Effects of Prehydration With Selected Liquids Upon Exercise in a Hot and Humid Environment.

William Irvin Dickens II
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EFFECTS OF PREHYDRATION WITH SELECTED LIQUIDS UPON EXERCISE IN A HOT AND HUMID ENVIRONMENT.

THE LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COL., ED.D., 1978

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EFFECTS OF PREHYDRATION WITH SELECTED
LIQUIDS UPON EXERCISE IN A HOT
AND HUMID ENVIRONMENT

A dissertation
Submitted to the Graduate Faculty of the
Louisiana State University and
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in partial fulfillment of the
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in
The Department of Health, Physical, and Recreation Education

by
William Irvin Dickens, II
B.S., East Carolina College, 1967
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The purpose of this investigation was to study the effects of prehydration with selected liquids prior to exercise in a hot and humid environment. The primary purpose was to determine if the prehydration with Quickick, water, or milk yielded a significantly different exercise time before reaching criterion heart rate during a two-bout exercise period. Two secondary purposes were to study recovery heart rates and weight losses.

Sixteen male volunteers from the Varsity Football Team at Louisiana State University were tested. Each subject served as his own control since the order of testing was counterbalanced to negate the effects of test sequence or practice. The work period was a two-stage bout of exercise on a bicycle ergometer with the subject pedalling at a workload of 720 kpm/minute. The hot and humid environment was established by using a sauna bath and hospital vaporizer which kept the environment at 90° F. and 85 percent relative humidity.

Prior to the testing, the subject was weighed and drank a volume of liquid equal to one ounce per twenty pounds of body weight. He then rested for a period of ten minutes to allow for partial digestion of the liquid as well as to achieve a resting heart rate.
The subject then entered the sauna and exercised under a trainer's supervision until reaching a criterion heart rate of 170 beats per minute. The subject exited the sauna for a rest period of ten minutes, during which time another volume of liquid equal to the first was consumed, and the subject rested while his heart rate was monitored at the end of each minute.

At the end of the rest period the subject re-entered the sauna for the second bout of exercise to the heart rate of 170 beats per minute. Upon reaching the end of the workout period, the subject exited the sauna for a fifteen-minute recovery period while his heart rate was again monitored at the end of each minute. After the recovery period the subject was weighed and was excused.

A three-way analysis of variance was used. The main factors were subject, treatment, and testing order. The time of exercise to criterion heart rate for water, milk, Quickick, and control were compared for the two work bouts. The final mean heart rates at both the rest and recovery periods were compared. In addition the weight losses for the groups were compared.

Significant F-ratios were tested for location of significance using Duncan's New Multiple Range Test. Graphs depicting mean heart rates for each experimental condition were plotted at the end of each minute during both the rest and recovery periods.
Findings

The findings in this study were as follows:

1. Prehydration with the three liquids produced significantly longer exercise times in Bout 1 than no prehydration.

2. Prehydration produced significantly longer exercise times in Exercise Bout 1 in the following descending order: (a) Quickick, (b) water, and (c) milk.

3. Quickick and water prehydration produced significantly longer exercise times during Exercise Bout 2 than the milk or control conditions.

4. There were no significant differences between Quickick and water or between milk and control conditions in Exercise Bout 2.

5. There were no significant differences among conditions with regard to heart rates at the end of the rest period between Exercise Bouts 1 and 2.

6. There were no significant differences among conditions with regard to heart rates at the end of the recovery period.

7. There were no significant differences in weight loss as a result of the experimental conditions.

8. Prehydration with milk elicited no complaints from the subjects involving dryness of the mucous membranes of the mouth, gas in the stomach, nausea, or discomfort.
CHAPTER 1

INTRODUCTION

Man is a very competitive animal. The need for survival has brought this about during his battles with environment, animals, and other groups of mankind. Success has been due to man's intellectual, psychological, and physical preparations made for these battles. This necessary competition in life has carried itself over to modern man's preparations for battle of another kind, that of competitive sport. Persons compete in a multitude of different activities which calls for tests of their physical abilities against those of other individuals, other teams, or their own previous performances.

In most athletic skills little differences exist between many athletes in their performances of short duration. Several hundred sprinters in the world can run the 100-yard dash in 9.5 seconds; many swimmers can swim 25 yards in 10 seconds; and many offensive linemen can perform at their maximum strength and speed for several consecutive plays. Contests of longer duration present the problem of endurance, or performing at or near maximum exertion for a long period of time.
The intensity of competitive sports often separates the winner from the loser by a very small margin. In an effort to widen this margin, recent experimentation has produced an increased use of substances which are theorized to aid man in his physical performance. Some of these purported aids are caffeine, pure oxygen, vitamins, dextrose, fructose, glucose, sodium chloride, gelatin, anabolic steroids, alcohol, hormones, fruit juices, wheat germ oil, and various stimulant drugs such as cocaine and benzedrine. Karpovich and Sinning state:

Few of the substances just discussed have an ergogenic action. The most powerful are hormones, caffeine, and cocaine. With the exception of caffeine, when consumed in moderation in tea and coffee, these substances are dangerous and their use should not be encouraged. . . .

Many substances are helpful only when they are used to replenish a previous lack, or as a precaution for a possible depletion during work. To this group belong sugar, sodium chloride, and vitamins.1

Athletes, trainers, and coaches have used all of the previously listed substances along with many more. The latest research has shown that some of the most critical substances depleted during exercise are the body fluids and electrolytes lost during profuse sweating, especially if the work is done in high temperature and relative humidity. The implications are that water and electrolytes losses in sweat severely hamper man's capacity

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for exhaustive work.\textsuperscript{2} Losing water and electrolytes deprives the body of vital elements which are important in two ways: (1) water aids in controlling thermal equilibrium, and (2) electrolytes conduct electric current. The necessity of the body to maintain the dynamic equilibrium of water and electrolytes is to minimize distortions in temperature and in the volume, composition, and distribution of body fluids.\textsuperscript{3}

The normal intake of water is regulated by the sensation of thirst. The early works of Adolph and Dill\textsuperscript{4} have shown that during prolonged exhaustive work in the heat man's thirst is not an adequate guide to the body needs for water and that man will ingest only one-half to two-thirds the amount of water that he is losing through the skin, respiration, and the kidneys. This "voluntary dehydration" combined with the effects of heat stress have produced heat exhaustion, heat stroke, and death.\textsuperscript{5}


\textsuperscript{3}Dr. Martin J. Broussard, Supervisor of Athletic Training at Louisiana State University, personal interview, November 25, 1974.


Many coaches, trainers, and athletes have been conditioned to the belief that drinking water before or during practice and competition is injurious to performance. Little, Strayhorn, and Miller stated in 1949:

It has been assumed that the ingestion of large amounts of water unfavorably influences the capacity for work in one or more of the following ways: (1) interference with the movement of the diaphragm as a result of increased intra-abdominal pressure, (2) decreased inclination for exertion due to the subjective impression of distention, and (3) heat cramp due to failure to replace salt when a large volume of water is ingested after copious sweating.6

Contrary to the introductory statement, the study showed that the ingestion of one to one-and-a-half liters of water three or four minutes before exhaustive exercise had no adverse effect on performance.

The fact has been exhibited many times that coaches and authorities are slow to accept into practice the findings of research. Breshnahan, Tuttle, and Cretzmeyer were typical of numerous track and field authors during the mid-1950s:

Some coaches and trainers tend to withhold water from competitors for a considerable time before competition. It is agreed that the drinking of water immediately before a contest might prove troublesome.

However, ample water can safely be allowed up to an hour before competition time.\(^7\)

In addition to water, salt and other electrolytes must be ingested to replace losses by sweating. Initially, salt replacement was accomplished by increasing the use of salt at meals. The use of salt tablets and salt water have led to the introduction several years ago of a group of thirst-quenching, salinized drinks. These have been marketed nationally under the brand names of Quickick, Gatorade, Take Five, Half-time Punch, Brake Time, and others.

Prior to development it was theorized that the electrolyte solutes in the water base would diffuse across the various membranes throughout the body when needed to replace those substances lost during sweating. Robinson stated:

> Water diffuses freely in either direction through capillary walls and cell membranes and thus serves as a solvent for both extracellular and intracellular solutes. On the other hand not all the solutes diffuse freely through the cell membrane. . . .\(^8\)

Three of the electrolytes do not diffuse freely across the cell membranes: sodium and chloride which are concentrated in the interstitial fluid and potassium which is concentrated in the cell. Robinson further stated:


Since water diffuses freely in either direction and these solutes are actively restrained from traversing the cell membrane, if the concentration of water on either side of the membrane is disturbed, water will move in the direction required to establish osmotic equilibrium.9

Of the popular electrolyte drinks mentioned, only Quickick has been chemically proven to be a true isotonic liquid.10 This indicates that the solutes as well as the water will be diffused through the cell membrane to replace those electrolytes lost in sweat.

Not only has the practice of drinking water before competition been questioned, but also milk has been criticized for merely being part of the athlete's diet.

The inclusion of milk in the diet of athletes in training is a controversial topic among coaches and trainers. The belief that milk impairs endurance performance is generally based upon one or more of the following contentions: (a) milk causes a decrease in salivary gland activity resulting in 'cotton mouth,' (b) milk consumed a few hours before competition 'curdles in the stomach' and interferes with maximum performance, and (c) milk in the athlete's diet raises the fat intake and lowers the respiratory quotient hence decreases efficiency.

Although opinions have been expressed regarding the effects of milk on performance, no basis of fact has been found for withholding milk from the diet of athletes. On the other hand, research data indicating milk is essential for maximum performance is also lacking.11

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9Ibid.

10Letter to Mr. Stan Cameron of Quickick International Company from Dr. James W. Campbell, Professor of Biology at Rice University, Houston, Texas, April 12, 1973.

In addition to the previous arguments against it, Nelson\textsuperscript{12} reported that milk is supposed to increase the secretion of mucus into the respiratory system and to interfere with performance by also forming excessive gas in the stomach.

Many authors however do not condemn milk. One example is Belik, author of The Trainer's Bible, who is quoted by Nelson:

> Milk is the most nearly perfect food. It contains 12 percent protein, 44 percent carbohydrate, 44 percent vitamins A, B, C, D, G, and K. Milk does not 'cut the wind.'\textsuperscript{13}

The use of milk has also been questioned as a part of the pre-game meal for the same previously reported reasons. Most recent research shows that eating a light pre-game meal of milk and cereal has no adverse effect on the times for running distances between 50 yards and 2 miles or swimming distances between 100 yards and 1 mile. The subjects in these studies experienced no problems with stomach cramps or nausea. Nelson indicated that drinking milk as close as one-half hour prior to competition had no adverse effect on performance times. On the other hand, research studies have not been reported which indicate that milk improves endurance performance or is useful as a fluid


replacement for dehydration during half-times or time-outs of competitive events.

Physical activity in the heat, especially of an endurance nature, places severe demand on the circulolrespiratory system of the body: the two primary demands being the transportation of oxygen and fuel to the muscles and the transfer of heat to the periphery. In maintaining thermoregulatory homeostasis, the body sweats, the sweat is evaporated, the skin cooled, and the internal body temperature is maintained. Unfortunately during this process large amounts of water and electrolytes can be lost and if not replaced can lead to muscle cramps, heat exhaustion, heat stroke, and even death. These potential heat injuries can become even more of a problem in the areas of the country where high relative humidity is a serious problem in addition to high environmental temperature. Performance can be hampered even more if the practice or competition is held on artificial playing surfaces, where the surface temperature has been recorded experimentally at over 150° F.14

It is generally accepted that man suffers a decrease in his physical work capacity while working in the heat.15


It is also apparent that there are differing opinions as to the effects of ingesting different liquids before, during, or after exercise.

Statement of the Problem

Will the ingestion of selected liquids before exercise in high heat and humidity enable an individual to perform for a longer time before reaching a criterion heart rate? Does prehydration with any of these liquids have any beneficial or adverse effects on the subjects' recovery heart rate or weight loss?

