CHANGES IN BLOOD GLUCOSE AND PHYSICAL WORK CAPACITY AFTER HEAT DEHYDRATION

by

Philippe Joseph Jacques Markon

B.Sc. (Ed.P.), Universite de Montreal

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF PHYSICAL EDUCATION

in the School

of

Physical Education

and

Recreation

We accept this thesis as conforming to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

MAY 1975

In presenting this thesis in partial fulfilment of the requirement for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of PHYSICAL EDUCATION

The University of British Columbia

Vancouver 8, Canada

Date May 1975

ABSTRACT

The purpose of this study was to examine the effects of a 4% lean body weight dehydration with two levels of rehydration for four hours on the changes in physical work capacity and blood glucose. Further, the study examined the effects on volume STPD, VO2, R.Q. and true O2 during the physical work capacity test. A total of 7 uviversity- aged males were involved in the experiment as subjects . Each subject was tested in two experimental conditions, i.e. 50% rehydration and 100% rehydration, on two separate days.

Each set of tests consisted of blood samples drawn from the finger tip, a physical work capacity test with expiratory gas collection. Six sets of tests were distributed as follows: one at 6 A.M.,and one half an hour after dehydration. The four other sets were hourly separated. The rehydration consisted of intake of tomato juice given after the set of tests 2, 3, 4 and 5. The amount given was equally subdivided and depended on the experimental condition.

Analysis of variance indicated significant changes over time for all dependent variables, except VO2; significant changes between level of rehydration for weight, and significant changes for the level of rehydration by time interaction for true O2 and weight. There was no significant individual simple

correlation coefficient between blood glucose and physical work capacity for each experimental condition.

There was a mean decrease of 30% in physical work capacity after heat dehydration and only 40% of the loss was recovered without significant difference between experimental conditions. Gas exchange was also affected. The volume STPD increased after dehydration, true O2 decreased after dehydration and a better recovery showed up in the 50% rehydration condition.

The R.Q. parameter, in fact, did not indicate significant changes but there was a slight decrease after dehydration. The level of blood glucose decreased after dehydration but there was an increase in the middle of rehydration, even with the expected increase in blood volume, from the liquid intake. This suggested a very high level of gluconeogenesis on those last hours, probably due to glucocorticoid hormone action.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

The author would like to express his sincere gratitude to the members of his thesis commettee for their help and support throughout the presentation of this study and in particular to Dr. Kenneth Coutts, committee chairman, who has given me so much expert advice and guidance over the last two years.

My appreciation is also extended to the seven subjects who not only gave two full days but also submitted themselves to this unpleasant experiment.

Finally, a special thanks is conveyed to my wife, Dominique Markon, and to Jeannine Kapelus for the format presentation of this study.

CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

A major criticism of amateur wrestling concerns the rapid weight loss often required before weighing for a competition. It is current practice for an athlete to dehydrate himself by the use of laxatives, diuretics, fasting, or a combination of these various techniques for lowering weight . It is very common for an individual to lose 10 to 12 pounds (Ribisl, 1974) within a few days and sometimes within a few hours.

When a subject submits himself to heat dehydration, this stress leads to biochemical and physiological changes which need to be recovered during rehydration . Heat dehydration is already known to significantly decrease the physical work capacity of an individual (Saltin, 1964B; Kozlowski, 1969). The physiological mechanisms involved (Saltin, 1964B; Kozlowski, 1969) in this loss have been investigated, and the decrease in capacity was revealed to be mainly caused by the reduction in the extracellular fluids which are lost during such dehydration. The biochemical (Simonson, 1971) changes are not well understood, but some available data give little information, such as a lower lactic acid concentration, during submaximal test, (Saltin, 1964B) and a lower R.Q. after heat deydration. (Saltin, 1964A).Glucocorticoid hormones are significantly secreted (Collins, 1968) during heat exposure. Their gluconeogenic effect should be traceable after dehydration and a change in blood glucose level would be an indication of this steroid release. Thus blood glucose data could give information on changes in energy metabolism during heat dehydration and on the effect of rehydration.

Statement of the problem

The purpose of this study was to investigate the changes in blood glucose level and physical work capacity after dehydration.

Subproblem

Secondly, this study was made to investigate the effect of a 4 hrs rehydration period on physical work capacity and blood glucose level.

Hypotheses

The hypotheses are :

1. Heat dehydration increases the blood glucose level and reduces the physical work capacity.

2. The level of rehydration , immediately after heat dehydration , affects blood glucose level and physical work capacity.

Definition of Terms

Heat dehydration: a deficit of body water caused by high sweat rates with exessive loss of body fluids in a high temperature environment.

Lean body weight: total body weight minus total fat body weight.

Physical work capacity 150: work load needed for a heart rate response of 150 beats/min.

Rehydration: recovery of body water towards normal level by absorption of liquid.

Delimitation

Inferences from this study should be restricted to people involved in a heavy training schedule in a environment at room temperature.

Limitation

1. The investigation is limited by the sample size of 7 subjects , and their type i.e. varsity wrestlers.

2. The accuracy of the results is limited by the equipment and the methods used.

3. The procedure involved in data collection may have influenced subsequent results, therefore interpretation of the data is limited by the experimental protocol.

Significance of the study.

At the present time most explanations advanced for the changes in physical work capacity, following heat dehydration, are concerned with the cardiovascular aspect of the problem. There were no data available on changes in blood glucose after heat dehydration, and, since blood glucose is a key in energy metabolism, such data could explain, to some extent, the biochemical processes involved in heat dehydration and during rehydration. This study should give a better understanding of the reasons for the loss of physical work capacity, of the main reasons for the negative effects of heat dehydration and of what is more important during rehydration (i.e. fluid recovery, electrolyte balance, rehydration time, etc.). Finally, it may give the athlete important information to help him decide whether to stay in a higher weight class or cut down rapidly his weight and settle for a limited recovery.

CHAPTER II

REVIEW OF LITERATURE

Physiological Changes

The loss of water and electrolytes decreases the ability to perform muscular work (Adolph, 1947; Pitts et al., 1944). The mechanisms are not well understood, but impaired cardiovascular function is considered to be an important factor (Adolph, 1947; Beetham and Buskirk, 1958; Buskirk et al., 1958; Saltin 1964A).

Blood and plasma volume are greatly affected by a heat dehydration, a 4% loss in body weight reduces significantly the Evans blue space and inulin space (Kozlowski and Saltin, 1964). For a 3.6% heat dehydration plasma is reduced by 13.6% with a plasma water loss of 8.0% (Horstman and Horvath, 1972). Giec (1969) found similar results. Saltin (1964A) found with a body weight reduction up to 5.2% during heat exposure, a reduction in plasma volume up to 25%.

Costill and Sparks (1973) studied eight males on three separate occasions during a 4% body weight thermal dehydration and during rapid fluid replacement, within three hours. They found a decrease in plasma volume of 12% (variance of 8 to 27%) without significant changes in red cell mass and mean cell volumes respectively during dehydration or a rehydration period. With the non rehydrated group the reduction in plasma volume remained almost the same. Either demineralized water or glucose-electrolyte solution completely restored the plasma volume to the prehydration level within three hours.

Such changes in circulating volume affect the cardiac functions (Mountcastle, 1968) such as heart rate, cardiac output and stroke volume. During submaximal work, after heat dehydration, the heart rate was significanthy increased (Costill and Sparks, 1973; Kozlowski, 1969; Saltin, 1964A; Saltin, 1964B; Strydom and Holdsworth, 1968) and came back, close to the predehydration level, after a complete rehydration within 3hrs (Costill and Sparks, 1973)

By recording the heart rate during work, after a 4% body weight dehydration, Kozlowski (1969) found a decrease of 30% in the physical performance of his subjects. Such changes in physical work capacity were noticable at a 1% body weight dehydration (Kozlowski, 1966). Such an increase in heart rate is compensating for a decrease in stroke volume for a similar cardiac output on a submaximal work test (Saltin 64A, Saltin 64B). Endurance was also significantly decreased (Saltin, 1964A).

The vital capacity was not impaired after a heat dehydration (Govindaraj, 1972), and neither was the oxygen consumption (Saltin, 1964A; Kozlowski, 1969). Ventilation equivalent did not show a significant change (Saltin, 1964A) but increased slightly.

Therefore the major physiological changes, after heat dehydration, affecting the physical work capacity are mainly from the cardiovascular changes i.e. blood volume, stroke volume and heart rate, but pulmonary functions (oxygen consumption, true 02) do not seem affected. Complete rehydration returns normal cardiac function during exercise without a complete recovery of plasma volume.

Biochemical Changes

The hormonal release, the changes in energy source for work, the loss of water and electrolytes are of great importance in relation to the changes in physical work capacity. These biochemical factors are revealed to be affected by dehydration and their level of significance needs to be considered.

1. Electrolytes:

Serum sodium and chloride concentration increased approximately 3% following 4% body weight dehydration (Costill and Sparks, 1973), but their loss through the sweat gland is still significant, (Kozlowski and Saltin, 1964; Greenleaf and Sargent, 1965; Johnson et al., 1942). Calcium is also lost at a rate of 20 mg/hr during dehydration (Consolazio et al, 1962) but this does not affect significantly the plasma concentration (Rose et al., 1970).

Magnesium is a very important cellular constituent. The normal function of cardiac and skeletal muscle and nervous tissue depends greatly on a proper balance between calcium and magnesium, but even if magnesium loss during dehydration is significantly detectable these losses should not be considered important for the proper balance of electrolytes (Consolazio et al., 1963).

Potassium is the most important electrolyte that can be affected during heat dehydration since it can influence muscular activity and the excitability of nerve tissue. Potassium deficiencies are manifested by muscular weakness and cardiac irregularities. After heat dehydration the concentration of potassium in plasma remains almost the same (Costill and Sparks, 1963; Griec, 1969). But the potassium concentration, during rehydration decreases if the liquid intake does not contain enough potassium. (Costill and Sparks, 1973).

In general then, heat dehydration of 4% body weight causes no important changes in blood electrolytes, but the rehydration should be made from an electrolyte solution containing enough sodium chloride and potassium in order to maintain the normal concentrations with increasing plasma volume.

2. Metabolism:

The principle sources of energy during work are carbohydrates and fatty acids. The relative amount of energy from each source , depends on the intensity level of the work (Scherrer, 1969; Vanroux, 1969; Froberg, 1969; Issekurtz and Miller, 1962; Masoro et al., 1966) and also the metabolic state (Baldwin, 1970; Herman, Sabim and Stifel, 1969; Leveille, 1970).

