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Title: Dehydration and Rehydration in Collegiate Wrestlers

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Donald E. Campbell

Eleven collegiate wrestlers were thermally dehydrated five percent of their body weight in 24 hours. Voluntary rehydration was allowed over a five-hour period on three different solutions: (1) normal water, (2) demineralized water, and (3) a glucose-electrolyte solution.

Mean exercise heart rate was measured at five predetermined time intervals. Predicted work capacity at a stable heart rate of 170 beats per minute and maximum oxygen uptake were predicted from mean exercise heart rate.

Thermal dehydration elevated mean exercise heart rate significantly at moderate and severe work loads ($P \leq .05$). PCW-170 was significantly lowered ($P \leq .05$), while maximum oxygen uptake was not modified.

Rehydration on demineralized water over a five-hour period did not result in study parameters recovering to normal values, while dehydration on a glucose-electrolyte solution allowed study parameters to exceed normal values. However, a fatigue factor may have been present allowing this result to be indicated.

Dehydration and Rehydration in Collegiate Wrestlers

by

Robert Scott Tomasovic

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R. S. T.

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DEHYDRATION AND REHYDRATION IN COLLEGIATE WRESTLERS

CHAPTER 1

INTRODUCTION

Investigations concerning the effect of thermal and exercise dehydration on competitive athletes have been numerous.

In particular, the American Medical Association has issued a position statement on the practice of high school and collegiate wrestlers' practice of reducing body weight through dehydration.

The purpose of "making weight" through dehydration is to wrestle in a lower weight class, thereby gaining a physical and psychological advantage over the opponent. This dehydration will occur over the last twenty-four to forty-eight hours prior to competition. Urinary samples collected at the 1972 Iowa State High School wrestling tournament of 60 finalists indicated they were in a dehydrated state at the time of weigh-in. Scholastic wrestlers have a period of one-half hour to one hour to recover from the effects of dehydration while collegiate wrestlers have five hours before competing.

The extent of this practice indicates that the competitors and coaches do not feel this practice is harmful, or at least, the competitor has sufficient time to recover. A study of the effects dehydration has on performance indicated by a former successful high school and collegiate wrestler may provide some insight. In eight years of competition the author frequently dehydrated through thermal means. The structure of this study is designed to simulate the most frequently practiced procedure of thermal dehydration. The procedures used to study the effects of dehydration were intended to reveal the effects of dehydration on performance by a competitive wrestler.

Statement of the Problem

The proposed problem was to determine the effects of thermal dehydration on three selected cardiovascular condition indicators. The study is concerned with two major areas:

1. The effects thermal dehydration has on selected cardiovascular condition indicators.
2. The length of time required for rehydration to restore the selected cardiovascular indicators to pre-hydrated levels.

Objectives of the Study

The objectives of the study were as follows:

1. To establish the mean exercise heart rate predicted work capacity (170 bpm), and maximum oxygen uptake in a normal condition.
2. To determine the effect a 5 percent reduction in body weight, through thermal dehydration, has on mean exercise heart rates, predicted work capacity (170 bpm), and maximum oxygen uptake.
3. To determine the effect voluntary rehydration has on mean exercise heart rate, predicted

work capacity (170 bpm), and maximum oxygen uptake at predetermined time intervals.

4. To determine if rehydrating on a glucose-electrolyte solution allows a greater rate of recovery than rehydrating on demineralized water.

Significance of the Study

The first comprehensive study of the effect of maintaining a normal hydrated body state was conducted on soldiers during World War II. Since that time many studies have pointed out the significance of maintaining a hydrated state during athletic competition.

This study showed that predicted work capacity (170 bpm), exercise heart rate, and maximum oxygen uptake were significantly affected by rehydration from a dehydrated body state.

Purpose of the Study

The purpose of the study was to analyze rehydration following dehydration. Particular attention was devoted to three selected variables: exercise heart rate, predicted work capacity (170 bpm) and maximum oxygen uptake.

Three research questions were of concern in this study:

1. What effect does a 5 percent reduction in body weight, through thermal dehydration, have on mean exercise heart rate, predicted work capacity (170 bpm), and maximum oxygen uptake?

2. Upon rehydration what occurs to mean exercise heart rate, predicted work capacity (170 bpm), and maximum oxygen uptake at predetermined time intervals?
3. Does rehydrating on a glucose electrolyte solution allow a greater rate of recovery than rehydration on demineralized water?

Hypothesis to be Tested

On the basis of these research questions, the following null hypothesis were developed and tested:

Hypothesis one: No significant difference existed in exercise heart rate among three rehydration procedures.

Hypothesis two: No significant difference existed in predicted work capacity among three rehydration procedures.

Hypothesis three: No significant difference existed in maximum oxygen uptake among three rehydration procedures.

Analysis Procedures

Each hypothesis was tested with double classification ANOVA involving three conditions, six time intervals, and eleven subjects.

Delimitations and Limitations

Restrictions on the nature and scope of this study were imposed to effect a workable research problem. Eleven male college varsity wrestlers served as subjects. All were active in collegiate wrestling and competed at the varsity level.

When human subjects perform in scientific experiments which require maximal voluntary responses, serious limitations are inevitable. Learning factors are a complex array of variables which provide countless possibilities for outcome. In addition, physical stress factors, such as encountered in this study, can result in varied motivational responses. Every precaution was taken to prevent motivational factors from affecting performance.

Instruction on methods and procedures for testing was a standardized presentation. Clarification of this information only was offered in response to questions posed by the subjects. Despite this degree of experimental control, however, the physical nature of the specific tasks, the criterion instruments, the number of trials and the length of the trial intervals impose limits upon the interpretation of the data.

Definition of Terms

Dehydration - the reduction of body fluids below normal body levels.

Rehydration - the replacement of body fluids when they are at a level below normal

Predicted Work Capacity (170 bpm) - the intensity of work in kilo-pound-meters of work per minute; which produces a sustained heart rate of 170 beats per minute.

Maximal Oxygen Uptake - the point at which further increase in exercise is not accompanied by an increase in oxygen uptake.

CHAPTER II

REVIEW OF THE LITERATURE

One of the oldest competitive athletic events of history has been under sharp criticism. Wrestling as an interscholastic and collegiate sport has grown in popularity at all age levels. With this growth there has been a proportional outcry over one of the practices of many wrestlers - lowering body weight through dehydration.

Despite repeated admonitions by medical, educational, and athletic groups (2, 5, 9, 17), most wrestlers have, through instruction, peer pressure or tradition, lost weight in order to wrestle in a weight class below their pre-season weight (24, 26). This weight loss is accomplished by a combination of food restriction, fluid deprivation, and sweating by thermal or exercise procedures (2, 9, 15, 17, 24, 26, 27, 28). The method most frequently chosen appears to be dehydration through thermal methods.

The purpose of reducing body weight prior to competing is to gain a physical and hopefully a psychological advantage over the opponent. Scholastic wrestlers have a period of one-half hour to one hour while collegiate wrestlers have five hours before competing to recover from the effects of dehydration. The question then arises as to the effect of thermal dehydration upon factors that affect the athlete's performance and if the athlete can recover from those effects in that allocated time.

Accordingly, the related literature has been organized for presentation in the following manner:

General factors affecting measurements.

Exercise heart rate.

Predicted work capacity.

Maximum oxygen uptake.

Summary.

General Factors Affecting Measurements

The study of the affects of dehydration on man is limited to stress factors on participants as reported by recent research. Dehydration if not carefully controlled can be a serious danger to participants. In general a reduction of two to three percent of the body weight by dehydration produces no abnormal physiological responses. Reductions of three to ten percent cause deterioration of physiological responses although the individual can remain alert and active. Dehydration beyond ten percent results in increased physical and mental deterioration. Death results at a reduction of 20 to 25 percent in body weight by dehydration (1, 3, 23).

The method of dehydration determines where water losses will occur in the body. Thermal dehydration without muscular work causes a relatively marked reduction in blood volume caused by a reduction in plasma volume (3, 8, 21, 23). While dehydration by heavy exercise leads to water loss from intracellular space and plasma volume (3, 16). The physical condition of participants affects subjects response to dehydration. The well-trained subject is less affected by dehydration during exercise or thermal dehydration (3, 7, 23). In both cases, cardiac output is not modified by dehydration of up to 5 percent of the body weight, while stroke volume is reduced (3, 19, 21, 22).

Electrolyte losses during dehydration cause lowered pH and sodium excretions while increasing specific gravity, osmolarity, creatinine excretion, potassium excretion and LAP activity (3, 8, 14, 26, 28). However, there seems to be no significant differences between electrolyte loss while undergoing thermal or exercise dehydration (14).

These factors affect the performance of competing athletes and contribute to the observed effects of dehydration.

Exercise Heart Rate

Mean heart rate is used as a means of predicting maximum oxygen uptake and predicted work capacity (3, 4, 6, 7, 10, 18, 19, 20, 21). In several cases dehydration has not seemed to affect heart rate. Bock (6) restricted fluid intake of ten Ohio State University freshman wrestling team members for a period of 40 hours. Weight lost varied from .04 percent to 3.85 percent of body weight. Mean heart rate was not significantly affected by dehydration, but showed a slight elevation upon rehydration.

