests were also carried out. From the results it was concluded that: (a) the subjects were able to maintain blood glucose levels during work at a significantly higher level in the fifth as compared to the first fast; and (b) motor speed and coordination were less impaired during the fifth than the first fast. Reaction time and pattern tracing were also improved in the fifth as compared to the first fast. It was generally concluded that repeated exposure to the fasting state results in an improved adaptation to fasting.

Summary

In summarizing this review of related literature, it may be concluded that:

1. High-ability wrestlers are characterized by low levels of body fat, with "optimal" levels of approximately six to nine percent.

2. The recommended minimum level of body fat is five percent.

3. Rapid weight reduction is practiced by the majority of amateur wrestlers and is primarily brought about through semi-starvation, exercise, and/or dehydration. This regimen may be repeated numerous times during the course of a competitive season.

4. Following a weight loss of greater than three or four percent of total body weight brought about by dehydration, muscular endurance will remain unchanged but physical working capacity may be impaired.

5. When a recovery period of five hours with unrestricted fluid intake is permitted following weight losses of up to seven percent of total body weight as a result of dehydration, physical working capacity will return to normal levels even though a complete replacement of body fluids does not occur.

6. A gradual weight reduction greater than approximately ten percent of total body weight through semi-starvation will significantly impair physical working capacity.

7. Subjects repeatedly exposed to fasting are observed to make an improved adaptation to subsequent fasting.

CHAPTER III

PROCEDURE

Research Method

This research was conducted to determine the relationship between nutritional control and selected physical parameters on twenty-five male college wrestlers. A "randomly" selected experimental group (EG) was placed on an individualized high carbohydrate-hypocaloric diet. A control group (CG) received no dietary direction to aid in reducing body weight.

Subjects

The EG was composed of the wrestlers who resided in the MSU dormitories. Dormitory cafeterias serve standardized food items which permitted accurate individualized menu planning and recording. The CG consisted of the wrestlers living off-campus (Table 3).

Table 3. Mean Age, Height, Weight, and Body Composition for the Pre-Test on 18 Collegiate Wrestlers.

Variable	EG	CG
Age (years)	18.6	20.0
Height (inches)	66.9	68.3
Weight (pounds)	149.4	165.9
Body Density	1.079	1.083
Lean Body Weight (pounds)	135.6	152.8
Percent Body Fat	9.2	7.6

Revised Population

Twenty-five male college wrestlers composed the original population. The EG was composed of eleven subjects, and the CG was made up of fourteen subjects. Of the original twenty-five subjects, only eighteen completed the testing for various reasons. In the EG, one subject sustained an injury preventing further testing; two subjects dropped out of the wrestling program; and one subject withdrew himself from further testing. In the CG, one subject sustained an injury and two subjects dropped out of the wrestling program.

Dietary Program

A. Experimental Group

1. A nutritional program based upon the foods available in the MSU dormitory cafeterias was individually designed for each subject:

a) based on their estimated basal metabolism as determined from body surface using the DuBois Nomogram (22), and

b) from an estimation of Kcal expended performing daily activities (Appendix A).

2. The degree to which each diet was calorically restricted was based on the relationship of how much weight each subject was required to lose in order to reach their weight classification and the time available for such a weight loss to occur. Several factors determine the weight classification in which the subjects compete: the subjects' total body weight and percent body fat, the number and quality of

teammates vying for the same varsity position, and conferences with the coach. The final decision is made by each wrestler.

3. The composition of all diets, regardless of the number of calories included, was composed of a minimum of 60 percent carbohydrates and contained a minimum of one gm of protein per kilogram of body weight.

4. Vitamin supplementation, protein powders, etc., were not permitted during the investigation for either group.

5. Subjects were counseled on how to measure standard portions of food items and how to keep records of foods not listed on their menu plan. Daily menu plans were posted in the MSU dormitory cafeterias each morning for each subject. The food items and amounts to be selectively consumed were listed. If, for any reason, a change in the daily menu occurred (i.e., substitutions, additions and/or omissions), they were recorded on the menu plan or daily recall list.

B. Control Group

1. The CG was required to reduce their body weight in order to reach their weight classification with no directions on the type or quantity of foods to be consumed.

2. Sample records of food intake were collected during alternating weeks of the investigation (Oct. 3-10; Oct. 24-31; and Nov. 7-14, 1983).

3. Each subject was counseled on how to perform routine record keeping of their food intake (i.e., portion size, ingredients). They were required to turn in each day a list of their previous day's meals (including all snacks). If, for any reason, a dietary record was not

turned in, then a memory recall for the missing time period was performed by a trained investigator.

Testing Battery

The testing parameters were as follows:

1. Body Composition
    a. Chest skinfold (CH)
    b. Subscapular skinfold (SU)
    c. Tricep skinfold (TR)
    d. Suprailiac skinfold (SI)
    e. Abdominal skinfold (AB)
    f. Thigh skinfold (AB)
    g. Percent body fat (PF)
    h. Lean body weight (LBW)
    i. Fat weight (FW)
2. Girths
    a. Neck (NE)
    b. Chest (CH)
    c. Shoulders (SH)
    d. Bicep (BI)
    e. Forearm (FA)
    f. Wrist (WR)
    g. Abdominal 1 (AB 1)
    h. Abdominal 2 (AB 2)
    i. Gluteal (GL)
    j. Thigh (TH)

k. Knee (KN)

l. Calf (CA)

m. Ankle (AN)

3. Height (HT)

4. Total Body Weight (TBW)

5. Muscular Endurance

   a. Squat

   b. Dips

   c. Pulldowns

   d. Seated overhead press

6. Power

   a. Modified-Wingate Test

7. Aerobic Endurance

   a. 1½-mile run

8. Urine Analysis

   a. Specific gravity

Testing Equipment and Procedures

Body Composition. Skinfold measurements were taken with Lange Skinfold Calipers. Standardized procedures were used as described by Keys (36), and Behnke and Wilmore (8). Three measurements to the nearest 0.5 mm were taken, with an average of the three used as the score. If one measurement deviated by more than 1.0 mm, the measurements were repeated. All measurements were performed on the right side of the body, and were located with the use of a plastic tape measure and marked to ensure accuracy and consistency. The sites of the skinfolds were as follows:

1. Chest (CH) - Halfway between the nipple and the armfold.

2. Subscapular (SU) - At the tip (inferior angle) of the right scapula, on a 45-degree line laterally downward.

3. Tricep (TR) - Vertical fold on the posterior line halfway between the tip of the acromion process and the olecranon process, arm hanging at side.

4. Suprailiac (SI) - Vertical fold on the right mid-axillary line just above the crest of the ilium.

5. Abdominal (AB) - Horizontal fold adjacent to the right of the umbilicus.

6. Thigh (TH) - Vertical fold on the anterior right thigh in the midline, halfway between the patella and the greater trochanter.

Density was computed from the skinfolds using an average of the following formulas:

$D_B = 1.1043 - .001327\ (TH) - .00131\ (SU)$ (Sloan)

$D_B = 1.1017 - .000282\ (AB) - .000736\ (CH) - .000883$ (Sharkey)

$D_B = 1.1080 - .00168\ (SU) - .00127\ (AB)$ (Forsyth-Sinning)

Density was converted to percent body fat using an average of the following formulas:

$\frac{4.57}{D_B} - 4.142 \times 100 = \text{Percent Fat (PF)}$ (Brozek)

$\frac{4.95}{D_B} - 4.500 \times 100 = \text{Percent Fat (PF)}$ (Siri)

Girths. Measurements of girth were taken using the procedures of Behnke and Wilmore (8) at the following sites:

1. Neck (NK) - Just inferior to the larynx.

2. Chest (CH) - Nipple line at mid-tidal volume in males.

3. Shoulders (SH) - Laterally, at the maximal protrusion of the deltoid muscles, and anteriorly, at the articular prominence of the sternum and second rib.

4. Bicep (BI) - Maximal girth of the mid-arm when flexed to the greatest angle with the underlying muscles fully contracted.

5. Forearm (FA) - Maximal girth with the elbow extended and the hand supinated.

6. Wrist (WR) - Minimal girth just distal to the styloid processes of the radius and ulna.

7. Abdominal 1 (AB 1) - Laterally, midway between the lowest lateral portion of the rib cage and the iliac crest, and anteriorly, midway between the xyphoid process of the sternum and the umbilicus. This level is the natural waist and is readily identified as the level of minimal abdominal width when the side profiles are slightly concaved.

8. Abdominal 2 (AB 2) - Laterally, at the level of the iliac crests, and anteriorly, at the umbilicus.

9. Gluteal (GL) - Anteriorly, at the level of the symphysis pubis, and posteriorly, at the maximal protrusion of the gluteal muscles.

10. Thigh (TH) - Just below the gluteal fold or maximal thigh girth.

11. Knee (KN) - Mid-patellar level, slightly flexed, weight transferred to opposite leg.

12. Calf (CA) - Maximal girth.

13. Ankle (AN) - Minimal girth, superior to the malleoli.

Height. The height of the individual was taken while standing with his back placed firmly against a wall, and with his chin parallel to the floor. Height was recorded from calibrated markings placed on the wall. Measurements were recorded to the nearest ¼-inch. A metal square was placed on top of the head and against the wall alongside the markings.

Weight. The weight of the individual was determined using a certified Toledo spring scale. Measurements were recorded to the nearest ½-pound.

Muscular Endurance. A measurement of muscular endurance was made by determining the number of repetitions which could be performed for a given percent of the subject's body weight. The subjects warmed up with ten minutes of stretching exercises. Verbal encouragement was given. The sequence of the tests remained uniform during testing periods, but rest periods were not standardized. All of the tests were routinely used in training by all subjects. The tests and procedures were as follows:

1. Squats - The lifter must take the bar off the rack in a horizontal position, hands gripping the bar, feet flat on the platform. He must wait for the signal to "squat." After the signal the lifter will bend the knees and lower the body until the top surfaces of the legs at the hip joint are equal to or below the tops of the knees. The lifter may recover at will, without double bouncing, to an upright position. The amount of weight to be lifted will be 150 percent of the subject's body weight for as many repetitions as possible.

2. Dips - The subject will start the lift in a fully extended arm position and when ready will lower the body until the top surface of the

shoulder is lower than the top of the elbow. The lifter may recover at will to a fully extended position, with elbows locked. The amount of weight to be lifted will be equal to body weight with an additional twenty percent of the subject's body weight added via a dipping belt.

3. "Lat" pulldowns - Utilizing a "Lat" Machine, the lifter will begin from a fully extended position. The bar must be pulled down to the top of the trapezius muscles at the base of the neck, after which the bar will again be returned to a fully extended arm position. The lifter's thighs must remain under the restraining bar throughout the test. The amount of weight to be utilized will be equal to the lifter's body weight for as many repetitions as possible.

4. Seated overhead press - The lifter will be seated on a bench and the bar will be placed behind the neck. The lifter will raise the bar from his shoulders to a fully extended position (elbows locked) and then lower it to a position behind the neck at the level of the trapezius muscles at the base of the neck. The amount of weight to be utilized will be equal to sixty percent of the lifter's body weight for as many repetitions as possible.

Power. A modification of the Wingate Test (31) was utilized as a measure of anaerobic metabolism. The test was modified by a one-minute reduction for both the warm-up and rest periods. The order in which the subjects performed the test was maintained between the Pre- and Post-Test. The subject warmed up on a bicycle ergometer for four minutes at 2 kp, with a sprint of four- to seven-seconds duration at one-minute intervals (1:00, 2:00, and 3:00). The warm-up was followed by a three-minute rest period. The test began at 2 kp, and the resistance was increased to a predetermined workload based on the subject's body weight in three to four seconds. The subject then performed an all out effort for thirty seconds without any pacing. The number of revolutions for each five-second period of the work test was recorded with the use of a Pacer 2000H (Sportronics) rpm meter. From this data, maximal anaerobic power, anaerobic capacity, and resistance to fatigue were determined.

Aerobic Endurance. Aerobic endurance was measured using a 1½-mile run. Testing was performed on an indoor 200-meter track in the MSU Fieldhouse. The test was done separately in two groups. Verbal encouragement was given, as well as the lap time and number. A ten-minute warm-up was given before testing began.