Purpose of the Study

The primary purpose of this study was to add to the knowledge of the ingestion of liquids before exhaustive exercise in high heat and humidity. The study investigated whether or not the prehydration with water, milk, or Quick-ick enabled a person to exercise longer in a heat stress environment before reaching a criterion heart rate. Two secondary purposes were to compare the liquid ingestion's effects upon recovery heart rates and relative weight losses.

Significance of the Study

In general, a person who exercises longer before reaching a maximal heart rate of 170 beats per minute than another individual will exhibit greater circulorespiratory efficiency. In performing this work, especially in the
heat, the body will incur deficits of water and electrolytes. The significance of this study was to investigate the effects of prehydration with water, milk, and Quickick before an exhaustive work bout to test if prehydration enables an individual to work longer before reaching a maximum heart rate. It was felt that an additional contribution to the existing body of knowledge would be the relationships or influences of prehydration with each liquid on recovery heart rates and weight loss.

It was believed that coaches, trainers, and physical educators who are interested in the performance and safety of performers would also benefit from this study.

This study was also deemed significant in attempting to determine the value of ingesting liquids during time-outs or between periods of competition and practice sessions.

Since there are differing opinions concerning the value of drinking milk prior to practice or competition, it was believed that this study would act to test the stigma concerning milk and its effects upon performance.

**Delimitations of the Study**

The subjects were limited to sixteen college athletes. These subjects were volunteers from Louisiana State University Varisty Football Team and not in training at the time of the study.

Two exercise bouts were performed until the subject reached a criterion heart rate of 170 beats per minute.
The two exercise bouts were separated by a ten minute rest period and followed by a fifteen minute recovery period.

The study was conducted in a sauna bath operated by the Louisiana State University Athletic Department. Only one condition of temperature and humidity was studied. The temperature was maintained at 90° F. and the relative humidity at 85 percent.

Only three liquids were selected for the study: Milk, water, and Quickick.

Limitations of the Study

In selecting the criterion heart rate of 170 beats per minute, the author accepted the fact that the subjects were capable of establishing and enduring higher maximum heart rates. The criterion of 170 beats per minute was chosen as the point where physiological limitations become evident.¹⁶

The selection of two exercise bouts was an attempt to structure the work bouts in the same general pattern as competition or practice: relatively brief but intense periods of work separated by periods of rest. Other combinations of work and rest or a longer submaximal work bout may have produced different results.

The single condition of heat and humidity was selected as a standardization of environment to approximate

¹⁶Herbert A. deVries, Physiology of Exercise for Physical Education and Athletics (Dubuque, Iowa: W. C. Brown Company, 1966), 79.
the heat stress conditions of athletic practice and
competition in the Southeastern United States. Other con-
ditions of heat and humidity may have produced differential
effects on the criterion studied.

Such factors as motivation, emotions, sleep, and
physical activity could not be accurately controlled in
this study. Care was taken to reduce their effects as much
as possible. The subjects were instructed not to eat or
drink anything for three hours prior to testing, but there
was no way of knowing whether these instructions were fol-
lowed.

Definitions of Terms

**Quickick.** This substance is a nationally marketed
thirst-quenching drink and has been specially formulated
to replace water and vital electrolytes in the body fol-
lowing exhaustive exercise. The chemical composition and
osmotic pressure of Quickick nearly duplicates that of
blood plasma thus making Quickick a true isotonic liquid.\(^{17}\)

**High heat and humidity.** For the purpose of this
study the combination of heat and humidity was 90° F. and
85 percent relative humidity.

**Work bout.** The bouts of exercise were identical.
The subject pedalled at the rate of sixty revolution per
minute with a load of two kiloponds. This established a

\(^{17}\)Campbell, *loc. cit.*
standard workload of 720 kpm/minute. Each work bout was continued until the subject's heart rate reached 170 beats per minute.

**Criterion heart rate.** For the purpose of this study the maximum heart rate was considered to be 170 beats per minute.

**Weight loss.** For the purpose of this study the weight loss was the difference between the subject's initial weight and post-exercise weight. The subject's initial weight was determined by adding the weight of the liquid ingested to the pre-exercise weight, an adjustment for the experimental intake of fluid.
CHAPTER 2

REVIEW OF RELATED LITERATURE

The summary of literature was divided into four areas: (a) effects of exercise and heat on the human body; (b) water replacement before, during, and after exercise; (c) electrolyte replacement before, during, and after exercise; and (d) the ingestion of milk before exhausting work.

Literature Related to the Effects of Exercise and Heat on the Human Body

Exercise

Whenever man exercises, whether it be for work or play, most of his body functions increase to provide energy for the activity. The heart rate increases, the respiratory rate is increased, body temperature is elevated and heat builds up in the body. Man produces heat in many ways--by cellular metabolism, muscular activity, ingestion of food, hormonal action, and in some cases by stimulation from his environment. Since the body tries to maintain

\[\text{\textsuperscript{1}}\text{Man, Sweat and Performance (Rutherford, New Jersey: Becton, Dickinson and Company, 1969), 1.}\]

14
an internal homeostasis, the heat produced must be eliminated and not allowed to build up.

Heat is eliminated from the body in four ways: radiation, conduction, convection, and evaporation. The first three are reversible processes, so that man loses heat when the environment is cooler than his skin temperature of approximately 92° F. and gains heat when the environment is hotter than skin temperature. In the latter case evaporation is the only process by which man can eliminate body heat.²

The delicate balance of heat in the body is regulated by a thermal regulatory mechanism, biochemical in nature, and consists of integrated parts of the circulatory system, sweat glands, neural impulses, and the endocrine system. Under normal conditions the majority of heat is dissipated through the skin by radiation, conduction, and convection. Evaporation, also occurring on the skin, accounts for approximately 20 percent of the total sweat loss but under normal conditions it is unnoticed and is referred to as insensible perspiration.

Sweat produced for the purpose of sensible perspiration is the result of a reflex body action to a thermal stimulus either from within or outside the body.³


³Man, Sweat and Performance, pp. 5, 13.
But the ability of the body to function efficiently depends on the loss of heat by way of evaporation of sweat--the sensible loss of water. When sweating occurs, insensible sweating ceases, though subcutaneous activity increases. In order for sweat to produce a loss of heat, it must evaporate. That part of it that is wiped away or permitted to run off the body has no cooling function. Similarly, athletes or exercise-minded people who wear pads, or rubber sweat suits inhibit evaporation of sweat. Such coverings act as airtight barriers that cause rapid buildup in the core, destroying the gradient and, without a gradient, the body helplessly continues to excrete water to the possible detriment of the person.4

Consequently, sweating and the concurrent evaporation are of prime requisites in reducing body heat. The rates of sweating and evaporation are a function of many factors including body weight, body surface area, air temperature, relative humidity, wind velocity, type and amount of clothing, and physical activity. Although these many factors play a role in the buildup of heat in the body, investigators showed as early as 1931 that the core temperature is independent of the environment and is regulated at a level which depends on the rate of exercise.5 This concept has been confirmed since then by many studies, notably those by


However, the regulation of temperature will fail if exhausting work continues under very severe environmental conditions of high heat and humidity. However, the regulation of temperature will fail if exhausting work continues under very severe environmental conditions of high heat and humidity.

The sweat lost contains four compounds necessary for proper physiological functioning: water, sodium, chloride, and potassium.

Water composes approximately 99 percent of sweat and is found within three fluid compartments in the body. The first two, both extra-cellular, are the blood plasma and the interstitial fluid. Water in these two compartments carries nutrients to all body parts and wastes to the excretory organs, such as the kidneys and sweat glands. The third water compartment is that within the cell as part of its protoplasm.

Sodium and chloride are found in the blood plasma and the interstitial fluids, while potassium is contained

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6Dr. Richard L. Westerman, unpublished study, Northeast Louisiana University, Monroe, 1971-73, p. 4.
10Kerslake, pp. 128-129.
within the cell membrane. All three are electrolytes, which conduct electricity and provide the basis for the transmission of nerve impulses and muscular contraction and relaxation.

When sweating occurs, water along with sodium and chloride are excreted through the skin from the extracellular fluids. The deficit of salt (NaCl) and water can cause problems ranging from mild heat cramps to complete heat prostration. An added problem will occur if potassium is depleted from the cell causing a depression in neuro-muscular activity. Obviously the water and electrolytes of sodium, chloride, and potassium must be replaced if the delicate heat balance is to be maintained. If thermal homeostasis is greatly disturbed, the body temperature will rise until death occurs.\textsuperscript{12}

During World War II, Adolph\textsuperscript{13} and associates found that man will not voluntarily drink enough water to replace that lost during heavy sweating and exercise, a procedure termed "voluntary dehydration." This hypohydration will affect the next exercise bout by inhibiting exercise sweating for two reasons: (a) an inadequate volume of interstitial fluid to supply the needs of the sweat glands and (b) an inhibition in the transfer of interstitial fluid to

\textsuperscript{12} Man, Sweat and Performance, pp. 16-17.

the sweat glands due to an increased osmotic pressure of the interstitial fluid.  

Since the thermal regulatory mechanism is a biochemical function of the circulatory system, sweat glands, nervous system and the endocrine system, the body will react immediately to fluids and electrolytes absorbed from the intestinal tract; therefore, the effects of rehydration are almost instantaneous depending on the digestive necessity of the compound ingested.  

Environment

Because of the fact that the human body at work produces heat, and that this heat must be dissipated for physiological efficiency, exercise in a hot environment produces an extra burden for the thermal regulatory mechanism.

In a hot-dry environment, sweating and the resultant heat loss is efficient since the relative humidity is low, allowing the sweat produced to be evaporated quickly. This sweating may go all but unnoticed since the sweat is evaporated almost immediately. In this case dehydration can occur very rapidly. This was exemplified in the studies by Adolph, many of which showed that a subject walking in

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15 Man, Sweat and Performance, p. 19.

16 Adolph, p. 9.
the desert, a very hot but dry environment, might lose more than a quart of water per hour by sweating, much of it insensible.

This concept has applications today where much of our competition in sports is upon artificial surfaces. A timely study was prepared by two agricultural engineers and the head athletic trainer at Auburn University in 1970. As the university was installing their Astroturf football field, wet-bulb and dry-bulb thermometers were placed in thermocouples inbedded in the artificial surface and in the soil of a nearby grassed practice area. Temperature measurements at the surface of the synthetic and grass areas were measured. September 1 at 1:30 P.M. the Astroturf surface temperature was 106° F. and the grass surface temperature was 106° F. At 10:00 A.M. the following day the Astroturf temperature was above the 150° F. measuring capability of the thermometer and the grass temperature was 100° F. At 3:00 P.M. the same day the readings were 135° and 102° F. respectively. The extreme heat retained by artificial surfaces makes athletic practice and/or competition dangerous for the related heat illness problems of heat cramps, heat exhaustion, dehydration, and heat stroke. 17

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The human body reacts to a hot environment with a resulting increase in most functions. Murray\textsuperscript{18} studied the effects of twenty-minute exposures of six resting subjects to heats of 300° and 400° F. and very low humidity. At 300° F. the average peak heart rate was 98 beats per minute and at 400° F. the average heart rate was 128 beats per minute.

High heat accompanied by high humidity produces an even greater reduction in bodily efficiency than mere heat alone. Morehouse and Miller\textsuperscript{19} reported a study by C. L. Taylor in 1945. The subjects could perform very moderate work for 60 minutes at 145° F. and 10 percent humidity. When they were placed in a hot-humid environment, they could work for 60 minutes when the temperature was only 104° F. but 90 percent relative humidity. This indicates the debilitating effect of high humidity on heat dissipation and reinforces the often heard complaint that "It's not the heat but the humidity."