By having five men dehydrate overnight in 115° F, Buskirk (7) found an elevated heart rate during sub-maximal work but a significant difference did not exist. The average loss was 5.5 percent of body weight.

In the majority of studies, exercise heart rate was elevated. This would be consistent with research indicating that cardiac output is not affected by dehydration but stroke volume is reduced (3, 19, 21, 22).

The comparison of exercise heart rates indicates the loss of body fluids through heavy exercise results in a greater increase in mean heart rate (19). Research in this area is not conclusive enough to indicate a marked difference. It does suggest that fatigue would not be a factor in studies of exercise heart rate. Maximal work time is decreased in both exercise and thermal dehydration (10, 19, 20, 21).

Costill (8) on three separate occasions reduced eight male subjects four percent of their body weight and followed this by rapid fluid replacement over a four-hour period. In one period, the men were allowed to replace body fluids voluntarily with demineralized water, in the second, with a glucose-electrolyte solution and the third, normal rehydration was permitted. The subjects averaged a 3.8 percent reduction in body weight. Plasma volume was reduced 12 percent and heart rate during exercise elevated twenty beats per minute. On the glucose-electrolyte solution, heart rates normalized in approximately two hours; with demineralized water normalized heart rate required approximately three hours of recovery time. Plasma volume was not restored in the four-hour period.

Dehydration, as a result of a high environmental temperature affected the heart rate responses less than that caused by exercise dehydration at sub-maximal work in the upright position (19). In both cases, the stroke volume was decreased with only minor changes in cardiac output. A decrease in plasma volume, leading to increased heart rate, was correlated with a reduction in stroke volume after thermal dehydration by Saltin (19) in this study.

In a similar study, Saltin (20) found that exercise heart rate was significantly higher (mean difference of thirteen beats per minute) at sub-maximal work loads, while no difference was observed at maximal workloads, but work times decreased markedly. These results were matched by a 5.2 percent thermal reduction of body weight for four subjects. Saltin (21) found an increase in heart rate during sub-maximal work matched to a 25 percent reduction in plasma volume.

Indications, therefore, are that thermal dehydration causes a significant increase in exercise heart rate at sub-maximal work loads due to a reduction in plasma volume with a reduction of four percent or higher in body weight.

Predicted Work Capacity

Since exercise heart rate at sub-maximal and maximal work loads is used to predict work capacity at a heart rate of 170 beats per minute (2), conditions that elevate heart rate would be expected to reduce PWC-170.

Herbert (10) measured the physical work capacity of nine college wrestlers under three conditions: in the normal state; after a 4.8 percent weight reduction in four days; after five hours of voluntary rehydration and food ingestion. Significant impairment in PWC-170 was observed following dehydration. Partial recovery was experienced following rehydration, although physical work capacity was still significantly reduced from normal values. The reduction in PWC-170 was related to an increase in exercise heart rate.

Eight wrestlers or former wrestlers were dehydrated five percent of their body weight in forty-eight hours by Ribsil (18). Physical work capacity was measured under three conditions: in the normal state; after thermal dehydration; after five hours of voluntary rehydration. Results indicated a significant reduction in working capacity occurred after dehydration($P \leq .05$). The study also indicated the five hours of rehydration seemed to return PWC-170 values to normal. However, the author did not account for a learning factor that was operating (18, 25).

Saltin (19) found work time definitely reduced after thermal dehydration and markedly reduced after exercise dehydration at maximal work loads coupled with an elevation in heart rate at sub-maximal work loads. PWC-170 was significantly reduced in the dehydrated state. The body weight decrease was up to 5.5 percent.

In a similar study, Saltin (20) reduced ten subjects 4.6 kg under three conditions: thermal dehydration; metabolic dehydration; combined thermal and metabolic dehydration. The study indicated a definite decrease in the capacity to perform extended (2-6 min) heavy work and that the performance was significantly more affected after exercise dehydration. Saltin (20) concluded the decrease in work time on a maximal work load, in fact, reflects a lowered physical work capacity in the dehydrated state.

In a final study measuring cardiac output and stroke volume of four subjects after thermal dehydration at two sub-maximal and one maximal work load, Saltin (21) found a marked decrease in maximal work time of 33 percent. The reduction was 5.2 percent of body weight and produced no significant change in oxygen uptake, cardiac output or stroke volume during maximum work. However, the significant reduction in work time indicated a reduced physical work capacity.

Thermal dehydration then would seem to cause a reduction in work time at maximal work loads. Coupled with an elevated heart rate at sub-maximal work loads, thermal dehydration results in a lowered physical work capacity in the cited literature.

Maximum Oxygen Uptake

Dehydration seemed to have little effect on maximum oxygen uptake. Bock (6) dehydrated ten subjects by restricting fluid intake over a forty-hour period. While seven of the ten subjects showed a reduction in maximum oxygen uptake, it was not significant. Rehydration of the subjects also showed no significant difference in maximum oxygen uptake from normal conditions.

Buskirk (7) dehydrated five men overnight in the heat (115^{o}) to approximately 5.5 percent of their body weight, under three conditions: physically conditioned and acclimatized to heat; physically conditioned; and sedentary. No significant was observed in maximum oxygen uptake under the three conditions. However, the physically conditioned subject did show an improvement in maximum oxygen uptake under both conditions. This improvement was not significantly different from the sedentary subjects' maximum oxygen uptake.

At maximal work in the upright position, there was no change in aerobic work capacity after exercise or thermal dehydration in spite of a body weight decrease of up to 5.5 percent (29). Saltin made these observations despite a reduction in plasma volume and stroke volume.

In a related study, Saltin (20) dehydrated ten subjects under thermal, metabolic, and combined thermal and metabolic methods. The subjects were then tested under sub-maximal and maximal work loads.

Under both sub-maximal and maximal work loads, no change in maximum oxygen uptake between normal and the three experimental conditions was observed.

Saltin (21) further reports that thermal dehydration resulting in a 5.2 percent reduction of body weight had no deleterious effects on maximum oxygen uptake. This was observed despite a reduction in plasma volume of up to 25 percent. The results were observed during sub-maximal and maximal work loads.

Therefore, the literature indicated that maximum oxygen uptake is not affected by thermal dehydration to any significant degree.

Summary

The related literature was organized into four major areas:

(1) General factors affecting performance

(2) Exercise heart rate

(3) Predicted work capacity

(4) Maximum oxygen uptake

Research indicates that thermal dehydration affects mean exercise heart rate and predicted work capacity while having no affect on maximum oxygen uptake. The ability of a trained, well-conditioned athlete to recover mean exercise heart rates and predicted work capacity within a five-hour period after thermal dehydration is not clearly defined. The need for investigation in this area seemed to be indicated.

CHAPTER III

METHODOLOGY

In preparation for this study, equipment and subjects were chosen to allow for optimum collection of data with minimal disruption of the subjects' normal routine. A Monark bicycle ergometer was used as the testing instrument. It offered the advantages of a lightweight, mobile and accurate assessment of work load to be assigned. The arms and chest remain relatively stable during exercise allowing good ECG tracings to be obtained. In addition, the mechanical efficiency is independent of body weight within the study limits (3, 13, 25). ECG tracings were obtained using a Lumiscribe Minigraph III Electrocardiograph. This model offered accuracy combined with reasonable cost and portability.

The topics to be considered in this chapter include the following:

Subjects

Equipment

Parameters Observed

Administration

Means of Analysis

Subjects

Approval of the use of human subjects for this investigation was granted by the Oregon State University Board for the Protection of Human Subjects (Appendix A).

Research has centered around the effects of procedures used by competitive wrestlers to compete in a specific weight class. In order to provide data relative to this practice, eleven collegiate wrestlers served as subjects for the study. The subjects were all competitive athletes from the same varsity wrestling team. All subjects had been involved in the same training program for three months prior to the onset of this investigation thereby minimizing cardiovascular differences due to conditioning techniques and practices. The subjects ranged from 62 kg to 92 kg in weight. This weight span included the ten collegiate weight classes. All subjects had achieved recognition as athletes at the high school and college level. Therefore, they represented a group of successful, motivated, experienced, competitive athletes. The mean age, height, and weight characteristics of each subject is presented in Table I. All subjects regularly reduced their weight in order to compete in a specific class and had done so on a regular basis for a minimum of four seasons. All eleven subjects completed a medical examination certifying fitness to participate in strenuous physical activity and a signed parental consent form. (Appendix B).

Equipment

Equipment utilized in this investigation included two basic instruments, the Monark bicycle ergometer and a Lumiscribe Minigraph III electrocardiograph. The Monark Bicycle ergometer was made available through the Department of Physical Education at Oregon State University. The electrocardiograph was provided by Microtronics of Portland, Oregon. During the initial test it was found that work loads of 720 KPM and 1080 KPM were sufficient to elevate the heart rate above 130 beats per minute and allow for accurate prediction of maximal oxygen uptake.