Urine Analysis. Urine samples were collected to provide information on the extent of dehydration in addition to body weight and subsequent rehydration in preparation for competition. Specific gravity was measured by an Adams Midget Urinometer Float. Samples were taken in the morning before the subjects had urinated, consumed food, ingested water, or exercised within an eight-hour period prior to weigh-in. All samples were collected between the hours of 7-8 a.m. A second urine sample was taken between 12-1 p.m., just prior to competition.

Testing Schedule

A pre- and post-test battery was given during the six-week study. Anthropometric testing was performed before the study began so that dietary programs for each of the subjects in the EG could be determined. The week prior to muscular endurance testing was used as a trial period to familiarize the subjects with testing procedures and to minimize the learning effect. Mid-point in the investigation (Oct. 24), skinfold testing was again performed in an effort to evaluate the progress of the EG dietary program, as well as the CG.

The testing schedule is given below:

Sept. 21-22	Anthropometric Testing (4:30)	Pre-Test
Sept. 30	1½-Mile Run (3:30)	
Oct. 4	Muscular Endurance Testing (4:00)	
Oct. 5	Modified-Wingate Test (3:00)	
Oct. 24	Anthropometric Testing (3:30)	
Nov. 10	1½-Mile Run (3:30)	Post-Test
Nov. 11	Muscular Endurance Testing (4:00)	
Nov. 14	Anthropometric Testing (3:30)	
Nov. 15	Modified-Wingate Test (3:00)	
Nov. 17-18	Urine Analysis (8:00 a.m. and 12:00 noon)	

Analysis of Data

An analysis of covariance between the EG and the CG for each variable tested was performed, using the pre-test as the covariate. The level of significance was established at 0.05. The tables, figures and statistics are expressed as means for all the variables measured in this investigation.

CHAPTER IV

RESULTS

The findings in this investigation are presented in Chapter IV. A discussion of the results will be presented in Chapter V. Findings from this investigation are presented under the following headings:

1. Diet Composition and Caloric Intake
2. Body Composition/Total Body Weight
3. Girths
4. Muscular Endurance
5. Power
6. Aerobic Endurance
7. Urine Analysis

Diet Composition and Caloric Intake

A nutritional program designed to optimize performance during the pre-competitive training period was implemented to aid the EG in reducing to their lowest functional body weights. The CG was left to their own methods to reduce body weight. The nutritional intake of the EG was monitored daily throughout the investigation, while the CG was monitored during every other week. Results of diet composition and caloric intake for the subjects are summarized in Table 4 and presented in Figure 1.

Table 4. Diet Composition and Caloric Intake.

	Week 1		Week 2		Week 3		Week 4	
Group	Comp (%)*	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Comp (%)	Kcal
EG	57/28/15	2635	59/26/15	2550	56/29/15	2471	61/26/14	2396
CG			52/33/16	3374			50/33/16	2846

	Week 5		Week 6		$\bar{X}$		$\bar{X}$
Group	Comp (%)*	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Kcal/kg/day
EG	62/25/13	2236	62/26/13	2246	60/27/15	2422	36.4
CG			52/32/16	2765	51/33/16	2991	39.9

* CHO/FAT/PRO

The EG had a higher percentage of CHO and a lower percentage of FAT and PRO for the proportion of foodstuffs consumed than did the CG (Table 4). The overall data on the diet composition for the EG consisted of an average of 60 percent CHO (range of 56-66 percent), 27 percent FAT (range of 22-31 percent) and 15 percent PRO (range of 14-15 percent)*. The CG consumed a diet consisting of an average of 51 percent CHO (range of 41-58 percent), 33 percent FAT (range of 26-36 percent) and 16 percent PRO (range of 14-22 percent).

* Sum of the averages does not equal 100 percent.

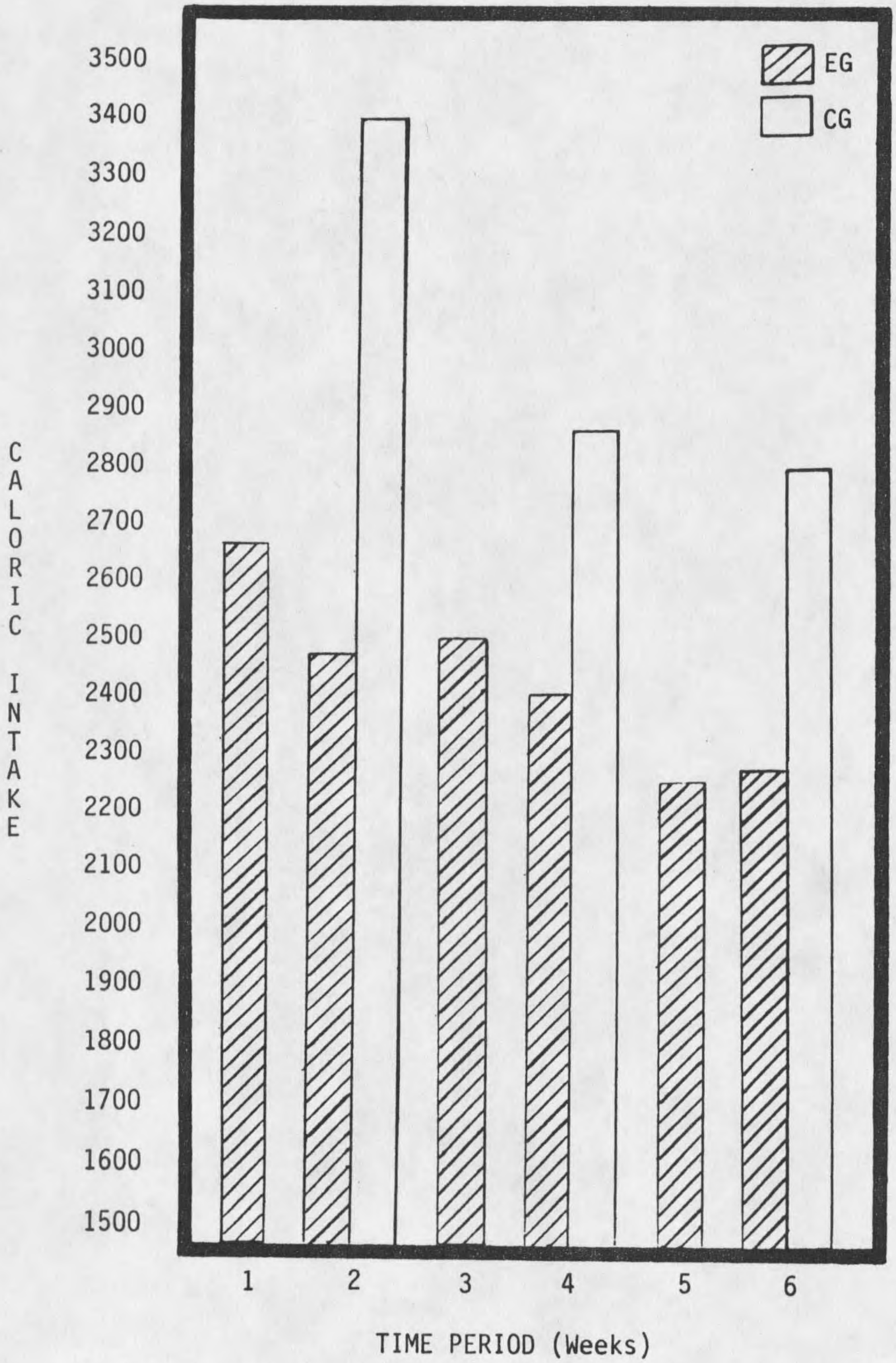

Figure 1. Caloric Intake.

The EG had a lower caloric intake than the CG throughout the investigation (Figure 1). The EG steadily decreased caloric intake from 2635 Kcal/day (Week 1) to 2246 (Week 6), with an average of 2422 Kcal/day (range of 2148-2739 Kcal/day). The CG reduced caloric intake from 3374 Kcal/day (Week 2) to 2765 Kcal/day (Week 6), with an average of 2991 Kcal/day (range of 2215-3474 Kcal/day). The EG consumed a lower number of calories in relation to body weight (Kcal/kg/day) than the CG, with values of 36.4 and 39.9, respectively.

Body Composition/Total Body Weight

The methods and procedures used were an attempt to measure the changes in body composition for eighteen collegiate wrestlers who participated in this investigation. Results of body composition for the subjects are summarized in Table 5 and individually presented in Figures 2 and 3.

From the data collected, it was found that the EG lost a significantly ($P<0.05$) larger amount of TBW than did the CG over the six-week study period, with mean weight losses of 6.0 and 1.9 pounds, respectively (Figure 2). Of the 6.0 pound weight reduction (4.0 percent of TBW) experienced by the EG, 5.0 pounds (83.3 percent) were derived from FW, and 1.0 pound (16.6 percent) from LBW. In contrast, the CG was found to have increased LBW by 1.4 pounds, a decrease in FW by 3.3 pounds resulting in a decrease in TBW by 1.4 pounds (1.0 percent of TBW). The differences between the two groups for TBW and LBW were statistically significant (Table 5).

Table 5. Analysis of Covariance Results Between the EG and CG Among the Body Composition Variables with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
Skinfolds							
SU	EG	7	10.0	7.8	7.0	0.11	7.26 *
	CG	11	8.2	7.7	8.2	0.07	
TR	EG	7	8.5	6.2	5.8	0.18	0.06
	CG	11	6.8	5.6	5.9	0.11	
CH	EG	7	4.4	3.3	2.9	0.04	1.20
	CG	11	3.3	3.0	3.2	0.03	
SI	EG	7	16.8	8.9	7.7	0.74	4.59 *
	CG	11	12.9	9.4	10.1	0.46	
AB	EG	7	13.9	8.1	7.4	0.27	0.00
	CG	11	10.8	7.0	7.4	0.17	
TH	EG	7	10.5	7.6	7.5	0.30	0.04
	CG	11	10.2	7.5	7.6	0.19	
Total Skinfolds	EG	7	64.0	41.9	37.4	4.90	3.80
	CG	11	50.2	40.1	43.0	3.02	
Body Density	EG	7	1.079	1.087	1.088	0.00	1.37
	CG	11	1.083	1.087	1.086	0.00	
LBW	EG	7	135.6	134.6	144.3	1.43	5.51 *
	CG	11	152.8	154.2	148.0	0.87	
PF	EG	7	9.2	6.0	5.6	0.15	0.98
	CG	11	7.6	5.8	6.1	0.10	
TBW	EG	7	149.4	143.4	152.3	23.94	8.62 *
	CG	11	165.9	164.0	158.3	14.80	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.

