UNIVERSITY OF IBADAN

THIS THESIS SUBMITTED BY

DR. ADEGUN, Joel Adekunle

WAS ACCEPTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY
IN THE FACULTY OF EDUCATION
OF THIS UNIVERSITY
THE EFFECTIVE DATE OF THE AWARD IS

11/12/92

9/02/94
DATE

SECRETARY
POSTGRADUATE SCHOOL

AEROBIC, ANAEROBIC AND HAEMATOLOGIC RESPONSES OF COLLEGE OF EDUCATION MALE STUDENTS TO DEHYDRATION REHYDRATION AND SUPERHYDRATION

BY

JOEL ADEKUNLE ADEGUN
B.Sc. (Ife), M.Ed. (Ibadan)

A THESIS IN THE DEPARTMENT OF PHYSICAL AND HEALTH EDUCATION

Submitted to the Faculty of Education in partial fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY

OF THE

UNIVERSITY OF IBADAN

D E D I C A T I O N

This thesis is dedicated to the Glory of GOD and to evergreen memory of my industrious and beloved mother, Mrs. Rachael Mogbonjubola Adegun, who worked tenaciously, but unable to reap the fruits of her earthly struggle.

ABSTRACT

The purpose of the study was to investigate the influence of dehydration, rehydration and superhydration on the aerobic, anaerobic, haematologic and some related body composition variables in College of Education male students. A repeated measures experimental design was used for the study. The subjects were twenty healthy Physical and Health Education students of Ondo State College of Education, Ikere-Ekiti. They were volunteers certified fit by the physician before they were allowed to take part in the study. The variables tested were maximum oxygen consumption (Maxvo_2), Recovery heart rate, myocardial oxygen consumption, speed, power, packed cell volume (PVC), osmotic fragility, percent body fat and lean body weight.

The subjects were pre-assessed on the selected variables. For the first condition, the subjects were dehydrated so that over 3% of the body weight of each was lost before the exercise and subsequent reassessment. Also, they were allowed two weeks after dehydration for rehydration to take place before being exposed to exercise and evaluation.

For superhydration, the subjects drank 2 litres of water each 30 minutes before the evaluation took place. Nine sub-hypotheses were formulated and tested at significant level of 0.05. The data were analysed, using descriptive and inferential statistics. The descriptive statistics used were mean, range and standard deviation. The inferential statistics was the ANOVA. The method of Scheffe was used to determine where the differences. The results showed significant differences in weight, speed, recovery heart rate, maximum oxygen consumption (Maxvo$_2$), myocardial oxygen consumption as well as the haematologic variables of packed cell volume (PVC) and Osmotic fragility among the three levels of hydration. Superhydration affected only maximum oxygen consumption (Maxvo$_2$), Recovery heart rate, myocardial oxygen consumption, PCV and Osmotic fragility. Other variables were not influenced significantly by the various conditions. It s concluded that dehydration was detrimental to physical performances and red blood cells while superhydration enchanced aerobic capacity.

ACKNOWLEDGEMENT

I wish to register my unalloyed gratitude to my supervisor Dr. V. C. Igbanugo for the wonderful way she handled the work. I thank her for her patience, constructive comments, unfailing and useful suggestions which led to the success of this worthwhile research.

I am also thankful to Professor J. A. Adedeji for his fatherly role towards my academic development. I am particularly grateful to Professor L. O. Amusa for his cordial relationship and for his scholarstic contribution towards the successful completion of this work.

My profound gratitude goes to Professor C. O. Udoh, Dr. O. Owolabi, Dr. (Mrs.) E. I. Nwankwo, Dr. Yomi Awosika and Dr. Omolabi for their encouragement and valuable suggestions towards this work. I am indeed very grateful to the administrative staff of the Department of Physical and Health Education for their contribution at every stage of the programme.

My immence thanks go to the students of the Department of Physical and Health Education, Ondo State College of Education, Ikere-Ekiti who volunteered to be subjects of the research despite the rigour and sacrifice involved.

I am grateful to the Laboratory Technologists in Specialist hospital, Ado-Ekiti and Mr coker of State hospital. Ikere-Ekiti for their contribution and help rendered in the area of haematology.

I am grateful to Dr. Adeniran of the Institute of Physical Education, Obafemi Awolowo University, Ile-Ife, for making his books available. I am also very grateful to my colleagues in the Department of Physical and Health Education, Ondo State College of Education, Ikere-Ekiti. I am particularly grateful to Messrs J. A. Adegboyega and S. A. Jegede for their services during the research.

I acknowledge the unreserved assistance of Dr. S. O. Bandele of the Computer Centre of Ondo State College of Education, Ikere-Ekiti, for his contribution right from the begining to the completion of this work.

The assistance of Mr. Ayo Odewumi, Mr. Tunde Olotu and Mrs Faremi was also very immense, and I am grateful to them.

I am also grateful to all my colleagues in the Faculty of Education, Ondo State University, Ado-Ekiti, for their concern about the work.

I am profoundly grateful to my beloved wife Mrs Olajiire Adegun and my sons Damola, Muyiwa and Yemi for their

patience, understanding and support. May God bless you all.

Joel Adekunle Adegun
Department of Physical and
Health Education
University of Ibadan
IBADAN.

C E R T I F I C A T I O N

I certify that this research was carried out by Mr. Joel Adekunle Adegun in the Department of Physical and Health Education, University of Ibadan.

SUPERVISOR

Dr. V.C. Igbanugo, M.S. (Smith College), Ed. D. (Applied Physiology, Columbia) D.P.E. (London)

TABLE OF CONTENTS

LIST OF PLATES

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Water is one of the prime necessities of life used to meet the body's physiological needs. The body of an average man contains approximately 40 litres of water. Water forms the bulk (about 75%) of all protoplasm and acts as a medium for the various enzymatic and chemical reactions. Water functions as a diluent of toxic wastes, aids in the transport of body nutrients and in the regulation of body temperature (Guthrie, 1975).

Homeostasis is preserved by the balance between the intake and excretion of water in the body. Dehydration and superhydration are conditions that negate balance of fluid in the body. People concerned with sports are recognising the impact of dehydration and superhydration as aspects of physiological stress on the performer and in respect of the potential dangers of these extreme situations.

Dehydration according to Harrison (1970) can lead to weight loss, amounting to two or three pounds per day, dryness of mouth, shrinking of the skin and eyes, decrease in fluid content of the body and decrease in capacity for physical activity. Buskirk and Grasley (1958) in their extensive research found that hyporexia, incoordination, mental dullness, elevated body temperature and fatique of the body can be caused by dehydration.

Some athletes especially those using weight as factor of performance have employed dehyration as a means of losing weight and this is a dangerous practice (Fox and Mathews, 1981). They said further that deliberate cause of excessive water loss through sweating for the purpose of losing weight is uncalled for, it is hazardous and has the risk of serious heat illness, thirst, discomfort, loss of appetite and a drastic reduction of sodium and chloride in the body.

It has been observed among workers that profuse sweating in industries may lead to severe cramps in the muscles of the limbs and of the abdominal wall and this occurence reduces productivity and job performance (Karpovish and Sinning, 1971). On the other hand, when a person drinks a large amount of water according to Smith (1951), a phenomenon called water diuress ensues.

He further said that dehydration may lead to anorexia, weakness, mental apathy, muscular twiching convulsion and even coma Fox and Matthews (1981) also warned that too much water should not be imbibed by athletes at any one time since the athletes may feel uncomfortable under these conditions. Hiller (1989) in his study also reported that dehydration is the most common reason for endurance athletes to need medical assistance. He therefore recommended that the ultra-endurance athletes should maintain proper fluid balance.

Rehydration has been an important phenomenon in replacing water that had been lost during dehydration. Mieschar and Furtney (1989) found that high body temperature, decrease in plasma volume subsided upon rehydration. Over-enthusiastic administration of water according to Robson (1979) can lead to nausea, mental confusion, headache and convulsions; but some researchers advocated unlimited consumption of water by athletes. Blyth and Burt (1961) emphasised that superhydration increased endurance performances. Endurance athletes and runners should be encouraged to frequently ingest fluids during competition and to consume fluid 30 minutes before competition. This is based on the fact that endurance activities last longer and water is needed by these athletes to maintain the necessary water balance in the body.

In Nigeria, the position may be critical because of the tropical nature of the climate. The sun increases the atmospheric temperature, which causes excessive sweating especially during the dry season. It is the aim of this study to investigate the aerobic, anaerobic, and haematologic responses of College of Education male students to dehydration, rehydration and superhydration.

Statement of Problems

Major Problem

People are concerned over the effects of dehydration and superhydration on performance of various sporting activities. Studies conducted by eminent scholars (Parks et al, 1986; Costil and Cote, 1982, Klafs and Arheim, 1975) on these two physiological extremes have shown evidence of their influence on the physical capability of individuals.

Some of these studies carried out on animals (Morimoto et al. 1986; Park et al, 1986; Januszewics et al, 1986). show conflicting results (Matthews, 1966; Robson 1979), and were mostly conducted in countries other than Nigeria. It seems that only few of the studies on humans looked at changes in Anaerobic performance and blood. This study was therefore designed to see whether there would be any significant difference in Aerobic, Anaerobic, Haematologic as well as related body composition variables of College of Education male students as a result of dehydration, rehydration and superhydration.

Sub Problems

Specifically, attempt would be made to answer the following questions:

1. Would there be any significant difference in maximum oxygen consumption (Max Vo_2) " as a result of dehydra-

tion, rehydration and superhydration?

2. Would dehydration, rehydration and superhydration have significant effect on recovery heart rate?

3. Would there be any significant difference in myocardial oxygen consumption as a result of dehydration, rehydration and superhydration?

4. Would there be any significant change in speed as a result of dehydration, rehydration and superhydration?

5. Would there be any significant difference in power as a result of dehydration, rehydration and superhydration?

6. Would dehydration, rehydration and Superhydration have any significant effect on packed cell volume?

7. Would there be any significant difference in Osmotic Fragility as a result of dehydration, rehydration and superhydration?

8. Would percent body fat be significantly affected by dehydration, rehydration and superhydration?

9. Would there be any significant difference in lean body weight (LBW) as a result of dehydrations, rehydration and superhydration?

<u>Major Hypothesis</u>

There would be no significant differences in aerobic, anaerobic, haematologic and the body composition variables as a result of dehydration, rehydration, and superhydration.

Sub Hypotheses

The following sub-hypotheses would be tested:

1. There would be no significant difference in maximum oxygen consumption ($Maxvo_2$) as a result of dehydration, rehydration and superhydration.

2. There would be no significant difference in recovery heart rate as a result of dehydration, rehydration and superhydration.

3. There would be no significant difference in myocardial oxygen consumption as a result of dehydration, rehydration and superhydration.

4. There would be no significant change in speed as a result of dehydration, rehydration and superhydration.

5. There would be no significant difference in power as a result of dehydration, rehydration and superhydration.

6. There would be no significant change in Packed Cell Volume as a result of dehydration, rehydration and superhydration.

7. There would be no significant difference in Osmotic Fragility as a result of dehydration, rehydration and superhydration.

8. There would be no significant difference in percent body fat as a result of dehydration, rehydration and superhydration.

9. There would be no significant difference in lean body

weight (LBW) as a result of dehydration, rehydration and superhydration.

Delimitation of the Study

The study was limited to investigation of the effect of dehydration, rehydration, superhydration on the aerobic, anaerobic, haematologic and body composition variables. The Physical and Health Education male students of Ondo State College of Education, Ikere-Ekiti served as subjects. The subjects were tested on the following variables:

1. Maximum oxygen consumption (Max VO_2) (Estimated)
2. Myocardial oxygen consumption (MVO_2)
3. Recovery Heart Rate
4. Blood Pressure
5. Speed
6. Power
7. Packed Cell Volume (PCV)
8. Osmotic Fragility
9. Body Weight
10. Percent Body Fat
11. Lean Body Weight

The study was carried out in the department of Physical and Health Education, Ondo State College of Education, Ikere-Ekiti, and Haematological laboratory of the Specialist Hospital Ado - Ekiti. The following tools were employed in testing, Health-O-meter beam scale, lange skinfold calipers and anthropometer to determine the weight, height, body density, percent body fat and lean body weight. Stethoscope, sphygnomanometer, micro-haematocrit centifuge were used in determining the heart rate, blood pressure and the Packed Cell Volume of the subjects. The athletic track facility of the Department of Physical and Health Education, Ondo State College of Education, Ikere - Ekiti was used for the 12 minutes run.

The study was also limited to the use of the following statistics for analysing the results: mean, range, standard deviation and Analysis of Variance (ANOVA)

<u>Limitation of the Study</u>

The following limitations were encountered during the course of carrying out the study:

1. Lukewarmness was shown by some of the subjects of the study which might have affected the result obtained.
2. Some of the test evaluated were done on the open sports field. The temperature, humidity, wind velocity could not be controlled. These environmental problems might have slightly affected the values obtained.
3. One of the conditions in the study involved loss of body water without immediate replacement, another condition involved taking of too much water at a time. This caused discomfort and temporary loss of freedom of

movement by the subjects. These situations might have caused the subjects not to exercise up to their full capacity.

4. Subjects were a little apprehensive about the possible physiological effect the experimental conditions could have on them. They were sure that there would not be negative effect on their health.

Significance of the Stúdy

Scientists and people concerned with training of athletes are concerned over the possible effects of dehydration and superhydration on the human body. One must be aware of the significance of these phenomena in sports. The results of this study would form the basis to make appropriate recommendations that coaches could use to prevent problems posed by these physiological extremes.

A knowledge of the effects of dehydration and superhydration on performance that would be revealed by the results of this study may prove useful to coaches and team physicians in planning practice and game procedures as it relates to water balance in the body. Such knowledge would help them to prepare athletes for competition in the hot parts of the world and to watch the water intake of athletes during training sessions and competitions.

It is very important also to use the atmospheric condition as a prevailing factor in schedulling training and competition. The results of this study might clear the air about some errorneous ideas on water intake before and during performances especially among athletes that have multiple events in track and field, and many games to play within short intervals.

There is increasing concern about the effects of various stresses on the Haematologic conditions of athletes. It is hoped that this study would provide useful information for coaches and trainers for proper care of the athletes, safeguarding them against conditions that could adversely affect them.

This area of study appears to be relatively new among researchers in Nigeria, the results of this study may stimulate more studies in the area.

<u>Definition of Terms</u>

<u>Dehydration:</u> The condition that results from excessive loss of water.

<u>Rehydration:</u> The replacement of lost water in the bod during dehydration.

<u>Superhydration:</u> The condition that results when large amounts of water is administered into the body system through drinking.

<u>Packed Cell Volume/Haematocrit Value</u> It is the percentage

of the blood volume that is made up of red blood cells. The normal range is 38 and 50.

Osmotic Fragility: It is the rate of heamolysis of the red blood cells, which is due to osmotic pressure of the surrounding fluid on cell wall as a result of trauma produced by physical stress.

Aerobic: In the presence of oxygen.

Anaerobic: In the absence of oxygen.

Maximum/Oxygen Consumption: Oxygen consumption ($Maxvo_2$) maximal rate at which oxygen can be consumed per minute: the power or capacity of aerobic or oxygen system.

Power: It can be defined as work done per unit time P = Wxt. Where P = Power; W = Work; T = Time (Fox and Matthews, 1981). It is the combination of strength and speed.

Resting Values: Measurements taken before subjects engage in physical performance.

Recovery Values: These are Measurements taken immediately after physical performance.

CHAPTER 2

LITERATURE REVIEW

The purpose of this study was to look at the aerobic, anaerobic and haematologic responses of College of Education male students to dehydration, rehydration and superhydration. Review of the related literature was done under the following headings:

(a) Water and uses

(b) Water balance

(c) Dehydration - causes

(d) Dehydration and Anaerobic work

(e) Dehydration and Aerobic capacity

(f) Dehydration and Body composition

(g) Uehydration and Physiological parameters

(h) Dehydration and Blood

(i) Rehydration and Superhydration

(j) Rehydration, Superhydration and performance

(k) Rehydration, Superhydration and Physiological and Haematologic variables.

(a) <u>Water Uses</u>:

Water is very essential for life, survival is limited to only two or three days without water because death occurs with loss of about 20 percent of body water (Tyler, 1979). Water is used as body builder (Guthrie, 1975) and it is present in the new materials that are synthesized in the body such as glycogen and fat. These materials can only accumulate in the body in the presence of water (Tyler, 1979).

There are many ways in which water is important in the body. It helps in flushing the various body organs and serves as the medium through which the waste products are taken to the kidneys and the skin for elimination from the body. Water is also essential in the lungs for gaseous exchange and generally for the maintenance of body temperature at $37^{o}C$. In digestion, water is used in making the enzymes used in food degradation. Saliva which also contains a lot of water, helps in moving from down the esophagus thus acting as lubricant. Water makes muscles, tendons, cartilage and bones flexible. So adequate amount of water is essential for proper growth and development (Atolagbe, 1986).

Water is the most abundant compound in living cells which usually contain 65-90% of water by weight, due to the polarity and hydrogen-bonding properties of the water molecules. It has several unique features that make it especially well suited to perform its biologic functions. It is a powerful solvent for many ionic compounds and neutral molecules (Tyler, 1979).

Water strongly influences the state of dissociation of the macromolecules of the cell. Thus water not only serves as a dispersing medium but also exerts a major influence on the extracellular fluid (Glyton, 1980). Total body water is distributed between two main compartments, intracellular and extracellular . According to Tyler (1979) the fluid within cells is called intracellular fluid. Since the fluid within each individual cell is fairly constant in composition, the concept of a single intracellular fluid compartment is a useful one, although what we really mean when referring to the intracellular fluid is an aggregate of the fluid present in a huge number of minute seperate compartments.

All the fluid outside ttle cell is collectively termed extracellular fluid, a mixture of (1) plasma, (2) interstitial and lymph fluid (3) dense connective tissue, cartilage and bone (4) transcellular fluids. Guthrie (1975) pointed out that water is about 60% of the total body weight and 70% of the lean mass. All the bones in the body, and the grey matter of the brain contain about 25 and 85 percent of water respectively. The blood is made up of plasma, and Plasma is 90 percent water (Schotchius, et al, 1973).

The wide distribution of water in the body suggests its importance in the body processes. The blinking of the eyes is facilitated by the secretion of tears from the tear gland which helps to moisten the surface of the eyes. The tear that is evenly distributed over the surface of the eye helps to give a clearer image of what is seen (Guyton, 1975).

The water intake comprises the fluid drunk and the water in the food eaten. The water formed by the oxidation of carbohydrate, protein and fat (metabolic water) is also available to the body. The output consists of urine, the water in the feaces and the water evaporated from the skin and lungs.

Passmore and Durning (1955) gave the daily water balance of a young man leading a sedentary life as follows: Intake comprises of water content of solid food 115ml/day, liquid drunk 2180ml/day, and metabolic water 275ml/day making up 2574ml/day. The output consists of urine 1295ml/day. Faecal water 56ml/day, and evaporative water loss 1214ml/day, making a total of 2565ml/day and a water balance of 5ml/day. From this analysis, the water and other fluid drinks are approximately equal to the urine output.

<u>Water Balance:</u>

Guyton (1975) said that about 25 of the 40 litres of fluid in the body are inside the approximately 75 trillion cells of the body and are collectively called intracellular fluids The fluid of each cell contains its own individual mixture of different constituents, but the concentrations of these constituents are reasonably similar from one cell to another. Also the total amount of fluid in the extracellular compartments averages 15 litres in a 70kg adult.

Equilibrium must be maintained between these two compartments for proper balance in the body and Guyton (1975) said that one of the most troublesome of all problems in clinical medicine is maintenance of adequate body fluids and proper balance between the extracellular and intracellular fluid.

Shephard (1982) states that water is lost from the body by four routes, the skin, as sensible and insensible perspiration, the lungs as water vapour in the expired air, the kidneys as urine, and the intestines in the feaces. It is customary to refer to the sum of the dermal loss (exclusive of visible perspiration) and the pulmonary loss as insensible losses. In very hot weather, or during periods of prolonged heavy exercise, water loss in sweat may increase to as much as 300ml/h which could obviously deplete the body fluids rapidly.

Certain conditions may prevail that might affect the amount of water in the body at a particular time. Inadequate water in the body due to loss is termed dehydration, the intake of excess water in the body increases the volume of the water in both the extracellular and intracellular compartments of the body and this conditions are called superhydration. After dehydration, there should be water replacement directly or indirectly of the lost amount during the process of water depletion and this replacement means rehydration. All these are different conditions that could happen when there is disequilibrium in water balance in the body.

Dehydration:

This is a situation whereby the supply of water is restricted for many reasons and when the losses of body water is excessive (Tyler, 1979). Getchell (1979) referred to dehydration as removal of the body water when the body is purposely overheated. Dehydration is associated with varying kinds and degrees of disturbance of salt (sodium chloride) metabolism. In addition to the losses of sodium, there are losses of other electrolytes such as potassium, resulting in changes of the acid-base balance (Harrison,1970).

Water is lost from the body by evaporation from the skin, evaporation from the lungs, or excretion of urine, In all these conditions, the water leaves the extracellular fluid compartment, but on doing so some of the intracellular water pass immediately into the extracellular compartment by osmosis thus keeping the osmolalities of the extracellular and intracellular fluids equal to each other. The overall effect of all these losses will result in dehydration.

Dehydration may be caused by restriction of water intake or by excessive water loss. Restriction of water intake is the commonest cause of dehydration. The deprivation of water is far more serious than the deprivation of food. Man loses approximately 25 percent of his total body water per day (about 1,200 millilitres) in urine, in expired air by insensible perspiration and from the gastrointestinal tract. If in addition to this loss, his loss through perspiration is greatly increased as in the case of the shipwrecked sailor on tropical seas or the athlete performing in a tropical climate within a few hours, the athlete may lose so much body water that he or she may go into state of shock and may die if appropriate steps are not taken.