TABLE I. MEAN AND STANDARD DEVIATION OF AGE, WEIGHT, AND HEIGHT CHARACTERISTICS OF 11 SUBJECTS

	Age (yrs)	Height (cm)	Weight (kg)
Mean	19.95	172.09	71.27
SD	2.24	7.85	9.10

Physical Description of Testing Site

The Monark bicycle ergometer was located in a 20' by 20' room that offered a quiet testing area free of unauthorized traffic. The testing site was maintained at a temperature of 21 degrees Centigrade and with good air circulation. Leads from the electrocardiograph machine were secured to the bicycle frame to prevent hindering the subject. The electrocardiograph was located on the left side of the subject and slightly behind his shoulder on a low table. The metronome was located directly in front of the subject just above normal eye level. Chairs and a low foam pad to rest on between trials were available. The room itself is part of a complex frequented by the subjects. The room was selected so as to elicit full cooperation of the subjects with as little physical scheduling inconvenience to them as possible.

Parameters Observed

This study measured exercise heart rate, predicted maximum oxygen uptake and predicted physical work capacity. The parameters were measured during moderate stress (720 KPM) and severe stress (1080 KPM). The cardiovascular condition indicators were measured in four conditions: Normal (S_1); dehydrated (S_2); rehydrated with mineralized water (S_3); and rehydrated with glucose-electrolyte solution (S_4); (See Figure 1).

Administration

In order to familiarize the subjects with the testing procedure and equipment, three tests were administered forty-eight hours apart.

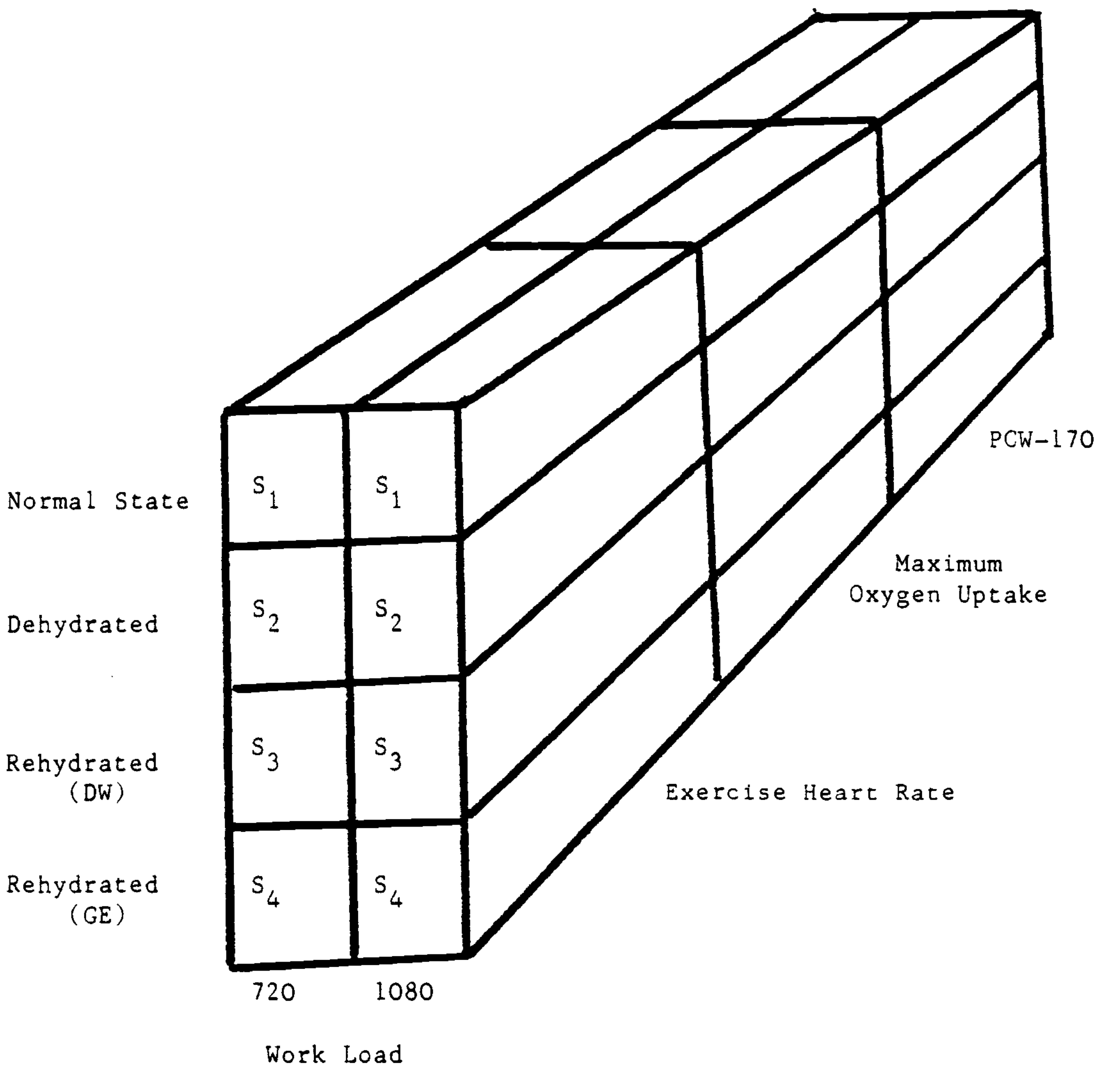

Figure 1. Study Model

This procedure also eliminated a learning factor that causes an improvement in PWC-170 values over the first three or four trials (38).

Data was collected from December 9, 1974 until March 17, 1975 and involved 11 subjects participating in 20 twelve-minute tests. Each subject reported for eight sessions with forty-eight to twenty-four hours between sessions. The time difference varied between sessions depending upon the stage of the experimental procedure. Each subject required thirteen days to complete the test with three of the eight sessions lasting five hours and thirty-six minutes. The other five sessions required one-half hour. In addition the subjects spent from five to eight hours over two twenty-four hour periods undergoing thermal dehydration. The schedule is presented in Figure 2.

Each subject was tested during the same time period. Every effort was made to maintain the same experimental conditions. The three preliminary sessions served to achieve total familiarity with the testing equipment and procedure for each subject. Each subject was given the following instructions prior to reporting for a session:

> "You have consented to participate in a study to determine the effects of thermal dehydration on your ability to compete. Please report to the testing site on ______ at six o'clock. Until that time participate in your normal daily activities but do not exercise strenuously. Dress in appropriate clothes for exercising."

Normal Condition (S_1)

Upon reporting the subject was weighed without clothes on a standard medical scale. After dressing the subject was allowed to warm up at a workload of 300 KPM for four minutes. Leads from the

Day 1 - Testing session 1, Preliminary bicycle ergometer 12 min. test.

(48 hours)

Day 3 - Testing session 2, Preliminary modified bicycle ergometer 12 min. test.

(48 hours)

Day 5 - Testing session 3, Preliminary modified bicycle ergometer 12 min. test.

(24 hours)

Day 7 - Testing session 4, Five modified bicycle ergometer 12 min. tests over 5 hours 36 min. Unrestricted access to water (S_1)

(48 hours)

Day 9 - Testing session 5, Modified bicycle ergometer 12 min. test (S_1)

(24 hours thermal dehydration)

Day 10 - Testing session 6, Five modified bicycle ergometer 12 min. tests over 5 hours 36 min. Voluntary rehydration on demineralized water. (S_2), (S_3)

(48 hours)

Day 12 - Testing session 7, Modified bicycle ergometer 12 min. test. (S_1)

(24 hours thermal dehydration)

Day 13 - Testing session 8, Five modified bicycle ergometer 12 min. tests over 5 hours 36 min. Voluntary rehydration on glucose-electrolyte solution. (S_2), (S_4)

Figure 2. Session Schedule

electrocardiogram were connected to the four extremeties and the chest.

The leads were secured in place to prevent shifting and distracting the subject. The metronome was set at fifty beats per minute with the ergometer at 2.5 kilograms producing a workload of 720 KPM. The subject pedaled the bicycle for six minutes at this load. Exercise heart rate was recorded during the sixth minute after a steady state had been reached (3). During the seventh minute the ergometer was increased to a setting of 3.5 kilograms producing a workload of 1080 KPM, the subject continued to ride for six additional minutes at this load. The exercise heart rate was recorded during the twelfth minute. The fourth trial was used as the starting point for the normal body state (S_1) in all subjects. The 12-minute modified bicycle ergometer test was repeated at the following intervals: one-half hour, one and one-half hours, three hours, and five hours. The subjects were allowed access to normal tap water during this period of time. The time schedule is presented in Figure 3.

Demineralized Water Procedure (S_3)

Forty-eight hours later the subject repeated the testing procedure to establish the start point for the demineralized water condition (S_3). The subject was given the same instruction with the following addition.

> "Through thermal dehydration you must lose 5% of your body weight over the next twenty-four hours. Participate in your normal daily activities, but you may not lose any weight by exercising . You may eat or drink anything you desire during this period as long as you achieve the 5% reduction. The sauna at _______________ is open to your use at any time."