There was a lower R.Q. during a submaximal work test after heat dehydration (Saltin, 1964A); which indicates an increase of fatty acid catabolism after such dehydration. Lower post-exercise lactic acid levels were also observed indicating less glycolysis (Saltin, 1964B), and therefore a lower glycogen breakdown.

Blood glucose level decreases slightly during submaximal work and returns to preexercise level within a short period of time (Reichard et al., 1961). There is a decrease in insulin release during activity (Conrad et al., 1969). There is also a decrease in insulin release after dehydration (Tepperman, 1967), and the insulin is inhibited by the acidosis (Selkurt, 1971) produced by the dehydration (Masoro, 1971). Insulin is also inhibited by cortisol release (Selkurt, 1971).

Hormone secretions are of very great importance during heat exposure since they can affect the level of blood glucose, some enzyme activities and the level of electrolytes. Aldosterone and cortisol are gluconeogenic hormones, and during heat stress the level of aldosterone, throughout sweating, is very high (Kozlowski, 1969; Gibinski, 1969; Collins, 1968). Aldosterone is responsible for 50-70% of the total mineralocorticoid activity, whereas deoxycortisone contributes very little either in its potency or its presence quantitatively. The remaining response to heat, in man, comes from cortisol and corticosterone (O'Connor, 1962).

This high level of aldosterone is stimulated by the heat stress, reduction in extracellular fluid volume, salt depletion and dehydration (Bledsoe, Island and Liddle, 1966). Cortisol showed a marked increase in plasma after one to two hours of heat exposure (Collins, 1968) and the hepatic removal of corticosteroids is lowered in a very high enviromental temperature (Collins, 1968). A small concentration of these steroids is found to be lost in sweat and in urine (Robinson and Macfarlane, 1958).

Since the adreno-corticosteroids are significantly released during heat dehydration their effect on blood glucose should be revealed because of their gluconeogenic properties. There are no studies in the literature which appear to consider the combined effects of heat dehydration followed by a rehydration on changes of physical work capacity and blood glucose.

Summary

The fluid shifts following heat dehydration leads to cardiovascular changes reflected by a decrease in physical work capacity. Glucocorticoid hormones secreted during heat dehydration are expected to be manifested by an increase in blood glucose. This study was intended to relate the changes in blood glucose and physical work capacity after dehydration and during rehydration and therefore determine the level of significance between the two.

CHAPTER III

METHODS AND PROCEDURES

Subjects

Seven subjects participated in the experiment. The age of the subjects ranged from 18 to 29, giving an average of 21years. Six of these subjects were undergraduate students and one was a graduate student at the University of British Colombia. All of them, members of the Varsity Wrestling Team, were well trained and accustomed to heat and metabolic dehydration.

Experimental Procedures

All subjects were tested four times during the week prior to the experiment on a physical work capacity 150 test with expiratory gas collection. These tests were given in order to eliminate any learning effect during the experiment and also to measure the physiological responses of the subjects in order to determine the work load to be used during the experiment. On their first pretest subjects were informed, to some extent, of the nature of the study (see appendix C: Subject information and instruction).

Before the day they were to be tested, subjects received the following instructions: to eat normally during the day before the experiment, have a good night's rest and do not discuss the experiment until after the last subject was tested.

These instructions were given in order that the subjects could present themselves for each experiment with approximately the same metabolic state.

The next morning the subjects arrived at 6 A.M. for one-half of the experiment. At that time the subjects were fasted and did not drink any water or other liquid that morning. Their lean body weight was predicted from six skin fold measurements, through the use of a Harpenden Skinfold Caliper and body weight, as stated by Yuhasz (1963). Four per cent of their lean body weight was calculated and set as the amount of weight to be lost during dehydration.

A one hundred microliter blood sample was then extracted from the finger tip as follows: the investigator wrapped the forearm of the subject with a hot towel and put one finger in a hot water bath for five minutes. Afterwards the forearm and the finger were dried with a towel and the subject was asked to spin his arm thirty times; and the finger tip was then pricked with a sterile lancet and the blood was collected, by capillary action, in a 100 microliter glass disposable micro sampling pipet (from Corning Laboratory Products Deparment, cat.no. 7099-S, 1/2% accuracy). The blood was immediately poured into a test tube pretreated with sodium fluoride 4%, and potassium oxalate 4%, containing 0.9 ml of 3% trichloroacetic acid solution. Then the sample was shaken laterally, capped and frozen.

A three lead set of ECG electrode was put on the subject who had to mount the bicycle ergometer (Monarck). He was then fitted up with a gas collection mask which consisted of a mouth piece breathing valve with a connecting tube to the gas meter in order to determine the gas volume and a 0.3% sample for gas analysis. The breathing valve was held by the mask, and the nose was blocked by a nose clip.

The gasmeter and the ECG recorder were placed in such a manner that the subject could not see the changes throughout the test. The height of the seat was always the same for each individual for all their tests.

The metronome was then set at 120 beats per minute with the sound corresponding to each down foot position, cycling at 60 revs/min. The subject started pedalling at a zero resistance a few seconds before the test in order to take up the speed. Then, exactly at the same time, the gas meter and the stop watch were turned on and, just after, the pre-determined work load was adjusted. This work load was set for the 6 A.M. test so that the heart rate would be at 100 beats per minute. The heart rate was recorded on the ECG during the last 15 seconds of each minute throughout the test. On the fifth minute, the work load was increased to obtain a heart rate responses of 110 beats per minute, and again at the ninth minute for a rate of 120 beats per minute. At the end of the twelfth minute the gas meter and the ECG were shut off. Then the subject was ready for his dehydration.

Immediately after each physical work capacity 150 test, the gas sample was analysed for oxygen and carbon dioxide concentration. The gas temperature was recorded on the sixth minute of the test and the barometric pressure was recorded before the test.

The subject went into the physiotherapy room, within the same building as the exercise physiology laboratory, and into a dry sauna, electric indoor, where the temperature was kept at 70 degrees Celcius. The relative humidity was recorded by a Bacharach Sling Psychrometer.

The subject had to lie down or sit down passively in the sauna. He could take a five minutes break each 15 to 30 minutes. During those breaks at room temperature, he could check his weight and was covered with a wool blanket while lying on a bed.

After the subject completed his 4% lean body weight dehydration, he went back to the exercise physiology laboratory where he had to lie on a bed, covered with a wool blanket for a 30 minutes rest. This was done to insure that the subject stopped sweating when the weigh in took place to determine his per cent dehydration.

During that time the investigator weighed all the clothes and equipment that the subject would have on him during rehydration. This was done to avoid the necessity of undressing for each successive weighing and of removing and replacing the electrodes.

Then the subject was submitted to the same blood test as at 6 A.M. in the morning, and his weight was recorded as the weight indicated on the weight scale minus the weight of his equipment. After this, the subject underwent the physical work capacity 150 test following exactly the same procedure as given earlier. This was done in order to compare the gas exchange between successive test and maintain a submaximal work load.

After this test the subject received a quantity of tomato juice (cooled to five degree Celcius) which he had to drink within five minutes. The quantity of tomato juice received was determined by the experimental condition for that day. Then the subject rested for approximately 35 minutes in the semi divided part of the laboratory where he could lie down or read. After this set of tests the room temperature and the relative humidity were recorded.

One hour after the previous blood test, the subject was again submitted to the same set of tests i.e. blood test, weight measurement, work capacity 150 test and rehydration with tomato juice. These hourly sets of tests were repeated three other times except on the last of these where the subject did not have to rehydrate himself as this was the completion of that half of the experiment for that subject.

Therefore each subject was submitted to six sets of tests on each of two experimental days which are identified throughout this investigation as times 1, 2, 3, 4, 5 and 6. Time 1 was taken as the baseline value for that day with time 2 at thirty minutes after a 4% lean body weight, heat dehydration. Times 3, 4, 5 and 6 were at one, two, three and four hours, respectively, into the rehydration period which immediately followed the dehydration period.

Blood Glucose Determination

A modification of the ortho-toluidine procedure for whole blood supplied by Sigma Chemical Company in their technical bulletin #635 (1974) was used for determining blood glucose. A one hundred microlitre blood sample from a fintertip puncture was used for analysis, and the normal procedure was followed utilizing proportional quantities of the various reagents.

Gas Determination

The expired air volume and temperature were recorded from a Max Plank Gasmeter, and a gas sample was collected in a sample bladder, model Pongs Geschutzt 1600774. Gas concentration was determined from the expired gas sample. Carbon dioxide analysis was made with a Godart Capnograph type 146, and oxygen analysis with a Westinghouse Pulmonery Function Oxygen Monitor, model No. 211.

Physical Work Capacity 150 Determination

The paper speed of the ECG preamplifier was set at 25 mm/sec. For each work load the corresponding heart rate was determined by calculating the distance in milimeters of twelve heart beats from the last two minutes of each work load. The distances were added, the sum divided by four and the value obtained was used to determine the heart rate from a chart (CAHPER, 1968). The three heart rates corresponding with the work loads were used to determine the physical work capacity 150 using a regression equation. The value obtained was multiplied by 360 to convert the resistance value for a given heart rate to a work load in kilopond-meters per minute at a heart rate of 150 per minute.

Rehydration Procedure

Commercial tomato juice was used, seasoned with less than 1% salt, containing approximately 21 calories per 100 grams, from Libby, McNeill and Libby of Canada Limited. The calculated weight for determining the tomato juice to be given to the subject was determined by a volumetric method, using a 500 mililiter beaker and a 100 mililiter graduated cylinder. It was approximated that one mililiter of tomato juice corresponded to one gram.

Experimental Design

The study was designed as a two by six factorial experiment with repeated measures on both factors and six dependent measures on each subject.

The two independent variables were:

A. Hydration level

H1: 50% rehydration.

H2: 100% rehydration.

B. Time:

T1: Pre dehydration at 6 A.M.

T2: Following a 4% lean body weight dehydration.

T3 to 6: One hour interval rehydration.

These two levels of rehydration were used in order to determine if the level of rehydration is important; the four percent dehydration was selected because it is similar to the practical situation of the wrestlers. Also, it is the most used value in the previous literature and it is known to produce significant physiological changes. The lean body weight was determined to standardize each subject i.e. using a value more related to their total body water. The four hours rehydration was used to simulate the practical situation between weigh in and competition. Tomato juice was used for its high level of electrolytes (Goodhart and Shils, 1973) and its low significant level of glucose.