As noted earlier in the literature, the major factor in causing physiological stress is the amount of effort expended by the individual and not the ambient weather.


conditions. Moreover, a combination of heavy work and a hot-humid environment will cause a potentially dangerous heat stress situation. Certain preventive measures have been suggested to reduce the possibility of circulatory embarrassment.

deVries suggested several steps that should be taken to minimize or eliminate the dangers of heat illness:

1. No activity during very high heat and humidity.
2. Acclimatization if the subject is changing climates.
3. Allow water ingestion on an ad libitum basis.
4. Replacement of salt and other electrolytes.
5. Regulate clothing to allow for maximum evaporation.
6. Adequate ventilation.

Becton, Dickinson and Company, an athletic training supply and drug company, recommends essentially the same as deVries but adds a greater emphasis on the forced replacement of electrolytes and frequently scheduled rest periods. The rest periods and amounts of fluids consumed per rest are calculated on a basis of weight lost at the preceding practice as seen in Table 1.

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20 deVries, pp. 325-328.
21 Man, Sweat and Performance, pp. 16-17, 29.
22 Ibid., p. 29.
### Table 1

**RECOMMENDED TABLE OF FLUID AVAILABILITY FOR STRENUOUS 90-MINUTE ATHLETIC PRACTICE***

<table>
<thead>
<tr>
<th>WEIGHT LOSS (Lbs.)</th>
<th>FREQUENCY OF BREAK (Min. Between)</th>
<th>AMT. OF FLUID PER BREAK (Oz.)</th>
<th>REQUIRED PER 11-MAN SQUAD (Gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>no practice recommended</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7 1/2</td>
<td>no practice recommended</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>8-10</td>
<td>6 1/2-8</td>
</tr>
<tr>
<td>6 1/2</td>
<td>10</td>
<td>8-9</td>
<td>6 1/2-7</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>8-9</td>
<td>6 1/2-7</td>
</tr>
<tr>
<td>5 1/2</td>
<td>15</td>
<td>10-12</td>
<td>5 1/2-6 1/2</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>10-11</td>
<td>5 1/2-6</td>
</tr>
<tr>
<td>4 1/2</td>
<td>15</td>
<td>9-10</td>
<td>5-5 1/2</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>8-9</td>
<td>4 1/2-5</td>
</tr>
<tr>
<td>3 1/2</td>
<td>20</td>
<td>10-11</td>
<td>4-4 1/2</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>9-10</td>
<td>3 1/2-4</td>
</tr>
<tr>
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<td>20</td>
<td>7-8</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>8</td>
<td>2 1/2</td>
</tr>
<tr>
<td>1 1/2</td>
<td>30</td>
<td>6</td>
<td>1 1/2</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>1/2</td>
<td>60</td>
<td>6</td>
<td>1/2</td>
</tr>
</tbody>
</table>

*Based upon an 80% replacement of weight loss.
Dr. Martin Broussard\textsuperscript{23} and Westerman\textsuperscript{24} emphasized the need for replacing potassium as much as sodium and chloride, since it is the guardian of cellular metabolism and neuromuscular function and also because potassium cannot be stored by the body, its excesses being excreted by the kidneys. Westerman advocated a system of forced rehydration rather than ad libitum water ingestion because of his and Adolph's findings related to voluntary dehydration.

Many studies have shown the adverse effects on sweat evaporation of athletic clothing, especially football gear. Experiments by Mathews, Fox and associates\textsuperscript{25} tested the effects of football uniforms, back packs of the same weight as the uniforms, hospital scrub suits, and shorts. Performed in relatively ideal weather conditions of 74-77° F. and 31-55 percent relative humidity, the results showed that working with the football uniform produced the highest significant heart rates and lowest significant sweating efficiency.

\begin{itemize}
\item Dr. Martin Broussard, Supervisor of Athletic Training at Louisiana State University, personal interview, June 9, 1975.
\item Westerman, pp. 5, 9.
\end{itemize}
Literature Concerning Water Replacement

Since it is accepted that dehydration causes a decrease in the cardiovascular efficiency and heat regulation and therefore may lead to several heat-related illnesses, several studies were reviewed concerning exercise after dehydration or hypohydration.

As previously stated in a study by Greenleaf and Castle, hypohydration can inhibit exercise sweating due to an inadequate volume of interstitial fluid to supply the needs of sweat glands.

Greenleaf and others studied 12 women who had lost 3.3 percent of their body weight in water loss by exercise. The investigators found significant increases in the resting pulse rates and recovery pulse rates following a modified Harvard Step Test.

Craig and Cummins found in 9 subjects dehydrated to 4.3 percent body weight loss that their normal treadmill walking time to exhaustion was reduced by 48 percent.

In a previously unpublished study by Costill the effects of dehydration by 4 percent of body weight and


29 David L. Costill, "Fluid Replacement During and Following Exercise," paper read at C. I. C. Symposium on
subsequent rehydration were investigated. The experimental groups ingested water, a glucose-electrolyte solution, a carbonated form of the same solution, and a control of no fluid replacement. During the standard 6 mile-per-hour treadmill run at 0 percent grade, the no-fluid replacement group experienced heart rates averaging 20 beats above their normal responses to the run.

Adolph\textsuperscript{30} observed that dehydration by only 1 percent of body weight would produce increases in circulatory strain and body temperature.

Other sources have reported tremendous weight losses by sweating. Westerman\textsuperscript{31} has discovered fluid losses as great as 15 pounds per day or 7 percent of body weight. In the high heat and humidity of August and September practices, football players at Louisiana State University have incurred weight losses up to 15-16 pounds per practice session.\textsuperscript{32}

In 1938 Adolph and Dill\textsuperscript{33} reported an hourly sweat rate of 1700 grams weight loss (approximately 3.9 pounds)

\begin{footnotesize}
\begin{itemize}
\item[\textsuperscript{30}] Adolph, p. 230.
\item[\textsuperscript{31}] Westerman, p. 1.
\item[\textsuperscript{32}] Broussard, interview.
\end{itemize}
\end{footnotesize}
and in 1949 Mitchell and Edman\textsuperscript{34} reported that working in a hot and humid environment could possibly cause the loss of up to 13 liters per day or a weight loss of nearly 26 pounds.

Many studies have been reported to indicate that water replacement during frequent rest periods increased circulatory efficiency, increased the rates and amounts of sweating and lowered body temperature.

In 1944 Pitts\textsuperscript{35} and others compared three water replacement schedules during alternate marching at a rate of 3.5 mph up a grade of 2.5 percent and resting in a 100\textdegree F. environment. With no water the rectal temperature increased steadily to high levels (about 103\textdegree F.) with no signs of reaching a steady state. A second group who consumed water on an ad libitum basis until thirst was quenched, experienced a rise in rectal temperature to 101\textdegree F. Their temperature remained in that steady state until the subjects had worked for 4.5 hours, after which it increased steadily. The third group was forced to drink water which equalled sweat losses. Their temperature remained at approximately 100.5\textdegree F. for the duration of the 6-hour test.

\textsuperscript{34}H. H. Mitchell and Marjorie Edman, Nutrition and Resistance to Climatic Stress (Chicago: Quartermaster Food and Container Institute for the Armed Forces, November, 1949), 38.

\textsuperscript{35}G. C. Pitts, R. E. Johnson and F. C. Consolazio, "Work in the Heat as Affected by Intake of Water," American Journal of Physiology, CXLII (September, 1944), 253-259.
In Costill's study mentioned previously in the review, 8 subjects dehydrated 4 percent of their body weights and rehydrated their fluid losses in 13 equal doses at 15-minute intervals during a 3-hour period. On the treadmill test of 6 mph and 0 percent grade, all three liquid replacement groups (water, glucose-electrolyte, and carbonated glucose-electrolyte) showed a gradual return of heart rate to normal and the no-water group remained at a heart rate 20 beats higher than the normal recovery response.

Gillis tested 27 varsity football players in full uniform in a heat stress environment. It was concluded that ingesting up to 12 ounces of water every 13 minutes decreased physiological cost and increased the work output of the subjects.

Four schedules of fluid replacement under extreme heat and humidity were investigated by Burt, Blyth, and Wyre. It was found that ingesting water every 16 minutes gave the longest treadmill runs to exhaustion times and lowest mean heart rates when compared with prehydration or

36 Costill, p. 132.


rehydration after 32 or 64 minutes into the exercise. One criticism was that it appeared that more water was ingested with each additional feeding.

Most literature has advocated forced hydration of fluids to replace losses during sweating. This has led to recommendations of overhydration or prehydration before exercise or during rest period early in the exercise period.

In a doctoral study Londeree investigated water replacement schedules upon work in 90° F. heat and 70 percent relative humidity. The 10 subjects involved ran on a treadmill in tennis shoes and full football uniforms. The treadmill run was devised to simulate a football practice by changing the rate of work and rest programs. On five consecutive days, four 1-liter water replacement schedules were tested against a control of no water consumption. Also tested were the theories of whole versus part consumption and early versus late consumption. The schedules were as follows:

- **Early-whole** - 1 liter ingested 10 minutes before exercise.
- **Late-whole** - 1 liter ingested 35 minutes into exercise.
- **Early-part** - ½ liter ingested 10 minutes before exercise, and ½ liter ingested 21 minutes into exercise.
- **Late-part** - ½ liter ingested 21 minutes into exercise, and ½ liter ingested 35 minutes into exercise.

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In order to reduce any carry-over effects from the previous test period, five salt tablets were given with water to each subject to bring his weight back to the initial status. Also, the subjects were acclimatized for three sessions prior to testing. The control group subjects posted the poorest results in heart rates and body temperatures. All hydration conditions were significantly better than the control, which reiterated the need for water ingestion to combat the effects of heat. Early ingestion of water was better than late ingestion, but the advantage was reduced toward the end of the workout. There were no significant differences between whole and part consumption. The primary recommendation was that prehydration and ingesting as much water as possible during practice seemed desirable in reducing the ill effects of heat.

Moroff and Bass\(^{40}\) studied the effects of overhydration on 30 subjects during a treadmill run of 3.5 mph on 0 percent grade. The hot and humid environment was 100° F. and 80 percent relative humidity. Both experimental groups ingested 1200 ml. of water during the treadmill test but the overhydration group drank 2 liters (2000 ml.) before the exercise bout. Overhydration resulted in significantly lower rectal temperatures and pulse rates and significantly higher sweat rates than exhibited by the control group.

Gillis\textsuperscript{41} also found overhydration to reduce circulatory and heat-related problems. He tested 27 subjects and used water replacement schedules of 1, 2, and 3 pints. It was concluded that ingesting 3 pints of water during exercise would produce significantly lower rectal temperatures and heart rates than either 1 or 2 pints.

DeVries\textsuperscript{42} recommends both early fluid replacement and overhydration to reduce the ill effects of heat and to maintain performance at a higher level.

Westerman\textsuperscript{43} concluded that dehydration was the major limiting factor upon athletic performance and recommended the possible advantages of prehydration and overhydration even though these were not a part of the study.

Several studies have indicated that the ingestion of water had no effect upon performance.

Little, Strayhorn and Miller\textsuperscript{44} in 1949 tested varsity athletes in a series of treadmill runs, 50- and 200-yard swimming freestyle sprints, and 220-yard track sprint times. The prehydrations of 1 and 1-1/2 liters of water 3-4 minutes before testing were extremely large at the time. In all of the tests the subjects felt effects

\textsuperscript{41}Gillis, abstract.

\textsuperscript{42}DeVries, p. 332.

\textsuperscript{43}Westerman, p. 6.

\textsuperscript{44}C. C. Little, H. Strayhorn and A. T. Miller, "Effect of Water Ingestion on Capacity for Exercise," Research Quarterly, XX (December, 1949), 398-401.
of distention and disinclination for exercise but exhibited no discomfort during or after the exercise. The major premise was that water would not decrease the capacity for strenuous exercise, as was the prevalent theory of the day. Their premise was supported when it was found that the comparisons of performance times with and without prehydration were not significantly different.