** Statistically adjusting the post-test score by using the pre-test as the equating factor.

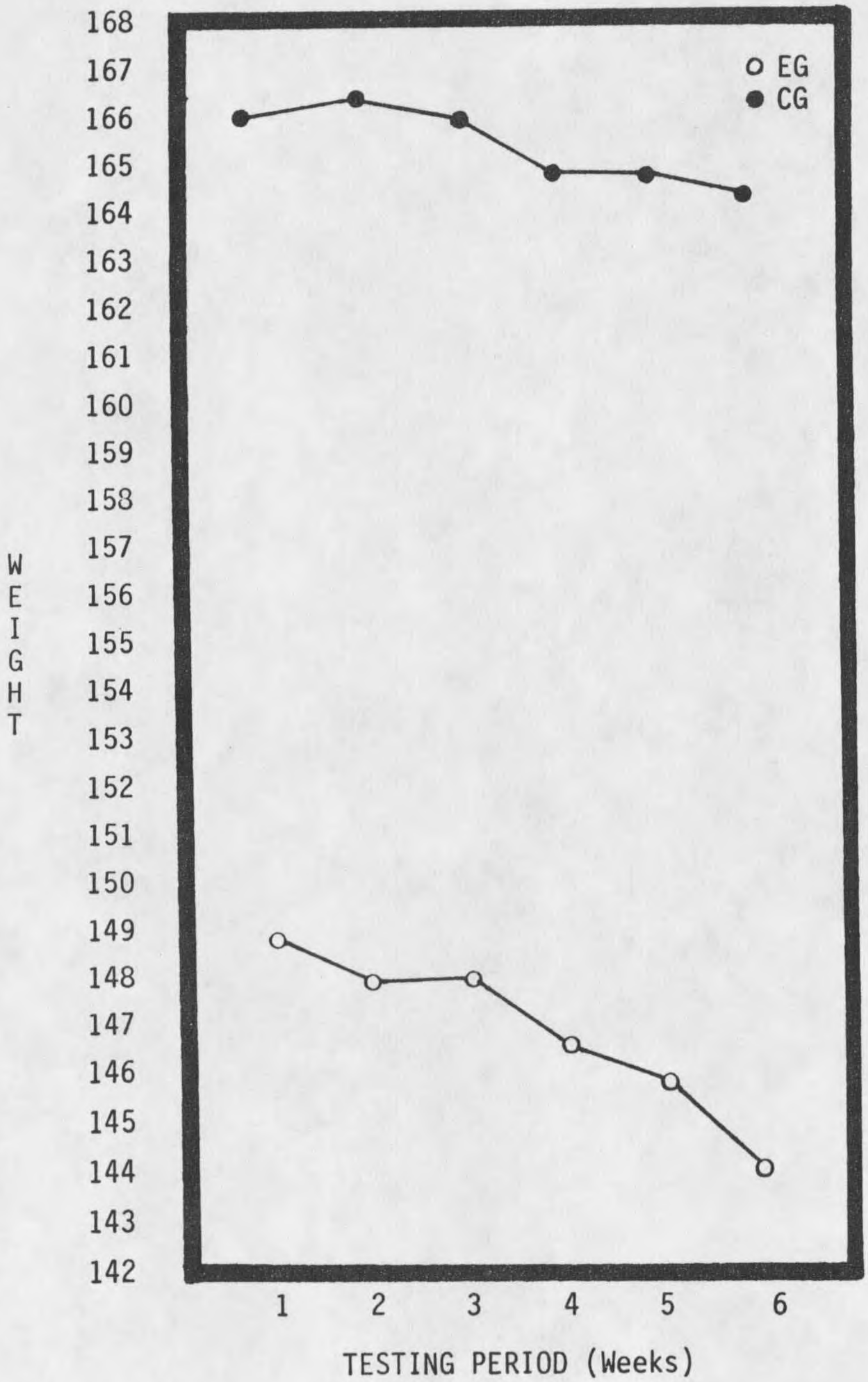

Figure 2. Total Body Weight.

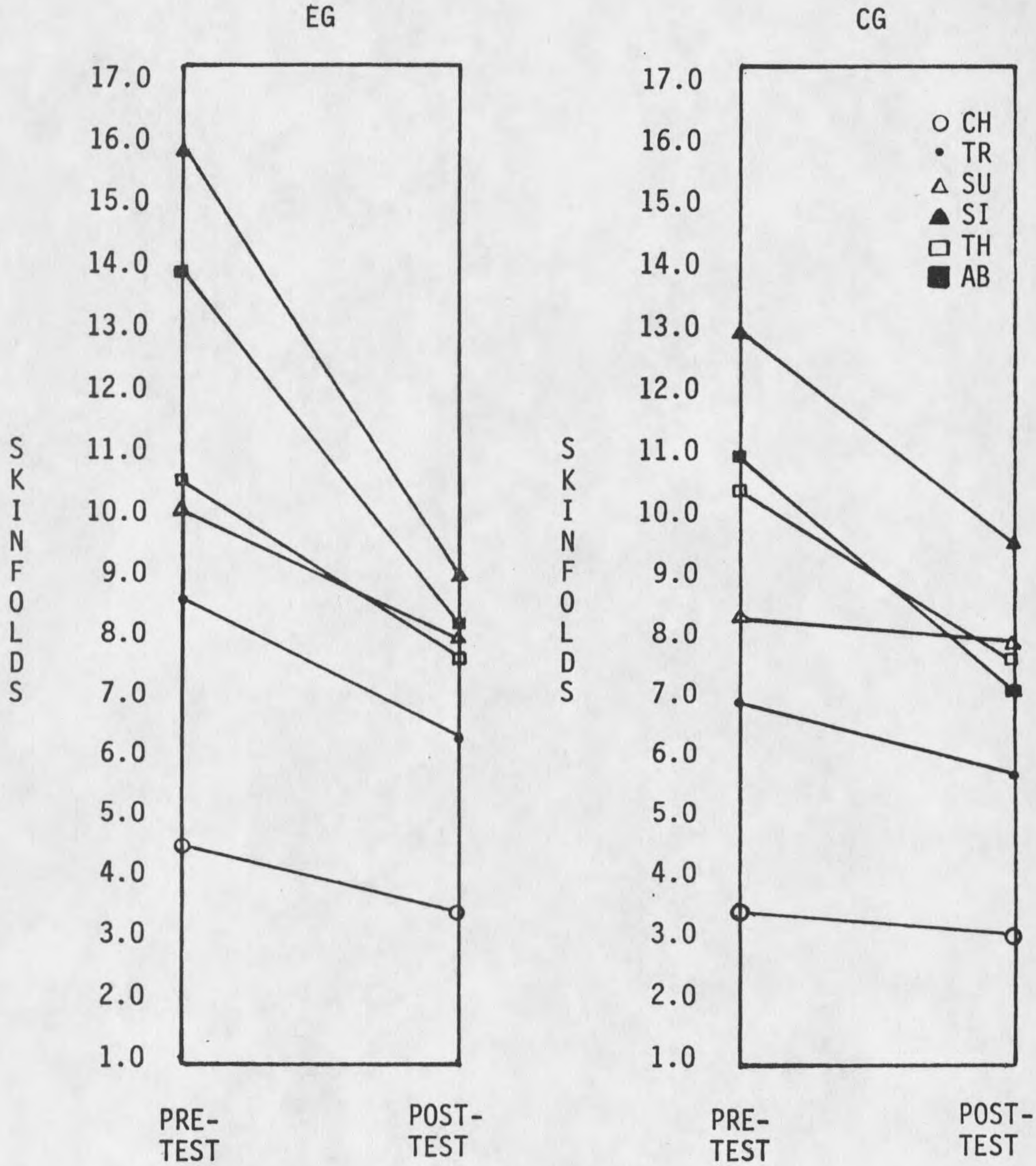

Figure 3. Skinfold Measurements.

Associated with the weight reductions were decreases at all skinfold sites for both groups. Figure 3 shows the changes at the skinfold sites. The EG had significantly ($P<0.05$) larger decreases at the SU and SI skinfold sites, while the differences for all other sites were not significant. The EG did exceed the CG for mean body density increase and PF decrease, although the differences between the two groups were not statistically significant for these parameters.

Girths

Changes in the cross-sectional areas of the body determined by circumference measurements provides an indirect method by which body composition can be estimated. Results of girth measurements for the subjects are presented in Table 6. The EG experienced decreases at all girth sites following the six-week weight reduction program. In the CG, girth sites were found to have decreased with the exception of increases at the SH by 0.3 cm, the NK by 0.2 cm, and the BI by 0.2 cm. Statistically significant ($P<0.05$) differences between the two groups were observed for the SH, BI, AB 1, and the TH girths. As previously mentioned, these sites were found to have decreased for the EG, whereas the CG maintained or even increased size at them.

Figure 4 shows somatographic profiles for both the EG and CG, using the girths from Table 6. The Somatogram (8) is a graphic representation of body proportionality showing the percent deviation of an individual from those of a reference man. If an individual's proportions conform to the reference symmetry, there would be no deviation (a vertical line through zero). It is evident that the proportions for both groups are

Table 6. Analysis of Covariance Results Between the EG and CG Among the Girth Variables with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
SH	EG	7	114.6	112.6	114.6	0.53	8.87 *
	CG	11	118.5	118.8	117.5	0.33	
NK	EG	7	38.5	38.0	38.9	0.13	2.48
	CG	11	40.0	40.2	39.6	0.08	
CH	EG	7	97.2	95.5	96.5	1.05	1.49
	CG	11	99.7	98.7	98.1	0.66	
BI	EG	7	33.8	33.5	34.7	0.05	4.64 *
	CG	11	35.8	36.0	35.3	0.03	
AB 1	EG	7	76.8	73.8	74.7	0.30	13.17 *
	CG	11	78.7	77.8	77.3	0.19	
AB 2	EG	7	76.9	74.0	75.4	0.25	3.54
	CG	11	79.7	77.6	76.6	0.16	
GL	EG	7	91.4	89.3	91.3	0.34	3.30
	CG	11	95.8	94.0	92.7	0.21	
TH	EG	7	56.2	53.5	54.3	0.24	11.65 *
	CG	11	57.8	57.0	56.5	0.15	
CA	EG	7	36.7	35.5	36.2	0.06	2.47
	CG	11	37.8	37.2	36.7	0.38	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.

** Statistically adjusting the post-test score by using the pre-test as the equating factor.

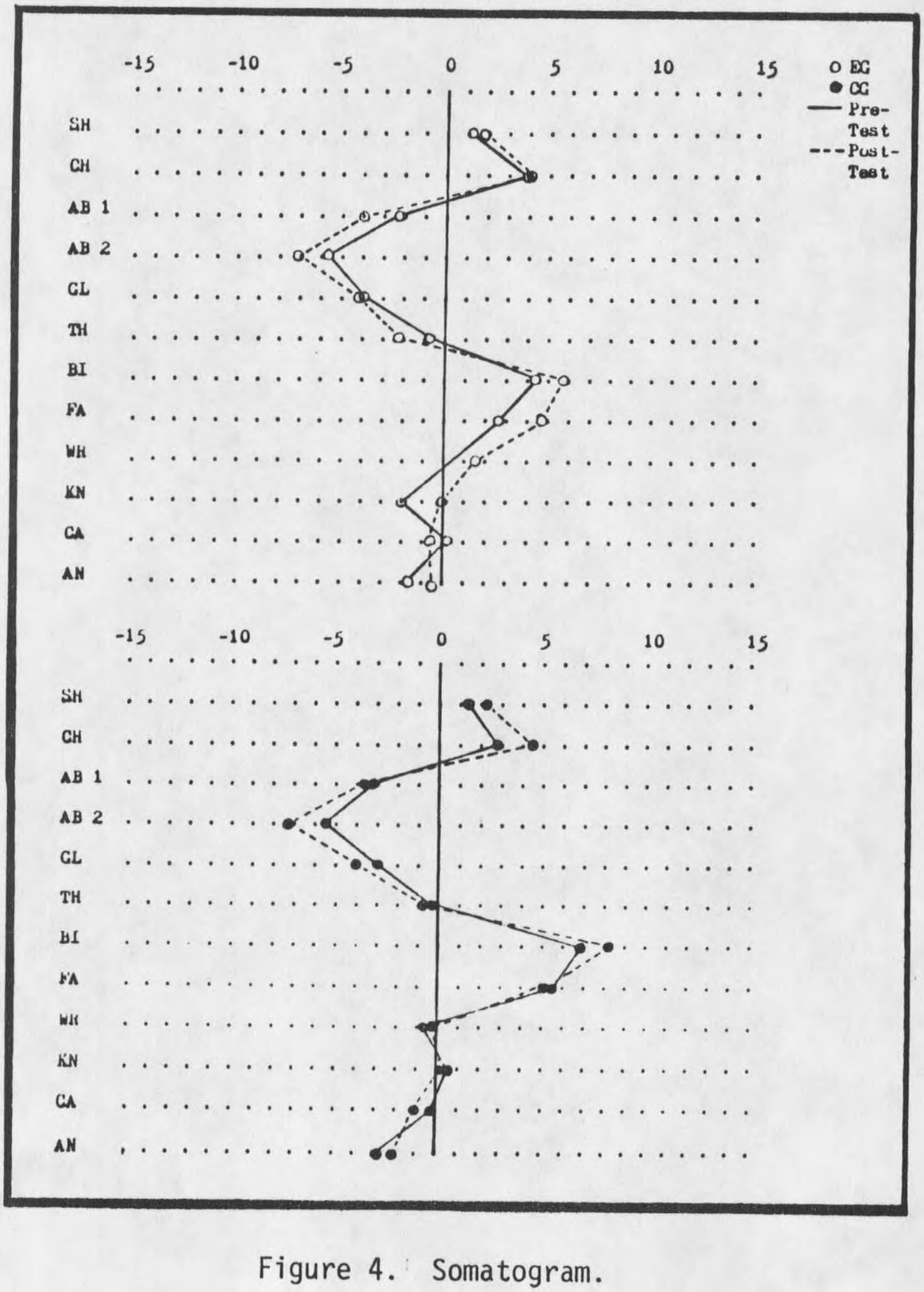

Figure 4. Somatogram.

large when compared to Behnke's reference man for the SH, CH, BI, and FA, and small in the GL, AB 1 and AB 2; while the proportional differences between the two groups are slight.