The six dependent variables were:

A. The physical work capacity 150 (Kpm/min).

B. The blood glucose level (mg%).

C. The volume (STPD) of expired air (L/min).

D. The R.Q.

E. The VO2 (L/min).

F. The true O2 (%).

The submaximal test, physical work capacity 150 was used to avoid any fatique effect since subjects were submitted six times to the test in a rather short period of time. The gas volumes and concentrations were of secondary importance in this investigation: they were calculated in order to determine the R.Q. and therefore the changes in energy source after dehydration and during rehydration. The VO2 was recorded to test the reliability of this study with previous publications. The volume STPD and true O2 were analysed for their information on the level of hyper or hypoventilation that can occur in such situation. All subjects were tested on the two experimental conditions: two of them had six days between the tests, four had seven days and one had eight days between the tests. Subjects were randomly assigned to one experimental condition, on their first test day and four of them were in the first condition while the others were tested on the other.

Experimental Conditions

All subjects were heat dehydrated until they had lost approximately 4% of their lean body weight. In one condition subjects were rehydrated of 50% of their weight loss in four hours and in the other condition subjects were rehydrated of 100% of their weight loss within the same period of time.

Rehydration procedure consisted of four equal hourly amounts of liquid (tomato juice) ingested within five minutes. Therefore in one condition the subject received 12.5%/hr of the amount lost (50% rehydration condition), while subjects in the other condition received 25%/hr of the weight lost (100% rehydration condition).

Statistical Analysis

To test the hypotheses, results from each subject for each dependent variable, were analysed as a two-factor experiment with repeated measures. These results were calculated at the U.B.C. Computing Centre by the use of the BMDP2V repeated measures analysis of variance program which gave the mean, standard deviation and the level of significance for changes with time, with level of hydration and with time by level of hydration.

The relationship between physical work capacity and blood glucose was further analyzed by calculation of correlation coefficients for each subject using a computer program (U.B.C. Simcort).

CHAPTER IV

RESULTS AND DISCUSSION

Results

Descriptive Statistics

Individual results for all dependent variables are presented in appendix A. From these results for each experiment, time one was considered as baseline and the other values obtained (i.e. from the other tests) were a per cent value relative to time one.

From these per cent values, means, standard deviations and analysis of variance were determined. Since the number of subjects observed at different times changed, the statistical analysis was repeated each time for a change in number of subjects within one observation. Missing observations are due to technical difficulties encountered during the testing of subjects T.H., F.D. and M.R. (see appendix A).

The number of subjects within one observation is shown in the graph, below the time observed, and the analysis of variance in this chapter, is given for times one to six along with the number of observations used. For complete analysis see appendix B.

Means for physical work capacity 150, blood glucose, weight, V STPD, R.Q. and true O2 are graphically displayed in Figures 1, 2, 3, 4, 5, 6 and the analyses of variance are presented in Tables I, II, III, IV, V and VI.

Correlation between physical work capacity test 150 and blood glucose for each individual under each experimental condition is presented in Table VII.

Analysis of Data, Test of Hypotheses

Individual subject graphs are shown in appendix A in order to compare the general trend. (Figure 8, 9, 10, 11, 12 and 13).

Physical Work Capacity 150 (Figure 1, Table I): The result shows significant differences throughout time with a $p<.001$. There is a significant loss of physical work capacity, after heat dehydration, of about 30% with a partial recovery within the four hours of rehydration. There is no significant difference between the percent rehydration conditions and also no signifiant interaction of time and level of rehydration.

Blood Glucose (Figure 2, Table II): Both conditions show the same pattern of change throughout time with a $p<.001$, i.e. a decrease in blood glucose followed by an increase on times 5 and 6. There is no significant change with treatment or treatment by time. The correlation between blood glucose and physical work capacity , from raw data, shows no consistantly high correlation (Table VII).

Weight (Figure 3, Table III): The independent variable weight shows a very significant change, $p<.001$, on time,

FIGURE 1

MEANS OF PHYSICAL WORK CAPACITY 150 EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

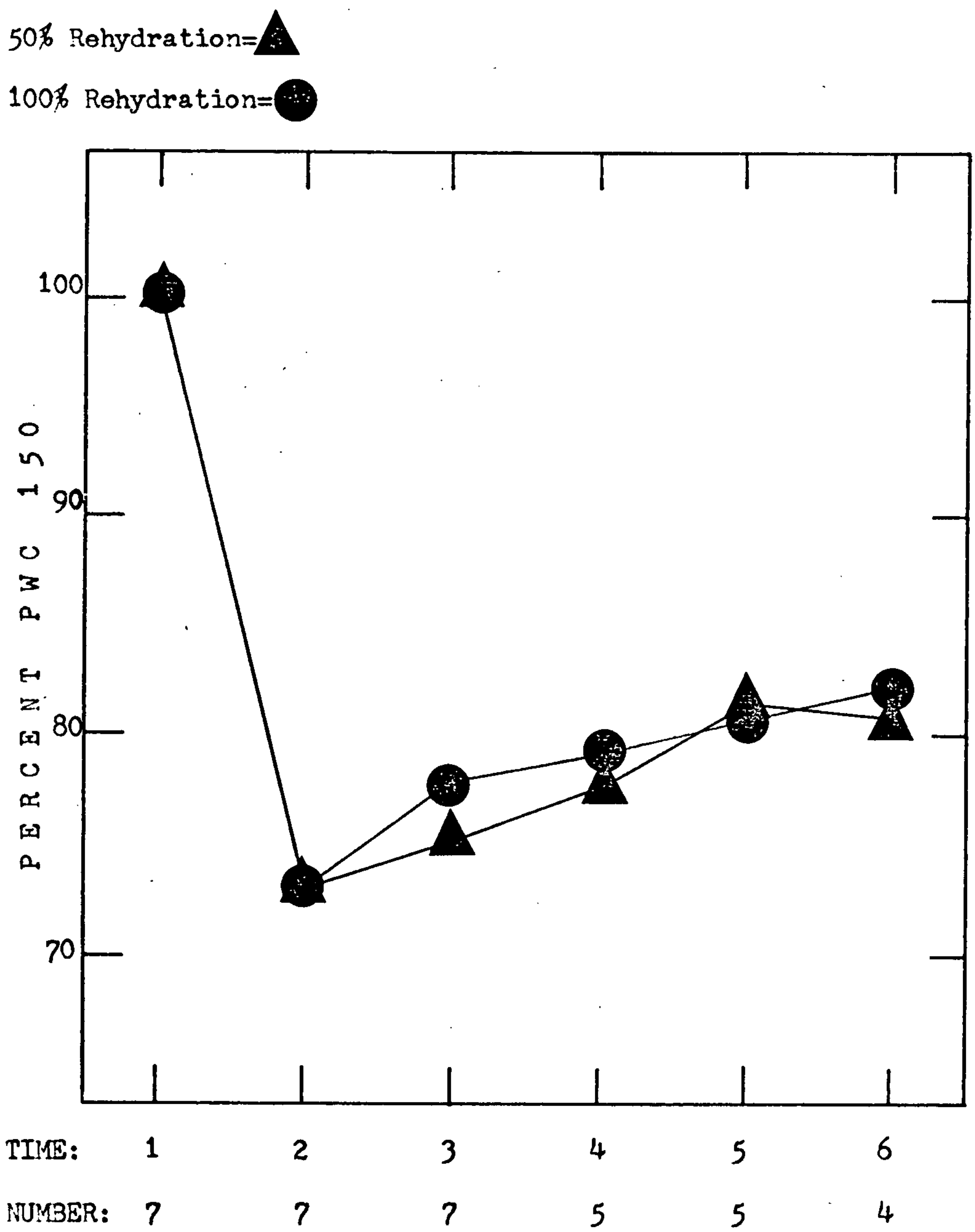


TABLE I

ANALYSIS OF VARIANCE FOR CHANGES IN PHYSICAL WORK CAPACITY 150
N= 4
TIME= 6

SOURCE	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARE	F	P
TIME	0.55833	5	0.11167	36.49	0.000
ERROR	0.04589	15	0.00306		
PERCENT	0.00321	1	0.00321	0.27	0.637
ERROR	0.03508	3	0.01169		
TP	0.00709	5	0.00142	1.04	0.429
ERROR	0.02040	15	0.00136		