At the conclusion of the twenty-four hours the subject was tested in the dehydrated condition (S_2) and then the procedure outlined for

Start: Normal Condition

2 min. weigh-in - 24 hrs. starts

6 min. test at 720 KPM plus 6 min. at 1080 KPM

Start: Dehydration Condition

2 min. weigh-in - end 24 hrs.

6 min. test at 720 KPM plus 6 min at 1080 KPM

Start 5 Hours: Rehydration Condition

28 min. rehydration

½ hour - 2 min. weigh-in

6 min. test at 720 KPM plus 6 min. at 1080 KPM

46 min. rehydration

1½ hour - 2 min. weigh in

6 min. test at 720 KPM plus 6 min. at 1080 KPM

76 min. rehydration

3 hour - 2 min. weigh-in

6 min. test at 720 KPM plus 6 min. at 1080 KPM

106 min. rehydration

5 hour - 2 min. weigh-in

6 min. test at 720 KPM plus 6 min. at 1080 KPM

Total time: 5 hours plus 36 minutes

Figure 3. Time Schedule

the normal condition (S_1) was repeated. He was allowed to voluntarily rehydrate on demineralized water between testing periods during the five-hour period. At the conclusion the subject was instructed to report again in forty-eight hours.

Glucose-Electrolyte Procedure (S_4)

The testing procedure for the glucose-electrolyte condition (S_4) was identical to the S_2 procedure with the following exception. The subject was allowed to voluntarily rehydrate on a solution consisting of sodium (22 mEq/l), chloride (17.2 m/Eq/l), potassium (2.6 mEq/l) phosphate (3.9 mEq/l), and glucose (10.6 g/100 ml) with an osmolality of 444 mOsm/l.

Means of Analysis

Exercise heart rate at 720 KPM and 1080 KPM was analyzed by linear regression to predict PWC-170 values in the normal condition (S_1); dehydrated condition (S_2); rehydrated with demineralized water (S_3); and rehydrated with glucose-electrolyte solution (S_4) at all test points.

Maximum oxygen uptake was calculated from heart rate, work load and pedal frequency using a standard pedal frequency.

Double classification ANOVA was used to compare heart rate at 720 KPM, heart rate at 1080 KPM and PWC-170 during conditions (S_1), (S_3), and (S_4). The analysis provided F values for all conditions, for time intervals and for subject difference.

The two-tailed *t*-test was used to test for significant difference in heart rate at 720 KPM, heart rate at 1080 KPM and PWC-170 during the four conditions, (S_1), (S_2), (S_3), and (S_4) using established F values.

Summary

Eleven collegiate wrestlers were examined in three series of tests. The subjects were competing wrestlers undergoing normal training procedures in their college wrestling program.

Three cardiovascular condition indicators were measured under four experimental conditions for each subject. The experimental conditions included the following: normal condition (S_1); dehydrated condition (S_2); rehydrated with demineralized water (S_3); and rehydrated with glucose-electrolyte solution (S_4). The selected cardiovascular condition indicators, exercise heart rate, maximum oxygen uptake and work capacity, were measured in all four conditions for each subject.

Heart rate was measured using an electrocardiogram under all experimental conditions. Predicted maximum oxygen uptake and predicted work capacity were measured using a modified Astrand-Sjostrand bicycle ergometer test. The test considered of two different work loads of 720 and 1080 KPM with six minutes at each level. A steady state exercise heart rate was taken in the sixth and twelfth minutes and used to predict maximum oxygen uptake.

Specific steps in the design of this study area:

Step 1. Establish a normal condition predicted work capacity for all subjects:

A. Four trials over a one-week period using the PWC-170 test.

B. All subjects were competing, trained athletes at the collegiate level.

Step 2. Establish values for exercise heart rate, maximum oxygen uptake and predicted work capacity in a normal condition.

Step 3. Achieve a 5% body weight loss over a 24-hour period through thermal dehydration.

Step 4. Establish values in the dehydrated condition for:

A. Exercise heart rate

B. Maximum oxygen uptake

C. Predicted work capacity

Step 5. Allow voluntary rehydration on demineralized water and measure all three study parameters at predetermined time intervals.

A. The subjects were tested at one-half hour, one and one-half hours, three hours, and five hours of rehydration.

Step 6. Steps two through five were repeated with a substitution of a glucose-electrolyte solution in step five. The solution consisted of sodium (22 mEq/l), chloride (17.2 mEq/l), potassium (2.6 mEq/l), phosphate (3.9 mEq/l), and glucose (10.6 g/100 ml) with an osmolality of 444 mOsm/l.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

In this study, exercise heart rate at 720 KPM and 1080 KPM, predicted work capacity 170 and maximum oxygen uptake were obtained from eleven wrestlers under three conditions. Exercise heart rate was measured using an electrocardiograph. Physical work capacity 170 was extrapolated from exercise heart rate at 720 KPM and 1080 KPM. Maximum oxygen uptake was calculated from exercise heart rate at a work load of 1080 KPM.

To facilitate a clear presentation, the chapter has been divided into six main parts:

Test reliability

Exercise heart rate at 720 KPM

Exercise heart rate at 1080 KPM

Predicted work capacity 170

Maximum oxygen uptake

Discussion of results

Analysis of Test Reliability

The reliability of criterion measure assessment procedures is critical to any experimental investigation. The criterion instruments used in this study have been proven reliable under similar conditions (3, 6, 8, 10, 20, 26, 28).

The Monark bicycle ergometer offered accurate prediction of the study parameters with mechanical efficiency independent of body weight

The Lumiscribe Minigraff III electrocardiograph had a maximum sensitivity of 20 mm/mv with the chart speed accurate within $\pm$ two percent at room temperature.

Methods of prediction used for PWC-170 and Max. VO_2 have been reported to be reliable and accurate procedures (3, 12, 13).

<u>Analysis of Exercise Heart Rate at 720 KPM</u>

Exercise heart rate during moderate stress (720 KPM) was measured under four conditions at six intervals after six minutes of a bicycle ergometer test.

Comparison of the mean exercise heart rate plus or minus one standard deviation during the six time separated intervals is illustrated in Figure 4. Subject exercise heart rate measured in the normal hydrated condition (S_1) illustrates a variance of plus 5.3 BPM at the start of each experimental condition. Thermal dehydration over a twenty-four hour period resulted in an average loss of 4.9% of the subject's body weight. Exercise heart rate in the dehydrated condition (S_2) exceeded one standard deviation of the normal condition (S_1).

Rehydration on a glucose-electrolyte solution (S_4) resulted in the mean heart rate rapidly dropping and becoming lower than the normal condition (S_1). Rehydration on demineralized water (S_3) initially resulted in a slow lowering of the mean heart rate followed by an increase. The mean heart rate, standard deviation and range for all conditions during the six time intervals are detailed in Table II.

Double classification ANOVA of exercise heart rate of 720 KPM was used to compare normal condition (S_1) to rehydrated DW (S_3) and