Muscular Endurance

Muscular endurance measures the requirements for wrestlers to push and pull against a resistance applied by an opponent. Although most of the muscles of the body may be utilized during a contest, the muscle groups primarily used in wrestling are the muscles of the back, hips, and arms.

Results for muscular endurance for the subjects are summarized in Table 7 and presented in Figure 5. The EG experienced slightly larger gains than did the CG for all the variables tested, but these differences were not statistically significant ($P<0.05$).

Table 7. Analysis of Covariance Results Between the EG and CG Among the Muscular Endurance Variables with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
Squats	EG	7	9.3	13.3	12.3	7.32	0.18
	CG	11	7.0	10.3	10.8	4.11	
Dips	EG	7	12.9	15.4	15.6	0.90	0.18
	CG	11	13.4	15.3	15.1	0.57	
Pulldowns	EG	7	5.1	9.1	9.7	0.43	0.22
	CG	11	6.7	9.6	9.3	0.27	
Overhead	EG	7	8.6	10.7	11.3	0.42	0.17
Presses	CG	11	10.0	11.7	11.4	0.27	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.

** Statistically adjusting the post-test score by using the pre-test as the equating factor.

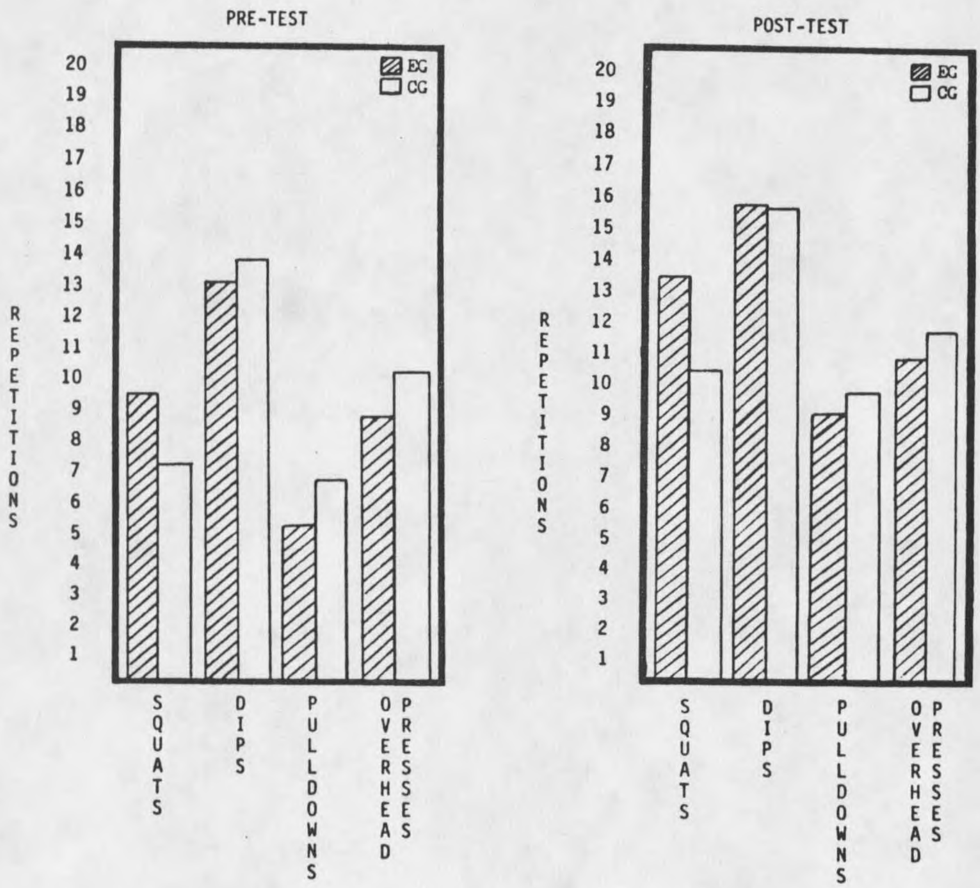

Figure 5. Muscular Endurance.

Power

The Modified-Wingate Test is designed to measure maximal anaerobic power, anaerobic capacity, and the resistance to fatigue (fatigue "index"). The results of the Modified-Wingate Test are summarized in Table 8 and presented in Figure 6.

Both groups experienced increases in maximal anaerobic power and anaerobic capacity and a decrease in the fatigue "index." The differences between the two groups were not statistically significant ($P<0.05$) for any of the above variables.

Table 8. Analysis of Covariance Results Between the EG and CG Among the Power Variables with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
Maximal Anaerobic Power	EG	7	120.1	137.4	138.4	16.27	0.22
	CG	11	123.4	136.5	135.9	10.33	
Anaerobic Capacity	EG	7	587.1	646.6	653.0	156.65	0.02
	CG	11	608.9	659.3	655.2	99.02	
Fatigue "Index"	EG	7	2.7	3.6	3.7	0.09	0.31
	CG	11	2.9	3.5	3.5	0.05	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.
** Statistically adjusting the post-test score by using the pre-test as the equating factor.

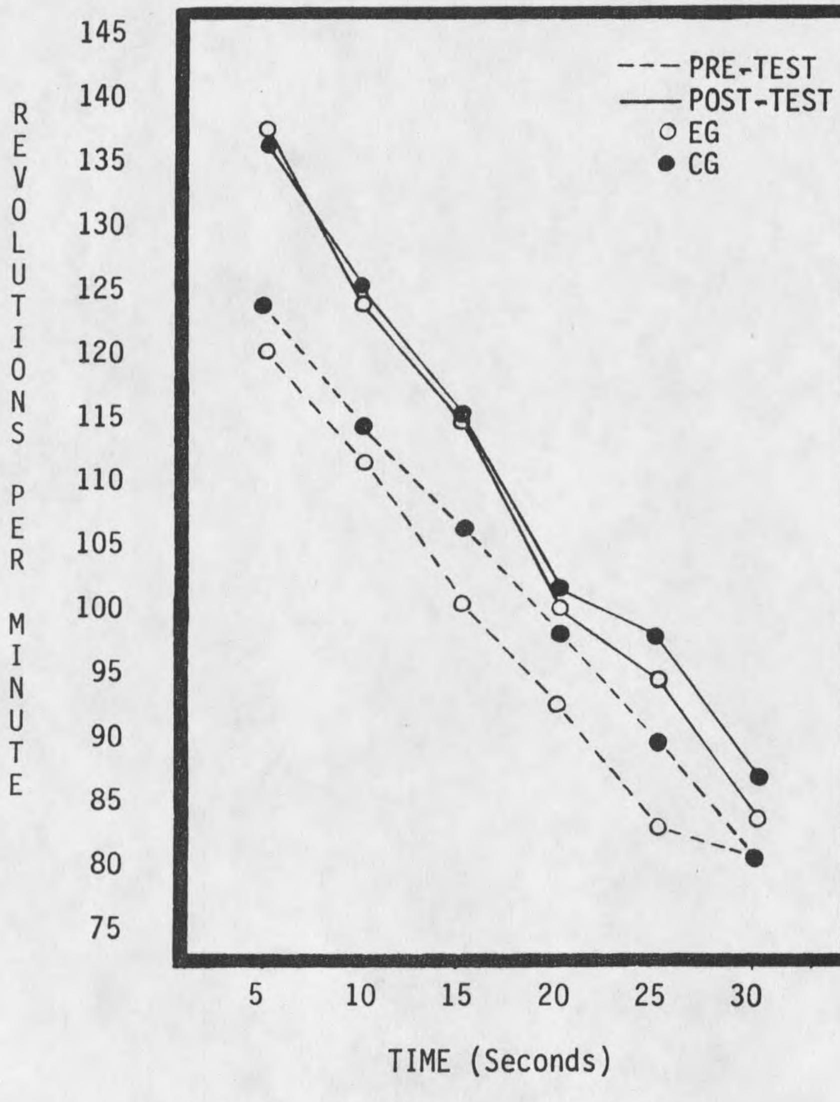

Figure 6. Modified-Wingate Test.

Aerobic Endurance

The 1½-mile run provides an indirect measure of aerobic endurance. Results of the 1½-mile run are summarized in Table 9 and presented in Figure 7.

Both groups decreased running time by over 30 seconds. The EG had a larger improvement in running time, but the difference between the two groups was not statistically significant ($P<0.05$).

Table 9. Analysis of Covariance Results Between the EG and CG Among the Aerobic Endurance Variable with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
1½-Mile Run	EG	7	9:39	9:05	9:06	0.09	0.32
	CG	11	9:44	9:11	9:10	0.05	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.
** Statistically adjusting the post-test score by using the pre-test as the equating factor.

Urine Analysis

In order to reach their respective weight classes, the subjects in the EG lost an average of 3.1 pounds of body weight and the CG lost an average of 4.6 pounds of body weight by rapid weight reduction methods. Following weigh-ins, a rehydration period of five hours was provided to replace body fluids. As a result of unrestricted fluid intake, the EG regained an average of 2.4 pounds and the CG regained an average of 1.7

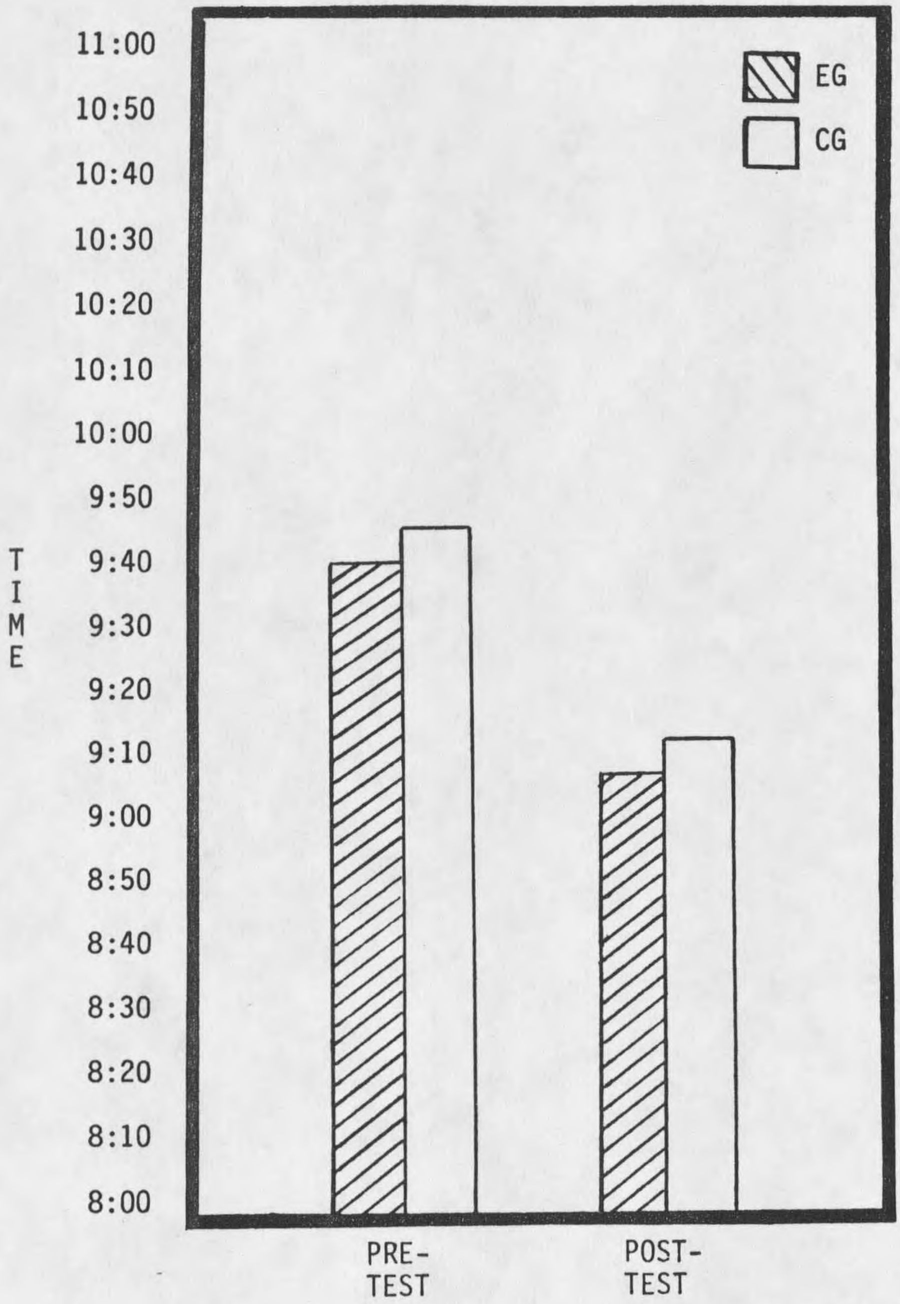

Figure 7. 1½-Mile Run.

pounds (Appendix B). No statistical treatment was applied to weight loss data.