When swallowing is difficult in extremely ill persons or when people can not respond to the sense of thirst because of age or illness or loss of consciousness, the failure to compensate for the daily loss of body water will rapidly result in dehydration.

Fox (1979) also explained that during heavy physical activity, particularly on hot or humid day, large quantities of water and some salt are lost by the body through sweating. He said further that it is not unusual for athletes to lose fithteen pounds of water during physical activity over a period of 1.5 to 2 hours.

Patients with diabetes insipidus (which results from insufficiency of antidiuretic hormone) are unable to concentrate normal urine and consequently would not maintain normal intake of water and excretion of urine. It has been said that these patients spend their lives running from kitchen to bathroom. The water that they lose in this disease has an extremely low concentration of salt.

Also excessive water loss can occur in persons with extensive burns, a large volume of water may be lost through the damaged skin. Similarly, excessive sweating without adequate water intake can produce severe dehydration. A rare cause of dehydration is loss of water from the lungs in the presence of hyperventilation - excessive rate of breathing.

The normal daily turnover of fluids in the gastrointestinal tract amounts to about eight litres in 2 hours, nearly 20 percent of total body water. In vomiting or diarrhea, large volume of water may be lost, always with an associated loss of electrolytes (e.g. sodium, potassium).

<u>Dehydration and Anaerobic Work</u>:

The ability to jump, sprint, throw shotput, javelin or perform fast starts as would be required are a few examples of athletes converting energy to power. The ability to develop considerable power is a prime factor in athletic success. High speed, intense work of short duration requires immediate energy that can not be attained from aerobic sources (Getchell 1979). Anaerobic means without oxygen, thus anaerobic energy is the output of energy when the oxygen supply is insufficient. Such high energy activities as short sprints and sudden bursts of activity are examples of anaerobic activities.

Briggs and Galloway (1979) emphasized that when water loss amounts to one percent of body weight, the sensation of thirst occurs. If water is not drunk, feeling of discomfort worsen, heart rate and body temperature rise and the ability to work and to think deteriorates. With greater depletion of body watery weakness, disorientation preclude physical efforts.

Burskirk and Grasley (1974) classified water depletion as part of heat disorder that is caused by prolonged sweating which leads to inadequate replacement of body fluid losses. The situation results in excessive thirst, mental dullness, fatique and weakness which affect muscular work. Hageman (1982) said that their research with college wrestlers and that of others have shown significant loss of strength due to 2 - 4% loss of body weight by dehydration. In addition, those studies also demonstrated that upon rehydration, these athletes were not able to attain maximal performance levels of strength, Speed is a variable selected for this study.

The speed is an anaerobic work. The speed tells how fast an object is moving, the distance an object will travel in a given time, but it tells nothing of the direction of movement. Verducci (1980) defines speed as the velocity of the body, parts or an object, that is the rate of motion it is concerned with the time required for a Student to move or swim a given distance. Speed is the rate at which an object moves and can be measured in kilometres per hour. Speed is uniform if an object travels the same distance during every second that it is moving, but speed can be varied according to the forces which are acting on the moving object (Hollis, 1976). Igbanugo (1986) showed that there are two forms of speed: speed of movement of body parts and running speed.

Saltin (1964) in his work found that there was a marked decrease in speed when ten subjeds performed standard exercise test at two submaximal loads and one maximal load before and 90 minutes after dehydration. Heat stress causes a sweat loss which reduces both the water volume and the electrolyte content in the body.

Burskirk, et al (1971) found that dehydration without aclimatization apparently limits a man's ability to work. Ladell (1955) in his study found that when man performs work in heart progressive dehydration commonly develops restilting from excess sweat production over voluntary water replacement, which would lead to loss of speed and impairment of performance.

The effects of heat was negative in a study on four physically fit young men carried out by Greenleaf and Sargent (1965). They found that there was an increase progressively in the feeling of fatique and decrease in speed.

Dehydration might not have an effect on the anaerobic ability of individuals. According to Craig and Cummings (1986), they claimed that although a man deprived of water would eventually become exhausted, but he can undergo a substantial much loss of strength. Costill (1974) observed that a group of men could walk 20 miles in the desert despite a decrease of 7% in their body weight as a result of dehydration. Power was selected as an anaerobic work in this study.

Muscular power according to Matthews (1979) is one's ability to get his body mass moving in the shortest period of time. He further said that power movements include activity that is performed in such a short period of time that oxygen is not required in producing the necessary energy. Muscular power is very important in athletics, Nwankwo (1986) showed that muscular power is fundamental for successful performance of various sports. in most sports activities, the greatest energy produced in the shortest period of time is the prime factor in successful performance.

There are many factors that can affect anaerobic work especially power. The factors are body weight, muscles viscosity, structural and nutritional features such as length of the body part or range of flexibility in the joint.

Briggs and Galloway (1979) found that dehydration of 2% - 4% causes thirsts discomfort, sense of oppression, loss of appetite, lagging pace, flushed skin, impatience, weariness, apathy and emotional instability. All the conditions mentioned above can directly or indirectly affect the anaerobic work of speed and power of man.

Wyndman and Strydom (1969), Buskirk (1968) reported that dehydration severely limits subsequent sweating, places dangerous demands on circulation, reduces exercise capacity and exposes athletes to health hazards associated with hyperthermia, heat stroke, heat exhaustion and muscle cramps.

Hubbard (1979) showed that over-exposure to heat leads not only to decrease in work performance but to a predisposition to heat illness. These disorders are categorised in order of severity as (1) heat cramps (2) heat exhaustion (3) heat stroke. He said further that the most frequent common denominators for all these disorders are heat exposure, loss of water and heat storage, usually reflected by high internal (rectal) temperature. Also he pointed out that the single most important factor for these disorders from a clinical stand point is loss of body water. He concluded that inattention to heat cramps and heat exhaution can lead to heat stroke and finally to death, because of irreversible damage to the central nervous system.

Fox and Mathews (1981) added that even ordinary activities such as cutting grass on an extremely warm day can induce heat illness if proper precautions are not taken. Karpovich (1971) said that it has been demonstrated in industry that in heavy work, especially work that involves exposure to high temperature output is considerably affected.

The influence of high temperature is especially evident when the work is streneous. It has been found that no man under such circumstdnces is able to work continuously, but must take short rests from time to time.

Yaglon (1963) found that men work practically steadily between environmental temperature of 40oF and 75^{0}F, but when it is above 75^{0}F the output falls off gradually untill 80^{0}F is exceeded. From there on, the fall in productivity is rapid. The output of work at 9 of 93^{0}F was only that of 70^{0}F.

It has also been observed that the profuse sweating in industries where men have to work at high temperature may lead to severe cramps in the muscles of the limbs and of the abdominal wall. The anaerobic capacity of the individual is significantly impaired. Studies of individuals suffering from muscles cramps have revealed that besides a dehydration of body tissue, there is an accompanied lowered concentration of sodium and chloride ions in the blood plasma resulting in an absence or a drastic reduction of sodium and chloride in the urine (Karpovish and Sinning, 1971). This is an indication of less energy output for muscular activities.

Dehydration does not change the excitability of the muscle membrane (Costil and Fink, 1974). Nevertheless, maximum isometric strength may be somewhat reduced (Bosco et.al 1968). This presumably reflects water loss from the muscle cytoplasm and associated electolyte disturbances. Elkins et.al (1953) noted that a substantial swelling of the muscles accompanies physical activity due to dehydration.

Dehydration and Aerobic Capacity:

Just as an anaerobic capacity is important in the performance of exercise of short duration, the aerobic capacity is a significant factor in the performance of prolonged activities. This stems from the fact that the aerobic system supplies the majority of energy required of these types of exercises (Fox and Matthews, 1981). The maximum rate at which someone can consume oxygen is the aerobic power of that person.

The higher an athlete's maximal Power the more successfully he or she will perform in the event, provided all other factors that contribute to a championship performance are present.

Maximum oxygen consumption ($MaxVo_2$), recovery heart rate and myocardial oxygen consumption had been found to be affected by dehydration at different intensities. Astrand and Rodahl (1970) regarded the maximum oxygen consumption as the highest oxygen uptake the individual can attain during physical work. Emiola (1982) has asserted that the single best indicator of an individual's cardiovascular endurance is his ability to consume great quantities of oxygen in a physically strenuous situation. Fox and Matthews (1981) defined it as the maximum rate at which oxygen can be consumed per minute. The power or capacity of the aerobic System is determined by the rate at which oxygen can be delivered to exercising skeletal muscles and therefore is limited by two connective systems, pulmonary ventilation and blood circulation and by two diffusing systems, the alveolar capillary and tissue capillary cell system.

Maximal oxygen consumption has been considered to be the primary physiological variable which best explains the capacity of the respiratory and cardiovascular systems during work stress (Custer et al 1977). This phenomenon is largely affected by dehydration which also affects the body homeo-stasis. Blyth and Burt (1967) determined the effects of dehydration upon the duration of all-out runs on the treadmill with the ambient temperature of 120° F. They found that dehydration lowered endurance.

Craiq and Cummings (1966) observed that dehydration had a greater effect on performance. The decrease in performance was in endurance rather than the ability to perform work at the maximal rate.

It is well documented that large sweat losses can dramatically impair performance of endurance athletes (Astrand and Saltin, 1964). It is because of the decrease in performance that is generally thought to be the result of diminished circulatory capacity. Hence it is not surprising that physiologists have concentrated their research on the cardiovascular responses of acute dehydrated man. Infact, it is generally agreed that a sweat loss constituting more than 2% of body weight can significantly reduce plasma volume and impair physical work capacity (Saltin, 1964; Costil and Sparks, 1973). Saltin (1964) found that the measurements of oxygen uptake under normal conditions and after dehydration gave different results. He even found a maximal decrease of 41% in performance of some of his subjects.

Shepherd (1982) found that acute heat exposure has little effect upon the performance of brief bouts of maximal work, particularly if the subject is in good condition. With the exception of Kalusen et al (1967) most authors found no immediate decrease of maximum oxygen intake (Saltin 1964); Saltin and Garggae et al (1972) opined that a decrease of maximum oxygen intake is seen if the body is preheated (Rowell et al 1969; Purney, et al 1970). Karpovish (1971) also found a reduction of aerobic power in the period following heat dehydration. The time of physical work before fatique at a fixed percentage of maximum effort is also shortened after dehydration. But Saltin (1964) maintained that up to 5% of body mass could be lost without change in maximum oxygen intake.

He also showed that there was a definite decrease in capacity to perform extended (2 - 6 min.) heavy work and the performance was significantly more affected after exercise dehydration. The decrease in work time on maximal load then reflects lowered physical work capacity.

Buskirk and Beetham (1960) also pointed out in one of their studies that the pace of the marathon runner was well sustained during his events despite a 2.5 - 7.4% decrease of body mass, many competitors were still capable of final sprint.

Shephard (1982) in his contribution recognised the fact that United States football teams have long-recognised their need for fluid replenishment. The Rome Olympic games stimulated interest in the thermoregulatory problems of track competitors. Fox (1960) pointed out that the rate of sweating and/or the evaporative capacity could be critical to body homeostasis in an endurance runner. Saltin (1964) maintained that oxygen transport in brief bouts (3 - 5 min.) of bicycle ergometer work is apparentely unchanged by dehydration, but the treadmill maximum oxygen intake is significantly reduced.

Dehydration and body Composition:

The variables concerned here are body weight and lean body weight. These variables make up the body composition of an individual. Lean body weight is supposed to be developed and improved upon for good results in performance.

The components of an adult human adipose tissue are 23.2% ash. 0.0078% calcium and 0.031% phosphorus (Guyton, 1978). The amount of fat carried by athletes differ considerable depending upon the sport in question (Daniel, 1974). Boileau and Lohman (1977) evaluated the body fat of various male athletes. They said that the average body fat of College age non-athlete is approxomately 15% for males and 20% for females. Among athletes, regardless of sports preference, the body fat is generally lower for both sexes.

Fox and Matthews (1981) state that the excess percentage of fat is detrimental in two ways

(1) cells do no contribute towards energy production

(2) energy is needed to move the fat.

They further gave example saying that an average girl weighing 60 kilograms (132 Ibs) would possess 15 kilograms (33 Ibs) of fat while the male of the same weight would possess 9 to 10 kilograms (20 - 22 Ibs) of fat. During performance, the female would be carrying 5 - 6 kilograms (11 - 13 Ibs) more of non-energy producing tissue than her male contemporary.

On the other hand, the lean body weight is the total weight minus the weight of the body's fat. Fox (1979) said that the fat-free weight reflects mainly the skeletal muscle mass but also includes the weight of other tissues and organs such as bones and skin. The amount of lean body weight is apparently affected by physical exercise. The body tends to increase its masculature with exercise. Parizkova (1968) showed that from the ages of eleven to fifteen years, boys who are very active had a higher absolute amount of lean body mass, less body fat than boys who are less active.

Saltin (1964) found a decrease in body weight after dehydration. Water depletion may be consciously acute as in American football player or distance runner who sweats profusely. Subacute dehydration occurs when an athlete trains for several days in a very hot environment or attempts to make weight. Tcheng and Tipton (1973) in their data from 747 high school wrestlers found that werestlers in particular may decrease their body mass 3 - 30% by water deprivation.

Weight has been used to assess dehydration in athletes. Shephard (1982) said that the simplest method of assessing dehydration is serial weighing. Sweat clothing and shoes must be removed, the bladder emptied and allowances made for food ingested and faeces passed. If an athletic team is spending several weeks in hot climates, there should be a daily check of body mass as well as urine composition and flow.

When examining wrestling contestants, the observed body mass should be matched with predictions based on body shape (Wilmore and Behnke, 1973). It is also useful to check a wrestler's weight in period of contests for evidence of dehydration. Intense weight reduction during a short period of time may seriously impair performance, it has been observed that in some individuals, a dehydration of as little as 2 % of the body weight causes significant deterioration in work performance (Buskirk, 1968).

Fox and Matthews (1981) observed that dehydration does not affect the percentages of fat in the body. They said that such a practice is in fact very hazardous. They went on further to show that persons who garb themselves in sweatsuits, jackets and other similar clothing in the hot days run the risk of serious heat illness and other health problems. Such persons may think they are melting off some kilograms but infact this practice has nothing to do with the real weight loss. Real weight loss is the loss of body weight, and body fat does not melt.

Kozlowski and Saltin (1964) found an average decrease in body weight (4.1%) under the conditons of rapid dydration imposed on fifteen male medical students. So, the effects of the dehydration are not on the fat or the muscles, but on the water in the body.

If no water is available, the body initially loses about 1 kg. of its mass per day. The affected person is conscious of thirst and weakness, the skin becomes dry, and the eyes are sunken. When 4 kg. of mass is lost, both the kidney and the circulation show signs of failure. Death usually occurs if the water loss exceeds 15kg. (Shephard, 1982).

<u>Dehydration and Physiological Parameters</u>:

For the purpose of this study, the selected physiological parameters are eart rate (Rest and Recovery) and blood pressure (systolic and diastolic). Fox (1970) defined heart rate as the number of times the heart beats per minute. Usually the heart beats between 60 and 90 times per minute are found in untrained male and female subjects, but the rate is generally much lower (40 to 50 beats per minute) in highly trained male and female endurance athletes.

deVries (1970) gave some of the factors that affect the resting heart rate as follows:

Age: The heart rate at birth is approximately 130 beats per flinute, and it slows down with each succeeding year until adolescence. rhe average rate in a resting adult male is approximately 7B beats per minute in the standing position.

Sex Tne resting heart rate in adult females averages 5 to 10 beats faster than adult males under any given set of conditions.

Ingestion of food: The resting neart rate is higherwhile di(géstive processes are in progress than in the postabs,Drptive state. This is also true in exercise, a given exercise load elicits a greater heart rate after a meal.

Emotion: Emotional stress brings about a cardiovascular response that is quite similar to its response to exerçise. An increase in heart rate is the most notable factor and it occurs in all but Fox and Matthews (1981) observed that the heart rate of a trained subject is also lower at any given time than that of his or her untrained counterpart.

Also related to the resting heart rate is the recovery heart rate which could be used to indicate physiological assessment of maximum performance. Cureton and Sterlin (1964) related it to tne utilization of oxygen in the body. Apart from type and intensity of exercise, postural changes and training, heart rate is influenced by body and environment temperature (Amusa and Igbanugo, 1986).

Saltin (1964) found that after dehydration, there was a marked increase in heart rate at the submaximal loads, but at maximal work, after dehydration, no significant change was found in maximal value of heart rate but there was a large reduction in work time.

Karpovich (1971) said that tne heart rate increases with body temperature. An increase in heart rate of 37 beats per minute has been recorded by Bazell (1968) for a rise of 3.6 ^{O}c in rectal temperature. There is rarely an exact parallel between any rise in rectal temperature and pulse rate. It has been observed that there is an increase of 15 beats per minute during reclining and 20 beats during standing for each rise of 10F ^{O}c in rectal temperature (Basell, 1968).

For the same intensity of work, the heart rate is higher with an increase in the environmental temperature. The higher the temperature,, the higher the heart rate. On a hot day, the heart has to do more work because the amount of blood circulating through the skin may be greatly increased. As a result of thisp less oxygen is supplied to working muscles and tactic acid begins to rise in the blood at a much lower intensity of work (Basell, 1968).

The Bureau of mine workers have repeatedly affirmed that the heart rate rather than the rise in environmental temperature apparently determines the extent of discomfort experienced in hot environment. People become uncomfortable after the heart rate exceeds 135 beats per minute (Kärpovish and Sinning, 1971). Brouha (1970) showed that temperature and high humidity have effect upon heart rate. He showed that at atmospheric temprature of 90^{0}F and 95^{0}F and relative humidity of between 65 and 95 percent, the heart rate after exercise does not return to normal immediately, it may take over 45 minutes to return to normal level.

Fox (1979) supported this notion that heat increases heart rate by asserting that the reduced tnermal and vapour pressure graditents of hot humïd environment greatly increase the demands placed upon the circulatory system and sweating mechanism. This is evidenced by greater increase in heart rate and sweating during hot as compared to cool environment.

Blood pressure is the force that moves the blood through the circulatory system. The highest pressure obtained is called the systolic pressure and the lowest the diastolic pressure (Fox and Matthews, 1981). Best and Taylor (1958) said that the maximum or systolic pressure in a young man under ordinary resting conditions is around 130 mm Hg. It may be a little above this value or below and still be considered within the normal range. The minimum or diastolic pressure under similar conditions is around 80 mm Hg.

Certain conditions can cause either rise or fall in blood pressure depending on the situation and magnitude of it. Muscular exercise causes a pronounced temporary rise in the blood pressure, the systolic pressure rising during strenuous exertion to 180 mm Hg or more (Best and Taylor, 1958). Also a rise in temprature of the body or that of the environment will increase the blood pressure of an individual. Karpovish (1971) said that the systolic pressure may either rise or fall because of high temperature, but the diastolic pressure constantly shows a fall due to high temperature.

Sherphard (1982) asserted that circulation adapts to dehydration of 4 - 5% decrease of body mass, but less well to a 7% loss. A parallel may perhaps be drawn with the response to Haemorrhage, a sudden fall of pressure occurs when a critical portion (10%) of the circulating blood volume has been lost. He stated further that factors contributing to the decrease in stroke volume include a depletion of central blood volume, with reduced diastolic filling of the heart.

Dehydration and Blood:

The estimation of the packed cell volume (PCV) is often a valuable guide in diagnosing certain blood diseases. the normal ranges of packed cell volume (PCV) are 38 - 50 percent. Also, the red cell fragility can be used to find the salt concentration at which the cells break up. When Red blood cells are suspended in an isotonic solution of saline, they remain intact. As the salt concentration is decreased (making of hypotonic solution), the membrane of the red blood cells disrupt causing heamolysis, at 0.45 - 0.39 percent and complete haemolysis occured at 0.33 - 0.30 percent. In some pathological conditions there is a great decrease in osmotic fragility causing anaemia (Bake, 1980).

These two selected haematological parameters of packed cell volume and osmotic fragility could be affected by dehydration. Estimates of blood volume are usually based on a combination of haematocrit reading and dilution of an indicator that is freely mixable with the plasma but escapes relatively slowly from the circulation (Sherphard, 1982).

Costill and Saltin (1974) have reported no change in packed cell volume due to dehydration and that 2% to 4% body decrease in weight induced marked shrinkage of the red cells which was also highly related to the increase in plasma osmolality.

Maloiy and Boarer (1971) worked on the response of the somali donkey to dehydration. They found increases in Packed Cell Volume (PCV) and red blood cells (RBC). The packed cell volume percent was 41.3 during dehydration and 34.5 in the control situation.

Water loss is extremely critical because the deficiency immediately affects circulatory and cell functions, and without adequate hydration performances deteriorate and the means of cooling the body during exercise is lost (Hagerman and Hagerman, 1982).

Rehydration and Superhydration:

In a day, about 1,900 litres of blood are Carried to the kidneys (Elbert et al, 1973). This is done in other to get rid of the body's waste product and other indigested poisonous substances. Guyton (1975) showed that only three pints of the fluid that pass through the filtering system of the kidney are excreted as urine. The other fluid are reabsorbed in the body.

The body is hydrated in various ways. Water is present in the foods eaten and beverages drunk either naturally or during meals. Besides, when food is burnt in the body for energy, some amount of hidden Water is released (Harper, 1975). Therefore, according to Atolagbe, (1984), rehydration is to balance up lost water and thus allow for optimum function of the body organ.

If people are deliberately exposed to heat and persistent sweating occurs, then there will be loss of body water. This phenomenum must be alleviated by additional consumption of Water for replacement and this process is termed rehydration.

Briggs and Calloway (1979) stressed that it is important that the water content of the body be replenished regularly to make up for continuous loss of this substance. they further said that the amount needed varies, depending on tne magnitude of water loss.