FIGURE 2

MEANS OF BLOOD GLUCOSE EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

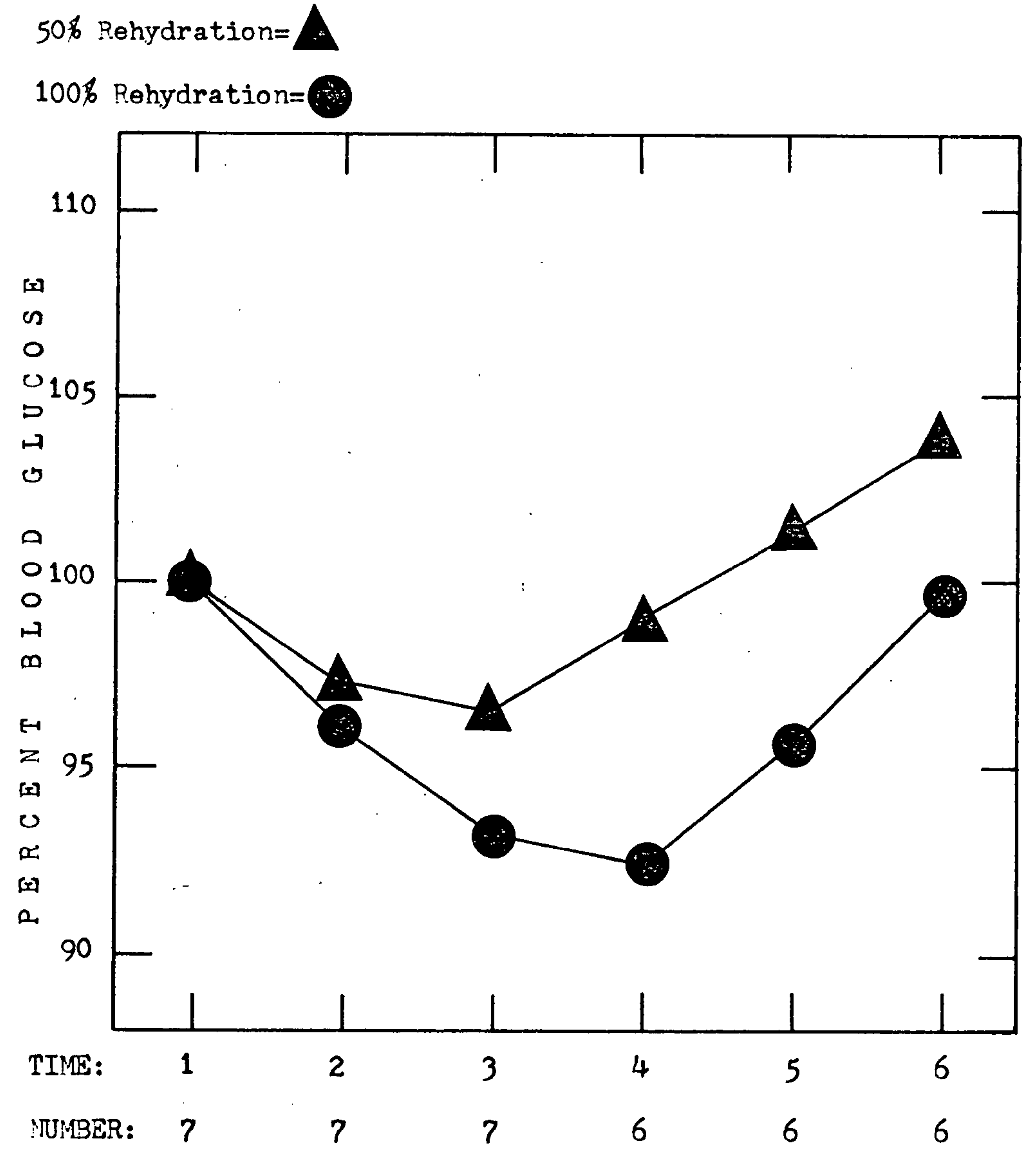


TABLE II
ANALYSIS OF VARIANCE FOR CHANGES IN BLOOD GLUCOSE

N= 6
TIME= 6

SOURCE.	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.06831	5	0.01366	7.86	0.000
ERROR	0.04341	25	0.00174		
PERCENT	0.05131	1	0.05131	1.17	0.328
ERROR	0.21826	5	0.04365		
TP	0.02243	5	0.00449	0.80	0.555
ERROR	0.13879	25	0.00555		

FIGURE 3

MEANS OF WEIGHT EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

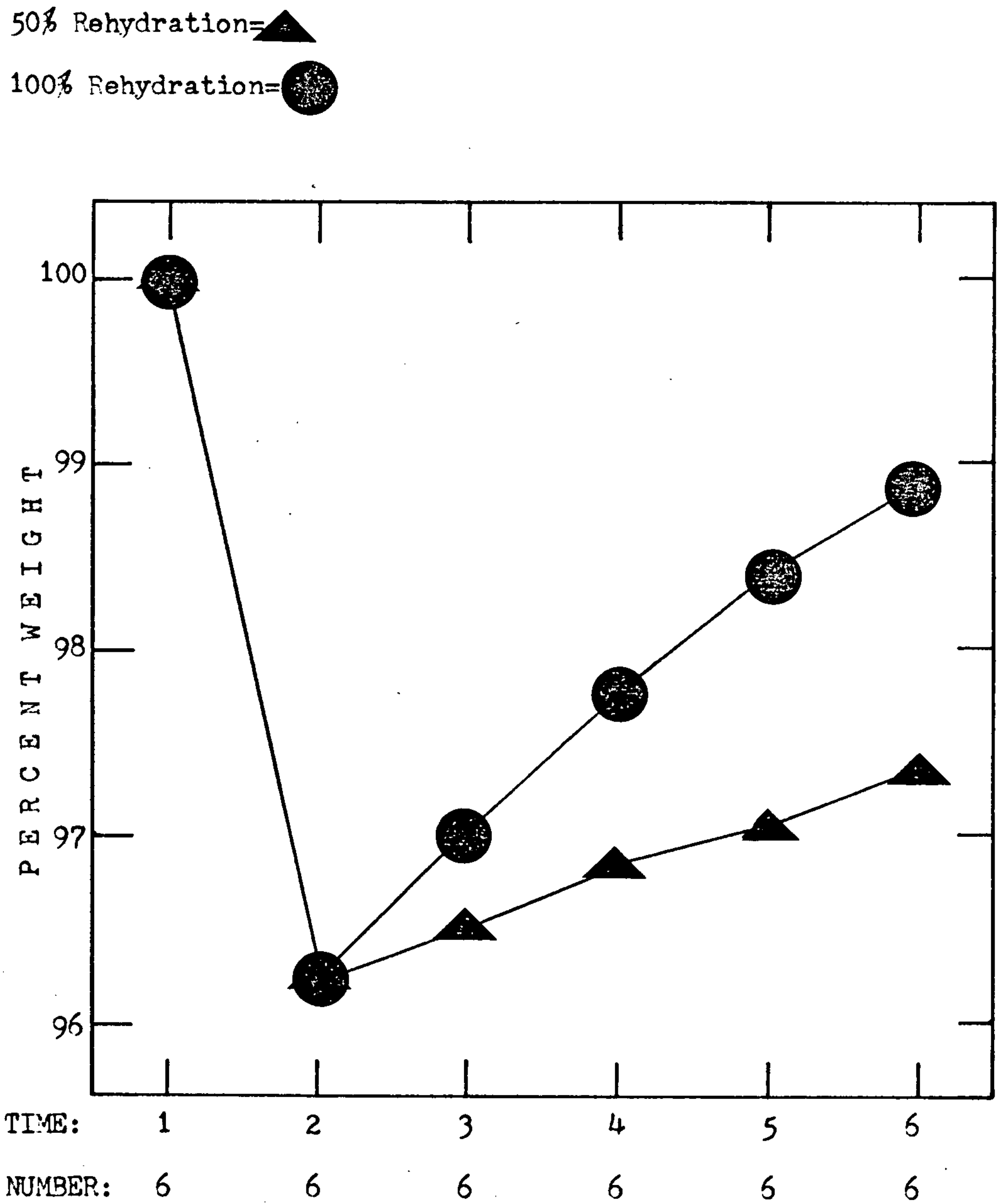


TABLE III
ANALYSIS OF VARIANCE FOR CHANGES IN WEIGHT

N= 6
TIME= 6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.01040	5	0.00208	1457.76	0.000
ERROR	0.00004	25	0.00000		
PERCENT	0.00099	1	0.00099	768.89	0.000
ERROR	0.00007	5	0.00001		
TP	0.00070	5	0.00014	116.48	0.000
ERROR	0.00003	25	0.00000		

FIGURE 4

MEANS OF VOLUME STPD EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

50% Rehydration=

100% Rehydration=

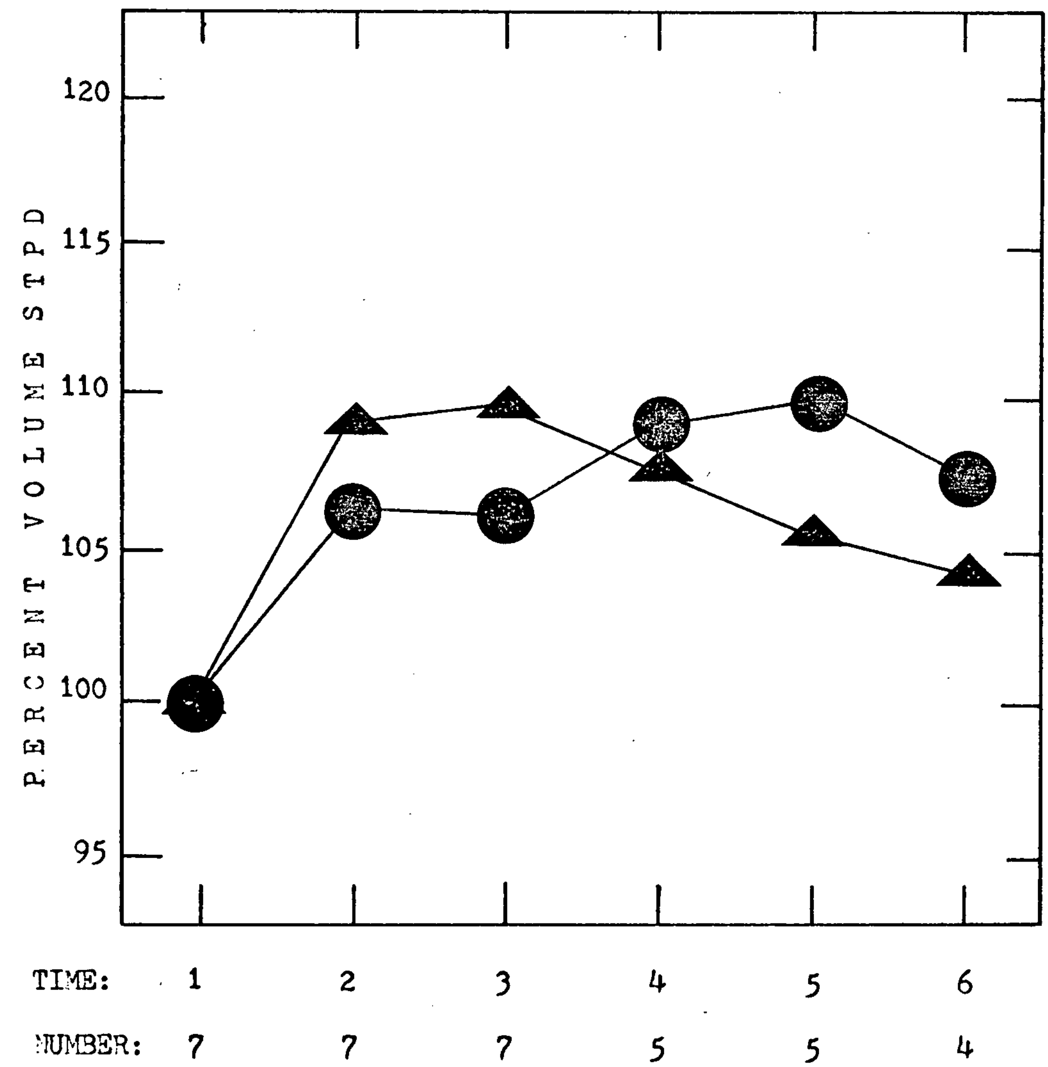


TABLE IV
ANALYSIS OF VARIANCE FOR CHANGES IN VSTPD

N= 4
TIME= 6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.05824	5	0.01165	2.99	0.045
ERROR	0.05830	15	0.00389		
PERCENT	0.00025	1	0.00025	0.02	0.891
ERROR	0.03360	3	0.01120		
TP	0.02147	5	0.00429	1.80	0.173
ERROR	0.03572	15	0.00238		