The raw data from the urine analysis is presented in Appendix N. In the EG, two subjects were severely dehydrated at weigh-ins as reflected by values of 1.038 and 1.037. One of the most dehydrated subjects was almost as dehydrated (1.036) five hours later, unlike all other subjects who reached post-test values between 1.022 and 1.029. Of the CG, only one subject reached a value of 1.038, while the others were moderately dehydrated with values of 1.034 or less. The mean differences between the two groups were not statistically significant ($P<0.05$) as indicated in Table 10. It can be seen in Figure 8 that both groups were similar, evidencing mild to moderate dehydration, but returned to borderline normal levels following a five-hour rehydration period, with one noted exception.

Table 10. Analysis of Covariance Results Between the EG and CG Among the Urine Analysis Variable with the Pre-Test as Covariate.

Item	Group	No. of Subjects	Pre-Test	Post-Test	Adjusted Post-Test **	Variance	F-Test
Urine	EG	7	32.7	26.9	26.5	0.01	0.01
Analysis	CG	11	31.8	26.2	26.4	0.01	

* Significant beyond $P<0.05$, with a 1 and 15 Degree of Freedom.
** Statistically adjusting the post-test score by using the pre-test as the equating factor.

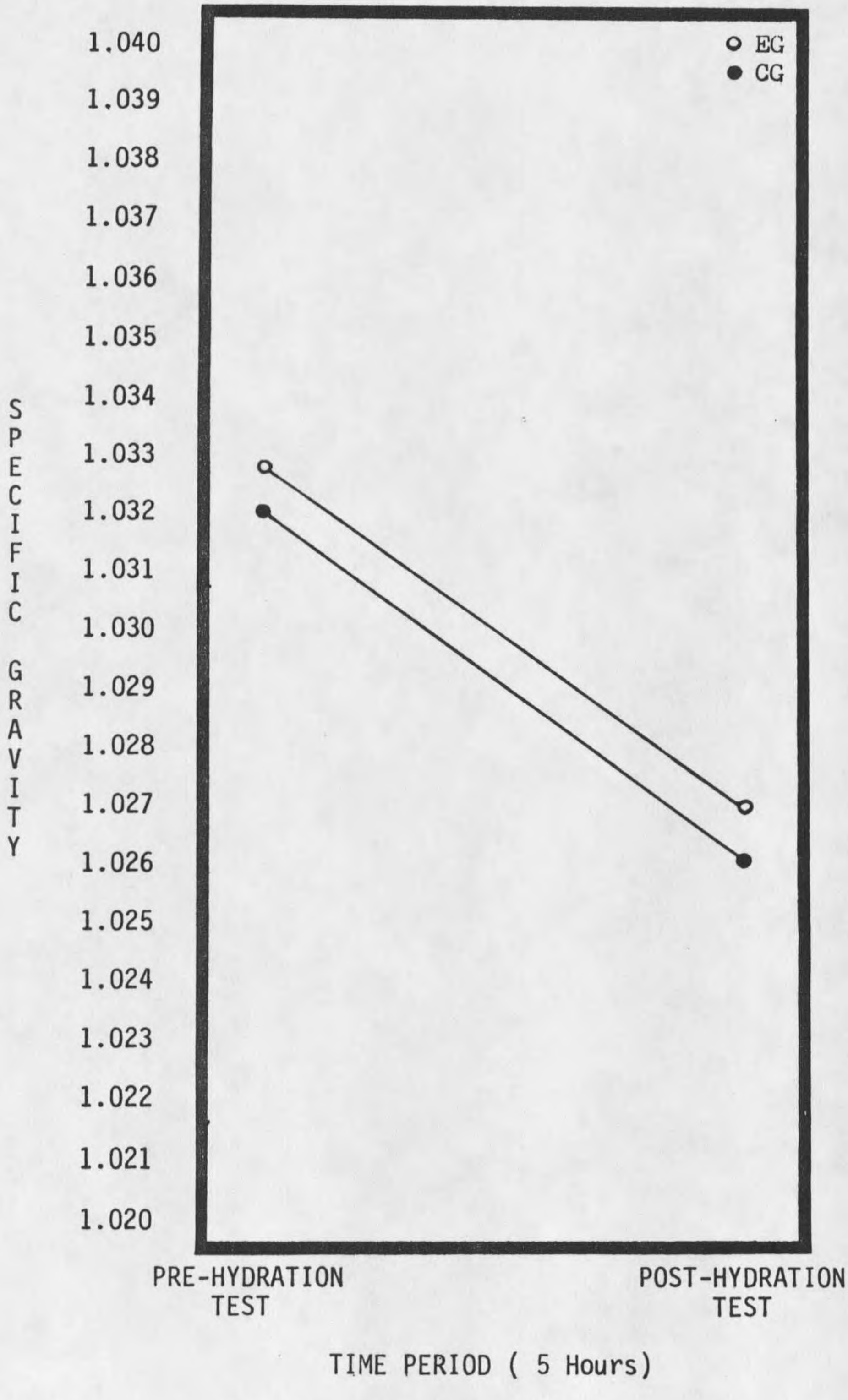

Figure 8. Urine Analysis.

CHAPTER V

DISCUSSION

The purpose of this investigation was to determine the effects of weight reduction resulting from dietary controls and no dietary controls during a collegiate wrestling pre-competitive training period. Results presented in Chapter IV will be discussed in this chapter and presented under the following headings:

1. Effect of Hypocaloric Diet on Body Composition
2. Muscular Endurance/Power
3. Aerobic Endurance
4. Urine Analysis

Effect of Hypocaloric Diet on Body Composition

The dietary program which was implemented to aid the EG in reducing TBW was designed to provide 60 percent CHO, 25 percent FAT and 15 percent PRO. The actual proportion of foodstuffs consumed were similar to the amounts planned for them (Table 4). As the study progressed the subjects became more conscientious in following the diet, resulting in an increase in the percentage of CHO and a decrease in the number of calories consumed. Due to the nature of utilizing human subjects, deviations from the controlled diet occurred. In some cases, individuals experienced difficulty in remaining on the high carbohydrate-hypocaloric diet though adherence was generally satisfactory (Appendix

0). The symptoms (i.e., hunger) associated with a reduced caloric intake were the major complaint even though the mean weight loss was only about one pound per week or approximately a daily caloric deficit of 500 Kcal. Weekends, particularly, presented a problem for keeping the subjects in the EG on the prescribed dietary program. Many disregarded the meal plans and, as a result, consumed more traditional meals (high FAT and PRO) of higher caloric content which ultimately resulted in fluctuations in TBW. This was especially evident during the first weeks of the investigation. Though the EG was more closely monitored during the investigation by having the foods to be selectively consumed chosen for them, the CG realized that by a specific date (Oct. 18, 1983) they would have to reach their respective weight classes to compete (Appendix B). For both groups a decline in caloric intake was observed over the six-week period (Figure 1).

As a result of training (increased energy expenditure) and following a chronic hypocaloric diet, the EG experienced a reduction in FW (5.0 pounds) and LBW (1.0 pound), resulting in an overall decrease in TBW (6.0 pounds). The CG had a decrease in FW (3.3 pounds) and an increase in LBW (1.4 pounds), resulting in an overall decrease in TBW (1.9 pounds). The changes found in body composition for the CG were primarily the result of training versus a hypocaloric diet to a larger extent than the EG.

Several factors can influence the composition (FW/LBW and body fluids) of weight loss. Among them is the severity of the caloric restriction, proportion of foodstuffs consumed, the duration of the hypocaloric diet, and the individual's PF. Data obtained in experiments of shorter duration involving acute and semi-starvation (particularly high PRO diets) in normals have indicated that during the early stages of caloric restriction much of the weight loss is from body fluids and LBW (17-20, 27, 54). As the duration of the hypocaloric diet extends, FW will increasingly compose a major portion of the weight loss (16, 35). In the EG, the extent of caloric restriction in the hypocaloric diet may have prevented the growth or maintenance of LBW, and therefore resulted in a decrease in both FW and LBW. This concurs with the findings of Widerman and Hagan (62) who reported similar results on one wrestler as a consequence of a chronic hypocaloric diet. In longitudinal studies on wrestlers, Kelly (34) and Zambreski (67) found that TBW decreased slightly during the wrestling season; FW decreased and LBW increased. These findings are in agreement with the results found in the CG.

Both groups in this investigation had decreases at all skinfold sites resulting in lower total skinfold values and therefore in PF. Although the differences between the two groups were not significant, the EG had larger decreases at all skinfold sites, a larger PF loss, and a larger increase in body density. The differences reflect the larger TBW and FW loss of the EG. Other investigators (34, 62, 67) have also reported decreases during the competitive season.

The decreases in all skinfold values correspond to a decrease in girths for the EG. The CG decreased all skinfold values. However, several girth sites (SH, NK and BI) were observed to increase. Kelly and co-workers (34) also found that a number of girth sites increased even though TBW decreased slightly. The increases in girth are associated with those body sites where muscular hypertrophy would increase.

Muscular Endurance/Power

Both groups increased muscular endurance and power during the pre-competitive training period. Although the differences between the two groups were not significant, the EG had larger increases for all the variables measured (Tables 7 and 8).

The results obtained in this study are in general agreement with other investigations involving wrestlers. However, the improvements found here are much higher. Wideman and Hagan (62) found that maximal isotonic strength was maintained following a significant weight reduction and when expressed in relation to body weight a small increase was observed; explosive power also increased. Kelly and co-workers (34) observed small increases in muscular strength and endurance during the competitive season, although TBW remained relatively stable. The small changes were attributed to the year-round training of the wrestlers. Others (16, 35, 54) using untrained subjects have also indicated that, for weight losses less than ten percent of TBW, maximal strength can be maintained. The improvements in muscular endurance and power observed in both groups over the six-week study period in this study would indicate that the subjects in this investigation began the pre-competitive training period in a relatively untrained state.

Aerobic Endurance

Both groups in this investigation had decreases of approximately 30 seconds in running time for the 1½-mile run with a non-significant difference between groups by the post-test (Table 9). Elements of the test that can affect performance (running time) are the subject's TBW, state of training ($\dot{V}O_2$ max), motivation and the establishing of an effective pace during the run.

Of particular interest to this investigation is the relationship of TBW to performance. Having a large body mass (muscle or adipose tissue) is a disadvantage to performance because bulk will not contribute to efficiency. Since the EG lost a significantly larger amount of TBW than the CG and also trained under similar conditions, it would seem that the EG would have a faster pace during the 1½-mile run, but this did not occur. One possibility for the similar trends may be related to the hypocaloric diet of the EG. The loss of 1.0 pound of LBW suggests that caloric deprivation prevented an adequate restoration of muscle glycogen. Other investigators (27, 54, 55) have found that caloric deprivation results in poor restoration of muscle/liver glycogen. This may lead to less than optimal cardiovascular efficiency (27, 35) and negatively influence the establishing of an effective pace during the 1½-mile run. Caloric deprivation also results in some degree of dehydration, with a major portion coming from the vascular compartment (9, 10, 54) and, consequently, the capacity of the circulatory system to transport oxygen to the working muscles is impaired, causing a decrease in performance during maximal workloads (1, 18, 35, 45, 46).