Overhydration may uccur when large amount of electrolyte-free solutions are administered. More frequently, however, water and electrolytes are both lost and the replacement with only water leads to a deficiency of electrolyte in the presence of normal excess total body water.

Water retention is the condition when excess fluid in the body causes overhydration. Water can be added to the extracellular fluid by ingesting and by absorption from the gastro intestinal tract into the blood. Excess water dilutes extracellular fluid, causing it to become hypotonic with respect to the intracellular fluid (Guyton, 1975). Rapid daily gain in weight indicates overhydration. Davidson (1975) showed that a general hazard is that of overloading the body with fluids.

Rehydration, Superhydration and Performance:

Rehydration is inevitable if the body system must respond adequately and effectively. The studies of Gargould

(1971), Tipton and Tcheng (1970) had demonstrated that upon rehydration after dehydration, the athletes used were not able to regain all of the lost weight nor were they able to attain maximal performance levels for strength and endurance recorded during normal hydrated condition.

Davidson et al (1975) stated that a general hazard is that of overloading the body with fluids. Toor et al (1959) exercised eight young adults in the desert and reported that these subjects who fore-drank during walk showed no rise in rectal temperature. But Moroff and Bass (1965) in their study demonstrated that a water load in excess of anticipated sweat loss, when given to unaclimatized human subjects working, produces effects generally regarded to be beneficial.

Young et al, (1959) made use of dogs in their study of water supplement. They found that provision of approximately 1.5 litres of water during work increased endurance capacity of the dogs. They found significant increase 79.8% in working ability associated with water intake.

In normal life where there is no stress, sometimes salt is retained in the body, but the tissue may subsequently become aedematous because of the large amount of water surrounding the cells (Briggs and Galloway, 1978).

Rehydration should be constantly maintained in the body after staying in the heat and water is lost. The water content of the body must be replenished regularly to make up for continuous loss of water in the body.

Water superhydration according to Sherphard (1982), is normally maintained by:

(i) Ingestion of fluid.

(ii) Ingestion of water as a constituent of food and

(iii) Production of water during the metabolism of foods.

A further significant result is the water of hydration produced with glycogen, depending on the extent of glycogen reserves, this can amount to 1000 - 1600 ml of water.

The water balance of a distance runner or team sportsman can be improved if he is preloaded with up to 500 ml of fluid 15 - 30 minutes before exercise commences (Kavanagh and sherphard, 1975). Sherphard (1982) recommended that small quantities of fluid be taken at regular intervals as exercise proceeds. It is important that the fluid be not only drunk, but absorbed.

Pathologically, oedema is caused by excess fluid in the body, but this is not usually apparent until the limb volume is increased to 10 percent or more. Matthew (1966) even encourages the runners to frequently ingest fluids during competition and to consume 400 - 500ml (13 - 17oz) of fluid 10 - 15 minutes before competitions.

Hunts and Pathak (1966) and Hunts (1961) noted that gastric emptying preceeded most rapidly when subjects ingested saline solution. Hunts (1961) also showed that subjects who ingested a single dnd relatively large volume of fluid, would not have possibility of adjustment in tonicity of subsequent gastric emptying.

Rehydration , Superhydration, Physiologic and Haematologic Variables:

The Physiological and Haematological parameters of Resting Heart Rate, Blood pressure, Packed Cell Volume (PCV) and osmotic fragility could be affected by the conditions of rehydration and superhydration. It is known that the prevention of dehydration by prior or concurrent replacement of anticipated sweat losses will reduce the impairments of performance, and Bass (1964) found that over-hydration with 2 litres of water resulted in significantly lower pulse rates than did the control state of hydration. The study was a cross-over design so that each man served as his own control. Maloiy and Boarer (1965) also recorded insignificant change in Packed Cell volume (PCV) of Zebu cattle between the control values of 34.5% and Rehydration value of 35.3%. Also there was no change in hemolysis of the red blood cells obtained in donkey after ingestion of large amount of water.

CHAPTER 3

METHOD AND PROCEDURE

The aim of this study was to determine the effects of dehydration, rehydration and superhydration on the aerobic, anaerobic, selected physiological and haematological variables of College of Education male students. The chapter is presented under the following headings:

(a) Research design

(b) Subjects

(c) Assignments of subjects to treatment

(d) Instrumentation - Equipment and materials

(e) Data collection procedure

(f) Method of data analysis

(A) Research Design

A repeated measure experimental design was used for this study. This is a longitudinal experiment. In a longitudinal experiment a subject serves as his own control and passes through control and experimental periods and where it serves any purpose recovery period.

(B) Subjects

The subjects involved in this were twenty healthy Physical and Health Education students of Ondo State College of

Education, Ikere - Ekiti. They were volunteers who were certified fit by a medical doctor to take part in the study. Those who had abnormal heat rate and blood pressure and were not certified by medical doctor were excluded. Subjects were briefed on the protocol involved, the processes of collecting the data and the level of their involvement. They signed an informed "consent form". As the study involved physiological stress testing, the researcher employed some motivational techniques which were both intrinsic and extrinsic in nature. The subject were encouraged during treatment and honourarium was given to them.

<u>Assignment of Subjects to Treatment</u>

The same subjects were tested under four conditions following the procedure of Blyth and Burt (1961). The four conditions were:

(a) Normal (control) - The subjects were made to go through the assessment of the selected variables with no prior treatment of any kind.

(b) Dehydration - The subjects abstained from water for 24 hours and sat in a hot room of 100 ^{0}F to 120 ^{0}F so that approximately 3% of the body weight of each of them was lost through sweating.

(c) Rehydration- The same subjects after dehydration were allowed a period of two weeks for rehydration. In this condition, they also went through the assessment of the selected variables.

(d) Superhydration - Two weeks following rehydration, the subjects were required to drink 2 litres of water each 30 minutes before the beginning of the evaluation of the selected aerobic, anaerobic, physiological and haematologic variables.

Test Stations

The Anthropometric, aerobic and anaerobic measures were carried out in the Department of Physical and Health Education and sports field of Ondo State College of Education, Ikere - Ekiti. The laboratory of the State Specialist Hospital was used for the Haematologic assessment of the subjects.

Measures

For the proper control of abstinence from water and for sweating to take place, the subjects were camped in a hot room of 100^{0}F to 120^{0}F for 24 hours. They were provided with food in the room but there was no taking of fluid of any kind. They were allowed to play Ludo, cards, Monopoly, Scrabble as well as take part in discussions. They maintained their normal food intake. A generator was used anytime there was power failure during the twenty-four hours for the purpose of maintaining the required room temperature.

INSTRUMENTATION

EQUIPMENT AND MATERIALS

The following were used during the study.

(i) Weight Scale

The researcher used the Owl Biomedical beam scale of Health-O-Meter to measure the weight of the subjects. The scale has a caliberation of 0kg to 160kg. The stadiometer attached to this scale was used to measure the heights of the subjects.

(ii) Stop Watch

The Hanhart brand manufactured by Heuer Trackmaster Swiss was used to measure the speed of the subjects.

(iii) Lange Skinfold Calipers

Lange skinfold caliper model 3003 Was used for the skinfold measurement. This was manufactured by Cambridge Scientific Industries, Inc. Cambrige Maryland. The characteristics of the skinfold caliper include accurate caliberation Of 0 - 60mm and a constant pressure throughout the range of skinfold thickness. Care was taken to ensure that the instrument was properly caliberated and in the closed position, that the caliper registered zero (Verducci, 1980).

(iv) Broad - Blade Anthropometer

The instrument was used to measure skeletal diameter of various sites of the body namely: the biacromial, chest, bi-iliac, bitrochanteric, knees, ankles, elbows and wrists. The caliberation was from 0cm to 61cm.

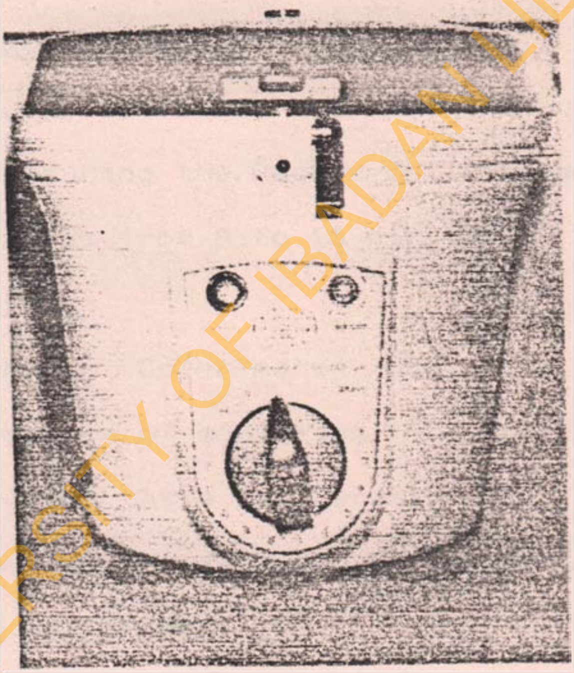
(v) Stethoscope

LAB 600G Gold Plated Sprague Rappaprt type improved stethoscope manufactured for Labtron Scientific Corporation in Japan was used to take the Heart rates and blood pressure of the subjects.

(vi) Sphygmomamometer

The Anaeroid Model was used to measure the resting blood pressure. It has caliberation from 0Hgmm to 250 Hgmm. This model was the Patrica Professional Sphygmomanometer Lab 1800 manufactured for Labtron Scientific Corporation in Japan.

PLATE 1



MICRO-HAEMATOCRIT CENTRIFUGE

(vii) Step Bench

A step bench was used to aid measurement of recovery heart rate. The bench was 20 inches high.

(viii) 400 Meters Athletic Track

The Ondo State College of Education Athletic track was used for the twelve minute run which was used to determine the level of maximum oxygen consumption of the subjects.

(ix) Microhaematocrit Centrifuge

Hawksley model was used for the purpose of duration of measuring the Packed Cell Volume (PCV). The Centrifuge was from 0 to 15 minutes.

(x) Colorimeter

GallenKamp Colorimeter model CS - 2000 was used for the pupose of measuring the osmotic Fragility. This instrument has a Caliberation of 0 - 1.0 optical density and was manufactured in England.

DATA COLLECTION PROCEDURES

1. Weight:- Weight was recorded with subjects dressed only in shorts and without putting on any shoe on a beam scale. Body weight was recorded in kilogrammes. The weight was taken prior to evaluation of all conditions.

2. Height: The height of the subjects were measured to the nearest centimeter using the stadiometer attached to

PLATE 2

COLORIMETER

the Owlbiomedical beam scale according to the procedure of Wilmore and Behnke (1968).

subject stood flat footed with eyes looking straight ahead and with the back in contact with the measuring bar.

3. Anthropometric Measurements:

(a) Skinfold Measurements:

The skinfold measurement was done using the lange skinfold caliper. The loose tissue over the predetermined area to be measured was grasped between the thumb and index finger. The caliper which was held in the right hand was placed about 1 centimeter distance away from the point of pinching. Skinfold measurement was recorded in millimeter. Seven sites were measured from the right side of the subject. Two trials were taken in each area and the mean of both values was used as the score.

The anatomical landmarks of the sites were:

(i) Thigh skinfold: The vertical skinfold on the anterior position of the thigh midway between the hip and knee.

(ii) Subscapular: A fold to the axillary border at the inferior angle of the scapula.

(iii) Triceps: This involved the fold parallel to the length of the arm midway between the acromial and olecranon processes on the posterior portion of the arm.

(b) Measurement of body diameters:

The body diameters were determined by a broad blade anthropometer following the procedure of Verducci (1980). It was done from one predetermined body prominence to another. The soft tissue was compressed so that the contact was bone to bone. The mean of two readings taken was used in calculating the lean body weight. The measurement was taken at the following sites.

(i) Bi-iliac: It was done while standing and between the two lateral projections of the iliac crest.

(ii) Bi-trochanteric: This was done in the standing position. It was measured between the most lateral projections of the greater trochanters.

(iii) Biacromial: With the elbows next to the body, it was measured as the distance between the lateral projection of the acromial processes.

(iv) Chest Width: With the arms abducted, slighty, the distance between the ribs was measured.

(v) Right and left Wrist: The measurement was the distance between the styloid processes of the radius and ulna.

(vi) Right and left elbows: With the elbows joint flexed, the measurement was the distance between the two condyles of the humerus.

(vii) Right and left knees: With the knee flexed at 90 degrees, the distance between the outermost projection of the tibial condyles was measured.

(viii) Right and left ankles: While standing the distance between the two malleoli was measured with the anthropometer pointing at an angle of 45 degrees from the floor.

MEASUREMENT OF PHYSIOLOGICAL VARIABLES

(a) Resting Heart Rate (RHR):

The measurement was taken with the aid of a stop watch and a stethoscope. The stethoscope was used to amplify the heart beat and this was counted for fifteen seconds and multiplied by 4 to get the beats per minute. Two readings was taken and the mean used.

(b) Resting Blood Pressure (RBP):

The measurement was done following the procedure described by Amusa and Igbanugo (1987). With the fore arm in the cradled position, the Cuff was applied snugly but not tightly so that the lower edge of the Cuff is about one inch above the antecubital space. The bell of the stethoscope was placed gently below the back of the elbow over the artery in the antecubital space allowing neither clothing nor the tubing to rub on the receiver. The Cuff was inflated about 30mm.Hg above ausillation pressure or to 200mm.Hg.

The Cuff was then deflated at a rate of 2 - 3mm.Hg per heart beat while watching the mercury column. The pressure at which the 'Korotkoff sounds' were first heard represented the systolic pressure. The Cuff continued to be deflated at the same rate. The sounds under went changes in intensity and quality. The pressure within the compression Cuff indicated by the level of the mercury column at the moment the sounds suddenly became muffled represented the first diastolic pressure. The second diastolic pressure was the pressure within the compression Cuff at the moment the sounds finally disappeared.

MEASUREMENT OF AEROBIC VARIABLES

The Maximum Oxygen Consumption ($MaxVo_2$):

The estimation of maximum oxygen consumption ($MaxVo_2$) was done using the field test of 12 minute run. The procedure developed by Cooper (1972), has been found to be very accurate. He found that the distance covered correlates with treadmill direct measurement of oxygen consumption and aerobic capacity (r = .90). The following procedure was followed.

The 400 meters track was marked off in eights. The subjects were aware that they were allowed to walk if they feel winded, but they were scored on the distance they covered in the run. The subjects were scored on the distance they covered in the run. The subjects were in pairs so that their partners counted the number of laps covered to the nearest completed eight. At the end, the researcher blew a whistle to signal all runners to stop. The laps table was used for checking the oxygen consumption level of the individual subject.

<u>Recovery Heart Rate</u>:

This variable was measured after the subjects had been placed on Harvard step test. The subject stepped up down at a pace of 30 steps per minute. He maintained a four-step counting, the subject led with the same foot during the stepping. A metronome set at 120 beats per minute was used to establish the rate of 30 steps a minute.

The stepping exercise lasted for 5 minutes. Immediately after completing the stepping, the subject sat quietly on a chair. The heart rate was counted 1 to 1.5, 2 to 2.5 and 3 to 3.5 minutes after stepping stopped. The average of the three counts was used.

ANAEROBIC VARIABLES MEASUREMENT

Speed:

This parameter was measured with 50 yard dash being performed by the subjects. The procedure of Verducci (1980) was employed. The subjects took positions in the starting line. On the command 'GO', the subjects ran the distance as quickly as possible passing through the plane of the finish line. The score for speed was the elapsed time between the command 'GO' and the time the chest crossed the plane of the finish line measured to the nearest tenth of a second. The test re-test realability coefficient of this instrument was put at .86 by Fleishman (1964).

Power:

This is the ability to exert a maximal contraction in one explosive act (Hockey, 1973). Vertical jump was employed to measure the explosive power of the subjects following the procedure described by Amusa and Igbanugo (1986). With the subject dressed to the nearest minimum, the weight was taken. The index finger of the subject was chalked with some quantity of magnesium chalk. Subject moved close to the smooth surface of a wall with his side turned to it. He stretched the chalked finger and established a mark on the wall. He then moved about a foot away from the wall with side turned to it. He assumed a semi-crouch position and leaped up as high as possible thus making another mark with the chalked finger, The distance between the former and later marks was recorded.

Three trials were allowed and the average of the trials was found. In order to make the jump reach test more valid as a measure of power, the Lewis Nomogram (1981) was used to determine the anaerobic power from the jump-reach score and body weight.

DETERMINATION OF HAEMATOLOGIC VARIABLE

Haematocrit or Packed Cell Volume (PCV):

It is the percentage of red blood cells in the blood as determined by centrifuged blood. This was done by the assessment of PCV (Packed Cell Volume). The microhaematocrit procedure was employed thus: Blood was collected from the subject at the antecubital vein and put inside a bottle that contains anti-coagulant. A plain capillary tube was filled with the blood and covered. Centrifuging was done by putting it inside the centrifuge for 5 - 6 minutes. Then the microhaematocrit reader was used to calculate the PCV. But it was impossible for the red blood cells to be packed completely together, about 3 to 8 percent of plasma remained entrapped among the cells. Therefore, the true haematocrit (H) average about 93 percent of the measured Haematorcit. The true

Haematocrit (H) is approximately 40% for a normal man and 36 of a normal woman (Guyton, 1981).

<u>Osmotic Fragility</u>

The measurement was done by employing the procedure of Bake (1980). Thirteen test-tubes were labelled 1 - 13 were set up in two racks. Measurement of 5ml Sodium Chloride Concentration was put into tubes Nos. 1 - 12 but 5ml of distilled water was put into tube 13. Addition of 0.05ml of well-mixed aerated blood was made to each tube. Using the blood under test for one rack and the control specimen for the other. The materials were mixed and allowed to stand at room temperature for at least 30 minutes. The tubes were gently centrifuged at 3,000 revolution for 5 minutes and the supernatant fluids were read in a calorimeter. Lysis was recorded as a percentage for each tube.

<u>Equations used</u>.

1. Body density, Sloan equation (Sloan,1967) was used for the purpose of determining body density. $x = 1.1043 - 0.0011327x_2 - 0.001310x_3$ where:

x = Body density

x_2 = Thigh skinfold

x_3 = Subscapuleir skinfold

2. Percentage Body fat:

The equation of Brozek et al. (1963) was used.

$$\% \text{ body fat} = \left(\frac{4.570}{D_b} - 4.142\right) \times \frac{100}{1}$$

where D_b = Body density

3. Lean body weight;

The equation of Behnke and Wilmore (1974) was employed in finding the lean body weight.

LBW = Lean body weight.

4. Myocardial oxygen consumption (MVO_2)

This was estimated from heart rate and systolic blood pressure (Astrand and Rodahl,1977) and was computed by using the equation of Kitamura et al (1972).

$$Mvo_2 = 0.16 \text{ (HR} \times \text{SBP} - 6.0)$$

where HR = Heart rate

SBP = Systolic blood pressure.

Data Analysis:

Descriptive statistics were employed in the treatment of aerobic, anaerobic, athropometric and physiological variables. ANOVA repeated measures was used to test the significance of the various differences. The hypotheses were accepted or rejected at the 0,05 level of significance. In cases of significant effects, the Scheffe' post Hoc test was employed to test critical difference among group means of normal, dehydration, rehydration and superhydration conditions.

CHAPTER 4

RESULTS AND DISCUSSION

The purpose of this study was to investigate the effects of dehydration, rehydration and superhydration on selected aerobic, anaerobic and he haematologic variables in College of Education, Ikere-Ekiti male students. This Chapter presents the results and analysis of findings as well as discussion.

RESULTS AND ANALYSIS

The means, standard deviation and ranges of the physical characteristics and body composition of the subjects for the various conditions are contained in table 1.

The results of the evaluation of the lean body weight for the different conditons were as follows:

A mean of 55.19, standard deviation of 5.952 and a range of 49.9 - 60. 4 was recorded for the normal condition. Dehydration produced a mean of 54.84, standard deviation of 6.046 and a range of 49.40 - 60.20. Rehydration gave a mean of 55.20, standard deviation of 5.970 and a range of 41.1-60.20. Superhydration exhibited a mean of 55.215, standard deviation of 5.890 and a range of 41.0 - 60.40.

TABLE I

PHYSICAL CHARACTERISTICS AND BODY COMPOSITION OF THE SUBJECTS FOR ALL CONDTIONS

	NORMAL			DEHYDRATION			REHYDRATION			SUPERHYDRATION		
VARIANCE	x	SD	RANGE	X	SD	RANGE	X	SD	RANGE	X	SD	RANGE
Age (yrs)	24.90	1.997	21-28	24.90	1.997	21-28	24.90	1.997	21-28	24.90	1.977	21-28
Weight (kg)	65.90	6.189	56.0-79.0	60.85	6.115	51-74	65.80	6.315	56-79.0	66.80	6.542	56.81
Body Fat(%)	7.113	0.917	6.2-9.4	6.88	0.46	6.20-7.60	7.115	0.909	6.1-9.4	7.10	0.806	6.3-990
Low (kg)	55.19	5.952	49.9-60.4	54.84	6.046	49.4060.20	55.20	5.970	41.1-60.2	55.215	5.390	41.0
Height (M)	1.68	0.102	1.50-1.86	1.68	0.102	1.50-1.86	1.688	0.102	1.50-1.86	1.688	0.102	1.50-7.86

TABLE 2

PHYSIOLOGICAL AND AEROBIC CHARACTERISTICS OF THE SUBJECTS FOR ALL CONDTIONS

	NORMAL			DEHYDRATION			REHYDRATION			SUPERHYDRATION		
VARIANCE	x	SD	RANGE	X	SD	RANGE	X	SD	RANGE	X	SD	RANGE
Heart Rate (b/pm)	68.60	8.438	60-84	80.0	5.44	72-88	69.40	7.486	60-80	66.6	8.029	56.0-80.0
Systolic blood Pressure (mmHg)	112.40	5.529	104-120	123.35	4.68	114-132	117.70	5.63	104-120	106.80	7.523	90.0-120.0
Diastolic blood Pressure (mmHg)	72.20	7.565	60-90	85.0	5.74	80-90	71-60	6.443	60-90	71.30	7.928	60.0-90.0
Recovery Heart Rate (b/pm)	107.655	4.897	97.3-163	127.05	9.61	112.0-160.1	107.115	4.503	100-115	102.30	3.799	96-110.0
Maximum Oxygen Consumption(MaxV$_2$)	44.795	5.282	33.4-52.3	40.651	6.33	29.12-50.44	45.755	5.317	34.2-53.8	49.647	4.034	42.30-58.40
Myocardial Oxygen Consumption (MV.02	1222.685	174.1	1030.8-1606.8	1590.31	125.61	135.3.4-181.0.3	1234.335	148.96	992.4-1530.0	1133.375	171.192	915.60-15.0

Also the data on table 2 shows that the normal condition produced a mean Resting Heart rate of 68.60 b/m, standard deviation of 8.438 and a range of 60 - 84 b/m. Dehydration gave a mean of 80, standard deviation of 5.447 and a range of 72-88 b/m. Post rehydration produced a mean of 69.40, standard deviation of 7.486 and range of 60 - 80 b/m. While superhydration had a mean of 66.6, standard deviation of 8.029 and a range of 56.0 - 8.0 b/m.