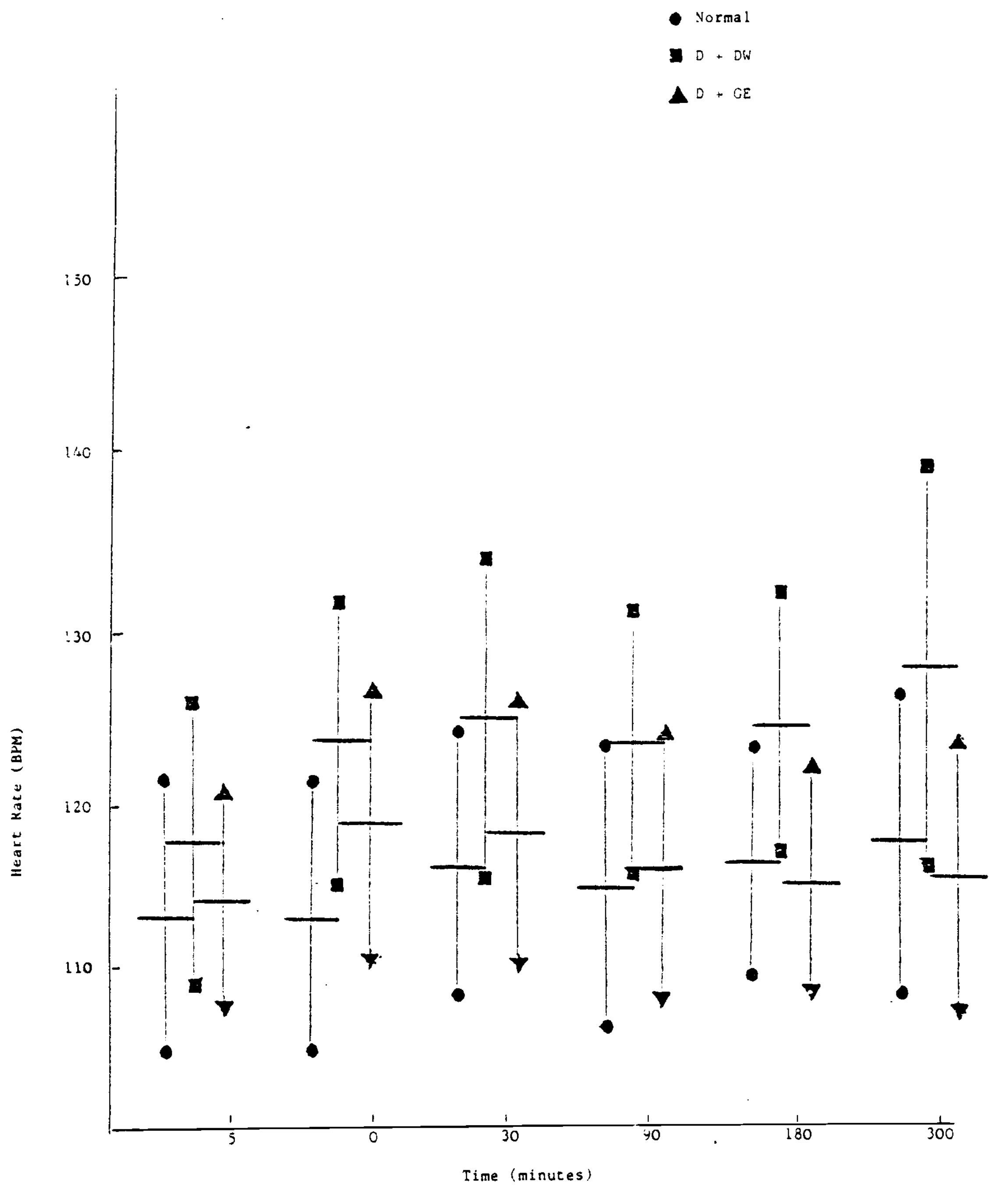

Figure 4. Mean Heart Rate after 6 Minutes of Work on Bicycle Ergometer at 720 KPM at Six Time Separated Intervals. The Bar Represents the mean and Legend Represents One Standard Deviation ±

TABLE II. MEAN HEART RATE, STANDARD DEVIATION AND RANGE FOR FOUR CONDITIONS AT 720 KPM

		Mean BPM	Standard Deviation BPM	Range BPM
Normal	(S_1)	118.3	9.4	32.0
Normal	(S_1)	118.3	9.4	32.0
N_{30}	(S_1)	121.9	8.7	27.0
N_{90}	(S_1)	120.2	9.7	28.0
N_{180}	(S_1)	122.0	7.7	29.0
N_{300}	(S_1)	123.6	10.3	33.0
Normal	(S_1)	123.6	9.7	29.0
Dehydrated	(S_2)	130.2	9.7	29.0
DW_{30}	(S_3)	132.0	10.6	37.0
DW_{90}	(S_3)	130.5	8.9	31.0
DW_{180}	(S_3)	131.5	9.1	29.0
DW_{300}	(S_3)	135.5	13.7	49.0
Normal	(S_1)	119.4	7.5	29.0
Dehydration	(S_2)	124.6	9.5	29.0
GE_{30}	(S_4)	124.0	9.1	37.0
GE_{90}	(S_4)	121.7	9.3	38.0
GE_{190}	(S_4)	120.7	7.7	28.0
GE_{300}	(S_4)	121.1	9.3	37.0

rehydrated GE (S_4). Table III shows the values obtained. The .05 probability level was used in all cases to determine significant differences. In comparing mean heart rate a significant difference was found among the three conditions.

Comparison of the six time intervals also provided a significant difference. Of particular interest to this study was the existence of significant difference between the normal hydrated condition (time 300), and dehydrated condition (time 0) and the rehydrated condition (time 300).

A significant interaction between subjects and condition X subject also resulted. Under moderate stress, the subject responded to the treatments with a significant difference.

Under a moderate stress of 720 KPM no significant interaction was observed between condition X time, time X subject, or condition X time X subject. The lack of significance when comparing the latter two is important to the validity of the study. The lack of interaction indicates subjects were consistent under the conditions of the study.

Of critical interest to the study is the ability of competing college wrestlers, who dehydrate, to recover from the effects of dehydration if thermal dehydration did affect the selected parameters. Provided the parameters were affected, a secondary concern was the effect of a glucose-electrolyte solution on the rate of recovery in five hours. Therefore a two-tailed t-test was selected to compare normal condition (S_1), rehydrated DW (S_3), and rehydrated GE (S_4) after 300 minutes under three treatments.

Significant difference was found between normal condition (S_1) and rehydrated DW (S_3) ($t=2.30$). A significant difference was also observed

TABLE III. ANOVA OF HEART RATE FOR THREE CONDITIONS (S_1, S_3, S_4) OF WORK AT 720 KPM

Source	DF	SS	MS	F
Condition	2	3787.40	1893.70	68.55[a]
Time	5	787.86	157.57	5.70[a]
Subject	10	9156.61	915.66	33.15[a]
Consition X Time	10	517.20	51.72	1.87
Condition X Subject	20	2547.15	127.36	4.61[a]
Time X Subject	50	1784.36	35.69	1.29
Condition X Time X Subject	100	2762.24	27.62	1.00

[a] $P \leq .05$

to be true between rehydrated DW (S_3) and rehydrated GE (S_4), (t-2.88). However no significant difference in mean heart rate was found between normal condition (S_1) and rehydrated GE (S_4) after 300 minutes at the moderate stress exercise. The _t_-test values are presented in Table IV.

Analysis of Exercise Heart Rate at 1080 KPM

Exercise heart rate during a severe stress (1080 KPM) was measured under four conditions at six intervals during the sixth minute of a bicycle ergometer test.

The mean exercise heart rate plus or minus one standard deviation during the six time separated intervals is presented graphically in Figure 5. Exercise heart rate measured in the normal hydrated condition (S_1) had a variance of 4.7 BPM at the start of each experimental condition. Thermal dehydration resulted in an average loss of 4.9 percent weight.

Mean heart rate in the dehydrated condition (S_2) was sharply elevated above the normal rate. Subjects rehydrating on the glucose-electrolyte condition recovered rapidly with a final mean heart rate below that of the normal condition.

Mean heart rate for dehydration on demineralized water recovered slowly to within one standard deviation of the normal condition. The mean heart rate then increased slightly over the last 210 minutes of rehydration.

The standard deviation and range for mean heart rate under severe stress (1080 KPM) is greater than the values found with moderate stress (720 KPM). Values for all conditions and times are found in Table V.

TABLE IV. t-RATIO BETWEEN THREE CONDITION HEART RATES AT 720 KPM AFTER 300 MINUTES

Condition	N_{300} (S_1)	DW_{300} (S_3)	GE_{300} (S_4)
N_{300} (S_1)		2.30[a]	0.59
DW_{300} (S_3)			2.88[a]
GE_{300} (S_4)			