The results obtained in this study are in general agreement with other investigations involving wrestlers, although methods of measurement differ. Hansen (26) found that when $\dot{V}O_2$ max was expressed in $l \cdot min^{-1}$ a decrease was observed, but when expressed in relation to body weight ($ml \cdot min^{-1} \cdot kg^{-1}$) no significant difference was found following a large weight loss. Widerman and Hagan (62) also found that $\dot{V}O_2$ max decreased when expressed in $l\ min^{-1}$, but found a small increase when expressed in $ml \cdot min^{-1} \cdot kg^{-1}$ following a large weight reduction. Henschel and co-workers (27) have shown that a decrease in $\dot{V}O_2$ max is related to a decrease in LBW. Kelly and co-workers (34) observed a small increase in VO_2 max ($ml \cdot min^{-1} \cdot kg^{-1}$) during the competitive season, while TBW remained relatively stable. The small changes were attributed to the year-round training of the wrestlers.

Urine Analysis

One of the expected outcomes of controlled weight reduction was the loss of a larger amount of TBW prior to the first competitive weigh-in, permitting the EG to be nearer their respective weight classes and, therefore, not as dehydrated as the CG. The differences found in the urinary profiles between the groups showed a reversal of expectations; the EG was more dehydrated (non-significant) at both the pre- and post-hydration tests than the CG (Table 10). The groups exhibited nearly identical trends during the rehydration period (Figure 8). At the morning sample a mean specific gravity of 1.032 was found for the subjects in this investigation, and a value of 1.026 was observed at the post-hydration test. Between Monday (initial practice) and Friday (competition), the subjects in the EG lost a mean of 2.7 percent and the CG lost 2.9 percent of their TBW, primarily through dehydration (Appendix B). The subjects were only moderately dehydrated according to the percentage of body weight lost, which is not in agreement with the degree of dehydration evident from the urine analysis (specific gravity), unless the subjects were already dehydrated on Monday.

The results obtained in this study are in general agreement with other investigations involving wrestlers. However, the subjects in this study were more dehydrated. In three separate studies, Zambreski and co-workers reported a mean value of 1.028 at weigh-ins and a value of 1.026 five hours (rehydration period) later in high school wrestlers (66), a value of 1.026 at weigh-ins in high school wrestlers (65), and a value of 1.029 in college wrestlers at weigh-ins (67). Each of these studies were conducted late in the competitive season.

Two factors may have contributed to the urinary values exhibited in both groups at the pre-hydration test. First, pre-season anxiety related to "making weight" and competition, and particularly a team run prior to bed the night before weigh-ins; and second, the hypocaloric diet followed by the EG may have influenced the degree of dehydration observed. Other researchers have reported that a hypocaloric diet contributes to a state of chronic dehydration and an increase in fluid ingestion only results in an increase in urine volume (18, 35, 54).

A limiting factor to the degree to which the subjects would attempt to restore body fluids (rehydration period) was the knowledge that an additional weigh-in was scheduled for the evening after the final round of wrestling for the day to serve as a weigh-in for the second day of the tournament (one pound weight allowance). Therefore, many of the subjects restrained themselves from consuming foods and fluids of such amounts that their combined weight could not be "removed" before the next scheduled weigh-in.

It had been previously reported that if a subject can replace the fluids lost from dehydration during an allotted rehydration period (five hours), physical working capacity will not be significantly impaired (3, 34, 38, 42, 43, 49). Based on these findings, it may be concluded that for the majority of the subjects in this investigation dehydration/ rehydration procedures did not significantly impair performance during competition.

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to examine the relationship between nutritional control and selected physical parameters in eighteen collegiate wrestlers attempting to attain their optimal body composition during a wrestling pre-competitive training period.

Two groups of wrestlers from Montana State University served as the subjects for the investigation. A "randomly" selected (dorm living) experimental group, consisting of seven subjects, was placed on an individualized high carbohydrate-hypocaloric diet. A control group (off-campus living), consisting of eleven subjects, received no dietary directions to aid in reducing body weight. The degree of weight reduction was limited to the amount required for each subject in both groups to reach a specified weight classification for competition.

A pre- and post-test schedule over a period of six weeks involved 31 tests and was administered to the subjects in both groups to measure the changes in body composition, total body weight, girths, muscular endurance, power, and aerobic endurance that occurred as a result of prescribed dietary controls in comparison to no dietary controls. An analysis of covariance between the two groups for each variable tested was performed, using the pre-test as the covariate. The level of significance was established at 0.05.

As a result of following a hypocaloric diet, significant differences were found between the two groups for total body weight and several variables of girth and body composition. No significant differences were observed for muscular endurance, power, and aerobic endurance, although results indicate that the EG made slightly larger improvements for almost every variable measured over the pre-competitive training period. In particular, the EG was found to have lost lean body weight while the EG gained. Also, at both weigh-in periods (dehydration/rehydration) the EG was more dehydrated than the CG was. It is interesting to note that not all of the CG made their predicted target weight for competition and wrestled in a higher weight classification, whereas, all the subjects in the EG did.

Conclusions

A number of factors may have influenced the results obtained in this investigation. There were a limited number of subjects composing the samples; other wrestlers may not evidence the same physiologic changes as a result of a prescribed dietary program. In addition, changes in some variables, or lack thereof, may in part reflect the prior state of training of each subject. However, trends may be indicated and noted for further study. Within the limitations of this investigation the following conclusions seem justified:

1. The changes found in body composition for the EG were the result of a combination of training (increased energy expenditure) and

prolonged negative caloric balance, whereas changes in the CG were primarily the result of training.

2. The subjects in the EG experienced a significant reduction in total body weight composed of both adipose and muscle tissue. The CG had an overall decrease in total body weight due to a decrease in adipose tissue partly offset by an increase in muscle tissue.

3. The differences between the two groups were not significant for total skinfolds, body density or percent body fat, but a trend was observed; the EG had larger decreases for all the variables measured.

4. All girth sites were observed to decrease in the EG, but the CG had several sites increase which were body sites where muscular hypertrophy would be found.

5. The differences between the two groups were not significant for muscular endurance and power, but a trend was observed; the EG had larger increases for all the variables measured.

6. There was virtually no difference found between the two groups for aerobic endurance.

7. The differences found in the urinary profiles between the two groups were not significant, but a trend was observed; the EG was more dehydrated than the CG at both the pre-competition weigh-in and five hours later. The majority of the subjects in both groups were able to adequately restore body fluids to near normal levels during the allotted rehydration period.

Recommendations

Based on the results of this investigation, the following recommendations are made:

1. Further studies of this nature should be conducted over an entire wrestling season.

2. If at all possible, a larger sample should be used.

3. It would be valuable to include muscle biopsies prior to competition to determine the changes in muscle glycogen concentration following rapid weight reduction methods.

4. Longitudinal measures of energy levels should be made to determine the changes resulting from weight reduction.

5. Measures of psychological factors should be included in future studies to determine any negative changes resulting from prolonged or rapid weight reduction methods.

6. Measures of maximal isotonic strength should be included in future studies.

7. It would be useful to include direct measures of $\dot{V}O_2$ max and body composition.

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APPENDICES

APPENDIX A

DIET COMPOSITION AND CALORIC INTAKE
(Approximation of Individual Dietary Needs)

STEP 1: ESTIMATED DAILY CALORIC (KCAL) EXPENDITURE

1.	BMR	=		(21)
2.	Sleep (hr x 27.5 Kcal/hr)	=		(36)
3.	Light Activity (hr x 13.5 Kcal/hr)	=		(36)
4.	Wrestling (hr x 450 Kcal/hr)	=		(36)
5.	Weight Lifting (hr x 450 Kcal/hr)	=		(36)
6.	Jogging (hr x 10 Kcal/min)	=	______	(36)
	Total			

STEP 2: ESTIMATED WEEKLY KCAL EXPENDITURE

1. Sum of Individual Daily Kcal Expenditure = Total Weekly Kcal Expenditure

STEP 3: AVERAGE DAILY KCAL EXPENDITURE

1. Total Weekly Kcal Expenditure ÷ 7 = Average Daily Kcal Expenditure

STEP 4: IMPLEMENTING A WEIGHT REDUCTION

1. Desired Weight Loss (lb) ÷ 6 Weeks = Weekly Weight Loss (lb)
2. Weekly Weight Loss (lb) ÷ 7 Days = Daily Weight Loss (lb)
3. Daily Weight Loss (lb) x 3500 Kcal = Estimated Daily Kcal Deficit
4. Average Daily Kcal Expenditure - Estimated Daily KCal Deficit = Kcal Allowance

STEP 5: DIETARY PRESCRIPTION (COMPOSITION OF FOODSTUFFS)

1. Proportion of CHO = .60 x Kcal Allowance/4 Kcal/gm =
2. Proportion of Fat = .25 x Kcal Allowance/9 Kcal/gm =
3. Proportion of PRO = .15 x Kcal Allowance/4 Kcal/gm =

STEP 6: CALCULATE MEAL PLAN INTO FOOD EXCHANGES (7)

APPENDIX B

PREDICTED AND ACTUAL COMPETITIVE WEIGHT CLASSIFICATION

Subject	Group	Pre-Test WT	(Pre-Season) Predicted Weight Class	Post-Test WT	Weight Class Competed in	Dehydration Weight Loss	Dehydration % WT Loss	Rehydration Weight Gain
1	CG	202.0	193.0	194.5	193.0	-1.5	0.8%	-0.5
2	CG	166.0	161.0	168.0	161.0	-8.0	5.0%	+2.0
3	CG	132.5	129.0	138.5	137.0	-4.0	2.9%	+2.0
4	CG	167.5	161.0	164.0	161.0	-3.0	1.9%	+2.5
5	CG	181.0	170.0	173.5	170.0	-3.5	2.1%	-1.0
6	EG	193.0	180.0	184.0	180.0	-4.5	2.5%	+3.0
7	CG	167.5	161.0	163.0	161.0	-2.5	1.6%	+0.5
8	CG	191.5	170.0	183.5	180.0	-3.5	1.9%	+2.5
9	EG	142.0	129.0	133.0	129.0	-4.5	3.5%	+5.0
10	EG	156.0	145.0	146.5	145.0	-1.5	1.0%	+2.0
11	CG	129.5	121.0	127.0	121.0	-6.0	5.0%	+2.5
12	EG	140.5	129.0	134.0	129.0	-5.5	4.1%	+2.5
13	CG	170.0	161.0	175.0	170.0	-5.5	3.2%	+2.5
14	EG	127.5	121.0	123.0	121.0	-4.5	3.7%	+2.5
15	CG	156.0	145.0	156.5	153.0	-5.0	3.3%	+2.0
16	EG	166.5	161.0	163.0	161.0	-5.0	3.1%	+0.5
17	CG	158.0	153.0	160.0	153.0	-7.0	4.6%	+2.5
18	EG	127.5	121.0	120.5	121.0	-1.5	1.2%	+1.0