The results of systolic blood pressure obtained for the different conditions revealed that dehydration showed a mean of 123.35mmHg, the standard deviation of 5.529 and a range of 114.130mmHb. Rehydration produced a mean of 111.70mmHg, standard deviation of 5.63 and a range of 104.120mmHg. Also superhydration yielded a mean of 160.80, standard deviation of 7.52mmHg and a range of 90.0 - 120.0mmHg.

The recorded results for resting diastolic blood pressure for all the conditions were a mean of 72.20, standard deviation of 7.565 and a range of 60 - 90mmHg for normal, dehydration had a mean of 85.0mmHg, standard deviation of 5.749 and a range of 80 - 90mmHg. Rehydration and superhydration showed a mean of 71.60, standard deviation of 6.443, a range of 60 - 90, a mean of 71.30, standard deviation of 7.928, a range of 60.0.90.0mmHg respectively.

The Aerobic, variables evaluated for the purpose of this study were recovery heart rate, maximum oxygen consumption, myocardial oxygen consumption. The data for the various descriptive statistics are also presented in table 2. The results obtained for Recovery Heart rate are as contained in table 2. A mean of 107.655 b/m, standard deviation of 4.503 and a range of 97.3-115 was recorded for normal condition, a mean of 107.115 b/m, standard deviation of 4.503 and a range of 100-115 b/m was recorded for rehydration while the mean of 127.05, standard deviation of 9.612 and a range of 112.0-160.0 was recorded for dehydration. Also superhydration had a mean of 102.30, standard deviation of 3.799 and a range of 96-110.00.

The maximum oxygen consumption (Max Vo_2) of the various conditions was evaluated with the 12 minute run. The normal condition showed a mean of 44.795ml/kg/min, standard deviation of 5.282 and a range of 33.4-52.3. Dehydration produced a mean of 40.651, standard deviation of 6.332 and a range of 29.12 - 50.44 ml/kg/min. Rehydration showed a mean of 45.735, standard deviation of 5.317 and a range of 34.2 - 53.8, superhydration also showed a mean of 49.647 ml/kg/min, standard deviation of 4.034 and a range of 42.30 - 58.40.

TABLE I

ANAEROBIC AND HAEMATOLOGIC CHARACTERISTICS OF THE SUBJECTS FOR ALL CONDTIONS

	NORMAL			DEHYDRATION			REHYDRATION			SUPERHYDRATION		
VARIANCE	x	SD	RANGE	X	SD	RANGE	X	SD	RANGE	X	SD	RANGE
Speed (Secs)	7.035	0.862	5.80-100	8.305	1.08	7.0-11.60	6.905	0.858	1.2-9.6	7.20	0.949	5.8010.45
Power (kgm/secs)	93.10	12.273	76-120	85.40	10.565	70.0-112.0	94.05	12.655	75.0-112.0	92.15	12.240	74.0-120.0
Packed Cell Volume (PCV)	42.76	1.954	39-44	38.45	1.572	260-42.0	42.3	1.689	38.0-45	45.15	1.954	38 - 44
Osmotic Fragility (OF)	30.0	6.10	20-40	34.7	3.80	30-40	31.2	4-60	20.37	35.7	1.8	35-45

The results of myocardial oxygen consumption obtained from the different conditions were a mean of 1226.855, standard deviation of 174.1 and a range of 1030.8 - 1606.8 for the normal condition, a mean of 1590.31, standard deviation of 125.617 and a range of 1353.4 - 1810.3 for rehydration. Rehydration gave a mean of 1234.335, standard deviation of 148.967 and a range of 992.4 - 1530.0. While superhydration showed a mean of 1133.0, standard deviation of 171.192 and a range of 915.60 - 1530.0

50 yard dash was administered for the purpose of evaluating the speed of the subjects. The results of speed in table 3 showed that normal condition gave a mean of 7.035, standard deviation of 0.862 and a range of 5.80 - 10.0 secs. Dehydration showed a mean of 8.305 secs, a standard deviation of 1.08 and a range of 7.0 - 11.60 secs. Also rehydration had a mean of 7.10 secs, standard deviation of 0.806 and a range of 6.3 - 9.40 secs.

The test used for the purpose of evaluating power was sergeant jump. From the results of the different conditions measured (Table 3), normal condition gave a mean of 93.10, standard deviation of 12.273 kgm/sec. and a range of 76 - 120kgm/sec, rehydration gave a mean of 94.05, standard deviation of 12.655kgm/sec and a range of 75.0 - 112.0 kgm/sec.

while superhydration produced a mean of 92.15 kgm/sec, standard deviation of 12.240 and 74.0 - 120.0 kgm/sec.

The results obtained for the Packed Cell Volume (PCV) showed a mean of 42.70, standard deviation of 1.954 with a range of 38 - 44 for normal condition, a mean of 40.15, standard deviation of 1.372 with a range of 39.44.0 for dehydration. Rehydration yielded a mean of 42.3, standard deviation of 1.689 with a range of 38.0 - 45 while superhydration gave a mean of 38.45, standard deviation of 1.572 with a range of 36.0 - 42.0.

The results of the osmotic fragility test showed that the normal condition produced gave a mean of 30.0, standard deviation of 6.10 with a range of 20 - 40. Dehydration showed a mean of 34.7, standard deviation of 3.80 with a range of 30 - 40 percent. Rehydration produced a mean of 31.2 percent, standard deviation of 4.16 and a range of 20 - 35. Superhydration showed a mean of 35.7, standard deviation of 1.80 with a range of 35 - 40 percent.

Table 4

SUMMARY OF ANOVA (Repeated Measure Design) FOR PHYSICAL PHYSIOLOGICAL VARIABLES FOR NORMAL CONDITION AND DEHYDRATION

Variable	SS	DF	MS	F
Weight (kg)	255.025	1	255.025	6.738*
Height (m)	0.000	1	0.000	0.000*
Heart Rate (b/m)	1512.90	1	1512.90	19.996*
Lean body weight (kg)	1.089	1	1.089	0.30
Percent body fat	1.190	1	1.190	2.249
Systolic blood pressure (mmHg)	1199.025	1	1199.025	45.684*
Diastolic blood pressure (mmHg)	1638.400	1	1638.400	36.299*

Key * = significant at 0.05 Level.

Table 5

SUMMARY OF ANOVA (Repeated Measure Design) FOR AEROBIC AND HAEMATOLOGIC VARIABLES FOR NORMAL CONDITION AND DEHYDRATION

Variable	SS	DF	MS	F
Recovery Heart Rate (b/m)	3757.568	1	3757.568	64.571*
Max Vo_2 ml/kg/min	171.731	1	171.731	5.051*
MVo_2	1320973.00	1	1320973.0	57.321*
Speed	16.899	1	16.899	17.694*
Power	592.900	1	592.900	4.522*
Packed Cell Volume	67.600	1	67.600	23.719*
Osmotic Fragility	0.023	1	0.023	8.805*

Key * = significant at 0.05 Level.

Table 4 and 5 show the results of the ANOVA (repeated measures design) for all the selected variables for normal condition and dehydration.

From the results, F ratio of 6.738 obtained for weight was significant. It implies that dehydration had a significant effect on the weight of the subjects. Heart rate had F ratio of 29.996 which was also significant at 0.05 level.

Therefore, dehydration has a significant effect on the resting heart rate.

The systolic and diastolic blood pressure produced F ratios of 45.684 and 36.299 respectively. The results were significant and it implies that dehydration had significant effect on the blood pressure.

The results obtained for all aerobic variables showed significant differences between dehydration and the normal condition. Recovery heart rate had an F ratio of 64.571, Maximum oxygen consumption exhibited F ratio of 5.051, myocardial oxygen consumption showed F ratio of 57.321. These results show that the aerobic capacity of the subject was adversely affected by dehydration.

Also the two anaerobic variables of speed and power showed significant differences over the normal condition. The F ratio of 17.694 was obtained for speed, while F ratio of 4.522 was recorded for Power. These results indicated that there was significant effects of dehydration on anaerobic variables of the subjects.

Packed Cell Volume (PCV) showed F ratio of 23.719 which was significant and the osmotic Fragility also produced a significant F ratio of 8.805. The results indicated that the haematologic variables of Packed Cell Volume and Osmotic Fragility were adversely affected by dehydration in College of Education male students.

Table 6

SUMMARY OF ANOVA (Repeated Measure Design) FOR PHYSICAL AND PHYSIOLOGICAL VARIABLES FOR REHYDRATION

Variable	SS	DF	MS	F
Weight (kg)	0.00	1	0.00	0.00
Height (m)	0.00	1	0.00	0.00
% Body Fat	0.020	1	0.020	0.024
Lean body weight (kg)	0.004	1	0.004	0.000
Heart Rate (b/m)	6.400	1	6.400	0.101
Systolic blood pressure (mmHg)	4.900	1	4.900	0.157
Diastolic blood pressure (mmHg)	3.600	1	3.600	0.73

Key * = significant at 0.05 Level.

Table 7

SUMMARY OF ANOVA (Repeated Measure Design) FOR AEROBIC AND HAEMATOLOGIC VARIABLES FOR REHYDRATION FOR REHYDRATION

Variable	SS	DF	MS	F
Recovery Heart Rate (b/m)	3.137	1	3.137	0.142
Max Vo_2 ml/kg/min	9.800	1	9.800	0.349
$M\dot{V}o_2$	566.903	1	566.903	0.022
Speed	0.081	1	0.081	0.112
Power (kgm/sec)	9.025	1	9.025	0.058
Packed Cell Volume (PCV) %	0.225	1	0.225	0.067
Osmotic Fragility %	0.002	1	0.002	0.543

Key * = significant at 0.05 Level.

The ANOVA (repeated measure design) of all the selected variables for normal condition and rehydration are contained in tables 6 and 7.

The results of weight, percent body fat and lean body weight yielded F ratios of 0.00, 0.024 and 0.000 respectively. This clearly indicated that none of these variables was adversely affected by rehydration.

F ratio of 0.101 was obtained for resting Heart rate which was insignificant at 0.05 level implying that the resting heart rate was not affected by rehydration. The resting blood pressure both systolic and diastolic showed F ratios of 0.157 and 0.073 respectively. The result indicated that rehydration had insignificant effect on the blood pressure (Systolic and Diastolic) of the subjects.

The results of the aerobic variables of Recovery Heart rate, Maximum oxygen consumption (Max Vo_2), Myocardial oxygen consumption (Mvo_2) showed F ratios of 0.142, 0.349 and 0.022 respectively. All these values were not significant at 0.05 level. Therefore these variables were not affected by rehydration.

Speed and power gave F ratios of 0.112 and 0.058 respectively for normal condition and rehydration. The values were insignificant at 0.05 level. This showed that rehydration produced insignificant effects on speed and power of the subjects.

Furthermore, Packed Cell Volume and Osmotic Fragility tests exhibited insignificant F ratios of 0.067 and 0.543 respectively indicating that these haematological parameters were not significantly affected by rehydration.

Table 8

SUMMARY OF ANOVA (Repeated Measure Design) FOR PHYSICAL AND PHYSIOLOGICAL VARIABLES FOR SUPERHYDRATION

Variable	SS	DF	MS	F
Weight (kg)	8.100	1	8.100	0.00
Height (m)	0.392	1	0.10	0.999
% Body Fat	0.064	1	0.064	0.086
Lean body weight (kg)	0.012	1	0.012	0.90
Heart Rate (b/m)	40.00	1	40.00	0.590
Systolic blood pressure (mmHg)	313.600	1	313.600	7.196
Diastolic blood pressure (mmHg)	8.100	1	8.100	0.135

Key * = significant at 0.05 Level.

Table 9

SUMMARY OF ANOVA (Repeated Measure Design) FOR AEROBIC ANAEROBIC AND HAEMATOLOGIC VARIABLES FOR SUPERHYDRATION

Variable	SS	DF	MS	F
Recovery Heart Rate (b/m)	287.836	1	287.836	14.988*
Max Vo_2 ml/kg/min	235.462	1	235.462	10.662*
Mvoz	87385.938	1	87385.938	2.932*
Speed (Secs)	0.156	1	0.156	0.190
Power (kgm/sec)	9.025	1	9.025	0.060
Packed Cell Volume (PCV) %	28.900	1	28.900	9.160*
Osmotic Fragility %	0.033	1	0.033	16.450*

Key * = significant at 0.05 Level.

Tab Tables 8 and 9 contain the summary of ANOVA (Repeated Measure for physical, physiological Aerobic, Anaerobic and Haematologic Variable for normal condition and superhydration. The results showed that the selected physical variables of the college men were not effected by superhydration. Weight gave F ratio of 0.00. All these values were not significant at 0.05 level.

The results of the selected physiological variables of resting heart rate and resting systolic blood pressure, and Diastolic blood pressure gave F ratios of 0.590, 7.196 and 0.135 respectively. Among these obtained values, only systolic blood pressure showed significant effect due to superhydration. Heart rate and Diastolic blood pressure were not significantly affected by superhydration.

The results of Aerobic variables showed F ratios of 14.988 for Recovery heart rate, 10.662 for maximum oxygen consumption while myocardial oxygen consumption recorded 2.932. All these three values obtained were significant at 0.05 level. This implied that the aerobic capacity of the subjects was significantly affected by superhydration. This effect was positive.

The result of speed was an F ratio 0.190 and that of power 0.060. The values obtained were insignificant when superhydration was compared with the normal condition. It indicated that superhydration had no signidicant effects on speed and power of the subjects.

Packed Cell Volume and Osmotic Fragility (%) gave F ratio of 9.160 and 16.450 respectively. These values were significant at 0.05 level. The result indicated that these two haematoligic variables were significantly affected by superhydration. In this case superhydration positively affected these components.

ANALYSIS OF PHYSICAL AND PHYSIOLOGICAL VARIABLES FOR ALL CONDITIONS

The following are the analyses of the selected variables compared under normal condition, dehydration, rehydration and superhydration.

Weight

Table 10 shows the computed analysis of variance (ANOVA) for dehydration, rehydration, and superhydration.

Table 10

ANOVA (REPEATED MEASURE DESIGN) OF WEIGHT FOR NORMAL DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	440.1250	146.7083	3.705*
Within Groups	76	3009.4375	39.5979	-
Total	79	3449.5625	-	-

Value of F + 3.10

Key * = Significant at 0.05 level

The computed F ratio of 3.705 was higher than the table value required for significance at 0.05, indicating a significant difference in weight among the treatments. For the purpose of determining which of the conditions was different, the Scheffe test procedure was applied.

FIG. 1. CHANGES IN WEIGHT DUE TO DEHYDRATION, REHYDRATION AND SUPERHYDRATION

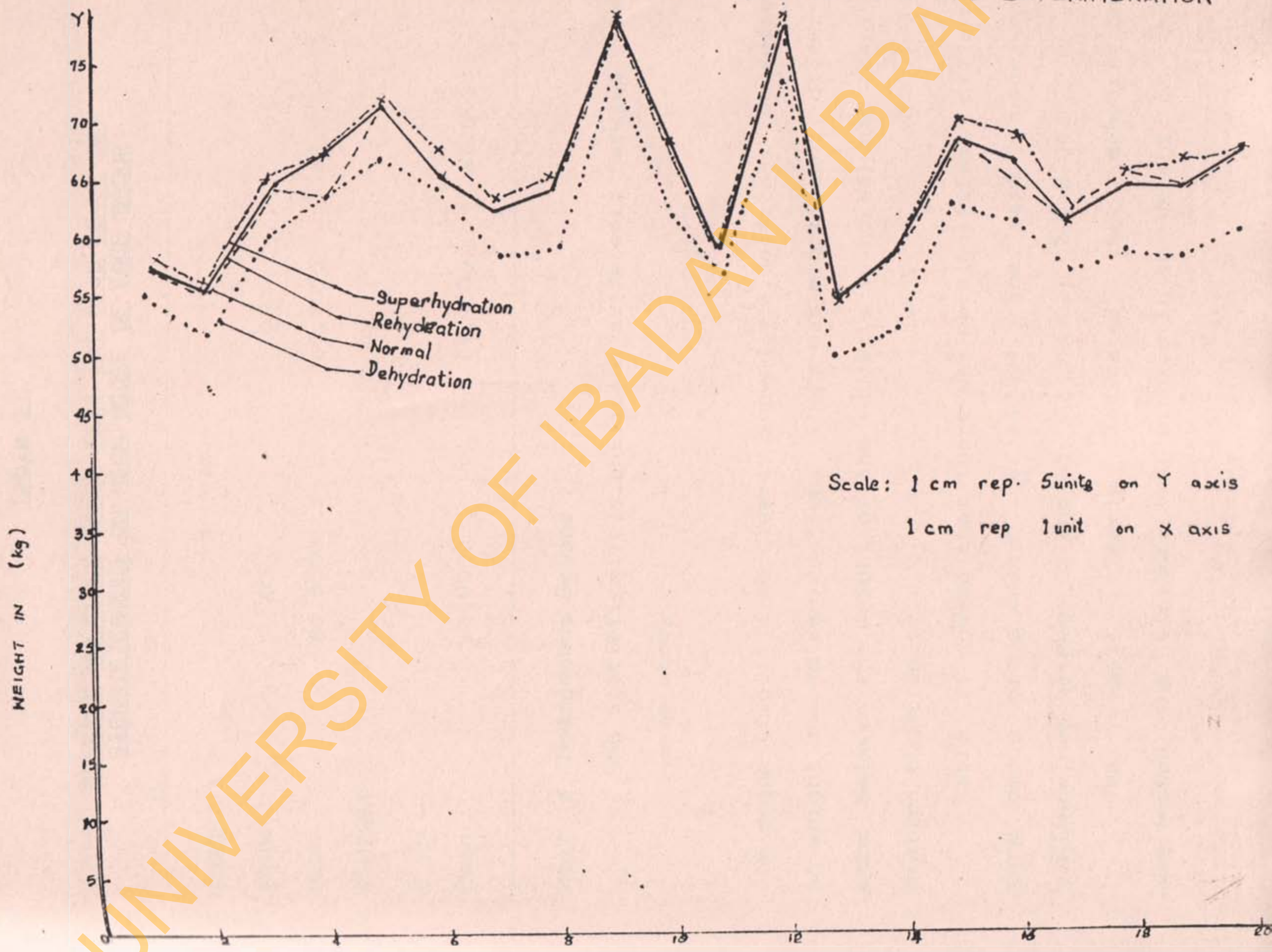


Table 11

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1			
GROUP	02	03	01
Mean	60.8500	65.9090	65.9000
*SUBSET 2			
GROUP	03	01	04
Mean	65.9000	65.9000	65.8000

Key: * Homogenous Groups

No Statistically significant difference between the mean score.

The graph (fig.1) also clearly showed a significant decrease in weight due to dehydration. There was significant difference between the weight of the subjects in normal and dehydration conditions.

Table 11 showed that there was no significant difference among group mean 03, 01 and 04. The main source of variance was between 02 and 03; 02 and 01; 02 and 04.

The result clearly indicated that dehydration manifested the variance that occured in the weight of the subjects for the various conditions.

Percent Body Fat

The computed ANOVA (table 12) for Body fat of the subjects showed the F ratio of 0.760 which was insignificant at 0.05 level.

Table 12

ANOVA OF PERCENTAGE BODY FAT FOR NORMAL DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	1.444	0.481	0.760*
Within Groups	76	48.163	0.634	–
Total	79	49.607	–	–

Percent body fat was not significantly affected by the conditions. Therefore, the subhypothesis which stated that dehydration, rehydration and superhydration would not affect percent body fat was accepted.

Lean Body Weight

Table 13

ANOVA FOR BODY WEIGHT (LBW) FOR NORMAL DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	1.832	0.611	0.017
Within Groups	76	2705.144	35.594	-
Total	79	2706.975	-	-

Table 13 shows that the computed F ratio for lean body weight was 0.017 which was not significant at 0.05 level. This value was far below the value required for significance.

These results strongly suggest that dehydration, rehydration and superhydration had no effect on lean body weight. Therefore, the subhypothesis which stated that lean body weight would not be significantly affected by dehydration, rehydration and superhydration was accepted.

Table 14 shows the computed F ratio of 15.071 for the four conditions which was significant at 0.05 level.

Table 14

ANOVA RESTING HEART RATE FOR NORMAL DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	2502.4375	834.1458	15.071*
Within Groups	76	4206.3125	55.3462	-
Total	79	6708.7500	-	-

Key * = Significant at 0.05 level.

In order to determine where the difference was, the Scheffe procedure was employed (table 15).