Burt, Blyth and Wyre⁴⁵ found that prehydration did not aid as much as a rehydration schedule of every 16 minutes. In their study, however, increasing amounts of water were ingested with each additional rest period.

Blank⁴⁶ tested the performance of 33 college track and field athletes on 220-yard sprint times after 2 prehydration schedules and a control of no water ingestion. No significant differences were found in times between a control group, a group who ingested 16 ounces of water 5 minutes before running, and a group allowed ad libitum water consumption for 5 minutes prior to running. The study was limited to one short duration performance and was not concerned with dehydration, heat dissipation, or a hot and humid environment.

⁴⁵Burt, Blyth and Wyre, cited in Londeree, p. 726.
Costill, Kammer, and Fisher\textsuperscript{47} made observations on the runners in the 1968 Boston Marathon and U.S. Olympic Marathon Trials and suggested that performance was unrelated to either fluid replacement or fluid loss during competition.

These observations prompted Costill\textsuperscript{48} to study four national champion marathoners during 2 hours of exhaustive treadmill running with and without fluid replacement. The two ingestion schedules consisted of water and a glucose electrolyte solution, each consumed at a rate of 100 ml. every 5 minutes during the first hour and forty minutes of the run. The runners experienced extreme fullness during the first few feedings which indicated they were consuming liquids faster than they were emptied from the stomach. Costill further found that the fluid consumption could not keep pace with the recorded sweat loss. This may indicate a need for more prehydration to allow for stomach emptying and intestinal absorption. It was also found that the marathoners seemed to sweat at a rate independent of fluid ingestion and exercise dehydration and that replacing fluids had no effect upon the heart rates of the 4 trained subjects during the two-hour run.


Literature Related to Electrolytes and Their Replacement

Some elements in the body, notably sodium, chloride, and potassium, have the capacity to give up electrons from or take on additional electrons into their atomic structure. Substances that have gained or given up electrons (dissociated) in this manner are called ions and are characterized by a positive electrical charge (cation) upon losing an electron and by a negative electrical charge (anion) when gaining an electron. A greater concentration of ions in a liquid will result in a lower resistance to electric current and the conductivity of that liquid becomes greater. Water and water solutions of most organic compounds, such as sugar, are poor conductors or nonelectrolytes. Substances which freely ionize (dissociate) in solution are good conductors of electric current and are called electrolytes. 49

Electrolytes in the human body provide the medium through which the electro-chemical nerve impulses pass and play a vital role in heat regulation, and faster recuperation from fatigue. Chloride is found in the red blood cells and interstitial fluid and aids in retaining sodium in the body. Sodium, found outside the body cells in the

extracellular fluid, aids in regulating the heart beat and controls the water balance of the body. Potassium is the most important cellular electrolyte, being the major base in the red blood cell. It is vital to cellular life by regulating metabolism and is a necessary agent for proper neuromuscular functioning.\(^{50}\)

Work in the heat has been shown to delete water and many electrolyte levels, possibly causing several heat-related illnesses, including heat cramps, heat exhaustion and heat stroke. Prevention is of more importance than cure since much of the damage caused to the brain and nervous system due to a high body temperature is permanent and irreversible.\(^{51}\)

Mild exercise in cold, temperate, and hot environments produces an increase in the urinary excretion of electrolytes; however, when exercise is severe or the environment is hot and humid, the excretion of sodium, chloride and potassium are markedly increased.\(^{52}\) Excesses of sodium and chloride have been shown to be conserved by the body so that they might be used in regulating water retention and heat dissipation. On the other hand, excesses of potassium are rapidly depleted during heavy exercise and

\(^{50}\)Broussard, interview.

\(^{51}\)deVries, p. 326.

not conserved by the body. This indicates a possible increased need,\textsuperscript{53} more than has been previously recommended.

For many years salt tablets and water were advocated to replenish the electrolyte depletions from exercise or heat. Either water or salt ingested alone were shown to produce effects detrimental to heat reduction. Ingestion of salt without water was proved to increase the sodium concentration of the plasma and interstitial fluid, thereby drawing water from the cells where it is needed for thermal homeostasis. Ingestion of water without salt reduced the sodium concentration and produced an increase in urinary output, depriving the body of the water needed in thermal regulation by sweating.\textsuperscript{54}

Combinations of water and salt nearly duplicating the concentrations of sweat were recommended by Adolph,\textsuperscript{55} Morehouse and Miller,\textsuperscript{56} and deVries,\textsuperscript{57} the latter two sources suggesting the addition of sugar to increase the palatability of the drink and to add fuel which might be used in endurance activities.

\textsuperscript{53}Westerman, p. 9; Broussard, interview.

\textsuperscript{54}Robinson, pp. 89-90.

\textsuperscript{55}Adolph, pp. 106-108.

\textsuperscript{56}Morehouse and Miller, pp. 222-223.

\textsuperscript{57}deVries, pp. 326-328.
Westerman\textsuperscript{58} exercised one group of football players and replaced their lost salt by tablets with water. This group showed the highest levels of urinary sodium chloride excretion in all of the testing. It was concluded that this was due to the failure of the subjects to drink all of the prescribed water with the salt tablets. Westerman suggested that the current recommendations for administration of salt tablets might be inappropriate, even though the tablets do not provide any more salt than the commercial salinized drinks. When compared to water intake, the tablets supplied more salt than needed and, as has been shown, may possibly be harmful on the basis of cellular water loss. On this basis Westerman recommended:

1. No salt tablets as long as daily weight loss does not exceed five pounds.

2. When weight losses exceed 5 pounds, then administer one (1) 600 mg. (10 grain) salt tablet for each additional pound of weight loss—taken with ample amounts of water.

Westerman maintained that a normal diet will by itself provide sufficient NaCl to cover the first 5 pounds of sweat loss (2-1/2 liter).\textsuperscript{59} He also recommended, that since there is a common tendency not to drink enough water when taking salt tablets, salinized drinks would be a much better

\textsuperscript{58}Westerman, pp. 7-8.

\textsuperscript{59}\textit{Ibid.}, p. 8.
way to get both water and electrolytes back into the body. He added that this was true only when the full rehydrating dosage was ingested.

Research in the past few years prompted several investigators to recommend the ingestion of potassium, as highly as the other electrolytes, to replace the losses in sweat. Its cellular deficit caused reduced neuromuscular functioning as reflected by weakness, fatigue, and sluggish physiological responses. Becton and Dickinson stated that a potassium deficit takes longer to correct since it must be absorbed through the cellular membrane.

Several commercial preparations of salinized drinks have been marketed in the past few years. Some of these are: Quickick (Cramer), Gatorade (Stokely Van Camp), Half-Time Punch (Bike), Take-Five (Cramer), Brake Time (Johnson and Johnson), Side-Line Sider (Cramer), and others. These drinks have been described as thirst-quenching beverages that replace, in differing amounts, the vital substances lost in perspiration, such as water, sodium, chloride, and potassium.

The thermal regulatory mechanism has been described as a biochemical function. Thus it can immediately make use of the water and electrolytes absorbed from the digestive

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^60 Man, Sweat and Performance; Westerman; and Broussard.

^61 Westerman, p. 9.

^62 Man, Sweat and Performance, p. 17.
tract, the rate of which depends on how fast they are emptied from the stomach and their digestion.

Fordtran and Saltin⁶³ tested intestinal absorption in five subjects and found that it was not significantly decreased by exercise as had been postulated. In addition, they found that the emptying of the stomach contents was only slightly decreased by exercise. It was well known that gastric emptying depended primarily on the type of solute ingested and its concentration. The investigators found that isotonic saline solutions were emptied from the stomach even more rapidly than water, but that the addition of even small amounts of glucose (5 percent) to water caused a further inhibition of gastric emptying.

Witten⁶⁴ tested four fluid replacement schedules following dehydration. The sodium concentrations were significantly lower for water and Gatorade than for Coca Cola or the control of no fluid. Potassium concentration diminished throughout the experiment. Witten also found that Gatorade was absorbed as rapidly or possibly faster than water.


Of all the commercial electrolyte drinks, reportedly only Quickick has been chemically proven to be isotonic to blood plasma.\textsuperscript{65} This indicates that Quickick will move freely across the cell membranes and between fluid compartments, therefore being capable of establishing osmotic equilibrium upon proper ingestion. Since Quickick is an isotonic fluid, it can be injected intravenously to immediately facilitate recovery in heat emergencies, rather than depending on slow stomach emptying and intestinal absorption.

Several studies were reported which used the commercially prepared electrolyte drinks in testing their effects on performance, weight loss, heart rate, and other physiological variables.

Westerman\textsuperscript{66} studied college football players in 1971-73 during late summer training camps of 10-14 days. The tests were conducted in a hot-humid climate in Louisiana and in a hot-dry climate in Arizona. Fluid losses as great as 15 pounds per day or 7 percent of body weight were reported. Westerman used six different fluid replacement drinks:

1. Side-Line Sider with sodium, chloride, and potassium.

2. Side-Line Sider with salt removed.

\textsuperscript{65}Personal correspondence between Dr. James W. Campbell, Professor of Biology at Rice University and Stan Cameron, Quickick International Company, April 12, 1973.

\textsuperscript{66}Westerman.

4. Quickick containing sodium, chloride, potassium, and sugar.

5. Side-Line Sider with electrolytes removed; only sugars, flavoring agents, and coloring.

6. Water plus 600 mg. salt for each pound of weight lost.

As had been found in other studies, Westerman reported voluntary dehydration when the subjects were allowed to drink on an ad libitum basis. If the subjects did not return to their initial weight before the next practice session, their resultant sweat loss was reduced, impairing performance during that period. Greater weight losses were found when the subjects had a liberal, often overhydration, liquid replacement policy during practice sessions. This indicated better thermal regulation during practices.

Based on the three-year study, Westerman made these recommendations:

1. No salt tablets if daily weight losses were not over 5 pounds.

2. If losses were over 5 pounds, administer one (1) 600 mg. salt tablet for each pound of weight loss over 5 pounds, taken with ample amounts of water.

3. Use of salinized drinks, especially Quickick, in replacing water and electrolytes, but only if taken in the full rehydrating dosages.
4. Include potassium in any dietary supplements.
5. Overhydration in fluid replacement schedules.

Randolph\textsuperscript{67} tested the effects of Gatorade, Take-Five, dextrose, and a placebo on the results of a modified Balke treadmill test. Twenty subjects showed no significant differences between the liquid ingestion conditions on maximal heart rate, exercise duration, or weight loss.

Gatorade, Coca Cola, water, and a control of no liquid were the variables studied by Witten.\textsuperscript{68} Gatorade was found to be absorbed as rapidly and possibly faster than water, but the subjects' treadmill performance times following ingestion of each liquid were not significantly different.

Eaves\textsuperscript{69} tested the rehydration effects of Gatorade, Take-Five, Coca Cola, and water on 5 college wrestlers. The subjects were dehydrated by 6 percent of their body weight and rehydrated 2 percent of their weight by drinking one of the four liquids. Statistical analysis revealed no significant differences in the test of cardiovascular endurance.


\textsuperscript{68}Witten.

The ergogenic value of Gatorade on performance in the mile run was investigated by O'Connor. The experimental conditions were Gatorade, a placebo, and a control group of no prehydration. It was concluded that Gatorade had no ergogenic value because its prehydration did not significantly affect the mile run times.

Wallace used Half-Time Punch, Pepsi Cola, water, and a control of no liquid in testing 10 members of a freshman college basketball team during practices. Each of the variables were used in 4 practice sessions and were ingested during a rest period halfway through the workout and at the end. The subjects were tested before and after practice on reaction time, grip strength, vertical jump, and a 3-minute step test. The only significant difference was found on the reaction time test when comparing Half-Time Punch and the control of no liquid. None of the experimental conditions, or the control, evidenced significant effects on the other three tests.