APPENDIX C

TOTAL BODY WEIGHT

Subject	Group	Sept. 21	Oct. 3	7	10	14	17	21	24	28	31	Nov. 4	7	11	14	16	17*/18
1	CG	202.0	202.0	199.5	197.0	-----	200.5	198.5	199.0	199.0	197.0	195.5	193.5	194.0	194.5	196.5	193.0
2	CG	164.0	166.0	164.5	163.0	164.5	166.0	166.5	169.0	166.0	168.0	167.0	166.0	168.0	168.0	165.0	160.0
3	CG	132.0	132.5	133.0	133.0	134.5	136.0	135.5	137.5	135.5	135.0	137.0	136.0	136.0	138.5	137.0	134.0
4	CG	170.0	167.5	168.0	168.0	167.0	169.0	167.5	168.0	167.5	166.0	-----	164.0	163.0	164.0	164.0	161.0*
5	CG	182.0	181.0	-----	181.0	180.0	181.5	179.0	180.0	-----	130.0	177.0	179.0	178.0	173.5	173.0	170.0
6	EG	193.0	193.0	-----	187.0	185.5	186.0	186.0	190.0	186.5	188.0	186.5	188.0	185.0	184.0	181.0	179.5
7	CG	168.0	167.5	166.0	163.5	165.5	165.0	164.0	165.0	164.0	163.0	-----	163.0	162.5	163.0	162.0	159.5
8	CG	191.5	191.5	189.0	184.0	184.5	187.0	-----	187.5	-----	186.0	183.5	185.0	-----	183.5	183.0	180.0
9	EG	141.5	142.0	-----	142.0	-----	144.0	140.0	138.5	139.0	137.0	136.0	134.0	133.5	133.0	133.0	128.5
10	EG	156.5	156.0	-----		-----	153.0	150.5	150.5	151.0	152.0	149.5	150.5	148.5	146.5	147.0	145.0
11	CG	128.0	129.5	129.5	130.0	128.0	129.0	-----	127.0	125.5	127.0	130.0	129.0	129.0	127.0	124.0	121.0
12	EG	140.5	140.5	139.0	136.5	137.5	137.0	137.0	137.0	-----	135.0	135.0	136.0	135.0	134.0	132.0	128.5
13	CG	173.5	170.0	173.5	173.0	173.0	174.0	173.5	174.5	173.0	173.0	174.0	175.0	174.0	174.5	174.0	169.5*
14	EG	126.0	127.5	125.0	128.5	125.0	126.5	127.0	127.0	124.0	125.0	124.0	124.0	122.5	122.5	121.5	118.5
15	CG	156.5	156.0	-----	157.0	155.0	158.0	154.5	154.0	152.5	156.5	154.0	156.5	154.5	156.5	156.0	151.5
16	EG	164.5	166.5	166.5	166.5	166.0	163.5	163.5	165.0	163.5	163.5	162.5	163.5	162.5	163.0	163.0	159.0*
17	CG	157.0	158.0	-----	156.0	157.5	159.0	158.0	159.5	-----	157.5	-----	155.0	158.0	160.0	157.0	153.0*
18	EG	125.5	127.5	127.5	-----	126.5	125.5	127.0	126.5	125.0	123.0	123.5	122.0	122.0	120.5	122.0	119.0

* Subjects not participating in competition but simulated dehydration procedures

APPENDIX D

ANTHROPOMETRIC DATA-PRETEST

Subject	Group	Height (in)	Weight (lb)	Neck Girth (cm)	Chest Girth (cm)	Shoulder Girth (cm)	Bicep Girth (cm)	Forearm Girth (cm)	Wrist Girth (cm)	Abdominal 1 Girth (cm)	Abdominal 2 Girth (cm)	Hip Girth (cm)	Thigh Girth (cm)	Knee Girth (cm)	Calf Girth (cm)	Ankle Girth (cm)
1	CG	73	202.0	41.2	107.7	126.1	38.3	31.1	18.5	88.2	86.0	105.4	65.7	40.7	38.5	24.3
2	CG	71 1/8	164.0	39.4	96.5	115.2	32.3	28.5	19.0	74.6	79.3	96.7	57.5	40.2	38.8	23.4
3	CG	65	132.0	36.0	86.4	108.0	32.5	29.0	17.7	72.2	75.1	86.6	52.8	36.7	36.0	22.6
4	CG	69 1/2	170.0	41.0	104.8	124.5	37.1	29.7	18.3	81.6	82.4	96.2	58.0	38.6	38.0	23.7
5	CG	73 1/4	182.0	41.3	104.0	121.2	36.2	30.2	18.8	81.8	83.4	97.6	59.5	38.4	38.7	22.5
6	EG	69	191.5	43.3	106.0	124.8	39.9	31.4	18.3	85.5	84.8	98.2	64.0	39.2	41.0	25.3
7	CG	70	168.0	39.2	101.0	118.4	35.1	29.5	18.8	79.4	75.3	93.5	56.5	38.4	37.5	23.5
8	CG	69 1/2	191.5	42.0	104.8	126.0	39.5	30.5	18.5	83.5	85.6	106.3	62.5	40.9	40.8	24.2
9	EG	66	141.5	36.8	94.1	112.6	33.0	26.8	16.9	77.0	78.8	87.0	55.0	37.4	34.1	21.8
10	EG	68	156.5	40.0	99.2	115.1	33.5	28.8	18.0	77.8	80.2	96.2	57.5	38.1	36.0	21.7
11	CG	65 1/2	128.0	35.5	90.0	108.5	32.5	28.3	16.7	68.7	69.5	88.0	50.5	34.5	34.0	21.8
12	EG	64	140.5	37.5	95.8	114.2	33.4	27.9	16.9	75.5	74.9	92.7	56.7	36.2	37.5	24.3
13	CG	64 3/4	173.5	43.3	101.9	121.4	38.2	31.1	18.2	80.8	82.4	98.3	60.5	39.2	39.4	23.2
14	EG	64	126.0	36.6	93.4	111.7	31.5	26.5	17.4	73.2	72.6	84.0	53.0	31.5	36.0	20.7
15	CG	60 3/4	156.5	40.4	100.7	115.4	35.4	28.8	17.4	77.5	78.5	91.7	57.5	37.0	35.5	21.5
16	EG	71 1/2	164.5	40.0	101.7	116.4	33.8	28.6	18.2	77.0	76.9	97.0	57.2	38.5	38.8	24.2
17	CG	69	157.0	40.4	98.5	118.5	36.6	28.9	17.6	77.7	79.1	93.5	55.0	37.6	38.5	23.1
18	EG	65 1/2	125.5	35.0	90.3	107.3	31.5	26.5	17.1	71.7	70.4	85.0	50.1	35.0	33.3	20.4

APPENDIX D

ANTHROPOMETRIC DATA-POSTTEST

Subject	Group	Weight (in)	Neck Girth (cm)	Chest Girth (cm)	Shoulder Girth (cm)	Bicep Girth (cm)	Forearm Girth (cm)	Abdominal 1 Girth (cm)	Abdominal 2 Girth (cm)	Hip Girth (cm)	Thigh Girth (cm)	Calf Girth (cm)
1	CG	194.5	41.7	102.5	123.6	38.3	30.6	84.2	84.5	100.9	63.8	37.9
2	CG	168.0	41.0	96.9	118.1	33.0	28.8	76.1	77.7	97.3	59.2	38.6
3	CG	138.5	36.7	94.8	112.1	33.1	27.8	76.2	73.6	87.2	54.3	35.6
4	CG	164.0	40.7	98.5	123.9	37.4	30.1	7[illegible].3	79.0	94.3	57.2	36.7
5	CG	173.5	41.4	99.0	118.4	35.7	29.8	79.5	80.6	95.9	56.9	38.3
6	EG	184.0	42.7	105.4	123.5	38.7	31.8	80.1	80.4	95.6	60.3	39.4
7	CG	163.0	38.6	97.5	117.5	35.6	29.6	76.9	72.5	92.7	55.0	36.3
8	CG	183.5	40.9	103.9	124.4	39.3	30.6	81.8	82.8	99.0	58.8	39.9
9	EG	133.0	36.2	92.5	111.1	32.5	26.8	74.1	72.1	84.3	54.1	32.5
10	EG	146.5	38.7	95.4	111.2	33.1	29.8	75.0	77.0	92.6	53.2	35.0
11	CG	127.0	34.9	89.8	108.3	32.3	28.1	68.0	68.5	87.9	50.7	32.5
12	EG	134.0	36.9	93.9	111.6	32.6	27.5	73.1	74.2	89.9	54.6	36.9
13	CG	175.0	44.3	102.8	123.8	39.4	31.3	79.4	80.3	95.7	59.9	39.3
14	EG	123.0	37.2	92.9	109.9	31.3	26.2	68.8	70.0	83.3	51.6	34.0
15	CG	156.5	42.3	100.0	115.0	35.4	28.9	76.9	76.3	89.9	56.5	34.8
16	EG	163.0	39.0	100.7	115.5	34.6	28.7	75.9	75.7	96.3	54.2	38.1
17	CG	160.0	39.4	100.3	121.4	36.5	29.1	77.6	77.6	93.7	54.6	39.3
18	EG	120.5	35.3	87.8	105.4	32.0	26.3	69.8	68.3	83.0	46.6	32.8

APPENDIX E

BODY COMPOSITION DATA-PRETEST

Subject	Group	Chest Fold	Subscapular Fold	Tricep Fold	Suprailiac Fold	Abdominal Fold	Thigh Fold	Sum of Folds	Body Density	Percent Body Fat	Total Fat Weight	Lean Body Weight
1	CG	3.0	9.0	11.0	21.0	17.0	17.5	78.5	1.0733	11.4	23.0	179.0
2	CG	3.0	7.5	5.5	12.0	6.0	8.0	42.0	1.0876	5.6	9.2	154.8
3	CG	3.0	7.5	7.5	10.0	8.0	7.0	39.5	1.0872	5.7	7.5	124.5
4	CG	3.0	7.0	5.0	13.0	10.5	5.0	43.5	1.0878	5.5	9.4	160.6
5	CG	4.0	8.5	8.5	11.5	14.0	9.5	56.0	1.0810	8.3	15.1	166.9
6	EG	4.0	11.5	9.5	18.5	13.5	14.0	71.0	1.0749	10.7	20.5	171.0
7	CG	5.5	10.5	7.0	13.0	15.5	14.0	65.5	1.0745	10.9	18.3	149.7
8	CG	2.0	9.0	7.5	19.0	14.0	17.5	50.5	1.0751	10.7	20.5	171.0
9	EG	10.0	12.0	13.0	28.0	25.0	15.0	103.0	1.0663	14.3	20.2	121.3
10	EG	4.0	8.0	5.5	12.5	13.0	12.0	55.0	1.0802	8.6	13.5	143.0
11	CG	2.5	7.0	5.0	7.5	7.0	6.5	35.5	1.0887	5.1	6.5	121.5
12	EG	4.0	12.0	10.0	22.0	19.0	11.5	78.5	1.0734	11.4	16.0	124.5
13	CG	4.0	11.5	7.0	19.5	15.0	14.5	71.5	1.0738	11.2	19,4	154.1
14	EG	2.5	9.5	8.0	15.5	11.5	12.0	59.0	1.0798	8.7	11.0	115.0
15	CG	3.0	5.5	6.0	6.0	5.0	4.0	29.5	1.0930	3.4	5.3	151.2
16	EG	3.5	10.0	5.5	14.0	6.5	4.0	43.5	1.0875	5.6	9.2	155.3
17	CG	3.0	7.0	5.0	9.0	7.0	9.0	40.0	1.0867	6.0	9.4	147.6
18	EG	2.5	7.0	8.0	7.0	8.5	5.0	38.0	1.0890	5.0	6.3	119.2

APPENDIX E

BODY COMPOSITION DATA-MIDTEST

Subject	Group	Chest Fold	Subscapular Fold	Tricep Fold	Suprailiac Fold	Abdominal Fold	Thigh Fold	Sum of Folds	Body Density	Percent Body Fat	Total Fat Weight	Lean Body Weight
1	CG	3.0	10.0	10.5	23.5	15.0	16.5	78.5	1.0786	9.2	18.3	180.7
2	CG	3.5	8.0	8.0	13.0	6.0	8.0	47.5	1.0898	4.7	7.9	161.1
3	CG	3.5	8.0	7.5	11.0	8.0	9.0	47.0	1.0874	5.7	7.8	129.7
4	CG	3.0	6.5	4.0	7.5	7.5	4.0	32.5	1.0915	4.0	6.7	161.3
5	CG	3.0	8.0	7.0	10.5	9.0	7.0	44.5	1.0878	5.5	9.9	170.1
6	EG	4.0	12.0	9.0	16.0	11.0	13.5	65.5	1.0798	8.7	16.5	173.5
7	CG	4.0	9.5	6.0	13.0	11.0	10.0	52.5	1.0838	7.1	11.7	153.5
8	CG	4.0	8.0	7.0	9.0	8.0	11.5	47.5	1.0862	6.1	11.4	176.1
9	EG	9.5	8.5	12.0	23.0	21.0	10.5	84.5	1.0781	9.4	13.0	125.5
10	EG	2.5	7.5	4.0	7.0	9.0	7.0	37.0	1.0885	5.2	7.8	142.7
11	CG	2.5	6.5	5.0	6.0	6.5	6.5	33.0	1.0910	4.2	5.3	121.7
12	EG	2.5	10.5	10.0	12.5	12.5	9.5	57.5	1.0826	7.6	10.4	126.6
13	CG	3.5	10.5	6.5	20.0	11.0	13.0	64.5	1.0818	7.9	13.8	160.7
14	EG	2.0	7.5	6.5	9.0	7.0	9.5	41.5	1.0886	5.2	6.6	120.4
15	CG	2.5	5.5	5.0	5.0	5.0	4.0	27.0	1.0939	3.1	4.8	149.2
16	EG	3.5	8.0	7.0	8.5	5.5	5.5	38.0	1.0903	4.5	7.4	157.6
17	CG	2.5	6.5	5.0	8.5	6.0	8.0	39.0	1.0906	4.4	7.0	157.5
18	EG	2.5	7.0	6.5	7.0	7.5	4.0	34.5	1.0911	4.2	5.3	121.2