Table 15

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1			
GROUP	04	01	03
Means	66.6000	68.6000	65.4000
*SUBSET 2			
GROUP	02		
Means	80.900		

* Homogenous Subset

The Scheffe test applied showed that groups 04, 01 and 03 are in subset 1 while group 2 is in subset 2. This indicated that there was no significant difference among group mean 04, 01 and 03. The main source of variance was between 02 and 04, 02 and 01 and 02 and 03. The findings indicated that the effect of dehydration on the Resting Heart rate was statistically significant. Only dehydration affected Resting heart Rate.

Systolic Blood Pressure:

Table 16

ANOVA OF SYSTOLIC BLOOD PRESSURE FOR NORMAL DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	2926.6875	975.5625	27.717*
Within Groups	76	2675.000	35.1914	-
Total	96	5601.6875	-	-

Key * = Significant at 0.05 level.

Table 16 shows the computed F ratio of 27.717 for systolic blood pressure which indicates significant differnece between the conditions at 0.05 level.

The Scheffe multiple range test (table 17) indicated that group 01 and 03 were in the same homogenous subset, also group 03 and 01 were in the same subset (subset 2).

Table 17

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1		
GROUP	04	03
Mean	106.8000	111.7000
*SUBSET 2		
GROUP	03	01
Mean	111.700	112.400
SUBSET 3		
Group	02	
Mean	123.350	

Key = * Homogenous Groups.

The results on table 17 indicated that the sources of variance was between dehydration and normal condition and between rehydration and superhydration.

Diastolic Blood Pressure

Table 18 contains the analysis of variance for Diastolic blood pressure for the various conditions.

Table 18

ANOVA OF DIASTOLIC BLOOD PRESSURE FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	2661.6250	887.2083	18.232*
Within Groups	76	3698.3750	48.6628	-
Total	96	6360.000	-	-

Key = * Significant at 0.05 level.

The F ratio obtained for the analysis of variance for normal, dehydration, rehydration and superhydration showed a significant value of 18.232mmHg at 0.05 level.

The Scheffe multiple range test (table 19) indicate.

Table 19

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1			
GROUP	04	03	01
Means	71.30	71.60	72.20
SUBSET 2			
GROUP	02		
Means	85.00		

* Homogeneous subset

Groups 04, 03 and 01 are in subset 1 while group 02 belongs to subset 2 and stood apart. It means that superhydration and rehydration had no contribution to the effect shown, also superhydration and rehydration had no significant effects on the Diastolic blood pressure of the subjects. But dehydration which is in Group 02 showed the main source of the significant effect found in the analysis of variance. It is therefore concluded that dehydration affected the diastolic blood pressure of the subjects.

AEROBIC, ANAEROBIC AND HAEMATOLOGIC VARIABLES

The Aerobic, Anaerobic and Haematologic variables evaluated for the purpose of this study were recovery heart rate, Maximum oxygen consumption, Myocardial oxygen consumption, speed, power, Packed Cell Volume (PCV) Osmotic Fragility and Recovery Heart Rate.

The computed F ratio for Recovery Heart Rate is shown in table 20.

Table 20

ANOVA OF RECOVERY HEART RATE FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	7193.2500	2397.7500	63.457*
Within Groups	76	2871.6875	37.7854	-
Total	79	100064	-	-

Key = * Significant at 0.05 level.

The table shows that the F ratio of 63.457 computed for the analysis of variance among the conditions was significant.

Table 21

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1			
GROUP	04	03	01
Means	102.30	107.10	107.66
SUBSET 2			
GROUP	02		
Means	127.05		

The Scheffe multiple range test throws more light on the source of variance. Groups 01, 03, and 04 were in subset 1 while Groups 03 was in subset 2. There was no significant difference between 03 and 01. The main source of variance was between 02 and and 04, 03 and 01. The findings show that Rehydration produced insignificant result, but dehydration had negative effect on the Recovery heart rate while superhydration affected it positively. The graph shown on figure 2, also indicated higher recovery heart rate for dehydration and lower recovery heart rate for superhydration.

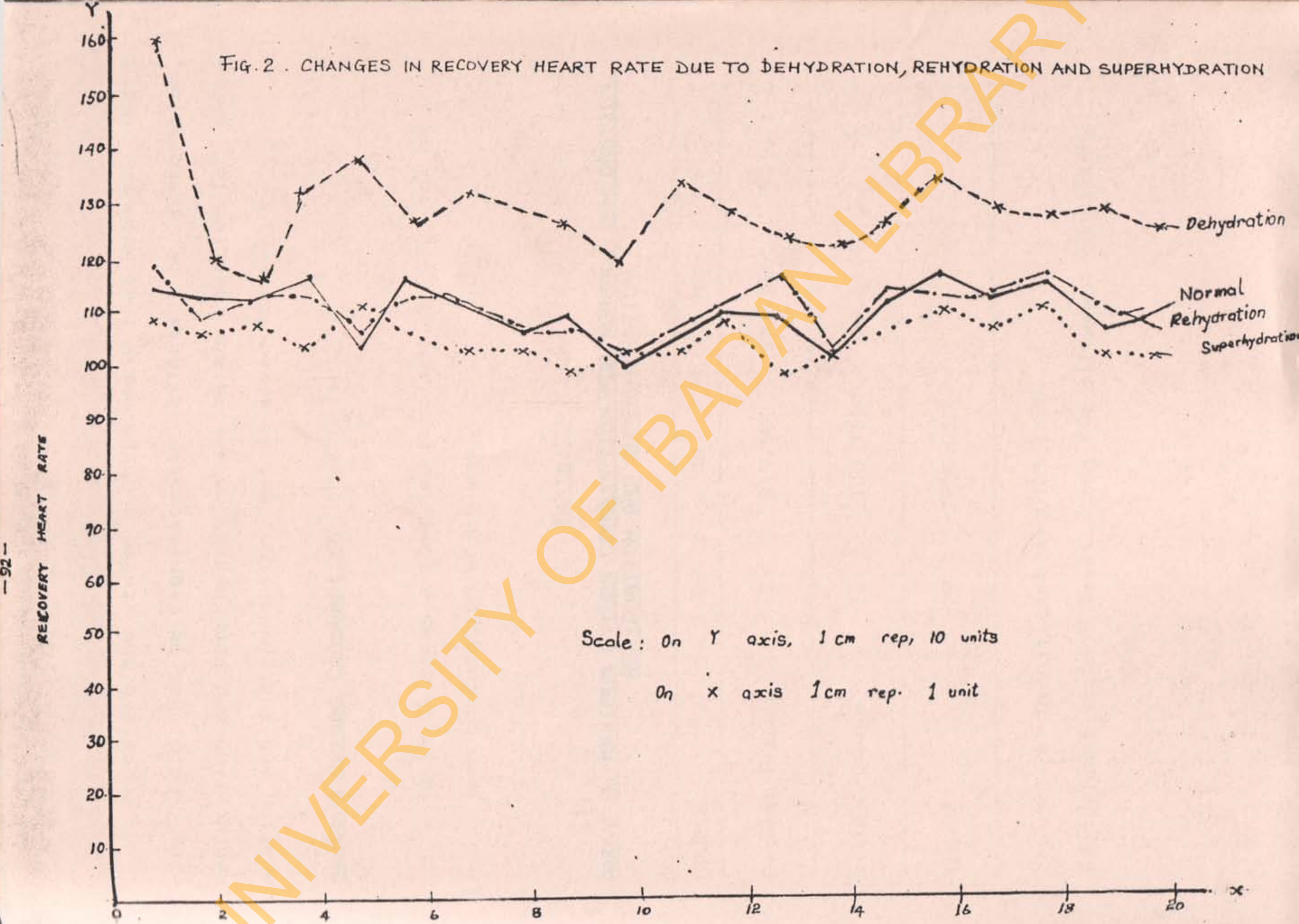


FIG. 2. CHANGES IN RECOVERY HEART RATE DUE TO DEHYDRATION, REHYDRATION AND SUPERHYDRATION

Therefore the stated subhypothesis that Recovery Heart rate would not be significantly affected by dehydration, Rehydration and superhydration was hereby rejected for dehydration and superhydration, but accepted for rehydration.

Maximum Oxygen Consumption (MaxVO_2):

Table 22 shows a computed F ratio of 9.707 for maximum oxygen consumption which was

Table 22

ANOVA OF MAXIMUM OXYGEN CONSUMPTION FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	819.500	273.1665	9.107*
Within Groups	76	2138.7500	28.1414	-
Total	79	2958.2500	-	-

Key = * Significant at 0.05 level.

Significant at 0.05 level among the different conditions.

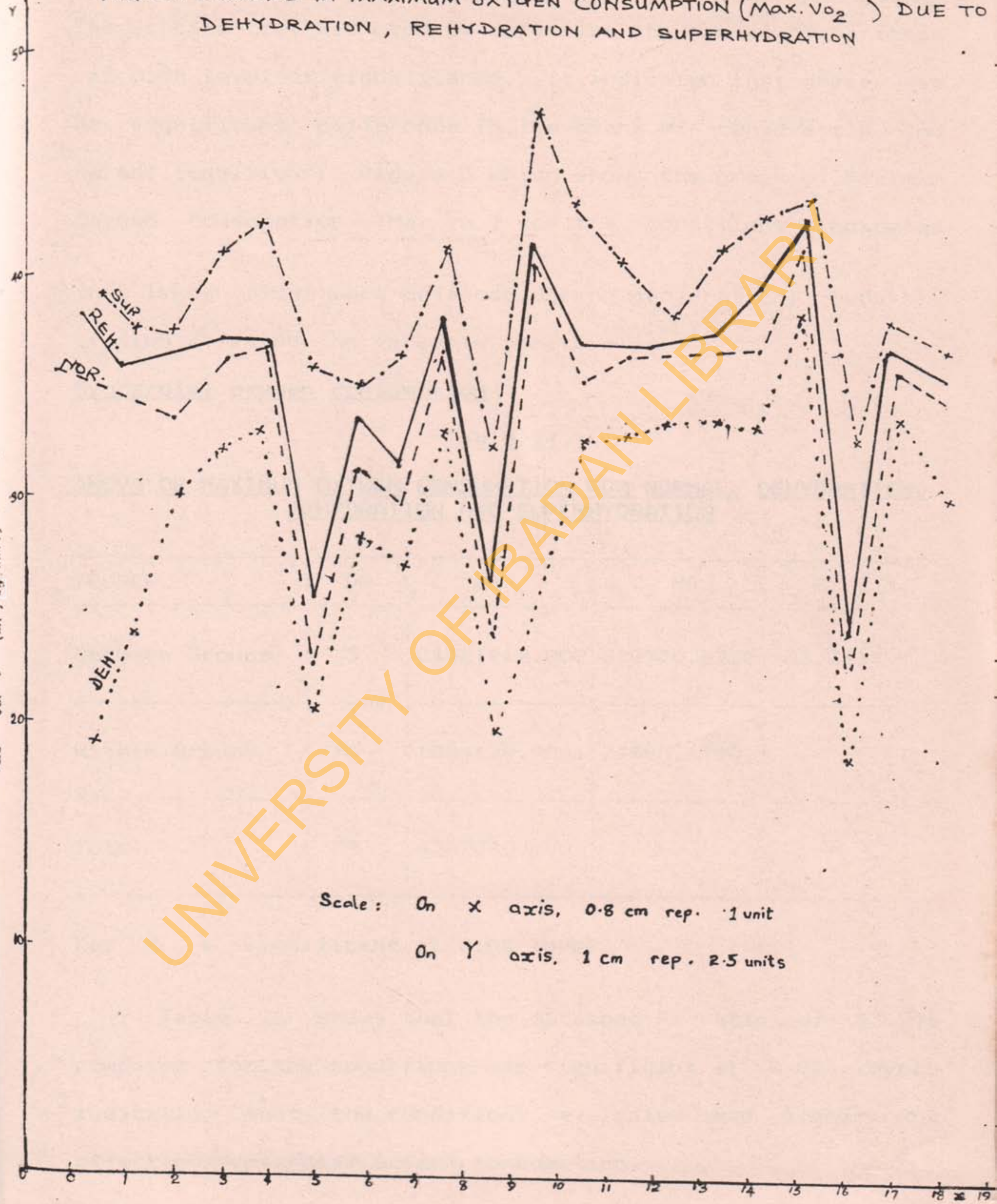
Table 23

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1		
GROUP	02	01
Means	40.6509	44.7949
SUBSET 2		
GROUP	01	03
Means	44.7949	45.7849
* SUBSET 3		
GROUP	03	04
MEAN	45.7849	49.6474

Key * = Homogenous Groups.

FIG.3. CHANGES IN MAXIMUM OXYGEN CONSUMPTION (Max. VO_2) DUE TO DEHYDRATION, REHYDRATION AND SUPERHYDRATION



The Scheffe test was used to determine the source of variance at 0.05 level of significance. It indicated that there was no significant difference in the means of rehydration and normal conditions. Figure 3 which shows the graph of Maximum oxygen consumption (Max vo_2) for the conditions indicated that lower values were obtained during dehydration. Superhydration affected the variable positively.

Myocardial oxygen consumption

Table 24

ANOVA OF MAXIMUM OXYGEN CONSUMPTION FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	2432912.000	810970.6250	33.341*
Within Groups	76	1854128.000	24396.4180	-
Total	79	4287040.000	-	-

Key = * Significant at 0.05 level.

Table 24 shows that the obtained F ratio of 33.241 computed for the conditions was significant at 0.05 level, indicating that the conditions evaluated had significant effect on myocardial oxygen consumption.

Table 25

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1

GROUP*	04	01	03
Means	1133.3749	1226.8538	1229.3838

SUBSET 2

GROUP	02
Means	1590.3083

Key * = Homogenous Groups.

Groups 04, 01 and 03 were in Subset 1, while subset 2 comprises only group 02. The main source of variance was between groups 02 and 04, 02 and 01, 04 and 01. This indicated that dehydration and superhydration produced significant effects on myocardial oxygen consumption. Superhydration and dehydration had significant effects on the variable while rehydration showed no significant effect. The subhypothesis that stated that myocardial oxygen consumption would not be significantly affected by dehydration, rehydration and superhydration was rejected for dehydration and superhydration but accepted for rehydration.

Table 26

ANOVA OF SPEED FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F.
Between Groups	3	25.3711	8.4570	9.631*
Within Groups	76	66.7383	0.8781	-
Total	79	92.1094	-	-

Key = * Significant at 0.05 level.

The F ratio obtained (table 26) was 9.631 and was significant at 0.05 level. It is an indication that one or more of these conditions had significant effect on speed.

Table 27

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1*			
GROUP	03	01	04
Means	6.9950	7.0850	7.2100
SUBSET 2	02		
GROUP	02		
Means	8.3850		

Key * = Homogenous Groups.

In determining the conditions that produced the significant effect, Scheffe procedure (table 27) was applied. The results showed that Subset 1 consists of Groups 03, 01 and 04. There was no significant difference between 03 and 01, 03 and 04. The source of the variance was found in he subset 2 which contains Group 02. The result then implied that Rehydration and superhydration did not produce significant effect. Therefore, the subhypothesis that stated that speed would not respond significantly to dehydration, rehydration and superhydration was rejected for dehydration but accepted for rehydration and superhydration.

Power

Table 28

ANOVA OF POWER FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	925.453	308.484	2.156
Within Groups	76	10871.996	143.053	-
Total	79	11797.449	-	-

Table 28, shows the ANOVA computed for power for the various conditions. The F ratio of 2.156 obtained was insignificant at 0.05 level, implying that the significant effect already shown when dehydration and normal condition were brought together. It could still be stated that rehydration and superhydration had no significant effect on power. Therefore the subhypothesis which stated that dehydration, rehydration and superhydration would not have significant effect on power was rejected for dehydration only but accepted for rehydration and superhydration.

Packed Cell Volume (PCV):

Table 29

ANOVA OF PACKED CELL VOLUME FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

SOURCE	DF	SS	MS	F
Between Groups	3	187.9375	62.6458	22.726*
Within Groups	76	209.5000	2.7566	-
Total	79	397.4375	-	-

Key = * Significant at 0.05 level.

Table 29 shows the F ratio of 22.726 which was significant at 0.05 level. This indicates that Packed Cell Volume was significantly affected by these conditions.

FIG. 4. CHANGES IN PCV DUE TO DEHYDRATION, REHYDRATION AND SUPERHYDRATION

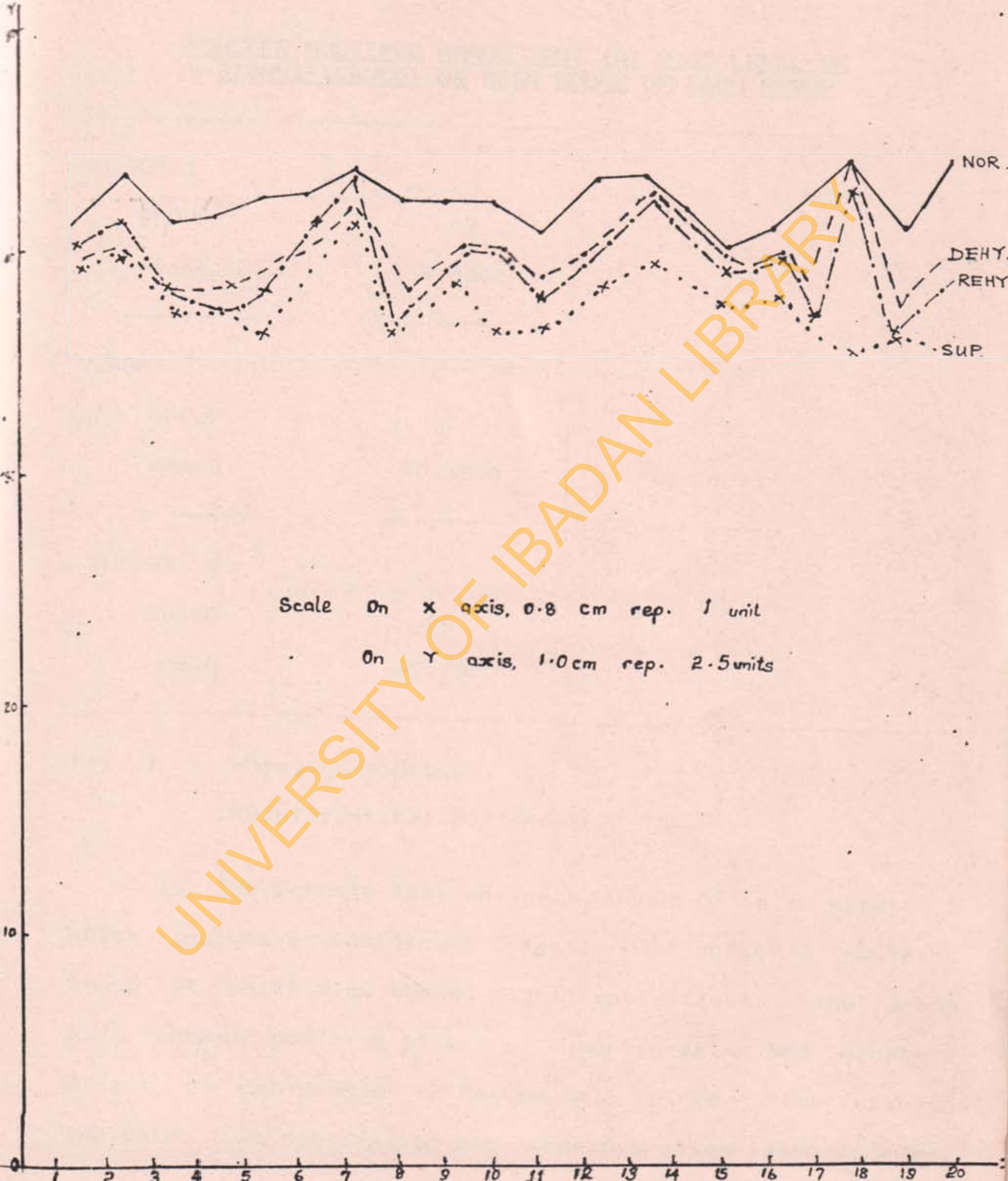


Table 30

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

SUBSET 1

GROUP	02
Means	38.4500

SUBSET 2

GROUP	01	03
Means	40.1500	40.3000

SUBSET 3

GROUP	04
MEAN	42.7500

Key * = Homogenous Groups.

No Statistical Difference.

In the Scheffe test analysis, Group 02 is in subset 1 which implies a significant effect. Also subset 3 contains Group 04 which also showed significant effect. The graph also shows a positive effect of superhydration and negative effect of dehydration on Packed Cell Volume. The results indicate that dehydration and superhydration significantly influenced Packed Cell Volume (PCV).

So the subhypothesis which stated that Packed Cell Volume (PCV) would not be significantly affected by dehydration, rehydration and superhydration was rejected for dehydration and superhydration but accepted for rehydration.

<u>Osmotic Fragility:</u>

Table 31 shows the ANOVA for Osmotic Fragility for normal, dehydration, rehydration and superhydration conditions.

<u>Table 31</u>

<u>ANOVA OF OSMOTIC FRAGILITY FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION</u>

SOURCE	DF	SS	MS	F
Between Groups	3	0.0454	0.0151	8.027*
Within Groups	76	0.1431	0.0019	-
Total	79	0.1885	-	-

Key = * Significant at 0.05 level.

The F ratio computed for the analysis of variance was 8.027 which was significant at 0.05 level.

Table 32

SCHEFFE MULTIPLE RANGE TEST (AT 0.05 LEVEL OF SIGNNIFICANCE) ON MEAN SCORE OF EACH GROUP

* SUBSET 1

GROUP	01	03
Means	0.3000	0.3125

* SUBSET 2

GROUP	03	02
Means	0.3125	0.3475

* SUBSET 3

GROUP	02	04
Mean	0.3475	0.3575

Key * = Homogenous Groups.