Several writers have stated that the addition of glucose to the rehydration fluid of water and electrolytes


would bring an increased endurance performance as endorsed by Pitts, Johnson, and Consolazio,\(^72\) deVries,\(^73\) and Morehouse and Miller.\(^74\)

Fordtran and Saltin\(^75\) compared their own glucose-electrolyte solution (13.3 percent glucose and .3 percent sodium chloride) with water in testing gastric emptying and intestinal absorption. They found that isotonic saline solution are emptied even more rapidly from the stomach than water but that adding even a small amount of glucose (5 percent) caused a drastic reduction in gastric emptying. It was also found that in testing 5 subjects for one hour of heavy exercise that neither the glucose-electrolyte nor water produced significant changes in heart rates.

As previously reported Costill\(^76\) studied 4 national champion marathoners during 2 hours of exhaustive treadmill running with and without fluid replacement. The two ingestion groups consisted of a glucose-electrolyte solution (glucose, sodium, chloride, and potassium) or water. One hundred ml.

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\(^72\)Pitts, Johnson, and Consolazio, pp. 253-259.
\(^73\)deVries, pp. 326-328.
\(^74\)Morehouse and Miller, p. 324.
\(^75\)Fordtran and Saltin, pp. 331-335.
of fluid was taken every five minutes for the first hour and forty minutes of exercise for a total of 2000 ml. Both liquid groups produced a significant levelling of rectal temperature after about 45 minutes of exercise while the no-water group experienced no thermal equilibrium for the 120-minute duration of exercise. Heart rates were not significantly affected by replacing fluids.

In an unpublished study, Costill\textsuperscript{77} tested 8 subjects who had dehydrated 4 percent of their body weight. Using the following liquids, the subjects rehydrated a quantity equal to their weight loss: (1) water, (2) a glucose-electrolyte solution, and (3) a carbonated glucose-electrolyte solution. It was discovered that all three fluid replacement groups achieved heart rates averaging 20 beats per minute lower than responses to the treadmill exercise under the no-fluid control condition.

Literature Related to the Ingestion of Milk before Exercise

Persons who have criticized milk because of its effects on athletic performance have stated several reasons to substantiate their beliefs. They are: (1) drying out of the mucus membranes of the mouth because of decreased activity of the salivary glands; (2) the curdling of milk in the stomach is supposed to form excess gas and interfere

\textsuperscript{77}Costill, as cited in "Fluid Replacement during Exercise," pp. 132-136.
with maximum performance; (3) milk in the athletic diet raises the fat intake and lowers the respiratory quotient and thereby decreases efficiency; and (4) milk is supposed to increase the secretion of mucus into the respiratory system, hence decreasing performance.  

Nelson studied the effects of varied amounts of milk in a balanced diet on the performance of short duration, sprint, and power types of events. He also studied the effects of three levels of protein content of milk. In testing 24 athletes who consumed milk on the testing days and sometimes within one hour of testing, no significant differences were found between no milk, one quart, or two quarts per day on starting and running, the vertical jump, or a bicycle ergometer work bout. Nelson also monitored heart rate and blood pressure in all subjects and found no significant differences among amounts of milk or levels of protein in all of the motor tests.

Van Huss and associates studied the effects of milk and no milk in an athletic diet on the endurance performance of nine trained track competitors. All subjects were tested in the post-absorptive state. Although the means


80Van Huss and others, pp. 120-128.
for body weight and all-out run times were higher for the milk group than the non-milk group, there was no significant evidence that the inclusion of milk in the regular athletic diet aided or hindered performance in an all-out treadmill run.

In addition to studies of the effects of drinking milk as part of a long-term diet, several studies have been completed which investigated the effects of a light milk and cereal meal at various times preceding performance. Ball 81 timed 18 varsity swimming team members for times of swimming 100 yards freestyle. None of the six time intervals between eating and swimming (1/2, 1, 1-1/2, 2, 2-1/2, or 3 hours) was found to have any more effect than any other interval on the 100-yard freestyle swimming time.

Asprey, Alley, and Tuttle, 82 investigated the effects of the same light meal on male and female swimmers. No differential effects on the swimming times for the 200 and 400 yards freestyle were found for any of three time intervals (1/2 hour, 1 hour, and 2 hours) between eating a milk and cereal meal, nor a control group who ate nothing for 3 hours before testing.


Using male subjects and the same three time intervals, Asprey, Alley, and Tuttle, found that the milk and cereal meal had no significant effect on the swimming times for the one-mile freestyle swim.

Youmans, Alley, and Tuttle, tested the effects of a meal of milk, cereal, and toast on running. They used six intervals between eating and testing: 1/2, 1, 1-1/2, 2, 2-1/2, and 3 hours. Neither the meal nor any of the time intervals had a significant effect on the starting times or running times for the 50-yard dash or the 100-yard dash.

A series of studies were done by Asprey, Alley, and Tuttle using the three time intervals of 1/2 hours, 1 hour, and 2 hours, and a control of no eating for 3 hours prior to performing several running events. They found that the light meal of milk and cereal had no effect on the running


times for the 440-yard dash or the 880-yard run,\textsuperscript{85} the one-mile run,\textsuperscript{86} or the two-mile run.\textsuperscript{87}

In all of the studies concerning the light meal of milk and cereal or milk, cereal and toast, the investigators reported no adverse effects in the form of nausea, stomach cramps, or discomfort during or after the sprints, runs, or swims.

Summary of Related Literature

Exercise and environment are two of the major factors which caused an increase in body metabolism and therefore an increase in body heat. It was discussed that the body uses a thermal regulatory mechanism to maintain homeostasis. As a biochemical function of the circulatory system, sweat glands, nerve impulses, and the endocrine system, this mechanism was shown to eliminate body heat in four ways.\textsuperscript{88} In a hot-humid environment heat was found to


\textsuperscript{88}Man, Sweat and Performance, pp. 1-13; Westerman, deVries, pp. 316-321; Kerslake, pp. 128-129.
be lost only by sweating and its subsequent evaporation.\(^{89}\)
The composition of sweat was discovered to be mainly water and electrolytes, namely sodium, chloride, and potassium. The location and importance of these chemicals in the body was discussed.\(^{90}\)

The body core temperature was found to be regulated by the rate of exercise and not by environment;\(^{91}\) however, exhaustive exercise in a hot-humid situation increased the chances of circulatory stress. This stress could lead to death if the temperature is elevated very high or the body fluids and electrolytes are not replaced.\(^{92}\) This was especially evident when the subjects wore football uniforms.\(^{93}\)

Adolph and others\(^{94}\) found that if men were allowed to drink water on an ad libitum basis that they would replace

\(^{89}\) Man, Sweat and Performance, pp. 12-17; Dill as cited in Wells, pp. 108-121; deVries, pp. 316-321; Morehouse and Miller, pp. 220-221; Kerslake, pp. 128-129; Greenleaf and Castle, pp. 847-853.

\(^{90}\) Robinson, p. 89; Man, Sweat and Performance, pp. 16-17.

\(^{91}\) Dill as cited in Wells, pp. 108-121; Westerman, p. 4; Craig and Froehlich, pp. 636-639; Kerslake, pp. 128-129.

\(^{92}\) Man, Sweat and Performance; Westerman; Mathews and Fox, pp. 611-615; Kerslake, pp. 128-129.

\(^{93}\) Adolph; Westerman; Man, Sweat and Performance; Murray, pp. 1717-1724; Morehouse and Miller, p. 219.

\(^{94}\) Adolph, pp. 254-270; Man, Sweat and Performance, pp. 16-17, 29; deVries, pp. 325-328.
only about 60 percent of their lost body weight. Dehydra-
tion was found to inhibit sweating, elevate exercise and
recovery heart rates, and decrease circulatory efficiency. 95
Tremendous weight losses by sweating were reported. 96

Most authors advocated the replacement of water,
even forced hydration or overhydration during frequent rest
periods. This was recommended to increase circulatory
efficiency, to increase the rate and amount of sweating and
to lower body temperature. 97 Other authors noted that the
ingestion of water had no effect upon performance.98

Electrolytes were discussed,99 and their replace-
ment before, during and after exercise recommended by
several sources.100 Ingestion of salt tablets or water

95 Greenleaf and Castle, p. 851; Greenleaf and others,
pp. 55-60; Craig and Cummings, pp. 670-674; Costill, "Fluid,"

96 Westerman, p. 1; Broussard; Adolph and Dill,
pp. 369-376; Mitchell and Edman, p. 38.

97 Pitts, Johnson and Consolazio, pp. 253-259; Costil,
"Fluid," p. 132; Gillis; Burt, Blyth and Wyre as cited in
Londeree, p. 726; Onderee, pp. 725-729; Moroff and Bass,
pp. 267-270; DeVries, p. 332; Westerman, p. 6.

98 Little, Strayhorn and Miller, pp. 398-401; Blank,
pp. 131-135; Costill, Kammer and Fisher, pp. 520-525; Costill,

99 Tuttle and Schottelius, pp. 34-35; Taylor and
Best, p. 99.

100 Man, Sweat and Performance; Westerman, DeVries,
pp. 325-326; Morehouse and Miller, pp. 222-223; Adolph,
pp. 106-108; Broussard.
alone was depicted as having a possible detrimental effect in heat regulation.\textsuperscript{101} Westerman\textsuperscript{102} made several recommendations regarding the administering of salt tablets. Several sources advocated the ingestion of potassium in addition to water, sodium, and chloride.\textsuperscript{103}

Several commercially-prepared salinized drinks were compared, and it was reported that only Quickick is isotonic to blood plasma.\textsuperscript{104} The drinks were recommended for replacement of water and electrolytes lost during sweating. Two sources found that the commercially-prepared drinks were absorbed as fast or faster than water.\textsuperscript{105}

The effects of the electrolyte drinks on athletic performances were tested. Two authors found an increase in sweating efficiency and greater thermal equilibrium,\textsuperscript{106} five sources found no significant differences in athletic performances,\textsuperscript{107} and six found that adding glucose to the

\textsuperscript{101}Robinson, pp. 89-90; Westerman, pp. 7-8.
\textsuperscript{102}Westerman, p. 8.
\textsuperscript{103}Man, Sweat and Performance, Broussard; Westerman.
\textsuperscript{104}Campbell.
\textsuperscript{105}Fordtran and Saltin, pp. 331-335; Witten, pp. 87-96.
\textsuperscript{106}Westerman; Costill, "Fluid," pp. 132-136.
\textsuperscript{107}Randolph, Witten, pp. 87-96; Eaves, O'Connor, Wallace.
water and electrolytes would increase endurance performances. 108

The inclusion of milk in an athletic diet or in pregame meals has been criticized; 109 however, the studies reviewed showed no detrimental or beneficial effect of milk on running distances between 50 yards and 2 miles or swimming distances from 100 yards to 1 mile. 110


109 Van Huss, p. 120; Nelson, p. 181.

CHAPTER 3

PROCEDURE FOR THE STUDY

Overview of Procedures

Sixteen subjects were tested to study the effects of prehydration before exercising on a bicycle ergometer in a hot and humid environment. Each subject was tested under three prehydration conditions of water, milk, and Quickick, and under a control test of no liquid. Two work bouts of 720 kpm/minute were continued until each subject reached a heart rate of 170 beats per minute. The two work bouts were separated by a ten minute rest period and followed by a fifteen minute recovery period.

The test was conducted in a sauna bath in the Louisiana State University Training Room. The temperature was regulated at 90° F. and the relative humidity kept constant at 85 percent by using a hospital vaporizer. Before and after each work bout, the subjects were seated in an air-conditioned dressing room.

The subjects were instructed not to eat or drink anything three hours prior to testing. Before the work bouts the subject voided his bladder and was weighed. He consumed one of the liquids in a volume equal to one ounce per twenty pounds of body weight. The subject rested for ten minutes to allow for partial digestion of the liquid.
During this rest period the electrodes for the cardio-
tachometer were attached to the sternum and chest of the 
subject.

A three-way analysis of variance was used to test 
for any significant differences between the experimental 
conditions. Graphs depicting average heart rates for each 
experimental condition were compared during rest and recovery.