FIGURE 5

MEANS OF R.Q. EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

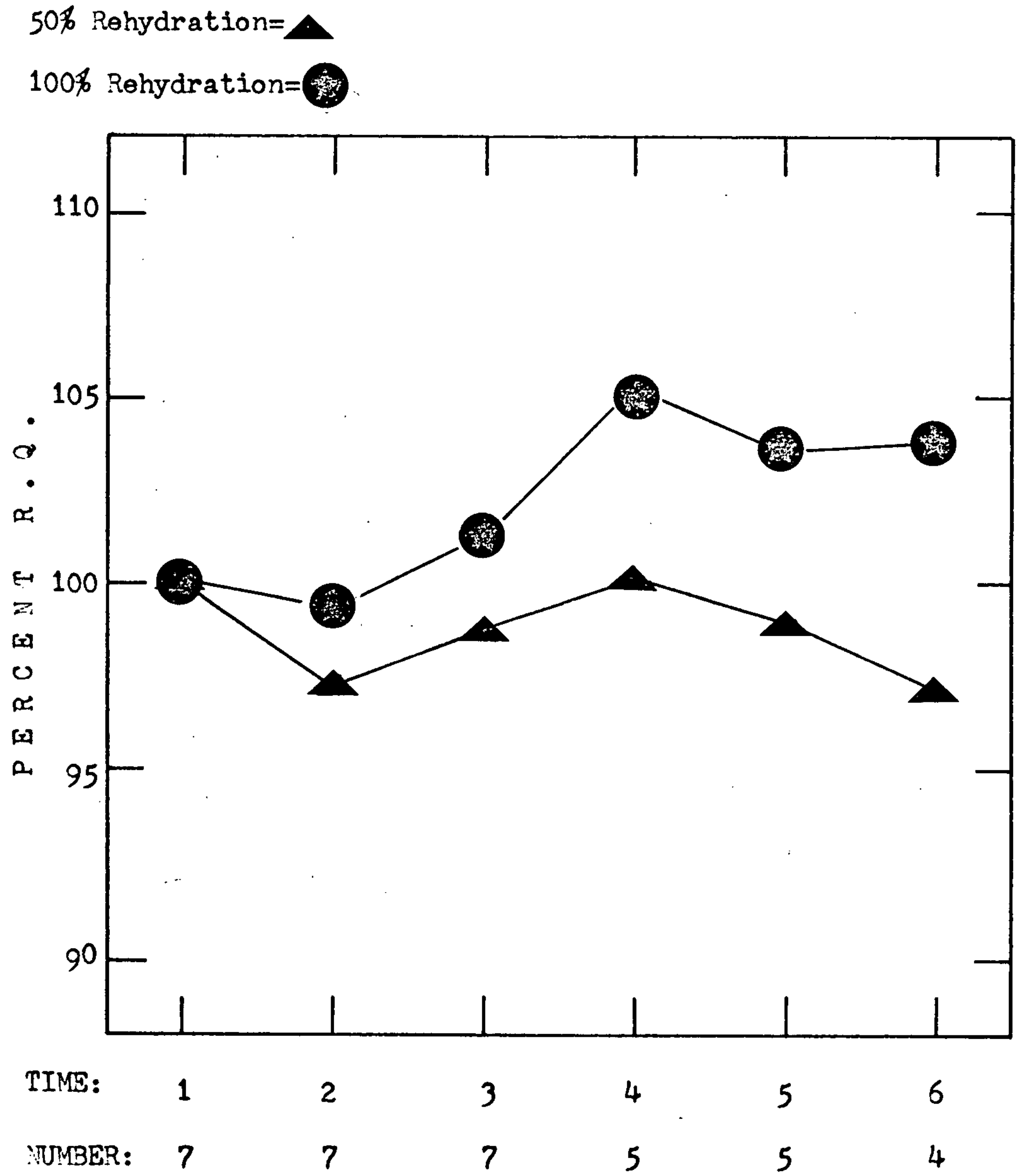


TABLE V
ANALYSIS OF VARIANCE FOR CHANGES IN R.Q.

N= 4
TIME= 6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.00732	5	0.00146	2.20	0.108
ERROR	0.00997	15	0.00066		
PERCENT	0.01902	1	0.01902	0.98	0.395
ERROR	0.05821	3	0.01940		
TP	0.00583	5	0.00117	0.42	0.827
ERROR	0.04163	15	0.00278		

FIGURE 6

MEANS OF TRUE O_2 EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

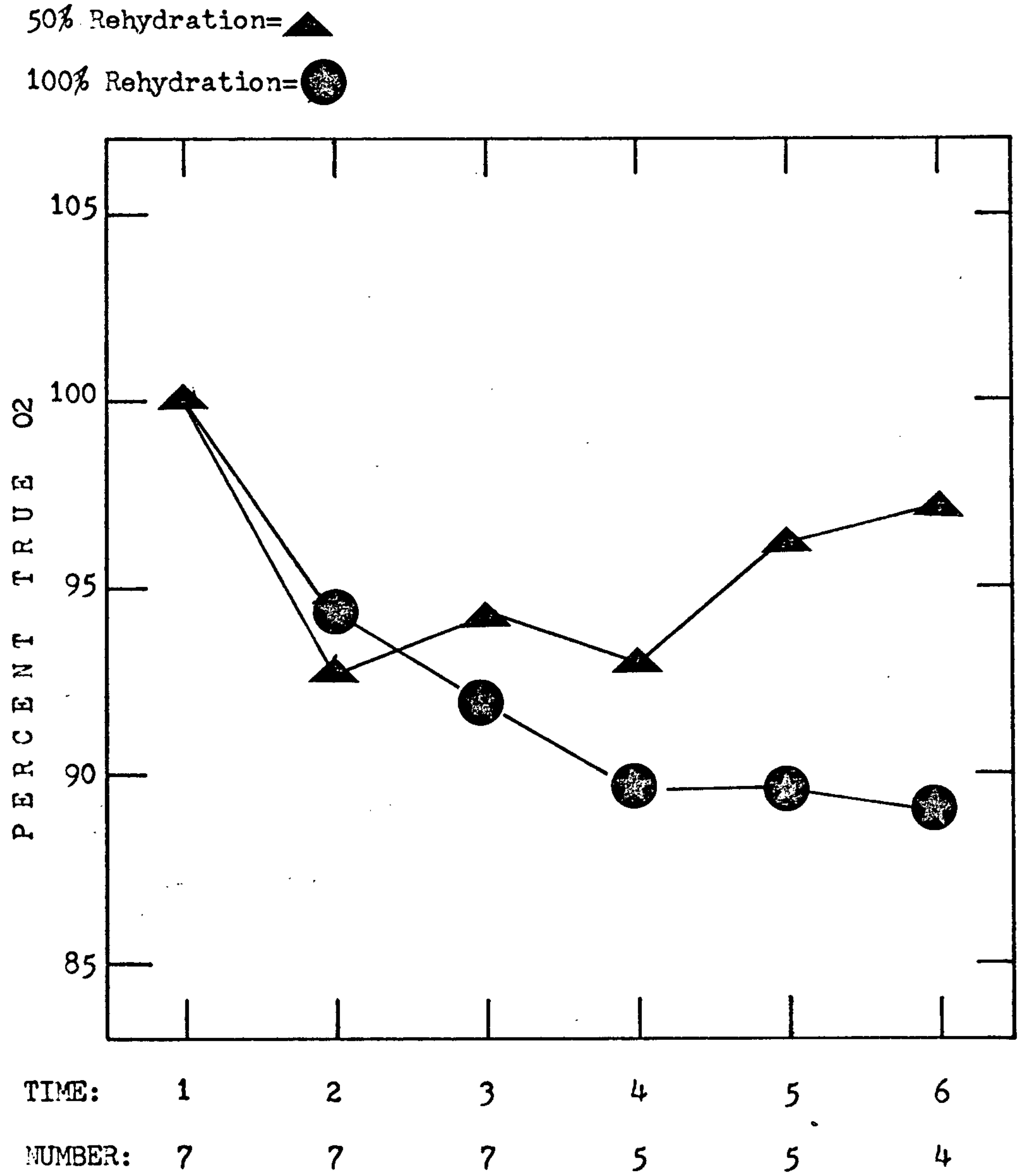


TABLE VI
ANALYSIS OF VARIANCE FOR CHANGES IN TRUE O2

N= 4
TIME= 6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.05763	5	0.01153	3.40	0.030
ERROR	0.05081	15	0.00339		
PERCENT	0.01163	1	0.01163	0.67	0.472
ERROR	0.05175	3	0.01725		
TP	0.02007	5	0.00401	3.48	0.027
ERROR	0.01729	15	0.00115		

TABLE VII

INDIVIDUAL PHYSICAL WORK CAPACITY AND BLOOD GLUCOSE CORRELATION COEFFICIENTS

SUBJECT	F.D.	J.M.	T.H.	R.L.	B.G.	M.R.	K.I.
50% REHYDRATION	.2080	.1026	.7608	.2948	.3881	.9485	-.3515
100% REHYDRATION	-.7532	.5583	.1081	.6802	.7334	.4910	.2538

treatment and treatment by time, which was to be expected as they were experimentally controlled.

Volume STPD (Figure 4, Table IV): There is an increase in volume STPD after heat dehydration with a $p<.05$. Percent rehydration and time by percent rehydration show no significant differences.

R.Q. (Figure 5, Table V): Results do not show any statistically significant changes. However changes with time, where $(p= 0.108)$, can be interpreted as a probable change.

True O_2 (Figure 6, Table VI): Percent rehydration shows no significant change, but change with time is significant $(p<.05)$ and the amount of liquid intake by elapsed time shows a $p<.05$.