[a] $P \leq .05$

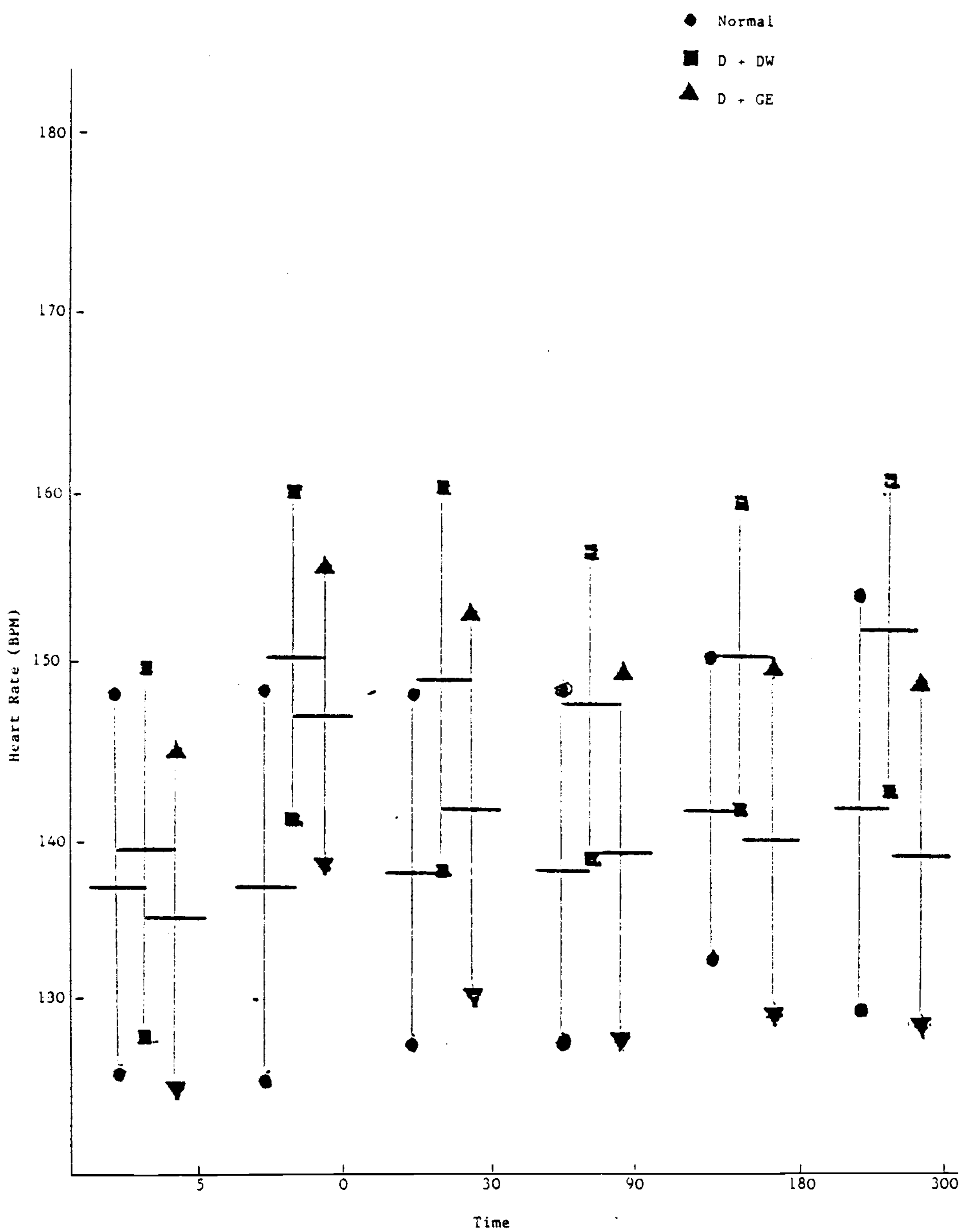

Figure 5. Mean Heart Rate after 6 minutes of Work on Bicycle Ergometer at 1080 KPM at Six Time Separated Intervals. The Bar Represents the mean and Legend Represents One Standard Deviation ±

TABLE V. MEAN HEART RATE, STANDARD DEVIATION AND RANGE FOR FOUR CONDITIONS AT 720 KPM

		Mean BPM	Standard Deviation BPM	Range BPM
Normal	(S_1)	149.8	12.6	39.0
Normal	(S_1)	149.8	12.6	39.0
N_{30}	(S_1)	150.7	11.9	38.0
N_{90}	(S_1	151.0	11.9	35.0
N_{180}	(S_1)	155.1	10.2	39.0
N_{300}	(S_1)	155.2	13.5	46.0
Normal	(S_1)	152.2	12.4	35.0
Dehydrated	(S_2)	165.4	11.0	35.0
DW_{30}	(S_2)	163.8	12.6	37.0
DW_{90}	(S_2)	162.1	10.2	32.0
DW_{180}	(S_3)	165.4	10.3	28.0
DW_{300}	(S_3)	167.1	9.0	30.0
Normal	(S_1)	147.5	11.4	34.0
Dehydrated	(S_2)	161.6	9.9	29.0
GE_{30}	(S_4)	155.3	13.0	41.0
GE_{90}	(S_4)	152.0	12.3	46.0
GE_{180}	(S_4)	152.8	11.6	38.0
GE_{300}	(S_4)	152.0	11.5	45.0

The results of the two by three ANOVA of heart rate for severe stress (1080 KPM) are presented in Table VI.

A significant difference in mean heart rate between subjects and condition X subject was obtained. This represented the same pattern experienced under moderate stress (720 KPM).

Time X subject interaction and condition X time X subject interaction again demonstrated the same pattern of significant difference.

However a significant difference was observed between conditions, time and condition X time interaction. Condition and time also showed a significant difference during moderate stress (720 KPM). Under severe stress a significant difference existed for condition X time. Different rates of recovery existed under severe stress (1080 KPM) between the three conditions (S_1), (S_2), and (S_4) during selected time intervals. This was not observed during moderate stress (720 KPM).

A two-tailed t-test was used to compare the results after 300 minutes of rehydration under two conditions (S_2), (S_4) to the normal condition (S_1) after 300 minutes. Results indicated a significant difference between condition (S_1) and condition (S_3). A significant difference also prevailed between rehydration DW (S_2) and rehydration GE (S_4). However this was not true between normal condition (S_1) and rehydrated GE (S_4). These results are presented in Table VII.

Analysis of Predicted Work Capacity 170

Using exercise heart rate during moderate stress (720 KPM) and severe stress (1080 KPM), PWC 170 was predicted by multiple linear regression for conditions (S_1), (S_3), and (S_4) at six time separated intervals.

TABLE VI. ANOVA OF HEART RATE FOR THREE CONDITIONS (S_1, S_3, S_4) OF WORK AT 1080 KPM

Source	DF	SS	MS	F
Condition	2	4415.52	2207.76	93.21[a]
Time	5	1829.48	365.90	15.45[a]
Subject	10	18423.42	1842.39	77.78[a]
Condition X Time	10	1326.29	132.63	5.60[a]
Condition X Subject	20	2316.14	115.81	4.89[a]
Time X Subject	50	1194.69	23.89	1.01
Condition X Time X Subject	100	2368.71	23.69	1.00

[a] $P \leq .05$

TABLE VII. t-RATIO BETWEEN THREE CONDITION HEART RATES AT 1080 KPM AFTER 300 MINUTES

Condition	N_{300} (S_1)	DW_{300} (S_3)	GE_{300} (S_4)
N_{300} (S_1)		2.43[a]	0.59
DW_{300} (S_3)			3.42[a]
GE_{300} (S_4)			

[a] $P \leq .05$

The PWC-170 exhibited a variance of 90 KPM at the start of condition (S_1), (S_3), and (S_4). Twenty-four hour thermal dehydration caused a drop of approximately one standard deviation from the mean of condition (S_1) for the mean PWC-170 value of condition (S_3) and condition (S_4).

Rehydration on demineralized water (S_3) over the next 300 minutes caused a slow rise in PWC-170 value for the first 90 minutes followed by a slight drop in values over the next 210 minutes. This follows the pattern established by exercise heart rate under moderate (720 KPM) and severe stress (1080 KPM).

Rehydration on a glucose-electrolyte solution (condition (S_4) caused a recovery of PWC-170 values, within 90 minutes, to within 5.9 KPM of condition (S_1) values. Over the last 210 minutes PWC-170 value under condition (S_4) exceeded that of condition (S_1) by 33.4 KPM. It should be noted that condition (S_1) values decreased by 50 KPM over this period of time. These results are presented graphically in Figure 6. Table VIII presents mean, standard deviation and range of PWC-170 values for all conditions.

Table IX presents the results of double classification two by three ANOVA for three conditions (S_1), (S_3), and (S_4) of work. No significant difference was observed in interaction of time X subject or interaction of condition X time X subject as presented in Table IX.

A significant difference existed between conditions, times, and interaction of condition X time. All combine to point towards a significant difference in the recovery rate of subjects under the experimental design from the effect of dehydration as indicated in Table X.