Personnel Required to Conduct the Study

One person was employed to serve in the dual role 
as laboratory assistant and medical assistant. He was 
responsible for preparing the testing area each day and 
for continual observation and care of the subject during 
the heat stress testing. This assistant was qualified as 
an athletic trainer experienced in treating heat stress 
problems if they should occur. The author was responsible 
for time monitoring and recording all data.

Selection of Subjects

Sixteen male volunteers were used in the study. 
They were members of the Louisiana State University Varsity 
Football Team and were tested during the summer of 1975. 
Each volunteer had been given a rigorous physical examin-
ation conducted by the medical staff of the Louisiana State 
University Athletic Department under the supervision of
Dr. Martin J. Broussard. The subjects' weights ranged from 169 to 241 pounds.

Grouping of Subjects and Testing Order

Subjects were assigned to one of four groups. The groups were then tested in a counterbalanced testing order in an attempt to negate the effects of practice and order of testing on the resulting data. The test sessions were separated by a period of at least five days.

Testing Apparatus

Stop Watch. Two stop watches were used for time measurements during the study. One was used to indicate exercise time and the other to measure rest and recovery periods.

Clock. A small clock was placed in the sauna with the subject and lab assistant for monitoring purposes.

Bicycle Ergometer. A Monark Bicycle Ergometer was used to induce a standard workload of 720 kpm/minute. This was accomplished by setting the force at two kiloponds and exercising at the rate of sixty pedal revolutions per minute.

Metronome. A Seth Thomas metronome was used to establish a pedalling rate of sixty revolutions per minute. This cadence was maintained by setting the metronome weight at 120.
Sauna. A Viking Sauna was used to regulate temperature at 90° F. It was capable of producing temperatures from 80 to 180° F.

Cardio-tachometer. In order to obtain accurate heart-rate measurements, a Model QI-609 Exercise Cardio-tachometer was used in this study. It has two basic components. The preamplifier was attached by shielded leads to the body and was powered by two nine volt batteries. A standard phone plug attached it to the main display unit. This unit was capable of displaying instantaneous or average heart rates, but for this study only the average mode of display was used.

Voltmeter. Since the operation of the cardio-tachometer is dependent upon the correct functioning of the preamplifier, a voltmeter was used to test the voltage levels of its batteries, which must be no less than 8.4 volts per cell.

Scales. A Health-O-Meter scale was used to weigh the subjects to the nearest one-quarter pound.

Humidifier. A vaporizer from the Louisiana State University Infirmary was used to raise the relative humidity in the sauna to 85 percent.

Thermometer. A standard indoor thermometer monitored the temperature, which was maintained at approximately 90° F.

Hygrometer. To measure the humidity a standard hygrometer was placed in the sauna to assure an experimental environment of 85 percent relative humidity.
**Sling Psychrometer.** In order to establish the accuracy of the thermometer and hygrometer a sling psychrometer was used. It contains two thermometers, a wet-bulb and a dry-bulb type. The psychrometer is swung around its base for a minimum of three minutes and readings from both thermometers are recorded. The relative humidity is found by the ratio of the wet-bulb reading to that of the dry-bulb thermometer.

**Chair.** A padded folding chair was used to seat the subject during all rest periods.

**Towels.** The subjects were permitted to towel off excess perspiration as they would during an athletic contest. This aided in preventing moisture from interfering with the proper functioning of the cardio-tachometer.

**Clothing.** The subjects wore only athletic supporters for the testing period. This was the only clothing allowed in order to standardize the amount of exposed body surface and to permit maximum surface area for thermal regulation.

**Procedures Employed before the Bicycle Exercise Bouts**

Prior to entering the sauna for the exercise period, the following procedures were undertaken:

1. Before each testing session the equipment was checked for proper functioning. The humidifier and sauna were in operation for at least two hours prior to testing.
to assure that the chamber reached the appropriate level of 90°F. and 85 percent relative humidity. The cardio-tachometer was operational 20 minutes before being used, and the batteries were tested with the voltmeter.

2. When the subject arrived he immediately voided his bladder and weighed himself nude. Weight was recorded to the nearest one-quarter pound. The subject then drank a volume of prehydration liquid equal to one ounce per twenty pounds of body weight. The subject donned the athletic supporter provided by the investigator and was seated in the chair for a ten minute resting period.

3. During the rest period the cardio-tachometer electrodes were attached to the subject's chest. The subject was informed that he would have two exercise bouts on the bicycle ergometer, pedalling in cadence with the metronome until his heart rate reached 170 beats per minute. He was further informed that the two exercise bouts would be separated by a ten minute rest and rehydration period and followed by a fifteen minute recovery period.

Procedures Employed during the Bicycle Exercise Bouts

1. The subject entered the sauna, and the laboratory assistant adjusted the bicycle seat to its proper height, and started the metronome. At the signal to begin the subject began pedalling the bicycle in cadence with the metronome. At the beginning the belt around the ergometer
wheel was slack, but the lab assistant immediately loaded it with a force of two kiloponds. This produced a standard work load of 720 kpm/minute.

2. At the beginning of the work bout the lab assistant started a large clock with a sweep second hand, which was used for monitoring by the subject and the lab assistant.

3. When the subject began profuse sweating about the head and neck area, the lab assistant towelled him dry to prevent electrical interference with the shielded electrodes.

4. The author was seated in the dressing room monitoring the subject's heart rate on the cardio-tachometer. He used a stop watch with a split-second hand, for use in determining both the minute intervals for monitoring heart rate and also the exercise time. The subject's heart rate was recorded at the end of each minute. Upon reaching 170 beats per minute the subject was instructed to stop pedalling and to sit in the air-conditioned dressing room. The same amount of the prehydration liquid was consumed and the subject then rested for ten minutes. This rest period simulated a time-out or half-time in a competitive sports situation.

5. At the end of each minute of the rest period the investigator recorded the subject's heart rate. The subject then entered the sauna for the second testing period. All procedures were repeated for the identical
second exercise bout. At the time the subject's heart rate reached 170 beats per minute, the second work bout was terminated.

Procedures Employed after the Bicycle Exercise Bouts

1. The subject exited the sauna and was seated in the resting chair. He was instructed not to talk or move about during the recovery period.

2. The author recorded the heart rate at the end of each minute during the recovery period. The subject was towelled dry by the lab assistant as needed.

3. At the end of the fifteen minute recovery period, the subject weighed himself again in the nude and was then excused.

Pilot Study

Three subjects including the author were tested under the experimental conditions. It was found that the humidifier should be in operation at least two hours prior to testing. Through trial and error it was also found that the proper work load on the bicycle ergometer would be two kiloponds at a rate of sixty pedal revolutions per minute. This resulted in a standard work load of 720 kpm/minute.

To avoid electrical interference of perspiration on the body contacts of the cardio-tachometer, it was found that the subject's head, neck, and chest area would have to be towelled dry by the lab assistant.
A three-way analysis of variance was used. The main factors were subject, treatment, and testing order. The time of exercise to criterion heart rate for water, milk, Quickick, and control were compared for the two work bouts. The final mean heart rates at both the rest and recovery periods were compared. In addition the weight losses of the four experimental conditions were compared.

Significant F-ratios for treatment were tested for location using Duncan's New Multiple Range Test. Graphs depicting mean heart rates for each experimental condition were plotted at the end of each minute during both the rest period and recovery period.

Analysis of the Effects of Initial Heart Rate

Analysis of Variance

The analysis of variance for initial heart rate is presented in Table 2. The analysis produced an F-ratio of .46 with 3 and 33 degrees of freedom. This low F-ratio indicated that covariance need not be used in the analysis of test data.

---

Table 2
Analysis of Variance for Initial Heart Rate in the Four Test Conditions

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>5103.50</td>
<td>15</td>
<td>340.23</td>
<td>12.49</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>37.25</td>
<td>3</td>
<td>12.42</td>
<td>.46</td>
<td>NS</td>
</tr>
<tr>
<td>Period</td>
<td>4.12</td>
<td>3</td>
<td>1.37</td>
<td>.05</td>
<td>NS</td>
</tr>
<tr>
<td>Per X Trt</td>
<td>134.12</td>
<td>9</td>
<td>14.90</td>
<td>.55</td>
<td>NS</td>
</tr>
<tr>
<td>Error</td>
<td>899.00</td>
<td>33</td>
<td>27.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6178.00</td>
<td>63</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis of the Effects of the Experimental Conditions on Time of Exercise in Bout 1

Analysis of Variance

The analysis of variance for time of exercise during Exercise Bout 1 is presented in Table 3. This produced an F-ratio of 174.45 for treatment which is significant at the .01 level of probability. In order to determine the location of significance, Duncan's New Multiple Range Test was computed. This information is found in Table 4. All of the treatment variables were significantly different from each other at the .01 level of confidence. Quickick resulted in the longest time, water next, milk, then control.
Table 3

Analysis of Variance for Exercise Times Required to Reach Criterion Heart Rate in Exercise Bout 1

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>979785.44</td>
<td>15</td>
<td>65319.03</td>
<td>113.12</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>302199.81</td>
<td>3</td>
<td>100733.27</td>
<td>174.45^a</td>
<td>.01</td>
</tr>
<tr>
<td>Period</td>
<td>10614.69</td>
<td>3</td>
<td>3538.23</td>
<td>6.13</td>
<td>.01</td>
</tr>
<tr>
<td>Per X Trt</td>
<td>187101.44</td>
<td>9</td>
<td>20789.05</td>
<td>36.00</td>
<td>.01</td>
</tr>
<tr>
<td>Error</td>
<td>19055.56</td>
<td>33</td>
<td>577.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1498756.94</td>
<td>63</td>
<td>23789.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^aP = .01

Order of Testing

The order of testing was tested for significance. Treatment, Period, and Period X Treatment produced significant F-ratios. This indicated that there were differences among periods of testing and that although the treatment differences were significant, they were not uniform for each period of testing and experimental condition.
Table 4

Duncan's New Multiple Range Test for Location of Significance of Difference in Exercise Times Required to Reach Criterion Heart Rate in Exercise Bout 1

<table>
<thead>
<tr>
<th>Mean Exercise Times in Seconds</th>
<th>Critical Difference Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quickick 561.12</td>
<td>66.38&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Water 483.06</td>
<td>144.44&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk 451.19</td>
<td>176.31&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control 627.50</td>
<td>78.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Quickick 561.12</td>
<td>109.93&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>483.06</td>
<td>31.89&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup><sub>P = .01</sub>

Analysis of the Effects of the Experimental Conditions on Heart Rates after the Rest Period

Analysis of Variance

Table 5 presents the analysis of variance for the mean heart rates at the end of the 10-minute rest period. As can be seen, the F-ratio of .17 was not significant.

Graphic Representation of Heart Rates for Experimental Conditions during the Rest Period

Figure 1 depicts graphically the similarity of mean heart rates for the experimental groups at the end of each minute during the rest period.
Table 5

Analysis of Variance for Mean Heart Rates at End of Rest Period

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>4288.75</td>
<td>15</td>
<td>285.92</td>
<td>5.75</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>26.14</td>
<td>3</td>
<td>8.71</td>
<td>.17</td>
<td>NS</td>
</tr>
<tr>
<td>Period</td>
<td>68.20</td>
<td>3</td>
<td>22.73</td>
<td>.46</td>
<td>NS</td>
</tr>
<tr>
<td>Per X Trt</td>
<td>547.78</td>
<td>9</td>
<td>60.86</td>
<td>1.22</td>
<td>NS</td>
</tr>
<tr>
<td>Error</td>
<td>1641.07</td>
<td>33</td>
<td>49.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6571.93</td>
<td>63</td>
<td>104.32</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis of the Effects of the Experimental Conditions on Time of Exercise in Bout 2

Analysis of Variance

The analysis of variance for the group means for exercise times during Exercise Bout 2 is found in Table 6. The F-ratio of 26.27 for treatment with 3 and 33 degrees of freedom is significant at the .01 level.