Discussion

The mean changes in physical work capacity show a decrease of 30% after a 4% lean body weight heat dehydration which is similar to Kozlowski (1969) and in accordance with Costill and Sparks (1973), Strydom and Holdsworth (1968), Saltin (1964A), and Saltin (1964B), where they noted an increased heart rate on submaximal work. There was only a 12% recovery within the four hours on 100% rehydration conditions . This is not in accordance with Costill and Sparks (1973), but the difference in results can be due to the rehydration procedure. Costill and Sparks (1973), rehydrated their subjects within three hours with twelve equally subdivided amounts of liquid and studied their subjects on a treadmill where they were submitted to only one submaximal work load i.e. heart rate of 120 beat per minute.

The 50% rehydration shows almost the same recovery and this is more related to the previous study mentioned, since the rehydration level is also related to the plasma volume. This lead to the conclusion that the decrease in plasma volume is not the sole cause for elevated heart rates following heat dehydration (Costill and Sparks, 1973).

Among the factors which can explain the decrease in physical work after heat dehydration are the expiratory gas volume and concentrations. Oxygen consumption shows no significant changes throughout the study, see appendix B, as Saltin (1964B), and Kozlowslki (1969), stated. This is very normal because oxygen consumption is related to the amount of work done and in this study the subject, within the same experiment, was submitted to the same amount of work.

The significant ventilation increase after dehydration is not reported in previous literature. Respiratory rate and gas volume are mainly regulated by the chemoreceptors which are influenced by the level of CO_2. The level of CO_2 would be sensed as increased since the blood volume is reduced but the amount of CO_2 released is not increased. Also, the acidosis produced by dehydration, as reported by Masoro (1971), can be interpreted as a cause for such changes.

Recovery in volume STPD does not show a significant decrease with time but in the 50% rehydration condition, it has a lower mean on time six, which can be partially explained by true O_2 changes. Saltin (1964B) reported a decrease in true O_2, but the decrease was not statistically significant.

The volume STPD and true O_2, for the same amount of oxygen intake, normally have a negative relationship, but the better recovery in true O_2 in the 50% rehydration condition, which is statisticaly significant, can be explained by the higher level of absorption of liquid during 100% rehydration which may have caused an increase in blood supply in intestinal regions. This would tend to lower the arterio-venous oxygen difference and reduce the efficiency of oxygen transport as indicated by the lower true O_2.

R.Q. is reported to decrease after heat dehydration (Saltin, 1964A). Our results showed no statistical level of significance in the the changes of R.Q. and the means tendency showed not enough evidence for accurate interpretation.

The main purpose of this study was to investigate the changes in blood glucose after heat dehydration and during rehydration even if it is revealed that blood glucose is not related to the physical work capacity (Reichard et al, 1961; Kosiek; 1969). The investigator believed that the hormonal changes produced by the heat stress should be sufficient to show significant changes in blood glucose. Therefore a negative correlation was expected between blood glucose and the changes in physical work capacity after dehydration and during rehydration.

Results from this investigation show no consistent correlation between the two parameters (Table VII), which differs from expected values. Blood glucose shows a significant change with time during the two experimental conditions, with a decrease after dehydration and an increase on tests five and six. These results do not support the first hypothesis which projected an increase in blood glucose after dehydration. Finally the second hypothesis is partially supported since there is a significant change in blood glucose and physical work capacity during rehydration, but the level of rehydration shows no significant effect.

The level of the glucosteroids was not analysed in this investigation, but previous studies showed (Collins, 1968; Bledsoe, 1966; Kozlowski, 1969 and Gibinski, 1969), that cortisol and aldosterone level are increased during heat stress. Research in more detailed articles gives a better understanding of the mechanism of those hormones and justifies the delayed increase in blood glucose. The initial decrease in blood glucose was probably due to normal blood glucose utilisation, especially by the muscle tissue.

Glucocorticoids have the ability of inducing specific RNA and protein synthesis (mainly gluconeogenic) in some tissues (liver) while suppressing RNA, protein synthesis and gluconeogenesis in other tissues (muscle), (Thompson and Lippman, 1974). Cortisol is transported in human plasma, but more than 90% is bound to a specific alpha globulin, i.e. corticosteroid binding globulin . Only the unbound portion is of physiologic consequence with target tissues (Rosner, 1972 and Rosenthal, Sanberg and Transcortin, 1969).

As already stated the inhibitory effect on insulin of cortisol (Selkurt, 1971) also decreases glucose uptake in extrahepatic tissues. This inhibition is delayed for 3 to 5 hours in muscle tissue (Munck, 1971). An in vitro study on rat livers revealed that the gluconeogenic effect of cortisol only started to show up after two hours, (Exton et al, 1970) and showed an increse in blood glucose after two hours with adrenalectomized fasted rats which were subcutaneously injected with 2.5mg of cortisol, (Munck, 1962).

Therefore the gluconeogenic effect of glucosteroids expected in this study in fact was probably delayed by the time necessary for the cortisol to show up in plasma after heat exposure i.e. one to two hours ; by the delayed inhibition of glucose absorbtion in muscle i.e. 3 to 5 hours and finally by the specific inducing effect on RNA and protein (enzymes) synthesis in the liver which only shows up within two hours.

While the time course of the blood glucose changes over the relatively long time span of the dehydration and rehydration periods in this study suggests a primary involvement of glucocorticoids and gluconeogenesis in these changes, glucagon and epinephrine, through their role in regulating hepatic glycolysis, may also contribute to the overall effect of the treatments on blood glucose.

In the light of this study it would seem that the advantages to a wrestler of cutting down weight by heat dehydration before competition will be counteracted by the loss in physical work capacity. However this interpretation does not take into account the fact that a wrestler normally also eats during the rehydration period. This aspect might warrant futher study. This study also shows that recovery is not only a matter of fluid reabsorption; the changes in blood glucose suggest that the body is affected on the cellular level, and a four hour rehydration period does not seem sufficient to counteract these biochemical changes.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to examine the effects of a 4% lean body weight dehydration with two levels of rehydration for four hours on the changes in physical work capacity and blood glucose. Further, the study examined the effects on volume STPD, VO2, R.Q. and true O2 during the physical work capacity test. A total of 7 uviversity- aged males were involved in the experiment as subjects . Each subject was tested in two experimental conditions, i.e. 50% rehydration and 100% rehydration, on two separate days.

Each set of tests consisted of blood samples drawn from the finger tip, a physical work capacity test with expiratory gas collection. Six sets of tests were distributed as follows: one at 6 A.M.,and one half an hour after dehydration. The four other sets were hourly separated. The rehydration consisted of intake of tomato juice given after the set of tests 2, 3, 4 and 5. The amount given was equally subdivided and depended on the experimental condition.

Analysis of variance indicated significant changes over time for all dependent variables, except VO2; significant changes between level of rehydration for weight, and significant changes for the level of rehydration by time interaction for true O2 and weight. There was no significant individual simple correlation coefficient between blood glucose and physical work capacity for each experimental condition.

There was a mean decrease of 30% in physical work capacity after heat dehydration and only 40% of the loss was recovered without significant difference between experimental conditions. Gas exchange was also affected. The volume STPD increased after dehydration, true O2 decreased after dehydration and a better recovery showed up in the 50% rehydration condition.

The R.Q. parameter, in fact, did not indicate significant changes but there was a slight decrease after dehydration. The level of blood glucose decreased after dehydration but there was an increase in the middle of rehydration, even with the expected increase in blood volume, from the liquid intake. This suggested a very high level of gluconeogenesis on those last hours, probably due to glucocorticoid hormone action.

Conclusions

1. A 4% lean body weight heat dehydration significantly reduce physical work capacity and while significant recovery occurs over a four hour rehydration period, there is no difference between 50% and 100% rehydration within that time.

2. The level of blood glucose decreases after dehydration but is not correlated to the change in physical work capacity.

3. Two to three hours after heat dehydration, blood glucose increases without being affected by the level of rehydration.

4. Volume STPD increases after dehydration and almost plateaus during rehydration.

5. True O2 decreases after dehydration and a better recovery comes with the 50% rehydration condition.

BIBLIOGRAPHY

Adolph, E.F., and Associates, Physiology of Man in the Desert, New York: Interscience, 1947.

Astrand, P.O., and K.Rodahl, Textbook of Work Physiclogy, Toronto, Mc Graw-Hill Book Co., 1970.

Baldwin, R.L., "Metabolic Function Affecting the Contribution of Adipose Tissue to Total Energy Expenditure, " Fed. Proc., 29:1277, 1970.

Beethman, W.P.J.r. and E.R. Buskirk, "Effects of Dehydration, Physical Conditioning and Heat Acclimatization on the Response to Passive Tilting," J. Appl. Physiol., 13:465, 1958.

Bledsoe, T., D.P., Island and W.G. Liddle, "Studies of the Mechanism Through Which Na Depletion Increases Aldosterone Biosynthesis in Man," J. Clin. Invest., 45:524, 1966.

Bledsoe, T., G.W. Liddle, A. Riondel, et al., "Comparative Fates of Intravenously and Orally Administrated Aldosterone: Evidence for Extrahepatric Formation of Acid Hydrolyzable Conjugate in Man," J. Clin. Invest., 45:264, 1966.

Buskirk, E.R., P.F. Iampietro and D.E. Bass, "Work Performance After Dehydration: Effects of Physical Condition and Heat Acclimatization," J. Appl. Physiol., 12:189, 1958.

Canadian Association for Health, Physical Education and Recreation, The Physical Work Capacity of Canadian Children, Published by C.A.H.P.E.R., Ottawa, 1968.

Collins, K.J. and J.J. Weiner, "Endocrinological Aspects of Exposure to High Environmental Temperatures," Physiol. Rev., 48: 785, 1968.

Conrad, V., H. Brunnengraber, R. Vanroux, A. Deschaepdrjiver, E. Moermans and J.R.M. Franckson, "Influence of Muscular Exercise on Glucose Regulation," Biochemistry of Exercise, Medicine and Sport, New York, pp. 114-115, 1969.

Consolazio, C.F., et al., "Relationship Between Calcium in Sweat, Calcium Balance, and Calcium Requirements," J. Nutr., 78:78, 1962.

Consolazio, F.C., Le Roy, Nelson, Harding and Canhan, "Excretion of Sodium, Potassium, Magnesium, Iron in Human Sweat and the Regulation to Each to Balance and Requirements," J. Nutr., 63: 407, 1963.

Costill, D.L. And K.e. Sparks, "Rapid fluid Replacement Following Thermal Dehydration," J. Appl. Physiol., 34:299, 1973.

Exton, J.H., L.E. Mallette, L.S. Jefferson, et al., "The Hormonal Control of Hepathic Gluconeogenesis," Recent Prog. Horm. Res., 26:411, 1970.