The Scheffee multiple range test was used to determine the source of variance. Groups 01 and 03 are in subset 1, 03 and 02 in subset 2 and subset 3 consists of 02 and 04. The source of variance was between normal condition and dehydration, normal condtion and superhydration. So dehydration and superhydration had significant effect on Osmotic Fragility of

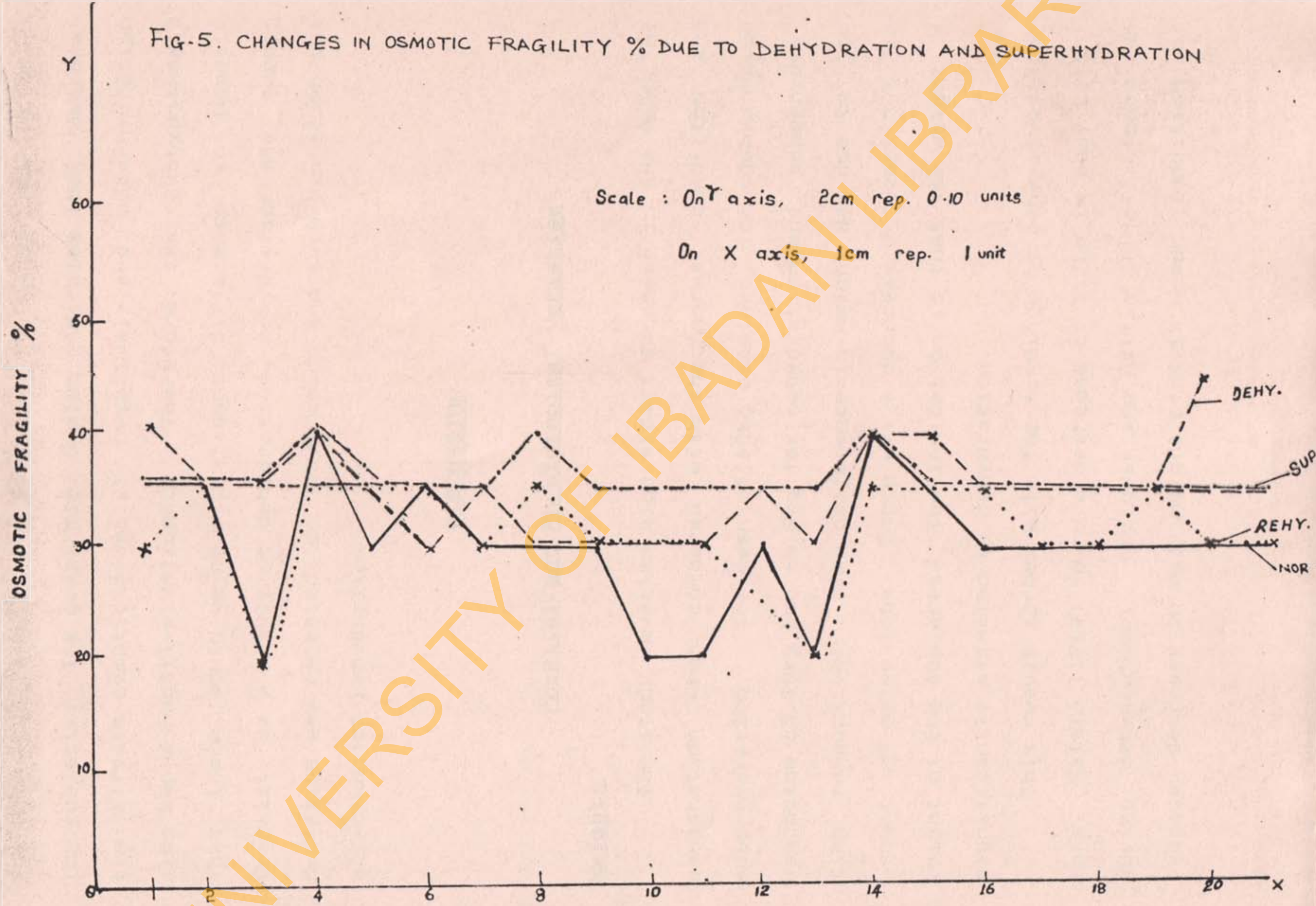


FIG-5. CHANGES IN OSMOTIC FRAGILITY % DUE TO DEHYDRATION AND SUPERHYDRATION
Scale : On Y axis, 2cm rep. 0·10 units
On X axis, 1cm rep. 1 unit
Y
OSMOTIC FRAGILITY %
60
50
40
30
20
10
0
2
4
6
8
10
12
14
16
18
20
X
DEHY.
SUP.
REHY.
NOR

the subjects. The graph fig. 5 also indicates that dehydration affects osmotic fragility negatively and superhydration also had a negative influence. Therefore, the subhypothesis that there would be no significant difference in Osmotic fragility as a result of dehydration, rehydration and superhydration was rejected for dehydration and superhydration but accepted for rehydraiton.

DISCUSSION

Physical and Physiological Variables

Weight:

The study revealed significant decrease in the mean of dehydration when compared with the normal condition and superhydration. The mean of 60kg obtained for dehydration was below 65.90kg and 66.8kg for rehydration and superhydration respectively. The difference in weight was due to the amount of water loss. There was a decrease of over 30% in weight of the subjects. The indication is that the weight is significantly affected by dehydration.

This result agrees with the findings of many investigators. Saltin (1964) found a decrease of 2.7kg in body weight during dehydration. Kozlowsk and Saltin (1964) found an average decrease in body weight of 4.1% under condition of rapid dehydration.

Also the result is in agreement with the finding of Caldwell et.al (1984) who found a mean weight loss of 4.1% in 62 non-endurance athletes following dehydration. Craig and Cummings (1960) used water restriction to achieve dehydration and recorded a loss of 3 % of the initial body weight. Webster and Weltma (1990) recorded a loss of 4.9% of body weight due to dehydration among seven intercollegiate wrestlers. The loss is high because of the high temperature and humidity that prevailed. Rehydration had no effect on weight because it represents the fluid replacement of what had been lost during dehydration. The athletes were properly hydrated which led to the value obtained.

In case of superhydration, the two litres of water imbibed resulted in no significant change in the body weight. Perhaps delay of 30 minutes before the evaluation of the selected variables was done might have reduced the influence of the water consumed on the body weight. It could be stated that dehydration that involves water deprivation and sweating would adversely affect the body weight.

Percent Body Fat

The computed F ratio results of 2.246, 0.246, 0.024 and 0.086 for dehydration, rehydration and superhydration respectively showed that none of these conditions had any significant effect on percent body fat. Water does not contain calories and body fat is only lost through the burning of calories and not by losing water. This assertion is in agreement with that of Getchell (1979), Webster and Weltman (1970) who said that removal of body water is useless for fat reduction and this can be dangerous. Fox (1979), Fox and Mathews (1981) also opposed the deliberate use of excessive water loss through sweating for the purpose of losing body weight.

Rehydration and superhydration merely introduce water into the body. These have been observed to have no effect on the percent body fat. So, imbibing water would not significantly affect the level of percent body fat. In this study, the main factor of manipulation in all conditions (dehydration, rehydration and superhydration) was water and it has no caloric value, so the consumption absorption and even removal of it would not affect the amount of fat in the body significantly.

<u>Lean Body Weight (LBW)</u>

The results of the study gave means of 49.13kg, 48.85kg, 49.20kg and 49.215kg for normal, dehydration, rehydration and superhydration respectively for Lean Body weight (LBW). All the values of the computed ANOVA were not significant.

The lean body weight otherwise called fat free weight is not affected by water. Fox and Mathews (1981) agreed that in order to gain one pound of fat-free weight (muscle) an excess intake of about 2500 kcal. is required coupled with exercise. It is only intake of calories that can affect lean body weight.

So as far as this study was concerned, intake of water and loss of water did not affect the fat-free weight of the body either negative or positively. So water should not be consumed in place of food, because food is the primary variable for building fat and muscle.

Resting Heart Rate:

The results of the Resting Heart Rate evaluation for the conditions revealed computed F ratio of 29.996, 0.101 and 0.590 for dehydration, rehydration and superhydration respectively. The F ratio for the four conditons was 15.071. The Scheffe test further revealed dehydration to be the source of the variation. It means that Resting Heart Rate was significantly affected by dehydration. The result was in line with the findigs of Karpovish and Sinning (1971), Fox and Matthew (1981) and Saltin (1964). Gregory et. al (1988) also recorded heart rate rise from 78 to 119, so did Rastogi et. al (1988) who observed that the working heart rate exhibited an increase of 24 beats per minute among the bangle workers as a result of exposure to thermal radiation. They also recorded an increase of 30.5 b/m in Firemen. An increase in heart rate of 37 b/m was recorded by Bazett (1971) for a rise of $36^{\circ}F$ in rectal temperature.

The method of judging dehydration involved exposure to heat in order to induce sweating. The rise in room temperature increased the body temperature at that time. So the rise in temperature and a water loss produced the corresponding increase in heart rate.

The results of other conditions were not significant. Rehydration was to bring the body to normal position of water balance and the water consumed for the purpose of superhydration was not enough, it was not cold or hot and did not significantly affect the temperature of the body. There is therefore a danger of increased heart rate from dehydration only.

Resting Blood Pressure

Resting Systolic blood pressure showed means of 123.35mmHg, 117.70mmHg and 106.80mmHg for dehydration, rehydration and superhydration respectively.

The results further showed that systolic blood pressure was significantly affected by dehydration and superhydration F ratios of 45.684 and 7.196 were recorded for the two conditons. The Scheffe test revealed that the significant effect produced was due to dehydration and superhydration.

The diastolic blood pressure showed means of 72.20mmHg, 85mmHg, 71.60mmHg and 71.30mmHg for normal dehydration, rehydration and superhydration conditions respectively. The result of Analysis of Variance (ANOVA) revealed that only dehydration had significant effect on diastolic blood pressure. Other conditions had no significant effect. The post Hoc test also revealed that dehydration was the main source of variance.

The results of thid study are in agreement with the findings of Karpovich (1971) who reported a rise in Resting Systolic Pressure and diastolic blood pressure.

Burskirk et. al (1958), Burskirk and Grasley (1974) found that body water deficit led to dehydration and this would severely place dangerous demands on circulation.

Whyndham and Strydom (1969), Shephard (1982) maintained that dehydration affects the blood pressure of an individual. Gregory et.al (1988) also found a decrease in arterial pressure from 115mmHg to 94mmHg ($P \geq 0.01$) during water deprivation.

Recovery Heart Rate:

The results of the computed ANOVA obtained for dehydration, rehydration and superhydration were 64.5711, 0.142, 14.988 respectively. The results further revealed that dehydration and superhydration had significant effect on Recovery Heart Rate.

Herbert and Ribisi (1972) found an increase in the Recovery Heart Rate (170 b/m) in their study. Saltin (1964), found that the heart rate was higher after dehydration and the increase was more marked as the reduction in body weight became larger. Burskirt et.al (1958), found that dehydration affected the circulating blood volume, and rapid elevations in heart rate occur even with moderate work, and early exhaustion ensues. The early demand on the circulation leads to increase in the recovery heart rate and corresponding reduction in exhaustion time. Subjets did not recover rapidly as was the case with the normal condition.

Superhydration had a significant effect on recovery heart rate. This is in line with the finding of Staff and Nilson (1971) who recorded a lower heart rate and correspondingly lower recovery heart rate when water was ingested during treadmill exercise. Also the rate of cooling of a subject following exertion is influenced by his state of hydration (Walder et.al, 1975).

If adequate fluid is provided, the rise in body temperature with effort is appreciably reduced. And increase in body temperature is a major factor in increase of heart rate. So when rehydration and even superhydration occur, there is tendency for heart rate and recovery heart rate to be lowered.

Maximum Oxygen Consumption (Maxvo$_2$)

The results of the maximum oxygen consumption showed means of 44.792 ml/kg/min, 40.651ml/kg/min, 45.755ml/kg/min and 49.64ml/kg/min for normal condition, dehyration, rehydration and superhydration respectively. The results further indicated negative significant effect of dehydration and positive significant effect of superhydration of Maximum Oxygen Consumption (Maxvo$_2$).

Many Researchers found a decrease in maximum oxygen intáke as a result of acute heat exposure especially when the body was preheated (Rowell et al 1969; Pirnay et.al, 1970). Pirnay and Petil (1968) also found a reduction in aerobic power in the period following heat dehydration.

Saltin (1964) found that the time to exhaustion at a fixed percentage of maximum effort is also shortened as a result of acute heat. Kozlowsk (1966) revealed that the oxygen uptake is similar in normal and hypohydrated subjects, but the endurance of maximum effort is curtailed in the later.

It is well documented that larger sweat losses can dramatically impair the performance of endurance athletes (Astrand and Saltin 1964); Saltin (1964); Costil, et.al (1976). Costil (1975) pointed out that decrease in performance are generally thought to be the result of diminished circulatory capacity. Also Costil (1978) found that the treadmill maximum oxygen intake is significantly reduced by dehydration.

But Saltin (1964) found a contrary result, he discovered that dehydration produced no significant change in oxygen uptake during maximal exercise in a sitting position. Also he observed that up to 5% of body weight could be lost without change in maximum oxygen intake. Burskirk and Beëthan (1960) also pointed out that the pace of the marathon runner was well maintained during his event, despite a 2.5-7.4% decrease of body mass. Many competitors were still capable of a final sprint.

Superhydration had a significant effect on maximum oxygen consumption. In this case, the availability of water ingested really enhanced the level of maximum oxygen consumption. This is in line with the findings of Kavanagh and Shephard (1975) who found an improvement in distance runners as a result of a preloaded 500ml of fluid 15 - 30 minutes before exercise commenced.

Myocardial Oxygen Consumption:

The results of ANOVA for myocardial oxygen consumption produced F ratios of 57.321, 0.022 and 2.932 for dehydration, rehydration and superhydration respectively. From the result, it could be inferred that dehydration and superhydration had significant effect on the intake of oxygen.

Blyth and Burt (1961) found that dehydration lowered endurance in both athletes and non-athletes. Craig and Cumming (1966) found that dehydration reduced the walking time by 22% and oxygen intake was reduced by 10%.

Myocardial oxygen consumption is related to the working of the heart muscle. The mycardial oxygen consumption in this study was significantly affected. Buskirk et. al (1971) and Saltin (1964) found that subjects exhibited a 20% reduction in endurance work. Anderson and Kunery (1986) also found a lower heat tolerance to sweat among women. There was significant change in oxygen intake. The heat or sweating affected the oxygen intake adversely.

According to the result, superhydration significantly affected the oxygen consumption. Saul and Bass (1965) found that overhydration was beneficial to men working in the heat. Adolph (1974) also confirmed that fluid ingestion during endurance work has been shown to effectively reduce temperature and minimise dehydration. Basett (1971) also recorded change in oxygen intake and heart rate due to rehydration or voluntary fluid consumption. The water must have enabled the muscle of the heart to contract very well and pump blood efficiently in the body.

Anaerobic work (Speed and Power):

The results obtained for speed were 7.035 secs, 8.0305, 6.905 and 7.10 respectively for normal, dehydration, rehydration and superhydration conditions. Only the F ratio for dehydration was significant 17.694. The power test also yielded the means of 93.10kgm/secs, 94.05kgm/secs, 85.40kgm/secs and 29.15kgm/secs for normal rehydration dehydration and superhydration respectively. The F ratio of 4.522 for dehydration was significant at 0.05 level unlike other values of 0.058 and 0.060 for rehydration and superhydration that were not significant. This shows that dehydration alone affected the power of the subjects.

The results of the study agreed with the findings of certain studies. For example, Speel (1988) showed that dehydration caused spastic muscles, inability of the subjects to balance with eyes closed and a reduced general capacity for work. Klafs and Arheim (1979) also confirmed that dehydration is marked by an impairment of performance. It has been observed that in some individuals a dehydration of as little as 2% of the body weight causes a significant deterioration in work performance. This might be due to the fact that the reduction in water would have adversely affected the enzymatic and chemical reactions in the muscle. So the rate of muscular contraction might have been slowed down.

It is infact, generally agreed that a sweat loss constituting more than 2% of body weight can significantly reduce plasma volume and impair physical work capacity (Saltin 1964, Costill and Sparks, 1973). Saltin (1964) found that the work times decreased markely (6 - 4 min) in ten subjects who performed standard exercise tests at two submaximal loads. There was a definite decrease in the capacity to perform heavy work and the performance was significantly more affected after dehydration. Also the decrease in work time reflects a lowered capacity for physical work.

But the result that dehydration had significant effect on anaerobic work of speed and power are at variance with the finding of Jacobs (1980) who found no significant change (P.0.05) in the ability to perform anaerobic test or its various indices at any stage of dehydration. Saltin (1975) suggested that no differences existed between metabolic and thermal dehydration. He explained that the greater exercise intolerance following exercise dehydration may be due to glycogen depletion from muscle fibers. Shephard (1984) however found that acute heat exposure has little effect upon the performance of brief bouts of maximal work: particularly if the subject is in good physical condition.

Dehydration does not change the excitability of the muscle (Costill and Fink, 1974). Nevertheless maximum isometric strength may be some what reduced (Bosco et.al 1968). Very drastic restrictions of fluid intake are sometimes adopted by boxers, Judokas and Wrestlers who wish to achieve a specific weight category.

The practice is very dangerous and very detrimental to anaerobic work of these athletes. In reaction to such unhealthy practice, America College of Sports Medicine (1976) condemned such practices. 'The College further said that this practice is hazardous to the individual who decreases his body mass. Another complication is that sodium loss in the sweat and the potassium leakage from muscle predisposes the athlete to ventricular fibrillation. Webster and Weltman (1990) found that anaerobic power and anaerobic capacity were significantly reduced in a dehydrated state. They conclude that typical wrestling weight loss techniques result in deleterious effects on strenghth, anaerobic power and anaerobic capacity.

<u>Haematologic Variables:</u>

Packed Cell Volume (PCV) computed F ratios of 23.72, 0.067 and 9.160 for dehydration, rehydration and superhydration respectively. The values for dehydration and superhydration were significant at 0.05 level.

Also the osmotic fragility had the computed F ratio of 8.805, 0.545, 16.450, for dehydration, rehydration and superhydration respectively. In these results too, dehydration and superhydration significantly affected the osmotic fragility of the subjects.

The results also confirmed that dehydration affected both Packed Cell Volume (PCV) and Osmotic Fragility negatively while superhydration affected the two variables positively. The means obtained for Normal condition for both Packed Cell Volume and Osmotic Fragility agreed with the findings of Bake (1980) who gave the normal ranges of 40 - 45 percent for men and 36 - 47 percent for women for Packed Cell Volume. For fragility test the range given for complete haemolysis is 0.33 - 0.30 percent. Removal of water must have affected the red blood cells and also increased the rate of fragility of the cells.

Costil, et al (1974) reported that dehydration (2 and 4% weight losses), induced marked shrinkage of the red cells and was highly related to the increase in plasma osmolarity. They also found that dehydration causes changes in red cell size and this was reflected in changes in haemoglobin concentration.

Dill and Costill (1974) found a relative change of red cells volume from 43.7m to 41.0ml in their subjects after 4% of their body weight had been lost through dehydration. Yagil et.al (1974) in their study also found that there was an increase in osmotic fragility during dehydration ($P \geq 0.05$). They further showed that dehydration made the red blood cells to become more fragile compared to rehydration or normal condition. Perk (1972), also stated that the susceptibility of the red blood cell is generally related to cell size and volume. The decrease might be due to decrease in salt concentration. Bake (1980) said that as the salt concentration is decreased (making a hypotonic solution), the cells disrupt causing haemolysis.

CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary:

The purpose of the study was to determine the effects of dehydration, rehydration and superhydration on aerobic, anaerobic and haematologic as well as related body composition variables of College of Education male students. The research design used for this study was repeated measure design in which the subject served as his own control and was exposed to three experimental conditions of dehydration, rehydration and superhydration.

The main hypothesis for the study was that dehydration, rehydration and superhydration would have no significant effect on the aerobic, anaerobic and haematologic variables of College of Education male students.

The subjects were twenty healthy Physical Health Education students of Ondo State College of Education, Ikere-Ekiti. The average age was 24.90 years. They were volunteers who were certified fit by a medical doctor to take part in the study. Subjects were briefed on the protocol, the process of collecting data and the level of their involvement after which they signed an "informed consent form".

The subjects were first tested under normal (control) condition. They went through the assessment of the selected variables with no prior treatment of any kind. For dehydration, the subjects abstained from water for 24 hours and were in a hot room of between 100°F to 120°F so that approximately 3% of the body weight of each of them was lost through sweating. The same subjects after dehydration were allowed a period of two weeks for rehydration. In this condition, they went through the assessment of the selected variables. After two weeks of rehydration, the subjects were required to drink 2 litres of water each 30 minutes before the beginning of the evaluation of the selected aerobic, anaerobic, physiological, body composition and haematologic variables.

A pilot study using 5 subjects from the target population was carried out in order for the researcher and the assistants to familiarise themselves with the testing instruments and the procedure for the data collection employed during the actual research.

The measurement done during the study involved the physical characteristics of height, weight, percent body fat, and lean body weight. The physiological variables evaluated included, the resting heart rate, resting blood pressure (systolic and diatolic). The evaluation also included the aerobic variables of maximum oxygen consumption (Max Vo_2), myocardial oxygen consumption (Mvo_2) and Recovery Heart Rate, the anaerobic variables of speed and power. Packed Cell Volume (PCV) and osmotic fragility were the haematologic variables evaluated.

The equipment and materials used during the study included the beam scale of Health-O-meter, stop watch, lange skinfold calipers, Broad-blade Anthropometer, Stethoscope, sphygmomamometer, step bench, and microhaematocrit centrifuge and Colorimeter.