In order to determine the location of significance, Duncan's New Multiple Range Test was computed for Exercise Bout 2. This information is found in Table 7. The test showed that both the Quickick and water prehydration groups exercised significantly longer than the milk or control groups before reaching a heart rate of 170 during Exercise Bout 2. There was no significant difference between Quickick and water.
Mean Heart Rates Of Experimental Groups After Each Minute Of Rest
Table 6
Analysis of Variance for Exercise Times Required to Reach Criterion Heart Rate in Exercise Bout 2

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>441135.00</td>
<td>15</td>
<td>29409.00</td>
<td>16.14</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>143548.37</td>
<td>3</td>
<td>47849.46</td>
<td>26.27</td>
<td>.01</td>
</tr>
<tr>
<td>Period</td>
<td>9173.62</td>
<td>3</td>
<td>3057.87</td>
<td>1.68</td>
<td>NS</td>
</tr>
<tr>
<td>Per x Trt</td>
<td>51536.50</td>
<td>9</td>
<td>5726.28</td>
<td>3.14</td>
<td>.01</td>
</tr>
<tr>
<td>Error</td>
<td>60113.50</td>
<td>33</td>
<td>1821.62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>705507.00</td>
<td>63</td>
<td>11198.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Order of Testing
The order of testing was tested for significance. Treatment and Period X Treatment both produced significant F-ratios. This indicated that although there were significant treatment differences, there were significant interaction factors between the period of testing and the experimental conditions.
Table 7

Duncan's New Multiple Range Test for Location of Significance of Difference in Exercise Times Required to Reach Criterion Heart Rate in Exercise Bout 2

<table>
<thead>
<tr>
<th>Mean Exercise Times in Seconds</th>
<th>Critical Difference Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quickick</td>
<td>Water</td>
</tr>
<tr>
<td>440.0</td>
<td>430.06</td>
</tr>
<tr>
<td>440.0</td>
<td>356.87</td>
</tr>
<tr>
<td>440.0</td>
<td>328.56</td>
</tr>
<tr>
<td>430.06</td>
<td>356.87</td>
</tr>
<tr>
<td>430.06</td>
<td>328.56</td>
</tr>
<tr>
<td>356.87</td>
<td>328.56</td>
</tr>
</tbody>
</table>

\[ a_p = .01 \]

Analysis of the Effects of the Experimental Conditions on Heart Rates after the Recovery Period

Analysis of Variance

An analysis of variance for the mean heart rates at the end of the 15-minute recovery period is found in Table 8. The F-ratio of .47 is not significant at the .05 level of probability.
Table 8
Analysis of Variance for Mean Heart Rates at End of Recovery Period

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>4392.19</td>
<td>15</td>
<td>292.81</td>
<td>7.59</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>54.47</td>
<td>3</td>
<td>18.16</td>
<td>.47</td>
<td>NS</td>
</tr>
<tr>
<td>Period</td>
<td>63.97</td>
<td>3</td>
<td>21.32</td>
<td>.55</td>
<td>NS</td>
</tr>
<tr>
<td>Per X Trt</td>
<td>331.12</td>
<td>9</td>
<td>36.79</td>
<td>.95</td>
<td>NS</td>
</tr>
<tr>
<td>Error</td>
<td>1273.69</td>
<td>33</td>
<td>38.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6115.44</td>
<td>63</td>
<td>97.07</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Graphic Representation of Heart Rates for Experimental Conditions during the Recovery Period

Figure 2 depicts graphically the similarity of mean heart rates for the experimental groups at the end of each minute during the recovery period.

Analysis of the Effects of the Experimental Conditions on Weight Loss

Analysis of Variance

Table 9 presents the analysis of variance for the mean weight loss for the experimental groups. The F-ratio of .51 for treatment does not meet the test of significance at the .05 level of probability.

Table 10 presents the mean initial weights and weight losses for the experimental conditions.
Mean Heart Rates of Experimental Groups After Each Minute of Recovery

- Water
- Milk
- Quickick
- Control
Table 9
Analysis of Variance for Mean Weight Losses

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject</td>
<td>5.93</td>
<td>15</td>
<td>.40</td>
<td>3.48</td>
<td>.01</td>
</tr>
<tr>
<td>Treatment</td>
<td>.18</td>
<td>3</td>
<td>.06</td>
<td>.51</td>
<td>NS</td>
</tr>
<tr>
<td>Period</td>
<td>1.33</td>
<td>3</td>
<td>.44</td>
<td>3.90</td>
<td>NS</td>
</tr>
<tr>
<td>Per X Trt</td>
<td>3.39</td>
<td>9</td>
<td>.38</td>
<td>3.31</td>
<td>.01</td>
</tr>
<tr>
<td>Error</td>
<td>3.75</td>
<td>33</td>
<td>.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>14.59</td>
<td>63</td>
<td>.23</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10
Mean Initial Weights and Weight Losses of the Experimental Conditions

<table>
<thead>
<tr>
<th>Experimental Condition</th>
<th>Mean Initial Weight</th>
<th>Standard Deviation</th>
<th>Mean Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>204.08</td>
<td>24.29</td>
<td>.41</td>
</tr>
<tr>
<td>Milk</td>
<td>204.30</td>
<td>23.71</td>
<td>.33</td>
</tr>
<tr>
<td>Quickick</td>
<td>203.60</td>
<td>23.56</td>
<td>.48</td>
</tr>
<tr>
<td>Control</td>
<td>201.98</td>
<td>24.05</td>
<td>.64</td>
</tr>
</tbody>
</table>
Summary

The purpose of this study was to compare the effects of prehydration with selected liquids prior to exercise in a hot and humid environment. The primary purpose was to determine if prehydration with Quickick, water, or milk yielded significantly different exercise times before reaching criterion heart rate during a two-bout exercise period. Two secondary purposes were to study recovery heart rates and weight losses.

Sixteen male volunteers from the Varsity Football Team at Louisiana State University served as subjects. Each subject served as his own control since the order of testing was counterbalanced to negate the effects of test sequence or practice. The work period was a two-stage bout of exercise on a bicycle ergometer with the subject pedalling at a work load of 720 kpm/minute. The hot and humid environment was achieved by using a sauna bath and hospital vaporizer which kept the environment at 90°F. and 85 percent relative humidity.
Prior to the test, between exercise bouts and during the recovery period the subjects were seated in an air-conditioned room. Prior to testing, the subject was weighed, drank a volume of liquid equal to one ounce per twenty pounds of body weight, and was seated during the attachment of the cardio-tachometer leads. He then rested for a period of ten minutes to allow for partial digestion of the liquid as well as to achieve a resting heart rate.

The subject then entered the sauna and exercised under a trainer's supervision until reaching a criterion maximum heart rate of 170 beats per minute. The subject exited the sauna for a rest period of ten minutes during which time another volume of liquid equal to the first was consumed. The subject then rested while the heart rate was monitored.

At the end of the rest period the subject re-entered the sauna for the second bout of exercise to the criterion heart rate of 170 beats per minute. Upon reaching the end of the workout period, the subject exited the sauna for a fifteen-minute recovery period while his heart rates was again monitored at the end of each minute. After the recovery period the subject was weighed and was excused.

A three-way analysis of variance was used. The main factors were subject, treatment, and testing order. The time of exercise to criterion heart rate for water, milk, Quickick, and control were compared for the two work bouts. The final
mean heart rates at both the rest and recovery periods were compared. In addition the weight losses for the groups were compared.

Significant F-ratios were tested for location of significance using Duncan's New Multiple Range Test. Graphs depicting mean heart rates for each experimental condition were plotted at the end of each minute during both the rest and recovery periods.

Findings

The findings in this study were as follows:

1. Prehydration with the three liquids produced significantly longer exercise times in Bout 1 than no prehydration.

2. Prehydration produced significantly longer exercise times in Exercise Bout 1 in the following descending order: (a) Quickidk, (b) water, and (c) milk.

3. Quickick and water prehydration produced significantly longer exercise times during the second bout of exercise than the milk or control conditions.

4. There were no significant differences between Quickick and water or between milk and control conditions in Exercise Bout 2.

5. There were no significant differences among conditions with regard to heart rates at the end of the rest period between Exercise Bouts 1 and 2.
6. There were no significant differences among conditions with regard to heart rates at the end of the recovery period.

7. There were no significant differences in weight loss as a result of the experimental conditions.

8. Prehydration with milk elicited no complaints from the subjects involving dryness of the mucous membranes of the mouth, gas in the stomach, nausea, or discomfort.

Discussion

The findings in this study gave support to the purported values of prehydration prior to exercise in a heat stress environment. The results indicated that any of the three liquids would increase performance time when compared to no hydration. However, there were some differences among the specific liquids ingested insofar as the amount of increased exercise times. Of the three liquids tested, Quickick produced the longest performance time, water next, then milk. All of the prehydration conditions were significantly different from each other, and all were superior to the control during Exercise Bout 1. These findings substantiated the claims made by Broussard, deVries, Dr. Martin J. Broussard, Supervisor of Athletic Training at Louisiana State University, personal interview, November 25, 1974.

Westerman,³ and Costill⁴ as to the values of prehydration prior to exercise.

This study confirmed the findings of Costill,⁵ Gillis,⁶ Burt et al.,⁷ Londeree et al.,⁸ and Moroff and Bass⁹ in that they reported an increase in cardiovascular efficiency by the ingestion of water. Although Burt et al.¹⁰

³ Dr. Richard L. Westerman, unpublished study, Northeast Louisiana University, Monroe, 1971-73, p. 4.


⁵ Ibid., p. 132.


¹⁰ Burt, p. 726.
found that water ingested after every 16 minutes produced the longest treadmill exhaustion times, this study reinforced findings of the previously-mentioned authors in that prehydration and early rehydration with water were most desirable.

Several investigators found that water prehydration had no effect upon performance. Costill, Kammer, and Fisher\textsuperscript{11} concluded that marathon performance was unrelated to either fluid replacement or fluid loss during competition in the 1968 Boston Marathon or the U.S. Olympic Marathon Trials. Costill\textsuperscript{12} further studied the effects of fluid replacement during prolonged exercise and found no effects upon the heart rates of four trained subjects. The present study produced evidence which disputed Costill's findings. The basis for the different findings may lie in the nature of the tests, the psychological factors that influence competition, and the tremendously high degree of conditioning required of distance runners.

In relation to electrolyte prehydration, only one of the studies reviewed showed significantly lower heart rates as a result of prehydration. Costill\textsuperscript{13} found

\textsuperscript{11}D. L. Costill, W. F. Kammer and A. Fisher, "Fluid Ingestion during Distance Running," \textit{Archives of Environmental Health}, XXI (October, 1970), 520-525.

\textsuperscript{12}Costill, "Fluid Replacement during and following Exercise," pp. 127-131.

\textsuperscript{13}D. L. Costill, unpublished study, as cited in Costill, "Fluid Replacement during Exercise," 132-136.
significantly lower heart rates on a treadmill test of subjects who were dehydrated 4 percent of their body weight and then rehydrated by water and electrolytes. The present study produced evidence supportive of Costill's findings. The remainder of the studies involving electrolyte prehydration found no significant differences in heart rates on endurance tests or performances in timed events.

The subjects in this study reported no adverse effects of discomfort, stomach distention, reduction in salivary gland activity, cramps, or nausea from the consumption of milk or any of the other liquids. This confirmed the studies reviewed involving milk, all of which found no adverse effects of consuming milk prior to exercise.

There was no significant evidence in any of the previous studies that the inclusion of milk either in the regular diet or as a pre-game meal would either aid or hinder performance. The present study yielded a significantly longer exercise time for the milk group compared to the control group in Exercise Bout 1. None of the other statistical comparisons or related literature lead this investigator to advocate the use of milk in aiding or improving cardiovascular efficiency.