Ferguson, G.A., Statistical Analysis in Psychology and Education, Third Edition, Toronto, Mc Graw-Hill Book Company, 1971.

Froberg, S.O., "Metabolism of Lipids in Blood and Tissues During Work," Biochemistry of Exercise, Medicine and Sport, New York, pp. 100-113, 1969.

Gibinski K., "Role of the Sweat Glands in Thermoregulation," Acta Physiol. Pol., 20:709, 1969.

Giec, L., "Mobilisation of Water-Electrolytes Reserves of the Body in Defense Against Hyperthermia," Acta Physiol. Pol., 20:717, 1969.

Goodhart, R.S. and M.E. Shills, Modern Nutition in Health and Disease, Fifth Edition, Philadelphia, Lea and Febiger, 1973.

Govindaraj, M., "The Effect of Dehydration on the Ventilatory Capacity in Normal Subjects," Am. Rev. Respir. Dis., 105:842, 1972.

Greenleaf, J.E. and F. Sargent II, "Voluntary Dehydration in Man," J. Appl. Physiol., 20:719, 1965.

Herman, R.H., D. Zakim and F.B. Stifel, "Effect of Diet on Lipid Metabolism in Experimental Animals and Man," Fed. Proc., 29:1302, 1970.

Horstaman, D.H. and S.M. Horvath, "Cardiovascular and Temperature Regulation Changes During Progressive Dehydration and Euhydration," J. Appl. Physiol., 33:446, 1972.

Horstaman, D.H. and S.M. Horvath, "Cardiovascular Adjustment to Progressive Dehydration," J. Appl.Physicl., 35:501, 1973.

Issekutz, B.Jr. and H. Miller, "Plasma Free Fatty Acids during Exercise and the Effect of Lactic Acid," Proc. Soc. Expt. Biol. Med., 110:237, 1962.

Johnson R.E., Belding, Consolazio and Pitts, Harvard Fatique Laboratory Report 13, Cambrige, Massachusetts, 1942.

Kosiek, J.P., V. Kersting, F. Kusters and E.J. Klaus, "Comparative Investigation on the Daily Rhythm of Blood Glucose After Rest, After Exhaustive Continuous Exercise," Biochemistry of Exercise, Medicine and Sport, New York, pp. 144-147, 1969.

Kozlowski, S., "Physical Performance and Maximum Oxygen Uptake in Man in Exercise Dehydration," Bull. Acad. Pol. Sci. Biol., 14:513, 1966.

Kozlowski S., "Role of Thirst in Regulation of Water Balance in the Body," Acta Physiol. Pol., 20:730, 1969.

Kozlowski S. And B. Saltin, "Effect of Sweat Loss on Body Fluid," J. Applied. Physiol., 19:1119, 1964.

Leveille, G.A., "Nutritional Factors in the Regulation of Lipid Metabolism," Fed. Proc., 29:1276, 1970.

Macfarlane, W.V., K.W. Robinson, B. Howard and R. Kinne, "Heat, Salt and Hormones in Panting and Sweating Animal," Nature , 182:672, 1958.

Masoro, E.J., L.B. Rowell and R.M. McDonald, "Intracellular Muscle Lipids as Energy Sources During Muscular Exercise and Fasting," Fed. Proc., 25:1421, 1966.

Masoro, E.S. and P.D. Siegel, Acid Base regulation: It's Physiology and Pathophysiology, Philadelphia, W.B. Saunder Comp., 1971.

Mountcastle, V.B., _Medical Physiology_, Twelfth Edition, St Louis, Mosby Company, 1968.

Munck, A., "Glucocorticoid Inhibition of Glucose Uptake by Peripheral Tissues. Old and New Evidence. Molecular Mechanisms and Physiological Significance," _Perspect. Biol. Med._, 14:265, 1971.

Munck, A. and S.B. Koritz, "Studies on the Mode of Action of Glucocorticoids in Rats. Early Effects of Cortisol cn Blood Glucose and on Glucose Entry Into Muscle, Liver and Adipose Tissue," _Biochim. Biophys. Acta_, 57:310, 1962.

O'Connor, W.J., _Renal Function_, London Arnold, 1962.

Pitts, G.C., R.E. Johson and F.C. Consolazio, "Work in the Heat as Affected by Intake of Water, Salt and Glucose," _Am. J. Physiol._, 142:253, 1944.

Reichard, G.A., Issekutz Jr., P. Kimbel, R.C. Putman, N.J. Hochella and S. Weinhouse,"Blood Glucose metabolism in Man During Muscular Work," _J. Appl. Physiol._, 16:1005, 1961.

Ribisl, P.M., "When Wrestlers Shed Pounds Quickly," _Physician and Sportsmedicine_, 2:30, 1974.

Rosenthal, H.E., W.R. Slaunwhite Jr. and A.A. Sanberg, "Transcortin: A Corticosteroid-Binding Protein of Plasma. X. Cortisol and Progesterone Interplay and Unbound Levels of These Steroids in Pregnancy," _J. Clin. Endocrinol. Metab._, 29:352, 1969.

Rosmer, W., R. Hochberg, "Corticosteroid-Binding Globulin in the Rat: Isolation and Studies of its Influence on Cortisol Action in Vivo," _Endocrinology_, 91:626, 1972.

Saltin, B., "Aerobic and Anaerobic Work Capacity After Dehydration," _J. Appl. Physiol._, 19:114, 1964A.

Saltin, B., "Circulatory Response to Submaximal and Maximal Exercise After Thermal Dehydration," _J. Appl. Physiol._, 19:1125, 1964B.

Scherrer M., "Acid-Base Imbalance and Gas Exchange During Heavy Work," _Biochimistry of Exercise, Medicine and sport_, New

York, pp. 2-14, 1969.

Selkurt E.E., Physiology, Third Edition Boston, Little Brown and Co., 1971.

Sigma Chemical Company, Sigma technical Bulletin No. 635(4-74), St Louis, Sigma Chemical Co., 1974.

Simonson, E., Physiology of Work Capacity and Fatigue, Springfield, Thomas Publisher, 1971.

Strydom, N.B. and Holdsworth, "The Effects of Different Water Deficit on Physiological Responses During Heat Stress," Int. Z. Angew. Physiol., 26:95, 1968.

Tepperman, J., Metabolic and Endocrine Physiology : an Introduction Text, Second ed., Chicago, Year Book Medical Publishers, 1968.

Thompson, E.B. and M.E. Lippman, "Mechanism of Action of Glucocorticoids," Metabolism, 23:159, 1974.

Vanroux, R., "L'Acidose Metabolique au Cours de L'Effort Musculaire," Biochemistery of Exercise, Medicine and Sport, 3:89, 1969.

Yuhasz, M.S., "The Effects of Sports Training on Body Fat in Man With Predictions of Optimal Body Weight," Ph.D Thesis, University of Illinois, 1962.

APPENDIX A

NAME: F.D.

AGE: 18years old.

PRETEST: PHYSICAL WORK CAPACITY 150.

1. 1794.20 Kp.m./min.

2. 1742.43 Kp.m./min.

3. 1640.07 Kp.m./min.

3. 1719.11 Kp.m./min.

Mean: 1723.95 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: Subject slept 5.5 hrs the night before and had a headache on the last set of tests.

100% Rehydration: The subject slept 3 hrs the night before and got drunk. He could not complete his 4% lean body weight dehydration. The belt broke on his fourth set of tests and therefore that test with the following were recorded but the physical work capacity 150 and gas exchange were not included in the statistical analysis.

SUBJECT: F.D. DATE: MARCH 20-75

LEAN BODY WEIGHT:

1- 5.2mm (chest)

2- 7.4mm (tricept)

3- 8.0mm (subscapular)

4- 7.5mm (supra iliac)

5- 7.0mm (abdomen)

6- 13.5mm (front thigh)

% total body fat = 48.6mm x 0.097+3.64 = 8.35%

FAT WT = 73.74Kg x 0.0835 = 6.16Kg

LBW = 73.74Kg - 6.16Kg = 67.58Kg

Condition: RH-50% % dehydration: 4.19%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1928.80	1550.30	1770.00	1699.74	1705.05	1545.67
Blood G mg%	118.86	114.86	103.00	107.43	110.14	109.86
Weight Kg	73.74	70.91	71.18	71.40	70.62	71.84
Liq in ml		354	354	354	354	
(O2)	0.1570	0.1540	0.1588	0.1513	0.1536	0.1530
(CO2)	0.0451	0.0470	0.0445	0.0489	0.0485	0.0489
Gas Temp.	27C	28C	28C	27.5C	27.5C	27C
VATPS li/min.	37.941	39.722	39.826	35.666	39.119	39.983
VSTPD li/min.	32.975	34.333	34.423	31.780	33.906	34.751
R.Q.	0.8469	0.8089	0.8447	0.8014	0.8333	0.8308
VO2 li/min.	1.764	1.982	1.801	1.927	1.961	2.031
True O2	5.325	5.774	5.233	6.065	5.784	5.845

Bar press.: 752.6mmHg
Time start: 6:15A.M.
Time D.H.: 3.50Hrs
Time finish: 2:15P.M.

Room Temp.: 25C
Sauna Temp.: 70C
Room rel.hum.: 47%
Sauna rel.hum.: 3.2%

SUBJECT: F.D. DATE: MARCH 20-75

LEAN BODY WEIGHT:

1- 5.0mm (chest)

2- 8.0mm (tricept)

3- 8.8mm (subscapular)

4- 8.1mm (supra iliac)

5- 8.7mm (abdomen)

6- 15.0mm (front thigh)

% total body fat = 54.4mm x 0.097+3.64 = 8.92%

FAT WT = 74.44Kg x 0.0892 = 6.64Kg

LBW = 74.44Kg - 6.64Kg = 67.80Kg

Condition: RH-100% % dehydration: 3.73%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1259.27	1070.27	1141.97	1234.55	2276.10	1668.53
Blood G mg%	116.00	125.00	115.40	121.83	131.33	135.56
Weight Kg	74.41	71.91	72.58	73.05	73.41	73.97
Liq in ml		632.5	632.5	632.5	632.5	
(O2)	0.1539	0.1529	0.1538	0.1562	0.1602	0.1579
(CO2)	0.0469	0.0482	0.0477	0.0430	0.0402	0.0429
gas Temp.	26C	2.65C	27C	26C	25.5C	25C
VATPS li/min.	45.39	44.785	46.540	42.210	34.745	34.999
VSTPD li/min.	40.443	39.847	41.296	37.656	31.080	30.398
R.Q.	0.8050	0.8145	0.8200	0.7623	0.7719	0.7894
VO2 li/min.	2.341	2.343	2.387	2.109	1.607	1.694
True O2	5.789	5.880	5.780	5.601	5.169	5.397

Bar press.: 768mmHg
Time start: 6:40A.M.
Time D.H.: 4.00Hrs
Time finish: 3;30P.M.