APPENDIX E

BODY COMPOSITION DATA-POSTTEST

Subject	Group	Chest Fold	Subscapular Fold	Tricep Fold	Suprailiac Fold	Abdominal Fold	Thigh Fold	Sum of Folds	Body Density	Percent Body Fat	Total Fat Weight	Lean Body Weight
1	CG	3.0	9.0	11.0	21.0	17.0	17.5	78.5	1.0733	11.4	23.0	179.0
2	CG	3.0	7.5	5.5	12.0	6.0	8.0	42.0	1.0876	5.6	9.2	154.8
3	CG	3.0	7.5	7.5	10.0	8.0	7.0	39.5	1.0872	5.7	7.5	124.5
4	CG	3.0	7.0	5.0	13.0	10.5	5.0	43.5	1.0878	5.5	9.4	160.6
5	CG	4.0	8.5	8.5	11.5	14.0	9.5	56.0	1.0810	8.3	15.1	166.9
6	EG	4.0	11.5	9.5	18.5	13.5	14.0	71.0	1.0749	10.7	20.5	171.0
7	CG	5.5	10.5	7.0	13.0	15.5	14.0	65.5	1.0745	10.9	18.3	149.7
8	CG	2.0	9.0	7.5	19.0	14.0	17.5	50.5	1.0751	10.7	20.5	171.0
9	EG	10.0	12.0	13.0	28.0	25.0	15.0	103.0	1.0663	14.3	20.2	121.3
10	EG	4.0	8.0	5.5	12.5	13.0	12.0	55.0	1.0802	8.6	13.5	143.0
11	CG	2.5	7.0	5.0	7.5	7.0	6.5	35.5	1.0887	5.1	6.5	121.5
12	EG	4.0	12.0	10.0	22.0	19.0	11.5	78.5	1.0734	11.4	16.0	124.5
13	CG	4.0	11.5	7.0	19.5	15.0	14.5	71.5	1.0738	11.2	19.4	154.1
14	EG	2.5	9.5	8.0	15.5	11.5	12.0	59.0	1.0798	8.7	11.0	115.0
15	CG	3.0	5.5	6.0	6.0	5.0	4.0	29.5	1.0930	3.4	5.3	151.2
16	EG	3.5	10.0	5.5	14.0	6.5	4.0	43.5	1.0875	5.6	9.2	155.3
17	CG	3.0	7.0	5.0	9.0	7.0	9.0	40.0	1.0867	6.0	9.4	147.6
18	EG	2.5	7.0	8.0	7.0	8.5	5.0	38.0	1.0890	5.0	6.3	119.2

APPENDIX F

MUSCULAR ENDURANCE-PRETEST

Subject	Group	Body Weight	SQUATS		PULLDOWNS		DIPS		OVERHEAD PRESS	
			WT	REPS	WT	REPS	WT	REPS	WT	REPS
1	CG	202.0	305.0	11	200.0	2	40.0	12	120.0	6
2	CG	166.0	245.0	0	165.0	1	32.5	8	100.0	1
3	CG	132.5	200.0	4	135.0	5	25.0	10	80.0	6
4	CG	167.5	255.0	0	170.0	10	35.0	22	100.0	20
5	CG	181.0	270.0	0	180.0	6	35.0	12	110.0	7
6	EG	193.0	285.0	12	190.0	3	37.5	22	115.0	15
7	CG	167.5	250.0	0	165.0	4	32.5	8	100.0	5
8	CG	192.0	285.0	6	190.0	3	37.5	10	115.0	15
9	EG	142.0	210.0	1	140.0	6	27.5	7	85.0	9
10	EG	156.0	235.0	2	155.0	9	30.0	13	95.0	5
11	CG	129.5	190.0	12	130.0	10	25.0	10	75.0	15
12	EG	140.5	210.0	12	140.0	8	27.5	13	85.0	14
13	CG	173.0	260.0	1	175.0	11	35.0	18	105.0	11
14	EG	127.5	190.0	0	125.0	3	25.0	12	75.0	4
15	CG	156.0	235.0	5	155.0	11	30.0	18	95.0	12
16	EG	166.5	245.0	0	165.0	4	32.5	8	100.0	3
17	CG	157.0	235.0	10	155.0	11	30.0	19	95.0	12
18	EG	127.5	190.0	12	125.0	3	25.0	15	75.0	10

APPENDIX F

MUSCULAR ENDURANCE-POSTTEST

Subject	Group	Body Weight	SQUATS WT	SQUATS REPS	PULLDOWNS WT	PULLDOWNS REPS	DIPS WT	DIPS REPS	OVERHEAD PRESS WT	OVERHEAD PRESS REPS
1	CG	193.0	295.0	17	195.0	5	40.0	10	115.0	7
2	CG	167.0	250.0	7	165.0	8	32.0	10	100.0	5
3	CG	136.5	205.0	13	135.0	10	27.0	13	80.0	10
4	CG	164.0	245.0	3	165.0	13	32.0	21	100.0	17
5	CG	176.0	265.0	6	175.0	10	35.0	12	105.0	11
6	EG	185.0	275.0	21	185.0	6	37.0	20	110.0	12
7	CG	163.0	245.0	1	165.0	6	32.0	12	100.0	6
8	CG	184.0	275.0	10	185.0	7	37.0	14	110.0	18
9	EG	136.0	205.0	3	135.0	9	27.0	13	80.0	11
10	EG	149.5	-----	--	150.0	10	30.0	13	90.0	9
11	CG	127.5	190.0	5	130.0	10	25.0	15	75.0	15
12	EG	134.0	200.0	18	135.0	11	27.0	17	80.0	14
13	CG	174.0	260.0	5	175.0	13	35.0	22	105.0	13
14	EG	121.0	180.0	0	120.0	8	25.0	20	70.0	7
15	CG	157.0	235.0	13	155.0	13	30.0	19	95.0	14
16	EG	162.0	245.0	1	160.0	8	32.0	10	95.0	10
17	CG	156.0	235.0	9	155.0	11	30.0	20	95.0	13
18	EG	120.5	180.0	11	120.0	12	25.0	15	70.0	12

APPENDIX G

MODIFIED WINGATE-PRETEST

Subject	Group	WT(Kg)	KP	30-3 TRIAL 1	2	3	4	5	6
9	EG	64.5	4.75	147	123	105	97	82	77
6	EG	87.7	6.50	100	101	87	74	69	72
7	CG	76.1	5.75	93	101	95	95	91	84
18	EG	58.0	4.25	132	116	108	101	91	82
12	EG	63.9	4.75	123	125	117	113	104	101
14	EG	58.0	4.25	98	96	81	83	70	69
8	CG	87.3	6.50	143	131	123	110	99	82
5	CG	82.3	6.25	141	126	117	109	90	78
11	CG	58.9	4.25	148	135	126	116	95	71
2	CG	75.5	5.75	132	120	104	96	89	88
4	CG	75.9	5.75	128	120	109	95	84	70
3	CG.	60.2	4.75	95	90	81	86	84	79
16	EG	75.7	5.75	129	120	106	87	67	73
17	CG	71.4	5.50	122	116	110	82	73	77
13	CG	78.6	5.75	118	120	110	107	98	93
1	CG	91.8	6.50	114	99	90	78	71	66
15	CG	70.9	5.50	113	110	103	96	92	91
10	EG	70.9	5.50	110	104	99	91	93	87

APPENDIX G

MODIFIED WINGATE-POSTTEST

Subject	Group	WT(Kg)	KP	30-s TRIAL 1	2	3	4	5	6
9	EG	60.5	4.75	140	135	112	93	81	77
6	EG	83.6	6.25	148	127	110	96	77	81
7	CG	74.1	5.50	108	104	95	90	85	77
18	EG	54.8	4.00	138	125	122	101	89	83
12	EG	61.4	4.75	146	132	121	111	102	95
14	EG	55.9	4.25	120	107	108	93	81	80
8	CG	83.4	6.25	148	132	121	118	102	94
5	CG	78.9	5.75	145	137	122	107	98	96
11	CG	57.7	4.25	141	135	124	104	82	70
2	CG	76.4	5.75	150	138	124	113	101	89
4	CG	74.1	5.50	148	132	113	96	90	85
3	CG	63.0	4.75	113	108	104	98	97	92
16	CG	74.1	5.50	135	127	112	95	86	77
17	CG	72.7	5.50	153	145	124	105	91	77
13	CG	79.5	5.75	131	128	115	102	95	96
1	CG	88.4	6.50	127	111	105	92	98	84
15	CG	71.1	5.50	138	126	112	99	82	90
10	EG	67.7	5.00	135	121	111	104	101	91

APPENDIX H

$1\frac{1}{2}$-MILE RUN

Subject	Group	Pre-Test	Post-Test
1	CG	11:04	9:10
2	CG	8:57	8:47
3	CG	9:58	9:27
4	CG	9:36	9:10
5	CG	9:25	9:18
6	EG	9:43	9:26
7	CG	9:29	8:58
8	CG	10:26	9:30
9	EG	10:11	9:05
10	EG	8:35	8:29
11	CG	9:06	8:49
12	EG	10:20	9:13
13	CG	9:14	9:05
14	EG	9:09	9:03
15	CG	9:08	8:55
16	EG	11:05	9:55
17	CG	10:39	9:55
18	EG	8:28	8:25

APPENDIX I

URINE ANALYSIS

		Pre-Test		Post-Test	
Subject	Group	Weight	Specific Gravity	Weight	Specific Gravity
1	CG	193.0	1.031	192.5	1.025
2*	CG	160.0	1.030	162.0	1.028
3	CG	134.0	1.030	136.0	1.025
4*	CG	161.0	1.031	163.5	1.027
5	CG	170.0	1.030	169.0	1.026
6	EG	179.5	1.031	182.5	1.025
7	CG	159.5	1.034	160.0	1.026
8	CG	180.0	1.032	182.5	1.028
9	EG	128.5	1.032	133.5	1.024
10	EG	145.0	1.037	147.0	1.029
11	CG	121.0	1.030	123.5	1.026
12	EG	128.5	1.038	131.0	1.036
13*	CG	169.5	1.030	172.0	1.026
14	CG	118.5	1.032	121.0	1.024
15	CG	151.5	1.038	153.5	1.027
16*	EG	159.0	1.030	160.0	1.028
17*	CG	153.0	1.034	156.5	1.024
18	EG	119.0	1.029	120.0	1.022

* Subjects not participating in competition but simulated dehydration procedures

APPENDIX J

DIET COMPOSITION AND CALORIC INTAKE
FOR THE EXPERIMENTAL GROUP (EG)

		Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Average	
Subject	Group	Comp (%)*	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Comp (%)	Kcal	Comp (%)	Kcal
6	EG	54/31/16	2753	55/30/15	2838	55/31/14	3149	60/27/12	2688	58/28/14	2585	58/29/14	2421	57/29/14	2739
9	EG	55/25/14	2939	57/28/15	2680	54/31/15	2295	60/27/13	2128	63/24/12	1627	60/26/14	1492	58/27/14	2194
10	EG	67/20/14	2290	65/20/13	2227	59/27/15	1785	69/19/15	2422	70/19/12	2249	64/25/12	2142	66/22/14	2186
12	EG	57/27/15	1956	59/27/14	2537	58/26/15	2382	61/26/14	1826	59/26/14	2376	63/25/12	1793	60/26/14	2148
14	EG	56/29/17	3111	58/27/15	2603	56/30/15	2803	60/26/14	2303	61/26/14	2236	66/24/13	2564	60/27/15	2603
16	EG	61/26/14	2819	66/21/14	2485	57/25/14	2434	61/25/14	2950	62/24/15	2140	58/29/15	2637	61/25/14	2578
18	EG	48/39/16	2574	56/28/17	2478	52/32/16	2448	58/29/14	2453	58/29/13	2441	63/27/11	2676	56/31/15	2512

* CHO/FAT/PRO