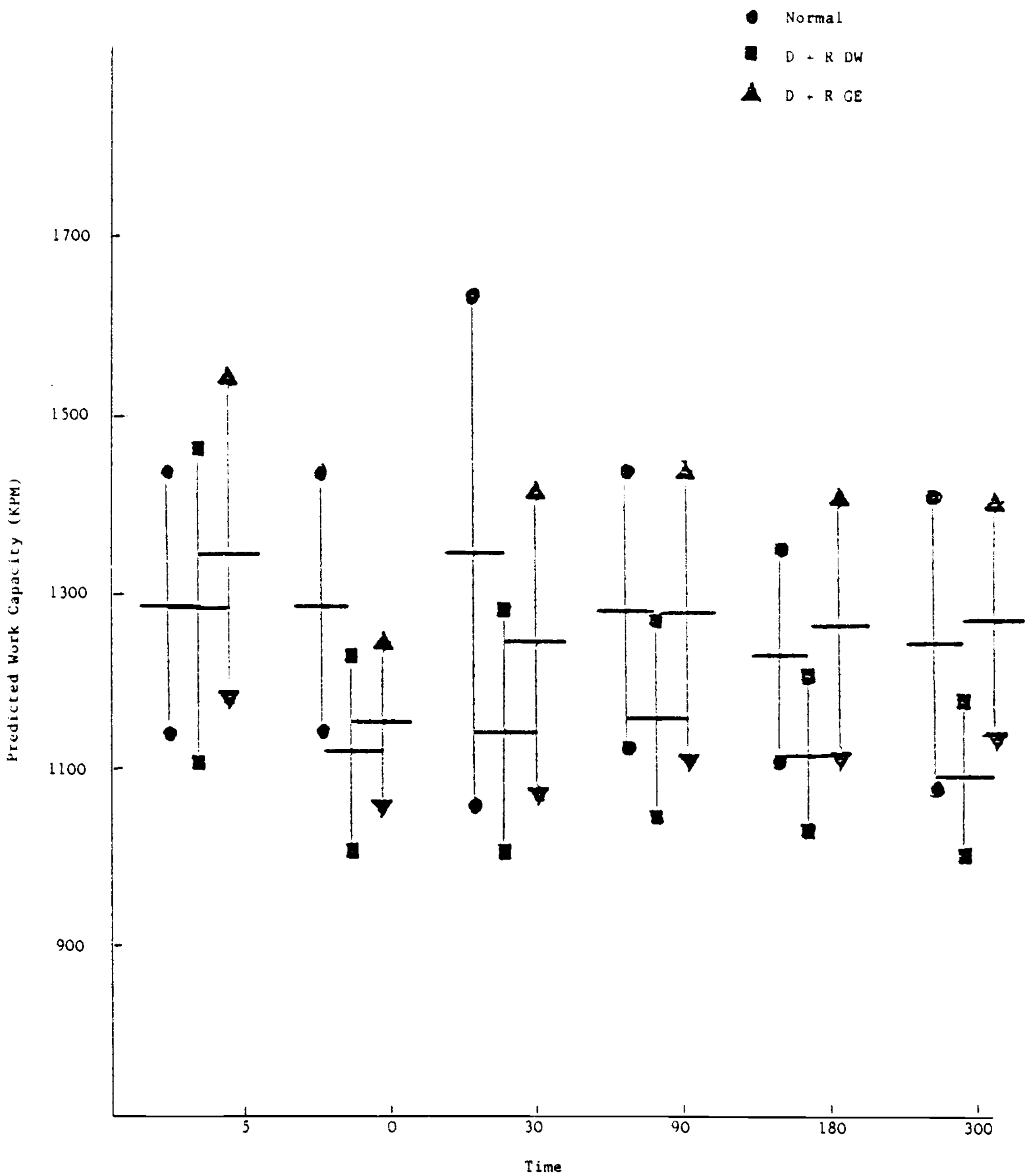

Figure 6. Predicted work capacity at a Heart Rate of 170 (BPM) at Six Time Separated Intervals. The Bar Represents the mean and the Legend Represents One Standard Deviation ±

TABLE VIII MEAN STANDARD DEVIATION AND RANGE OF PREDICTED WORK CAPACITY 170 FOR FOUR CONDITIONS

		Mean KPM/min	Standard Deviation KPM/min	Range KPM/min
Normal	(S_1)	1332.8	184.2	588.4
Normal	(S_1)	1332.8	184.2	588.4
Normal	N_{30} (S_1)	1402.2	335.0	1243.6
	N_{90} (S_1)	1323.9	179.8	555.1
	N_{180} (S_1)	1258.8	140.2	516.9
	N_{300} (S_1)	1273.9	196.0	637.3
Normal	(S_1)	1331.5	206.7	700.0
Dehydrated	(S_2)	1137.4	123.2	375.3
	DW_{30} (S_3)	1164.8	156.5	452.1
	DW_{90} (S_3)	1179.3	129.9	415.5
	DW_{180} (S_3)	1134.8	107.6	291.2
	DW_{300} (S_3)	1099.0	107.9	364.4
Normal	(S_1)	1422.5	210.6	533.9
Dehydrated	(S_2)	1176.9	106.7	307.2
	GE_{30} (S_4)	1283.7	195.5	567.7
	GE_{90} (S_4)	1318.0	191.8	703.3
	GE_{180} (S_4)	1301.7	165.0	517.5
	GE_{300} (S_4)	1307.3	155.1	570.0

TABLE IX. ANOVA OF PREDICTED WORK CAPACITY 170 FOR THREE CONDITIONS (S_1, S_3, S_4) OF WORK

Source	DF	SS	MS	F
Condition	2	833242.90	416621.45	55.70[a]
Time	5	490018.40	98003.68	13.10[a]
Subject	10	3763054.11	376305.41	50.31[a]
Condition X Time	10	357178.65	35717.86	4.78[a]
Condition X Subject	20	907121.00	35356.05	4.73[a]
Time X Subject	50	518641.48	10372.83	1.39
Condition X Time X Subject	100	748006.98	7480.07	1.00

[a] $P \leq .05$

TABLE X. t-RATIO BETWEEN THREE CONDITION PREDICTED WORK CAPACITY 170 AFTER 300 MINUTES

Condition	N_{300} (S_1)	DW_{300} (S_3)	GE_{300} (S_4)
N_{300} (S_1)		2.57[a]	-0.44
DW_{300} (S_3)			-3.64[a]
GE_{300} (S_4)			

[a] $P \leq .05$

As indicated in Table X, a two-tailed t-test to analyze results after 300 minutes of rehydration showed significant difference between rehydrated DW (S_3), normal condition (S_1) and rehydrated GE (S_4). However no significant difference existed between normal condition (S_1) and rehydrated GE (S_4). This pattern is identical to that established by exercise heart rate at work loads of 720 KPM and 1080 KPM.

Analysis of Maximum Oxygen Uptake

Maximum oxygen is presented in Figure 7. The pattern suggests that no significant difference existed. This is supported by the literature.

Discussion of Results

Mean exercise heart rate during moderate stress (720 KPM) and severe stress (1080 KPM) will be discussed together. By comparing Figure 4 to Figure 5 little variance is to be observed. The pattern created by graphing MHR versus time during three conditions results in similar responses at both work loads.

In the normal state no significant difference is observed. The reliability of the criterion instrument for measuring these parameters under normal condition is well established (3, 11, 12, 13, 23, 25).

Dehydration produced a significant difference between normal condition (S_1) and rehydrated DW (S_3), rehydrated GE (S_4) before rehydration. Research by Saltin (19), Myhre (16), Costill (8), Herbert (10) and Ribsil (18) all indicate that thermal dehydration results in an elevated heart rate. However Bock (6) and Buskirk (7) reported no

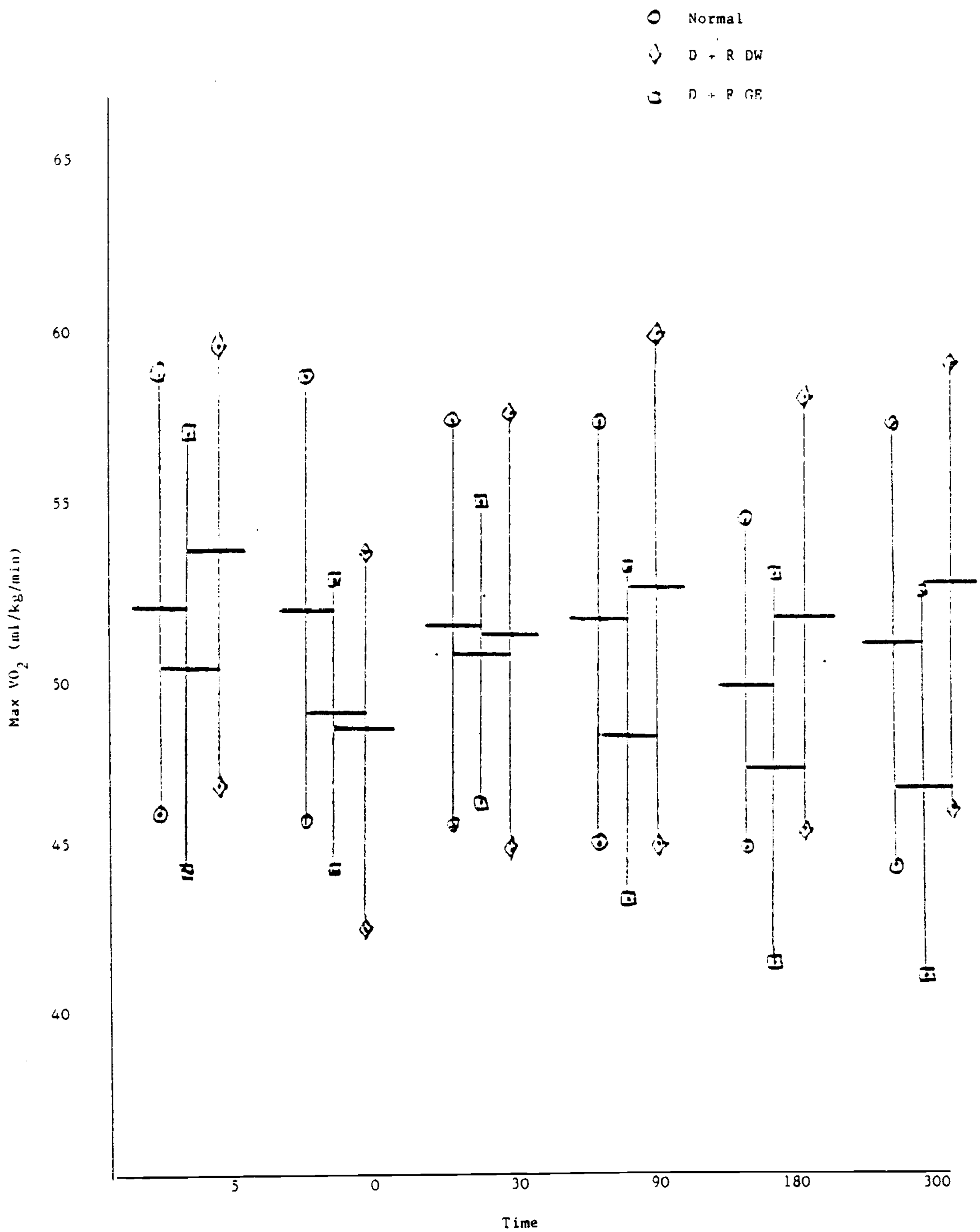

Figure 7. Maximum Oxygen Uptake at 1080 KPM at Six Time Separated Intervals. The Bar Represents the mean and Legend Represents One Standard Deviation ±

significant difference. Thermal dehydration can cause a loss of plasma blood volume of up to twenty-five percent during a four to six percent weight loss (3, 16, 21). In order to maintain cardiac output and stroke volume a significant elevation in heart rate occurs. Saltin (21) has reported no significant reduction in stroke volume or cardiac output in the dehydrated state thus heart rate must increase.