The analysis of data involved the descriptive statistics employed in the treatment of aerobic, anaerobic, anthropometric, physiological and haematological variables of the subhjects. Analysis of variance (ANOVA), the repeated measures design in which each subject served as his own control was used to test the significance of any changes. The hypotheses were accepted or rejected at the 0.05 level of significance. In cases of significant effects, the Scheffe test was employed to test the critical difference among group means of normal, dehydration, rehydration and superhydration.

The results of the study were:

1 The weight recorded during the normal condition showed a mean of 65.70kg and standard deviation of 6.189. The means weight for dehydration, rehydration and superhydration were 60kg, 65.80kg and 66.8kg respectively. The result of the analysis of variance for weight for dehydration, rehydration and superhydration

respectively. The result of the analysis of variance for weight showed a computed F ratio of 3,705 which was significant. The result of Scheffe test indicated that the significance was brought about by the effect of dehydration on weight. Rehydration and superhydration did not have any significant effect.

2. The percentage body fat showed means and standard deviation of 7.13 + 0.917, 6.885 + 0.467, 7.115 + 0.909, 7.10 + 0.806 for normal, dehydration rehydration and superhydration conditions respectively. The computed F ratio results showed no significant effect of any of the conditions on percent body fat.

3. The resting heart rate gave the means of 68.60, 80.0 69.40 and 66.6 for normal dehydration, rehydration and superhydration respectively. The F ratio computed for the four conditions was 15.071 which was significant. Scheffe test indicated that dehydration produced the significant effect.

4. Systolic blood pressure showed the means of 112.40, 123.35, 111.70 and 106.80 for normal, dehydration, rehydration and superhydration respectively. The calculated F ratio was 27.712, and was significant. Also the Scheffe test revealed that dehydration and superhydration produced the significant effects.

5. Diastolic blood pressure showed means of 72.20mm.Hg, 85mm.Hg and 71.30mm.Hg for normal, dehydration rehydration and superhydration conditions respectively. The F ratio computed revealed a significant effect. The post Hoc test showed that rehydration produced the significant change exhibited.

6. The Recovery Heart Rate showed means of 107.66, 127.05, 107.115 and 102.30 for normal, dehydration, rehydration and superhydration respectively. The F ratio of 63.457 was significant at 0.05 level. The results further revealed significant effects by dehydration and superhydration. Therefore the stated subhypothesis that Recovery Heart Rate would not respond significantly to dehydration, rehydration and superhydration was rejected for dehydration and superhydration but accepted for rehydration.

7. The maximum oxygen consumption of the various conditions showed means of 44.792ml/kg/min, 40.65ml/kg/min, 45.735 and 49.647ml/kg/min respectively. The ANOVA indicated significant differences for dehydration and superhydration.

Also myocardial oxygen consumption showed means of 1226.86ml/min, 1590.31ml/min, 1234.334, 1133.0 for normal, dehydration, rehydration and superhydration respectively. The obtained F ratio among the conditions was 33.24 and was significant. The effect was produced by dehydration and superhydration. Thus the subhypothesis which stated that dehydration, rehydration and superhydration would have no significant effect on maximum oxygen consumption was rejected for dehydration and superhydration but accepted for rehydration in both variables of maximum oxygen consumption (Max Vox_2) and myocardial oxygen consumption.

8. Speed yielded means of 7.035 secs, 8.0305, 6.905 and 7.10 secs respectively for normal, dehydration, rehydration and superhydration. The F ratio computed indicated a significant efect of these conditions on speed. But the effect was shown to have been produced by dehydration from the Scheffe test. The subhypothesis that dehydration, rehydration and superhydration would not significantly change speed was rejected for dehydration but accepted ror rehydration and superhydration.

9. The power test showed means of 93.10kgm/sec, 94.05, 86.40 and 92.15 for normal, dehydration, rehydration and superhydration. The F ratio of 2.156 computed for power showed no significant effect. Therefore, the subhypothesis that stated that speed

would not respond significantly to dehydration, rehydration and superhydration was accepted for all conditions.

10. Packed Cell Volume (PCV) showed means of 40.15, 42.76, 38.45 and 40.3 for normal superhydration, dehydration and rehydration respectively. The F ratio computed was 22.727 whith was greater than the table value at 0.05 significant level. This indicates that PVC was significantly affected by one or more of these conditions. Post hoc indicated that superhydration and dehydration significantly affected the Packed Cell Volume of the subjects. So the subhypothesis which stated that PCV would not be significantly influenced by dehydration, rehydration and superhydration was rejected for dehydration and superhydration but accepted for rehydration.

11. The F ratio computed in the analysis of variance for osmotic fragility was significant. Indicating significant differences in dehydration and superhydration in relation to the normal condition, the subhypothesis that osmotic fragility would not respond significantly to dehydration, rehydration and superhydration was rejected for dehydration and superhydration.

Conclusion

The following conclusions were derived from the results of this study:

Dehydration significantly and negatively affected the aerobic capacity of the subjects, the variables affected were Recovery Heart Rate, myocardial oxygen consumption (Max Vo_2). So dehydration is highly detrimental to endurance performances of any kind. Dehydration also significantly and negatively affected the haematological variables indicating an adverse affect on the red blood cells and function of blood. The anaerobic capacity was affected in the area of speed.

Dehydration had no significant effect on the body components of fat and lean body weight. Dehydration is only the removal of water. It is hereby noted that water deprivation and excessive water loss by sweating would not reduce the fat and the lean body weight of an individual. Superhydration only affected the aerobic capacity of the subjects. So water should be made available to endurance athletes and workers for proper functioning of the body. The haematologic variables of packed cell volume (PCV) and osmotic Fragility were affected by superhydration. Constant supply of water would enhance the performance of blood cells.

Recommendations and Suggestions for further work.

From the result of the study, the following recommendations are offered:

1. Coaches, trainers and team managers should monitor the movement of their athletes some days before competition to avoid unecessary loss of water through exposure to heat. Their camping rooms should be well ventilated and any source of heat that would induce sweating should be avoided.

2. Water should be made available to endurance athletes during training and competition and the international rules for various sports should include water time outs especially in hot climate of the tropics to avoid the consequences of dehydration and for athletes to consume abundant water for better performance.

3. Athletes should avoid dehydration to lose body weight during competition. It is very dangerous to the health of the athletes and might affect homeostasis of the body and consequently affect the performances of the athletes.

4. This study should be carried out in more standard laboratories using sophisticated equipment for more accurate results. More variables could be added in areas of metabolism and haematology.

5. The present study had made use of College of Education male students. The study was intended to add to the knowledge of improving the performances of athletes of all categories throughout the country.

Therefore other researchers could make use of elite athletes in carrying out similar study.

REFERENCES

Adolph, E.F. (1974) Physiology of Man in the desert. New York: Interscience.

American College of Sports Medicine (1975). Guidelines for Graded Exercise Testing and Exercise Prescription. Philadelphia: Lea and Febiger.

American College of Sports Medicine (1976) Position statement on prevention of injuries during distance running. Med. Science Sports 7: pp. 7 - 8.

Amusa, L.O. and V.C. Igbanugo. (1986) Laboratory Experiences in Exercise Physiology. University of Ibadan.

Anderson, C.R. and Houpt, T.T. (1990). Hypotonic and hypovolenic stimulation of thirst in Pigs. American Journal Physiol. Regul. Intergr. Comp. Physiol. 258(1), pp. 149 - 154.

Astrand, P. O. and K. Rodahl (1970) Textbook of Work Physiology. New York: MC Graw-Hill Book Co.

Atolagbe, J. E. (1986) You live your way to Health. In J.A Ajala (Ed.) Deflating the Inflation Monster. Ibadan: Univeristy of Ibadan.

Atolagbe, J. E. (1984) The Role of Exercise in Attaining and Maintaining a discipline lifestyle. A paper presented at 14th Annual Conf. of Nigeria Association of Physical and

Health Education. Ibadan.

Bake, F. J. (1980) Introduction to Medical Laboratory Technology. London: R. B. Silerton Butternoth and Co.

Baker, M. A. and Turlejska, E. (1989) Thermal fainting in deyhdrated goat: Effects of Plasma Volume Expansion and drinking, Arch. Eur. J. Physiol. 413(5) pp. 511 - 515.

Behnke, A. R. (1961). Quantitative Assessment of Body Build, J. Appl. Physiol. 16 p. 960

----, and J. B. Wilmore (1975) Evaluation and Regulation of Body Build and Composition. New Jersey: Prentice Hall Inc.

Best, L. and A. Taylor (1958). The Living body A text in Human Physiology. London: Chapman and Hall Limited.

Blair-West, J. R., Denton, D. A., Mckinley, M. J. and Weisinger, R. S. (1989). Sodium Appetite and thirst in cattle subjected to dehydration. Am. J. Physiol. Regul. Integr. Comp. Physiol. 50 (5) p. 5.

Blyth, C. S. and J. J. Burt (1961). Effect of Water Balance on ability to perform in High Ambient Temperature. Res. Quart. American Ass. Health Phys. Education, 32 pp. 301 - 307.

----, and W. C. Grasley (1974). Heat Injury and Conduct of athletes. Science and Medicine of Exercise and Sport. New York: Harper and Row.

Caldwell, J. E. Ahomen, E and Nousiainen, U. (1984) Differential effects of sauna, diuretic and exercise induced hypohydration, J. Appl. Physiol. Respir. Envirm. Exercise Physiol. 57 (4) pp. 1018-1023.

Cooker, K. H. (1968). A means of Assessing Maximal Oxygen intake, correlation between field and Treadmill testing JAMMA 208 (3) pp. 191 - 198.

Cooper, K. H. (1972) The new aerobics. New York: Bantam Books Inc.

Costil, D. L. (1974) Calculation of percentage changes in volumes of blood, plasma and red cells in dehydration. Journal of Appl. Physiol. Vol. 37, pp. 247 - 255.

----, Cote, R. and W. Fink (1976). Muscle water and electrolytes following varied levels of dehydration in man. Journal Appl. Physiol. 40 (1) p. 6011.

----, W. Fink (1974) Plasma volume cnages following exercise and thermal dehydration. Journal of Appl. Physiol. 37 (4) pp. 521 - 525.

----, W. F. Kammer and A. Fisher (1970) Fluid Ingestion during distance running. Arch Envrion. Health. 21 pp. 520 - 525.

----, and B. Saltin (1975) Muscle glycogen and electrolytes following exercise and thermal dehydration. In H. Howald (ed.) Biochemistry of Exercise II. Baltimore: University Park Press.

----. amd K. Sparks (1973). Rapid fluid replacement following thermal dehydration. J. Appl. Physiol. 34 pp. 299 - 303.

Craig, F. N. and E. G. Cumming (1966) Dehydration and Muscular work, J. Appl. Physiol. 21(2) pp. 670-674.

----, and Froethilick, H. L. (1968) Endurance of pre-heated men in exhausting work. J. Appl. Physiol. 24 pp. 636-639

Cureton, T. K. and L. F. Sterling (1964) Interpretation of the cardiovascular component resulting from the factor analysis of 104 test variables measured in 100 normal young men. Journal of Sports Medicine and Physical Fitness, 4: pp. 1 - 24.

Fleishman, E. A. (1964) The structure and measurement of physical fitness. Eaglewood Cliffs: Prentice Hall Inc.

Fox, L. E. (1979) Sports Physiology. Philadelphia: Saunders College.

Gargould, F. (1971) Effects of dehydration and rehydration on muscular strength and cardiorespiratory endurance of College wrestlers. Unpublished Master's Thesis. Ohio Universitry.

Getchel, B. (1979) Physical Fitness: Away of Life. New York: John Wiley and Sons Inc.

Goldfarb, A. H. Hatfield, B. D., Armstrong, D. and Potts, J. (1970) Plasma beta endorphin concentration: Response to intensity and duration of exercise. Med. Sci. Sports Exerc. 22 (2) pp. 241 -244.

Greenleaf, J. E. and Sargent (1964) Voluntary Dehydration in Man. J. Appl. Physiol. 20 (4) pp. 719 - 724.

Gregory, L. C. Quillen, E. W., Keil, L.C. (1988) Effect of Vasopress in blockable on blood pressure during water deprivation in intact and baroreceptor - denervated conscous dog. Am. J. Physiol. Endo crinol Metabol. 254 (4) pp. 490 - 495.

Guthrie, J. A. (1975) Introductory Nutrition. St. Louis: C. V. Mosby Company.

Guyton, A. C. (1975) Functions of the Human Biology. Philadelphia: S. W. Saunders Co.

----, (1981) Textbook of Medical Physiology> London: M Saunders Co.

Hagerman, F. and G. Hagerman (1982) Weight loss in the non-obese Athletes. Unpublished work. New York.

Hardinge, M.G. (1978) A Philosophy of Health. Loma Linda: Education material Centre.

Harper, H. A. V. M. Rodwell, and P. A. Meyes (1977) Review of Physiological Chemistry. Los Angeles: Lange Medical Publications.

Harrison, M. H. (1976) Intravascular volume and electrolyte changes with acclimatization to heat in man. Journal of Physiol. (London) 258 pp. 30 - 31.

Herbert, W. G. and Ribisi, P. M. (1972) Effects of dehydration upon physical working capacity of wrestlers under competitive conditions. Res. Quart. 43 pp. 416 - 422.

Hiller, W. D. B. (1989) Dehydration and Hyponatremia during Triathlons. Med. Sci. Sports Exerc. 21 (5) pp. 219 - 221.

Hockey, R. V. (1981) Physical Fitness: The Pathway to Healthful Living. London: The C. V. Mosby.

Hollis, M. (1976) The Practical Therapy: Oxford: British Scientific Foundation.

Hubbard, R. W. Sandick, B. L., Matthew, W. T. (1984) Voluntary dehydration and alliesthesia for water. J. Appl. Physiol. Respir. Environ. Exercise Physiol. 57 (3) pp. 868 - 873.

Hunts, J. N. (1961) The osmotic control of gastric emptying. Gastroenterology. 41: pp. 49 - 51.

Hunts, J. N. and Patak, J. D. (1960). The Osmotic effect of some simple molecules and ions on gastic emptying. J. Physiol. (Lond.) 154 pp. 254 - 269.

Igbanugo, V. C. (1986) Physiological determinants of Athletic performance. In L. O. Amusa (Ed.) The role of sports science and medicine in a developing nation. Ibandan: Nigeria Association of Sports Science and Medicine.

Januszewics, B. (1986) A trila nutriuretic factor and vasopressin during dehydration and rehydration in rats. Am. J. of Physiol. Vol. 251 pp. 151-256.

Karpovish, P. V. and W. E. Sinning (1971) Physiology of Muscular Activity. Philadelphia: W. B. Saunders.

Kavanagh, T. and Shepherd, R. J. (1975) Maintenance of hydration in post-coronary marathon runners. British Journal of Sports. Med. 9 pp. 130 - 135.

----, (1977) On the choice of fluid for the hydration of middle-aged marathon runners. Brit. J. Sport. Med. 11 pp. 26 - 35.

Kitamura, K. Jorgensen, C. R, Gobel, F. L. Taylor, H. L. (1992) Hemodynamic Correlates of myocardial oxygen consumption during upright exercise. Journal of Appl. Physiol. 32 (3) pp. 516 - 522.

Klafs, C. E. and D. D. arheim (1971) Modern Principles of Athletic Training. St. Louis: C. V. Mosby. Klausen, K. (1969). Exercise under Hypotonic conditions. Medicine and Science in Sports, 1 pp. 43 - 56.

Knuttgen, H. C. (1967) Aerobic cpacity of Adolescents. J. Appl. Physiol. 22 (4) pp. 655 -658.

Kozlowsk, S. (1966). Physical performance and maximum oxygen uptake in man in exercise dehydration. Bull Aced. Pol. Sci. (Biol.) 14 pp. 513 - 519.

----, and Saltin, B. (1964) Effect of sweat loss on body fluids. J. Appl. Physiol. 19 (6), pp. 1119 - 1124.

Lamb, D. R. (1978) Physiology of Exercise Response and Adaptations. New York: Macmillian Publishers Co. Inc.

Ladell, W. S. (1955) Effects of water and salt intake upon performance of men working in hot and humid environments. J. Physiol. (Lond.) 127 pp. 11 - 46.

Maloiy, G. M. and D. H. Boarer (1971) Changes in blood components in normally hydrated, dehydrated and rehydrated donkeys and Zebu cattle. J. Appl. Physiol. 30 (4) pp. 36 - 40.

Matthews, D. K. (1978) Measurement in Physical Education. Toronto: W. B. Saunders.

Miescher, E. and Fartney, S. M. (1986) Responses to dehydration and rehydration during heat exposure in young and older men. Am. J. Physiol. Regul. Integr. Comp. Physiol. 25 (2) pp. 1050 - 1056.

Miller, D. K. and E. T. Allen (1981) Physical Fitness: A Life-time commitment. Mineapolis: Burgess Publishing.

Morimoto, A. N. Mirakami and Yakuya, O. (1986). Dehydration enhances endotoxira fever by increased production of endogenous pynegen. Am. J. of Physiol. 6; pp. 41 - 47.

Moroff, S. V. and D. Bass (1965) Effects of overhydration on man's physiological responses to work in the Heat. J. Appl. Physiol. 20 (2) pp. 167 - 170.

Nicolaidis, S. Galaverna, O. and Metzler, C. H. (1990). Extracellular dehydration during pregnancy increases salt of offspring. Am. J. Physiol. Regul. Integr. Comp. Physiol. 258 (1) pp. 281- 283.

Neufer, P. D. Young, A. J. and Sawka, M. N. (1989) Gastric emptying during exercise: Effects of heat strees and hypohydration. Euro. J. Appl. Physiol. Occup. Physiol. 58 (4) p. 439.

Nwankwo, E. (1986) The role of modern technology in sports training in L. O. Amusa (Ed.) The Role of Sports Science and Medicine in a Developing Nation. Ibadan: Nigeria Association of Sports Science and Medicine.

Park, R. G. Congu, M Denton, D. A. (1986) Volume, Influences on thirst and Vasopresin Secretion in dehydrated sheep. Am. J. of Physiol. 6 pp. 62 - 626.

Passmore, R. and Durning, J. V. (1955). Human energy expenditure. Physiol. Rev. 35 p. 801.

Perk, K. (1972) Osmotic hemolysis of the Camel's erythrocytes I. A. Micro-cinema tographic study, J. Exph. Zoll. 163 pp. 241 - 146.

Pirnay, F. Petit, J. M. Deroanne, R. and Hausman, A. (1968). Aptitude a L'exercise musculaire sons contranite thermique. Arch. Ind. Physiol. Biochem. 76 pp. 867 - 892.

Purney, F. Deroanne, R, and Petit, J. M. (1970) Maximal oxygen consumption in a hot environment. J. Appl. Physiol. 28 pp. 642 - 645.

Rastogi, S. K. Gupta, B. N. Husain, T. and Mathur, N. (1988) Physiological responses to thermal stress in a glass bangle factory. Ind. J. Soc. Occup. Med. 38 (4) pp. 137 - 142.

Reiskick, S. Neuringer, M. Hasnain, R. and Connor, W. E. (1990). Polydipsia in reheous monkeys deficient in Omega-3 fatty acids. Physiol. Behav. 47 (2) pp. 315 - 323.

Robson, J. S. (1978) Disturbances in Water and Electrolyte Balance and in Acid-Base Equilibrium. In Aistead, S. and Girdwod, H. R. (Eds.) Textbook of Medical Treatment. Edinburgy: Longman Group Limited.

Rowell, L. B. (1974) Human cardiovascular adjustment to Exercise and thermal stress. Physiol Rev. 54 pp. 75 - 103.

----, Brengelmann, A. Murray, J. A. Kraning, K. K. and Kusumi, F. (1969) Cardiovascular responses to substained high skin temperature in resting man. Journal of Appl. Physiol. 27 pp. 673 - 680.

Saltin, B. (1964) Aerobic work capacity and circulation at exercise in man. With special reference to the effect of prolonged exercise and/or heat exposure. Acta Physiol.

Scand. 62 (Suppl. 230) pp. 1 - 52.

-----(1964) Aerobic and anaerobic work capacity after dehydration. J. Appl. Physiol. 19 (2) pp. 1114 - 1118.

----,(1964b) Aerobic work capacity and circulation at exercise in man.Acta Physiol. Scand. 62 (Sup.) pp. 1 - 52.

----,(1964) Circulatory response to sub-maximal and maximal exercise after thermal dehydration. J. Appl. Physiol., 19, pp. 1125 - 1132. ,

----,B. Gagge, A.P. Bergy, V., and Stolwijk, J.A. (1972) Body Temperature and Sweating during Exhaustive Exercise, J. Appl. Physiol. 32 (4) pp. 635 - 643.

----,(1978) Fluid, electrolyte, and every losses and their replenishment in prolonged exercise. In J. Parizkova and V.A. Rogozkir (Eds.) Nutrition, Physical Fitness and Health. Bàltimore: University Park Press.

Scholtelius, B.A. and D. Scottelius (1973) Textbook of Physiology. St. Louis: C.V. Mosby Co.

Senay, L.C. and Christensen (1965) Cutaneous Circulation during dehydration and heat stress. J. Appl. Physiol. 20 (2) pp. 278 - 282.

Shephard, R.V. (1982). Physiology and Biochemistry of Exercise. New York: Praeger Publishers.

Speel, E.F. (1988) Nutrition and Physical Fitness. Toronto: Galloway.

Sproles, C.B. Smith, D.P. Byrd, R.J. and Allen, T.E. (1976) Circulatory responses to submaximal exercise after dehydration and rehydration. J. Sport Med. Phys. fitness. 16 pp. 98 - 106.

Staff, P.H. and Nilson, S. (1971) Vaeske, O.G. Sukkertilforsel under langvarig intenstysigk ativitet. Tidssdrigt. for Den Morske laege forening, .16 p. 1232.

Tcheng, R.J. and Tipton, C.M. (1973) Iowa Wrestling Study: Anthropometic Measurements and the Prediction of a Minimal Body Weight for High School Wrestlers. Med. Sci. Sport. 5 pp: 1 - 70.