One of the secondary purposes of this study was to observe the effects of prehydration on the recovery heart rate. Since no significant differences among the treatments were found, the results indicated that recovery heart rate was based on factors independent of the type of liquid
ingested, or even whether or not any liquids were ingested. Testing recovery criteria other than heart rates could possibly have produced differing data.

The other secondary purpose was to determine the effects of prehydration on the subjects' weight losses. No significant differences among the conditions were recorded. This finding indicated that possibly the exercise period was too brief or that the gross measurement of weight loss to the quarter-pound was not an adequate determinant of true weight loss.

This study was designed to simulate a competitive situation such as football or basketball where the players have a very short period of time between intense periods of work. It was designed to study the effects of prehydration before work and rehydration during a brief period of rest. An extra burden of high heat and high relative humidity was included to simulate working in a heat stress environment.

The evidence indicates that prehydration prior to work could be a very valuable practice in producing greater cardiovascular efficiency. Since heat illnesses often result in irreversible brain damage, prehydration should be considered most valuable in preventing such illnesses rather than treating them as first aid or emergency room cases after the brain damage has occurred.

Both Quickick, an electrolyte replacement drink, and water produced significantly longer exercise times during both bouts of exercise. Although milk prehydration
produced significant times when compared to a control of no hydration, this was only true for the first bout of exercise and not the second; hence, this investigator was reluctant to recommend milk as a prehydration liquid until further testing.

The lack of evidence that prehydration has any effect in altering recovery heart rates may have indicated that recovery was a function more of prior conditioning and individual differences than of water-electrolyte replacement, especially for the length of the test. The brevity of the test, although to 170 beats per minute, probably influenced the recovery heart rate data and also resulted in no significant weight losses.

It is possible that the Hawthorne Effect may have been in evidence here. Regardless of the fact that 170 beats per minute was used as the criterion heart rate, the psychological effect of having a liquid prior to exercise, especially Quickick, could have influenced the physiological responses. Also, the significant F-ratios for Period and Period X Treatment indicated that even though there were significant differences between treatments, these differences were not uniform for each period of testing and experimental condition.

Conclusions

Within the limitations of this study the following conclusions were made:

1. Prehydration is advised prior to exhaustive
exercise, especially in a hot and humid environment.

2. Quickick and water appear to be equally effective as prehydration liquids.

3. There is no evidence that prehydration will affect recovery heart rates.

4. Although milk is apparently not quite as effective as a prehydration liquid as are Quickick and water, the drinking of milk produces no subjective effects such as nausea, discomfort, fullness, or dryness in the mouth prior to, during, or following exercise.

Recommendations

1. A study should be conducted to compare the prehydration effects of low fat milk with whole milk and water.

2. A study should be conducted to compare the effects of Quickick and other electrolyte solutions, including a placebo such as Kool Aid.

3. Since most of the physiological criteria in this investigation were gross indicators of body functioning, a study should be conducted which compares the effects of prehydration with selected liquids on a microbiological criterion such as plasma sodium concentration.
BIBLIOGRAPHY
BIBLIOGRAPHY

A. BOOKS


B. PERIODICALS


C. THESIS AND DISSERTATIONS


D. SECONDARY SOURCES


E. UNPUBLISHED MATERIALS

Campbell, Dr. James W. Professor of Biology at Rice University, Personal correspondence with Stan Cameron of Quickick International Company, April 12, 1973.


Westerman, Dr. Richard L. Unpublished study, Northeast Louisiana University, Monroe, 1971-73.

F. OTHER


Broussard, Dr. Martin J. Supervisor of Athletic Training at Louisiana State University. Personal interviews on November 25, 1974 and June 9, 1975.

APPENDIX A

TEST DATA SHEET

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>TEST SESSION</th>
<th>TREATMENT</th>
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<tr>
<td></td>
<td>1</td>
<td>Water</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Milk</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Quickick</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Control</td>
</tr>
</tbody>
</table>

WEIGHT: Before ________

After ________

Diff. ________

EXERCISE DURATION: Bout #1 ________ seconds

Bout #2 ________ seconds

Amount of Liquid

RESTING HEART RATE (after 10-minute rest period): ________ bpm.

<table>
<thead>
<tr>
<th>Bout #1</th>
<th>Rest</th>
<th>Bout #2</th>
<th>Recovery Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min.</td>
<td>Rate</td>
<td>Min.</td>
<td>Rate</td>
</tr>
<tr>
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<td>____</td>
<td>1</td>
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<tr>
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<tr>
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<tr>
<td>6</td>
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<tr>
<td>16</td>
<td>____</td>
<td>16</td>
<td>____</td>
</tr>
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</table>
APPENDIX B

COUNTERBALANCED ORDER OF TESTING

<table>
<thead>
<tr>
<th>Group*</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3</th>
<th>Test 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Water</td>
<td>Milk</td>
<td>Quickick</td>
<td>Control</td>
</tr>
<tr>
<td>Milk</td>
<td>Milk</td>
<td>Control</td>
<td>Water</td>
<td>Quickick</td>
</tr>
<tr>
<td>Quickick</td>
<td>Quickick</td>
<td>Water</td>
<td>Control</td>
<td>Milk</td>
</tr>
<tr>
<td>Control</td>
<td>Control</td>
<td>Quickick</td>
<td>Milk</td>
<td>Water</td>
</tr>
<tr>
<td>(no liquid)</td>
<td></td>
<td></td>
<td></td>
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*4 subjects were assigned to each of the testing groups - 16 total.
APPENDIX C

AMOUNTS AND WEIGHTS OF LIQUIDS INGESTED

<table>
<thead>
<tr>
<th>Body Weight</th>
<th>1 oz. per 20 lbs. of Body Weight</th>
<th>Total Fluid Ingestion</th>
<th>Total Weights of Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>170</td>
<td>8.5 oz.</td>
<td>17 oz.</td>
<td>16.5 oz.</td>
</tr>
<tr>
<td>180</td>
<td>9.0</td>
<td>18</td>
<td>17.5</td>
</tr>
<tr>
<td>190</td>
<td>9.5</td>
<td>19</td>
<td>18.5</td>
</tr>
<tr>
<td>200</td>
<td>10.0</td>
<td>20</td>
<td>19.5</td>
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<td>210</td>
<td>10.5</td>
<td>21</td>
<td>20.5</td>
</tr>
<tr>
<td>220</td>
<td>11.0</td>
<td>22</td>
<td>21.5</td>
</tr>
<tr>
<td>230</td>
<td>11.5</td>
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<td>240</td>
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<td>250</td>
<td>12.5</td>
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<td>24.5</td>
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<tr>
<td>260</td>
<td>13.0</td>
<td>26</td>
<td>25.5</td>
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</table>
APPENDIX D

MEAN SCORES FOR EACH TREATMENT FOR EACH TEST CRITERION

<table>
<thead>
<tr>
<th></th>
<th>Resting Heart Rate</th>
<th>Exercise Bout 1</th>
<th>Rest Period</th>
<th>Exercise Bout 2</th>
<th>Recovery Period</th>
<th>Weight Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>66.56</td>
<td>561.12</td>
<td>84.00</td>
<td>430.06</td>
<td>81.87</td>
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<tr>
<td>Milk</td>
<td>66.94</td>
<td>483.06</td>
<td>82.91</td>
<td>356.87</td>
<td>81.03</td>
<td>1.37</td>
</tr>
<tr>
<td>Quickick</td>
<td>68.19</td>
<td>627.50</td>
<td>82.69</td>
<td>440.00</td>
<td>80.25</td>
<td>1.33</td>
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<tr>
<td>Control</td>
<td>68.31</td>
<td>451.19</td>
<td>84.12</td>
<td>328.56</td>
<td>82.72</td>
<td>1.42</td>
</tr>
</tbody>
</table>

N = 16
APPENDIX E

RESEARCH USING HUMAN SUBJECTS
DOCTORAL DISSERTATION
Willam I. Dickens, II

I. Nature of the Study

I wish to study the effects of administering liquids before and during an exercise bout in a simulated summer weather condition. In most heat stress situations, body fluid replacement does not occur until after the exercise bout, i.e., summer football practice, hard labor in industry or construction, etc. My purpose is to study the merits of administering different liquids before exercises and during a rest between two periods of exercise in simulated high heat and humidity.

A. Simulated summer weather condition. - By using a sauna bath and a hospital vaporizer, I have created an artificial environmental chamber which regulates the heat at 90 degrees Fahrenheit and 85% relative humidity. These figures approximately duplicate a typical summer day in which many athletes and persons would be working.

B. Liquids tested - Three liquids will be tested for their prehydration effects on the exercise bout. Water, milk, and Quickick will be the liquids tested as well as a control group of no liquid.

C. Physiological functions to be monitored. The major indicator of the subject's ability to continue working in high heat and humidity is his heart and circulatory system. The heart rate during exercise and recovery will be continuously monitored using a cardiotachometer. The weight loss after exercise will also be computed.

II. Subjects - The subjects will be sixteen male volunteers who are members of the L.S.U. Football Team.

III. Exercise work bout. - The standard exercise bout will consist of two phases of exercise on a bicycle ergometer with a workload of 2 kilopounds at 60 pedal revolutions per minute. This will constitute a constant workload of 720 kg.M/min.
Each phase will end when the subject's heart rate reaches 170 beats per minute. Between the two bouts of exercise there will be a ten minute rest period in an air conditioned room and the subject will be given another quantity of liquid equal to the pre-hydration quantity.

After the second bout of exercise the subject will be observed during a fifteen minute recovery period while his heart rate is monitored.

IV. Safeguards

A. Complete physical examination - each subject has undergone one of the most thorough physical examinations for athletes in the country. It is administered by the L.S.U. Athletic Department medical staff of Dr. Barelle Addis, Dr. Alvin Stander, Dr. C. E. Girod and other specialists under the supervision of Dr. Martin J. Broussard.

B. For safety purposes during the exercise period Mr. Gary Lewis, senior student trainer, will be in the sauna with the subject at all times. He is trained in all phases of athletic training and first aid including heat stress cases.

C. The sauna to be used in the experiment is located within the L.S.U. Athletic Department Training Room. This area ranks as one of the most complete in the nation for its equipment, facilities, safety procedures, and staff training. It is superior to many hospital emergency rooms.

D. The subjects are trained college athletes who are familiar with intensive training. They have experienced training and practice conditions much more severe than the ones to be used in this experiment.

E. To eliminate the possibility of heat stress for the subjects, they will wear only athletic supporters. This attire, when compared to a full football uniform to which they are accustomed, will allow for the maximum reduction of internal body heat. In addition to this, the subjects will rest between the phases of exercise in an air conditioned room.

F. Pilot study - a preliminary study has been completed using three volunteer subjects. All testing procedures are complete and none of the subjects considered the test too severe.
VITA

The author was born in Wilson, North Carolina on December 24, 1944. After graduating in 1963 from R. L. Fike Senior High School in Wilson, he earned a Bachelor of Science Degree in Physical Education in 1967 from East Carolina University in Greenville, North Carolina.

After a year as graduate teaching assistant at East Carolina University, he was awarded the degree of Master of Arts in Education in August, 1968.

The author held the position of Instructor of Physical Education and Coach of Tennis, Football, and Lacrosse at East Carolina University from September of 1968 through May of 1971.

He entered the graduate program at Louisiana State University as graduate assistant in 1971. He also worked with the Athletic Department at Louisiana State University from 1971 until August of 1975.

The author is currently Assistant Professor, and Coordinator of Health and Physical Education at Northern Kentucky University in Highland Heights, Kentucky.
EXAMINATION AND THESIS REPORT

Candidate: William Irvin Dickens, II

Major Field: Health, Physical & Recreation Education

Title of Thesis: Effects of Prehydration with Selected Liquids upon Exercise in a Hot and Humid Environment

Approved:

[Signature]
Major Professor and Chairman

[Signature]
Dean of the Graduate School

EXAMINING COMMITTEE:

[Signature]
[Signature]
[Signature]

Date of Examination:

Dec. 8, 1977