Rehydration under rehydrated DW (S_3), and rehydrated GE (S_4) when compared to the normal condition (S_1) resulted in the heart rate following the same pattern under both work loads. After 30 minutes heart rate of rehydrated DW (S_3) was one standard deviation above normal condition (S_1). Heart rate of rehydrated GE (S_4) was within two to five BPM of normal condition (S_1). At 90 minutes rehydrated DW (S_3) heart rate was still elevated one standard deviation while only one to one-and-a-half beats difference existed between normal condition (S_1) and rehydrated GE (S_4). Heart rate at 180 minutes showed a difference of one standard deviation between rehydrated DW (S_3) and normal condition (S_1). While rehydrated GE (S_4) heart rate had actually dropped lower by one to three BPM when compared to normal condition (S_1) heart rate. Three hundred minutes of rehydration indicated the same heart rate existed. Rehydrated DW (S_3) heart rate was still elevated one standard deviation while rehydrated GE (S_4) heart rate is within two BPM of normal condition (S_1) although still lower.

These results agree with those reported by Bock (6), Costill (8), Herbert (10), and Ribsil (18) with one important difference. Rehydration on a glucose-electrolyte solution (S_4) resulted in a return to normal values of exercise heart rate after 300 minutes. While normal exercise heart rate (S_1) increased in mean heart rate, Bock (6), Costill (8), and Herbert (10) did not indicate the recovery of exercise heart rate. While Ribsil (18) did report exercise HR recovered, he did not account for the learning factor inherent in the bicycle ergometer.

Predicted work capacity 170 followed the same pattern as exercise heart rate. Research by Herbert (10), Ribsil (18), and Saltin (19) indicated a drop in PWC 170 under thermal or exercise dehydration conditions. Rehydration on the glucose-electrolyte solution (S_4) resulted in a return to normal of PWC-170 values. The work loads used in this study differed from previously reported studies. The highest reported work load used was 900 KPM (5, 16). Table XI summarizes the significant difference found when comparing condition HR 720, HR 1080, and PWC-170.

No significant difference was found in maximum oxygen uptake under the three conditions. This result agrees with research done by Bock (6), Buskirk (7), Saltin (19), and Saltin (20). Maximum oxygen uptake is dependent upon cardiac output and stroke volume. Dehydration causes an increase in exercise heart rate due to the reduction in plasma volume but does not reduce the heart's ability to supply blood to the working muscles or modify tissue demand for oxygen.

TABLE XI. SUMMARY TABLE OF SUBJECT X TRIALS ANOVA

Variable	F
HR 720	68.55[a]
HR 1080	93.21[a]
PWC-170	55.70[a]

[a] $P \leq .05$

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Problem. The purpose of this study was to investigate the effects of thermal dehydration on selected cardiovascular indicators. The design of the investigation allowed for (1) confirmation or rejection of previous results in related studies; (2) conclusions to be drawn on recovery time; and (3) whether a glucose-electrolyte solution is favorable liquid for rehydration.

Experimental Equipment. The experimental equipment consisted of a Monark bicycle ergometer, Lumiscribe minigraphy III electrocardiograph, metronome and rehydrating solutions.

Experimental Procedures. Eleven male subjects took part in this study. All were competing trained athletes from the Umpqua Community College wrestling team.

All subjects participated in eight laboratory sessions. The first three sessions were devoted to equipment orientation and practice to establish accurate beginning values. These sessions consisted of one modified Astrand-Sjostrand bicycle ergometer test. The tests took twelve minutes and were conducted forty-eight hours apart. Testing sessions four, six, and eight lasted five hours and thirty-six minutes wiht five modified bicycle ergometer tests conducted. Sessions five and seven consisted of one modified bicycle ergometer test. Twenty-four hours lapsed between sessions three, five, seven and sessions four, six, and eight. Forty-eight hours lapsed between sessions four, five, six and seven. During sessions, four, six, and eight subjects were allowed to maintain body weight or rehydrate on normal water, demineralized water or a glucose-electrolyte solution. The selected cardiovascular indicators were measured or predicted during all sessions.

Analysis of the Data. The analysis of the data was divided into three main parts.

1. Testing for significant difference in mean heart rate at 720 KPM, mean heart rate at 1080 KPM, PWC-170 and maximum oxygen uptake during all four body conditions.

2. Comparison of mean heart rate at 720 KPM, mean heart rate at 1080 KPM and PWC-170 during three body conditions.

3. Discussion of results. The indicators analyzed were mean heart rates at 720 KPM and 1080 KPM, predicted work capacity (170 bpm) and maximum oxygen uptake. A two-tailed *t*-test and two by three ANOVA were used to analyze the data.

Prior to experimentation, a significant level of .05 for rejection of the null hypothesis was chosen.

Conclusions

Within the limits of this study, the following conclusions seem justified.

1. A significant difference ($P \leq .05$) was found to exist between exercise heart rate during rehydration DW (S_3), normal

condition (S_1) and rehydrated GE (S_4), therefore Hypotheses One was not accepted.

2. A significant difference ($P \leq .05$) existed among the three rehydration procedures when predicted work capacity (170 BPM) was monitored, therefore Hypotheses Two was not accepted.

3. Maximum oxygen uptake is not significantly affected by thermal dehydration exceeding 4 percent of body weight in twenty-four hours, therefore Hypotheses Three could not be rejected.

4. Rehydration on a glucose-electrolyte solution permits the significantly affected cardiovascular indicators to return to normal values within a five-hour period, but not within one-half hour to one hour. However, a fatigue factor may be present that could alter this result.

Recommendations for Further Research

During the course of this study, possibilities for further related studies were suggested. The following may merit further considerations:

1. Conduct the same experiment with elimination of intermediate tests during the five-hour rehydration period to minimize the fatigue factor.

2. Rehydration on a glucose solution and an electrolyte solution to determine which is more beneficial to the dehydrated subject.

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APPENDICES

APPENDIX A

OREGON STATE UNIVERSITY

Committee for Protection of Human Subjects

Chairman's Summary of Review

Title: Dehydration and Rehydration In Collegiate Wrestlers

Program Director: Donald E. Campbell

Recommendation:

X Approval

___ Provisional Approval

___ Disapproval

___ No Action

Remarks: This revision of the original proposal takes care of the objections raised in the earlier review.

Date: July 9, 1975 Signature: ___

If the recommendation of the committee is for provisional approval or disapproval, the program director should resubmit the application with the necessary corrections within one month.

APPENDIX B

Dear Parent & Son:

I am a graduate student at Oregon State University. As a wrestling coach and former athlete I am concerned with the effects dehydration has on an athlete's ability to perform. At the present time, I am conducting research into the effect dehydration has on selected cardiovascualr condition indicators.

The study would include the following procedures:

1. The subject's voluntary thermal dehydration of 5% of his normal body weight over a 24 hour period.

2. The subject participating in five 12-minute tests over a five-hour period on a Bicycle Ergometer as he undergoes voluntary rehydration. The test will allow prediction of his maximum oxygen uptake and predicted work capacity.

3. The subject will undergo voluntary dehydration twice to allow rehydration on two different solutions--demineralized water and a glucose-electrolyte solution of sodium (22 mEq/l), chloride (17.2 mEq/l), potassium (2.6 mEq/l), phosphate (3.9 m/Eq/l), and glucose (10.6 g/100 ml) with an osmolality of 444 mOsm/l.

The subject may experience the sensation of thirst but will be allowed to eat regularly and/or drink minimal amounts during the 24-hour thermal dehydration period. All that is required is a 5% weight loss over the 24-hour period.

It is hoped that the study will help determine whether or not the practice of dehydration by wrestlers of all age groups, in order to compete in a lower weight class, is detrimental to their performance.

I will be happy to answer any questions concerning this study. Please feel free to contact me at 672-5571 during the day or 672-5142 during the evening.

The subject's commitment to participate in this study is appreciated, but the commitment is not binding. The subject is free to withdraw and discontinue his participation at any time.

Thank you for your help in this study.

Sincerely

Robert S. Tomasovic

Consent to Participate

I consent to participate as a subject in the research study conducted by Robert Tomasovic concerned with the effects of thermal dehydration has on selected cardiovascular indicators.

Parent signature ____________________ Date ____________

Subject's Signature ____________________ Telephone Number ____________