Tyler, D.D. (1979) Water and Mineral Metabolism in Hanper, H.A. Rodwell, V.W. and Mayes, P.A. (Eds.) Review of Physiological Chemistry. California: Language Medical Publication.

Verducci, F.M. (1980) Measurement concepts in physical Education. St. Louis: C.V. Mosby.

Vernon, J H.M. (1969) Industrial Fatigue in Relation to Atmospheric conditions. Physiol. Rev. 8 p. 130.

Walder, G.R. Kurtz, P. and Wilmore, J. (1975). The Influence of Plasma Volume Changes on Thermoregulation during Recovery from Supine Exercise. Personal Communication.

Webster, S. Rutt, R. and West man, A. (1990) Physiological effects of a weight loss regimen practised by College Wrestlers. Med.Sci. Sports Exerc. 22 (2) pp.229-234.

Wells, C.L. and Horvath, S.M. (1974) Metabolic and thermoregulatory responses of women to exercise in two thermal environments. Med.sci. Sports. 6, pp. 8 - 13.

Wydham, C.H. and Strydom, N.B. (1969) The dangers of inadequate water intake during marathon running. S. Afri. Med. J. 43 pp. 894 - 896.

----, Morrison, J. F., Williams, C.G. Bredell, G.A.G. Maritz, J. S., and Munro, A (1965) Criteria for Physiological Limits for work in Heat. J. Appl. Physiol. 20 (2) pp. 37 - 45.

----,(1973) The Physiology of exercise under heats stress. Ann. Rev. Physiol. 35 pp. 193 - 220

----,(1977) Heat stroke and hyperthermia in marathon runners, In: The Marathon: Physiological, Medicals Epidemiological and Psychological Studies. (Ed.) P. Milvy. Ann. N.Y. Acada. Sci. 301 pp. 128 - 139.

Yagil, U.A. Sod-monah and Meyerstem (1974) Dehydration and camel blood III. Am.J. Physiol. 226 (2), pp.305-308.

Young, D.A. Iacovico and H. Spector (1959) Effect of time after feeding and Carbohydrate or water supplement work in dogs. J.Appl. Physiol. 14 (6) pp. 1013 - 1017.

APPENDIX A

Informed Consent Form

INFORMED CONSENT FORM

(To be completed in duplicates)

I, ____ of

(Name)

____

(Name of Institution and Department)

after being briefed by researcher and getting a thorough explanation, hereby express my willingeness to participate in the research as a subject.

I voluntarily submit myself to the constraints and control of the reseach procedure. I solemly promise to abstain from the following till the end of the reseach or as may be demanded by the researcher.

1) Smoking
2) Alcoholic drinks
3) Kolanuts
4) Drugs
5) Caffinated drinks such as coffee during the research.

6) Any form of vigorous exercise twenty four hours to the exercise test. And in particular arbitrary consumption of water.

I promise to abide strictly by the instructions provided by the researcher. I shall cooperate fully in the experiment and do my possible best to aid the researcher to collect reliable data for the research.

---------------------- ---------------

Subject's Signature Date

APPENDIX B

DATA COLLECTION SHEETS

Appendix B

PHYSICAL CHARACTERISTICS ASSESSMENTS

<u>Date</u>
<u>Name</u>
<u>Height</u>
<u>Skinfolds</u> 1 2 3 X
Triceps
Abdominal
Subscapula
Thigh
<u>Diameters</u>
Biiliac
Biacrimial
Bitrochanter
Elbow (R)
Elbow (L)
Sum of Elbows
Wrist (R)
Wrist (L)
Sum of Elbows
Knee (R)
Knee (L)
Sum of Knees
Ankles (R)
Ankles (L)
Sun of Anles LBW=
Chest width %FAT=

Appendix B2

DATA RECORDING SHEET

MEASUREMENT OF PHYSIOLOGICAL CHARACTERISTIC FOR NORMAL, DEHYDRATION, REHYDRATION AND SUPERHYDRATION

Subjects Name --

---------------------- Time ------------------------------

Weight ------------------------------------ kg

Resting Heart Rate --

Resting Blood Pressure: Systolic ------------------------------

Diastolic ------------------------------

Recovery Heart Rate ---

ESTIMATION OF MAXIMUM OXYGEN CONSUMPTION ($MaxVo_2$)

A. Work Rate Laps covered -------------------------

Miles/metres -------------------------

B. Average Estimated ($MaxVo_2$) ---------------------------------

--- ml/kg/min.

Appendix B 3

DATA RECORDING SHEET

MEASUREMENT OF ANAEROBIC AND HAEMATOLOGIC VARIABLES

Subjects Name --

A. Speed Trial I --

Trial II --

Average --

B. Sargent Jump Trial 1 ------------------------------------

Trial 11 ------------------------------------

Estimated power ------------------------------

C. Packed Cell Volume (PCV) ------------------------------------

D. Osmotic Fragility --

APPENDIX C

STANDARD FOR 12 - MINUTES TEST

Standard for Cooper's 12 - minutes test for men

Fitness Gategory	Distance covered	Estimated Maximum Oxygen consumption (in millilitres/min)
I. Very Poor	less than 1.0 mile	28.0ml or less
II. Poor	1.0 to 1.24 miles	28.1 to 34 ml.
111. Fair	1.25 to 1. 9 miles	34.1 to 42ml.
IV. Good	1.50 to 1.74 miles	42.1 to 52ml.
V. Excellent	1.75 miles or more	52.1 ml or more.

(Cooper, 1968)

APPENDIX D

RAW DATA OF THE SUBJECTS

PHYSICAL AND BODY COMPOSITION VARIABLES FOR NORMAL CONDITION

S/N	AGE (YRS)	WEIGHT (KG)	HEIGHT (M)	%BODY FAT	LBW (KG)
1.	28	58	1.54	7.4	43.70
2.	26	57	1.51	6.2	39.96
3.	21	65	1.63	6.6	46.18
4.	22	68	1.50	7.1	43.91
5.	26	72	1.57	7.6	49.54
6.	28	66	1.64	6.4	48.4
7.	26	63	1.86	6.8	51.7
8.	25	65	1.58	7.8	45.4
9.	25	79	1.79	9.4	57.8
10.	26	69	1.66	8.6	42.9
11.	27	60	1.55	6.6	52.6
12.	22	78	1.74	7.5	60.4
13.	23	56	1.64	9.1	40.3
14.	26	60	1.58	7.6	53.2
15.	24	70	1.80	6.3	58.9
16.	22	68	1.52	6.7	45.8
17.	25	63	1.60	6.3	47.4
18.	25	66	1.67	6.5	48.4
19.	26	66	1.66	6.8	54.7
20.	25	69	1.73	6.9	52.6

PHYSICAL AND BODY COMPOSITION VARIABLES FOR DEHYDRATION

S/N	AGE (YRS)	WEIGHT (KG)	HEIGHT (M)	%BODY FAT	LBW (KG)
1.	28	55	1.54	7.1	431.2
2.	26	52	1.51	6.2	396.26
3.	21	60	1.63	6.6	461.1
4.	22	63	1.50	7.0	436.2
5.	26	67	1.57	7.5	495.0
6.	28	60	1.64	6.4	47.8
7.	26	59	1.86	6.8	51.4
8.	25	60	1.58	7.2	44.7
9.	25	74	1.78	7.2	57.7
10.	26	64	1.66	7.6	43.0
11.	27	57	1.55	6.4	52.7
12.	22	74	1.74	7.4	60.2
13.	23	51	1.64	7.0	39.4
14.	26	53	1.58	7.6	52.6
15.	23	64	1.80	6.3	58.4
16.	22	63	1.52	6.5	44.7
17.	25	59	1.60	6.3	47.5
18.	25	60	1.67	6.4	47.9
19.	26	60	1.66	6.6	54.5
20.	25	62	1.73	6.8	52.5

PHYSICAL AND BODY COMPOSITION VARIABLES FOR REHYDRATION

S/N	AGE (YRS)	WEIGHT (KG)	HEIGHT (M)	%BODY FAT	LBW (KG)
1.	28	58	1.54	7.4	43
2.	26	56	1.51	6.2	40.1
3.	21	65	1.63	6.5	45.4
4.	22	64	1.50	7.0	43.8
5.	26	72	1.57	6.8	50.1
6.	28	66	1.64	6.8	48.6
7.	26	64	1.86	6.7	50.5
8.	25	65	1.58	7.7	46.1
9.	25	78	1.78	9.4	57.9
10.	26	68	1.66	8.5	41.2
11.	27	60	1.55	6.6	52.8
12.	22	79	1.74	7.4	60.2
13.	23	56	1.64	9.0	41.4
14.	26	59	1.58	7.5	53.4
15.	23	70	1.80	6.3	58.7
16.	22	67	1.52	6.6	45.9
17.	25	63	1.60	6.1	48.1
18.	25	67	1.67	6.5	49.1
19.	26	66	1.66	6.8	54.9
20.	25	69	1.73	6.9	52.8

PHYSICAL AND BODY COMPOSITION VARIABLES FOR SUPERHYDRATION

S/N	AGE (YRS)	WEIGHT (KG)	HEIGHT (M)	%BODY FAT	LBW (KG)
1.	28	59	1.54	7.4	43.2
2.	26	57	1.51	6.3	40.0
3.	21	66	1.53	6.5	45.0
4.	22	68	1.50	7.1	44.0
5.	26	73	1.57	7.6	49.5
6.	28	68	1.64	6.4	48.5
7.	26	64	1.86	6.8	51.7
8.	25	66	1.58	7.7	45.8
9.	25	79	1.78	9.4	57.9
10.	26	70	1.68	8.6	42.88
11.	27	61	1.55	6.6	52.7
12.	22	81	1.74	7.4	60.4
13.	23	56	1.64	7.1	41.2
14.	26	60	1.58	7.6	53
15.	23	71	1.80	6.3	58.4
16.	22	70	1.52	6.7	45.7
17.	25	63	1.60	6.3	47.8
18.	25	67	1.67	6.5	49.0
19.	26	68	1.66	6.8	54.8
20.	25	69	1.73	6.9	52.9

PHYSIOLOGICAL VARIABLES FOR NORMAL CONDITION

S/N	HR (b/pm)	SBP mmHg	DBP mmHg
1.	84	120	80
2.	64	118	90
3.	64	120	90
4.	68	110	70
5.	60	110	70
6.	80	120	70
7.	60	120	68
8.	76	104	60
9.	64	108	70
10.	80	110	76
11.	68	106	68
12.	60	108	70
13.	64	104	80
14.	60	110	70
15.	60	110	70
16.	60	116	64
17.	68	118	70
18.	80	116	70
19.	80	110	68
20.	60	110	70

PHYSIOLOGICAL VARIABLES FOR DEHYDRATION CONDITION

S/N	HR (b/pm)	SBP mmHg	DBP mmHg
1.	88	124	86
2.	80	126	94
3.	78	130	94
4.	84	120	80
5.	76	128	82
6.	88	126	80
7.	80	122	80
8.	84	114	80
9.	82	120	86
10.	86	120	80
11.	74	122	90
12.	72	118	90
13.	80	126	94
14.	76	120	80
15.	80	122	80
16.	76	132	94
17.	86	132	94
18.	88	126	80
19.	88	126	80
20.	72	120	82

PHYSIOLOGICAL VARIABLES FOR REHYDRATION CONDITION

S/N	HR (b/pm)	SBP mmHg	DBP mmHg
1.	80	120	80
2.	64	116	90
3.	64	120	80
4.	72	110	70
5.	60	120	70
6.	80	120	70
7.	64	120	70
8.	72	110	60
9.	60	104	70
10.	80	110	70
11.	68	106	68
12.	60	110	70
13.	64	104	70
14.	68	110	70
15.	76	110	70
16.	64	110	70
17.	68	110	70
18.	80	110	80
19.	80	104	70
20.	64	110	70

PHYSIOLOGICAL VARIABLES FOR NORMAL SUPERHYDRATION CONDITION

S/N	HR (b/pm)	SBP mmHg	DBP mmHg
1.	80	110	80
2.	60	116	88
3.	64	112	90
4.	64	108	60
5.	60	110	70
6.	80	120	70
7.	56	110	70
8.	72	108	60
9.	64	102	70
10.	80	110	70
11.	64	90	70
12.	60	110	70
13.	64	100	70
14.	56	108	60
15.	72	110	70
16.	64	100	70
17.	68	90	70
18.	72	110	80
19.	76	102	68
20.	56	110	70

AEROBIC VARIABLES FOR NORMAL CONDITION

S/N	REC HR (Bpm)	Max VO_2 m/kg/min	MVO_2
1.	112	46.2	1606.8
2.	108	45.48	1202.32
3.	108	44.4	1228.2
4.	112	47.24	1155.6
5.	100	47.6	1050.0
6.	113.3	33.4	1530
7.	108.7	42.3	1146
8.	104	41.2	1258.6
9.	106	47.24	1099.9
10.	97.3	34.9	1402
11.	104	51.88	1142.3
12.	108	46.4	1030.8
13.	106.7	47.24	1059
14.	100	47.24	1050
15.	110	47.6	1261
16.	114.7	47.6	1107.6
17.	111.3	52.3	1277.8
18.	115.3	33.8	1478.8
19.	106	46.4	1402
20.	108	45.48	1050

AEROBIC VARIABLES FOR DEHYDRATION CONDITION

S/N	REC HR (Bpm)	Max VO_2 m/kg/min	MVO_2
1.	160	30	1739.9
2.	120	35	1606.8
3.	112	42.24	1616.4
4.	128	43.64	1606.8
5.	136	44.36	1550.5
6.	124	31.6	1768.1
7.	130	39.42	1555.6
8.	126.4	37.56	1526.2
9.	124	44.72	1568.4
10.	115.6	30.58	1645.2
11.	132	50.44	1438.5
12.	128	43.52	1353.4
13.	122	44	1606.8
14.	120	44.36	1453.2
15.	124	44.72	1556
16.	132.6	43.64	1574.8
17.	128.4	49.42	1810.3
18.	126	29.12	1768.1
19.	128	44.6	1683.4
20.	124	40.08	1376.4

AEROBIC VARIABLES FOR REHYDRATION CONDITION

S/N	REC HR (Bpm)	Max VO_2 m/kg/min	MVO_2
1.	114	48.4	1530
2.	106	46.6	1181.8
3.	108	44.8	1222.8
4.	110	48.4	1261.2
5.	104	47.8	1146
6.	110	36.4	1530
7.	108	44.6	1222.8
8.	104	42.4	1261.2
9.	104	48.8	992.4
10.	100	34.4	1402
11.	104	52.2	1147.3
12.	110	47.8	1050
13.	104	47.3	1059
14.	100	46.8	1190.8
15.	112	48.2	1331.6
16.	110.3	50.8	1120.4
17.	110.8	53.8	1190.8
18.	115	34.2	1402
19.	100	46.2	1325.2
20.	108	45.8	1120.4

AEROBIC VARIABLES FOR SUPERHYDRATIOON CONDITION

S/N	REC HR (Bpm)	Max VO_2 m/kg/min	MVO_2
1.	104	51.6	1402
2.	102	48.8	1107.6
3.	104	48.2	1146.9
4.	100	52.3	1099.9
5.	108	53.8	1050
6.	104	46.8	1533
7.	100	46.2	979.6
8.	100	47.3	1238.2
9.	96	52.3	1038.5
10.	100	42.6	1402
11.	100	58.8	915.6
12.	106	54.5	1050
13.	96	51.8	1018
14.	100	48.4	961.7
15.	104	52.3	1261.2
16.	108	46.4	1018
17.	104	53.15	973.2
18.	110	42.3	1261.2
19.	100	47.2	979.6
20.	100	47.2	979.6

AEROBIC AND HAEMATOLOGICAL FOR NORMAL CONDITION

S/N	SPEED	POWER	P.C.V.	OSMOTIC FRAGILITY
1.	7.1	80	41	0.35
2.	7.0	78	42	0.35
3.	7.1	89	39	0.20
4.	6.7	98	38	0.40
5.	6.7	120	39	0.30
6.	6.3	110	42	0.35
7.	6.4	85	44	0.30
8.	6.5	86	38	0.30
9.	7.0	100	40	0.30
10.	6.8	98	40	0.20
11.	7.2	90	38	0.20
12.	7.2	76	40	0.30
13.	5.8	105	43	0.20
14.	7.0	85	40	0.40
15.	8.2	96	39	0.35
16.	10.0	79	40	0.30
17.	6.6	95	38	0.30
18.	7.4	82	44	0.30
19.	6.9	112	38	0.30
20.	7.1	98	40	0.30

AEROBIC AND HAEMATOLOGICAL FOR DEHYDRATION CONDITION

S/N	SPEED	POWER	P.C.V.	OSMOTIC FRAGILITY
1.	8.3	75	42	0.40
2.	7.4	71	44	0.35
3.	8.6	84	42	0.35
4.	7.8	92	42	0.40
5.	7.6	112.0	43	0.35
6.	8.8	98	43	0.30
7.	8.9	80	44	0.35
8.	7.6	79	43	0.35
9.	9.8	92	43	0.30
10.	7.0	90	43	0.30
11.	7.6	84	39	0.30
12.	8.8	73	44	0.35
13.	7.3	95	44	0.30
14.	9.5	80	43	0.40
15.	8.3	91	40	0.40
16.	11.6	70	44	0.35
17.	8.8	88	42	0.35
18.	7.8	73	44	0.35
19.	7.4	91	42	0.35
20.	8.6	90	44	0.10

AEROBIC AND HAEMATOLOGICAL FOR REHYDRATION CONDITION

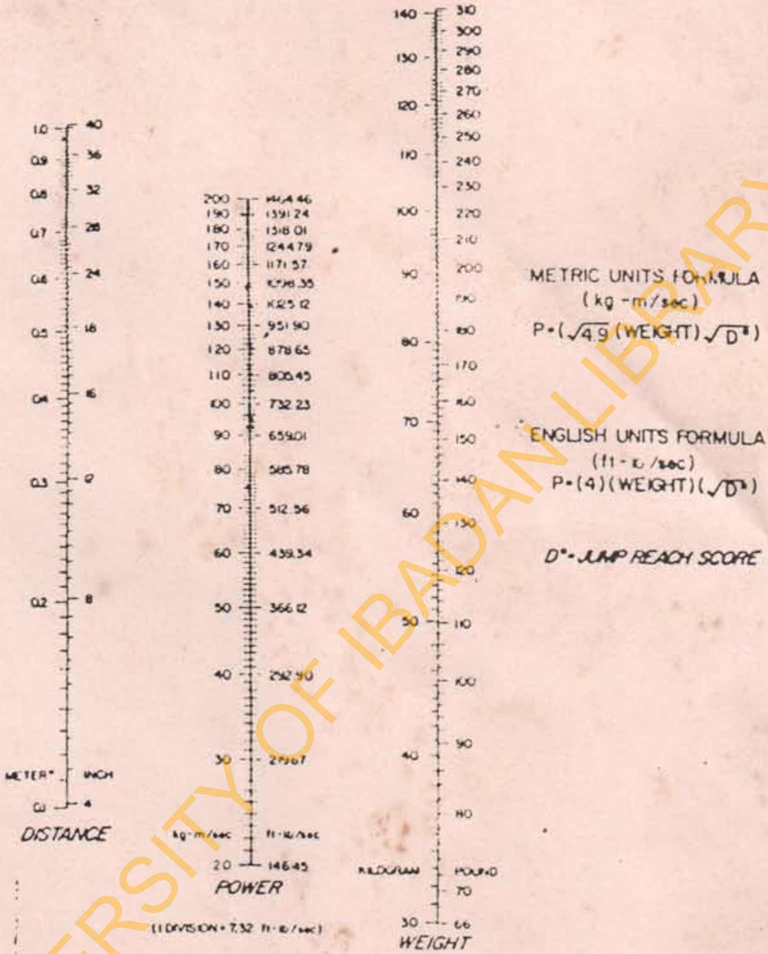
S/N	SPEED	POWER	P.C.V.	OSMOTIC FRAGILITY
1.	7.0	82	40	0.30
2.	7.1	80	41	0.35
3.	7.2	90	39	0.20
4.	6.8	98	39	0.35
5.	6.4	122	40	0.35
6.	6.2	112	41	0.35
7.	6.5	86	43	0.30
8.	6.3	86	39	0.35
9.	7.0	100	40	0.30
10.	6.7	100	40	0.30
11.	7.3	92	39	0.30
12	7.0	75	40	0.20
13.	5.4	106	43	0.35
14.	7.0	85	39	0.35
15.	8.3	98	40	0.35
16.	9.6	80	40	0.30
17.	6.8	95	39	0.30
18.	7.5	82	45	0.35
19.	6.8	114	38	0.30
20.	7.0	98	41	0.30

AEROBIC AND HAEMATOLOGICAL FOR SUPERHYDRATION CONDITION

S/N	SPEED	POWER	P.C.V.	OSMOTIC FRAGILITY
1.	7.1	80	40	0.35
2.	7.0	76	40	0.35
3.	7.2	90	38	0.35
4.	6.7	96	38	0.40
5.	6.9	120	37	0.35
6.	6.5	108	40	0.35
7.	6.6	86	42	0.35
8.	6.5	85	38	0.40
9.	7.0	98	40	0.35
10.	6.9	98	37	0.35
11.	7.2	92	38	0.35
12.	7.2	74	40	0.35
13.	5.8	102	40	0.35
14.	7.0	80	38	0.40
15.	8.8	97	38	0.35
16.	10.4	80	37	0.35
17.	7.2	95	36	0.35
18.	7.8	80	38	0.35
19.	7.0	110	38	0.35
20.	7.4	96	36	0.35

APPENDIX E

Normogram for Determining Anaerobic Power from Jump and Reach Test



Lewis Nomogram

(Fox and Mathew, 1981)