Room Temp.: 23C
Sauna Temp.: 70C
Room rel.hum.: 29%
Sauna rel.hum.: 3.4%

NAME: J.M.

AGE: 20years old.

PRETEST: PHYSICAL WORK CAPACITY 150

1. 1121.19 Kp.m./min.
2. 1278.60 Kp.m./min.
3. 1381.22 Kp.m./min.
4. 1408.00 Kp.m./min.

Mean: 1297.25 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: The subject had a headache on his third set of tests.

100% Rehydration: None.

SUBJECT: J.M. DATE: MARCH 20-75

LEAN BODY WEIGHT:

1- 5.9mm (chest)

2- 5.8mm (tricept)

3- 6.7mm (subscapular)

4- 4.0mm (supra iliac)

5- 8.2mm (abdomen)

6- 10.8mm (front thigh)

% total body fat = 41.4mm x 0.097+3.64 = 7.66%

FAT WT = 57.99Kg x 0.0766 = 4.44Kg

LBW = 57.99Kg - 4.44Kg = 53.55Kg

Condition: RH-50% % dehydration: 3.99%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1511.95	1020.00	1008.37	1071.11	1142.17	1253.96
Blood G mg%	134.47	136.11	134.47	130.29	125.92	134.37
Weight Kg	57.99	55.85	56.04	56.22	56.30	56.41
Liq in ml		267.5	267.5	267.5	267.5	
(O2)	0.1543	0.1671	0.1599	0.1625	0.1620	0.1587
(CO2)	0.0461	0.0348	0.0437	0.0415	0.0437	0.0445
Gas Temp.	27.5C	27.5C	27C	27C	27C	27C
VATPS li/min.	28.442	34.064	32.842	31.882	31.157	29.752
VSTPD li/min.	25.054	29.529	28.457	27.093	27.079	25.858
R.Q.	0.8098	0.7770	0.8485	0.8505	0.8950	0.8427
VO2 li/min.	1.418	1.311	1.455	1.342	1.313	1.356
True O2	5.659	4.440	5.115	4.844	4.849	5.245

Bar press.: 752.6mmHg
Time start: 6:00A.M.
Time D.H.: 3.50Hrs
Time finish: 2:00P.M.

Room Temp.: 25C
Sauna Temp.: 70C
Room rel.hum.: 47%
Sauna rel.hum.: 3.2%

SUBJECT: J.M. DATE: MARCH 27-75

LEAN BODY WEIGHT:

1- 7.2mm (chest)

2- 7.2mm (tricept)

3- 8.0mm (subscapular)

4- 4.6mm (supra iliac)

5- 9.6mm (abdomen)

6- 12.4mm (front thigh)

% total body fat = 49.0mm x 0.097+3.64 = 8.39%

FAT WT = 58.70Kg x 0.0839 = 4.93Kg

LBW = 58.70Kg - 4.93Kg = 53.78Kg

Condition: RH-100% % dehydration: 4.18%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	947.63	598.14	654.67	741.92	744.43	788.87
Blood G mg%	124.10	112.99	109.41	112.99	130.91	132.70
Weight Kg	58.70	56.45	56.85	57.17	57.61	57.82
Liq in ml		562.5	562.5	562.5	562.5	
(O2)	0.1541	0.1666	0.1661	0.1658	0.1690	0.1640
(CO2)	0.0531	0.0399	0.0410	0.0419	0.0360	0.0423
Gas Temp.	24.2C	25C	25C	25C	25C	25C
VATPS li/min.	37.696	44.505	44.121	42.882	42.131	39.642
VSTPD li/min.	33.895	39.937	39.598	38.861	37.796	35.563
R.Q.	0.9430	0.9067	0.9246	0.9420	0.8566	0.9065
VO2 li/min.	1.898	1.744	1.743	1.716	1.575	1.648
True O2	5.599	4.368	4.402	4.416	4.167	4.633

Bar press.: 766mmHg
Time start: 6:00A.M.
Time D.H.: 3.50Hrs
Time finish: 2:00P.M.

Room Temp.: 23.5C
Sauna Temp.: 70C
Room rel.hum.: 32%
Sauna rel.hum.: 3.2%

NAME: T.H.

AGE: 23years old.

PRETEST: PYSICAL WORK CAPACITY 150

1. 1688.77 Kp.m./min.
2. 1736.73 Kp.m./min.
3. 1696.84 Kp.m./min.
4. 1711.14 Kp.m./min.

Mean: 1708.37 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: None.

100% Rehydration: During the second rehydration period the subject was unable to complete the liquid ingestion for this and subsequent tests. Therefore, tests at 2, 3, + 4 hrs. of rehydration were not included in the statistical analysis.

SUBJECT: T.H. DATE: APRIL 1-75

LEAN BODY WEIGHT:

1- 5.4mm (chest)

2- 9.3mm (tricept)

3- 10.1mm (subscapular)

4- 6.2mm (supra iliac)

5- 8.2mm (abdomen)

6- 9.9mm (front thigh)

% total body fat = 49.1mm x 0.097+3.64 = 8.40%

FAT WT = 89.59Kg x 0.0840 = 7.53Kg

LBW = 89.59Kg - 7.53Kg = 82.06Kg

Condition: RH-50% % dehydration: 4.07%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1374.71	980.55	949.92	1015.30	1028.67	1024.45
Blood G mg%	136.67	127.00	120.00	130.00	126.33	118.33
Weight Kg	89.59	86.25	86.60	86.83	87.05	87.37
Liq in ml		417.5	417.5	417.5	417.5	
(O2)	0.1490	0.1562	0.1533	0.1550	0.1551	0.1541
(CO2)	0.0530	0.0422	0.0426	0.0418	0.0414	0.0428
Gas Temp.	23C	26C	26.5C	26.5C	26.5C	26.5C
VATPS li/min.	42.030	47.810	48.523	50.306	50.413	47.539
VSTPD li/min.	37.639	42.162	42.661	44.224	44.292	41.727
R.Q.	0.8436	0.7452	0.7075	0.7174	0.7107	0.7238
VO2 li/min.	2.351	2.371	2.551	2.558	2.561	2.450
True O2	6.247	5.622	5.979	5.785	5.783	5.872

Bar press.: 757.8mmHg
Time start: 6:30A.M.
Time D.H.: 2.5Hrs
Time finish: 1:30P.M.

Room Temp.: 22C
Sauna Temp.: 70C
Room rel.hum.: 33%
Sauna rel.hum.: 3.3%

SUBJECT: T.H. DATE: MARCH 26-75

LEAN BODY WEIGHT:

1- 5.3mm (chest)

2- 9.6mm (tricept)

3- 10.5mm (subscapular)

4- 6.2mm (supra iliac)

5- 7.9mm (abdomen)

6- 10.6mm (front thigh)

% total body fat = 50.1mm x 0.097+3.64 = 8.50%

FAT WT = 89.35Kg x 0.0850 = 7.59Kg

LBW = 89.35Kg - 7.59Kg = 81.76Kg

Condition: RH-100% % dehydration: 4.17%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1639.41	1329.41	1331.72	1159.89	1175.91	1139.52
Blood G mg%	132.04	122.33	138.83	132.82	137.67	141.75
Weight Kg	89.35	85.94	86.64	87.36	87.83	87.67
Liq in ml		855	855	855	855	
(O2)	0.1545	0.1602	0.1588	0.1611	0.1609	0.1610
(CO2)	0.0505	0.0428	0.0443	0.0417	0.0397	0.0385
Gas Temp.	22.4C	22.5C	21C	23C	25.5C	25.5C
VATPS li/min.	45.361	50.154	49.700	74.135	72.336	72.773
VSTPD li/min.	40.933	44.674	45.199	66.740	64.342	64.704
R.Q.	0.8936	0.8332	0.8400	0.8314	0.7734	0.7471
VO2 li/min.	2.299	2.279	2.367	3.348	3.278	3.308
True O2	5.699	5.100	5.238	5.016	5.094	5.113

Bar press.: 762.4mmHg
Time start: 6:30A.M.
Time D.H.: 2.50Hrs
Time finish: 2:00P.M.

Room Temp.: 20C
Sauna Temp.: 70C
Room rel.hum.: 29%
Sauna rel.hum.: 3.1%

SUBJECT: R.L. DATE: MARCH 29-75

LEAN BODY WEIGHT:

1- 5.6mm (chest)

2- 7.8mm (tricept)

3- 8.5mm (subscapular)

4- 5.0mm (supra iliac)

5- 8.4mm (abdomen)

6- 7.8mm (front thigh)

% total body fat = 43.1mm x 0.097+3.64 = 7.82%

FAT WT = 70.48Kg x 0.082 = 5.51Kg

LBW = 70.48Kg - 5.51Kg = 64.97Kg

Condition: RH-50% % dehydration: 4.02%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1202.79	833.78	739.13	798.82	906.10	941.49
Blood G mg%	133.83	118.23	131.20	132.52	133.65	145.68
Weight Kg	70.48	67.87	68.04	68.25	68.35	68.62
Liq in ml		326	326	326	326	
(O2)	0.1557	0.1601	0.1609	0.1612	0.1589	0.1555
(CO2)	0.0480	0.0448	0.0422	0.0422	0.0430	0.0441
Gas Temp.	23C	24C	25.5C	25.5C	26.5C	26.5C
VATPS li/min.	61.547	67.300	68.530	67.605	62.664	59.816
VSTPD li/min.	53.817	60.482	61.136	60.311	55.543	52.984
R.Q.	0.8623	0.8794	0.8775	0.8397	0.8117	0.7738
VO2 li/min.	2.977	3.060	2.919	3.009	2.921	2.999
True O2	5.532	5.060	4.775	4.990	5.260	5.661

Bar press.: 741.6mmHg
Time start: 6:00A.M.
Time D.H.: 3.00Hrs
Time finish: 1:30P.M.

Room Temp.: 20C
Sauna Temp.: 70C
Room rel.hum.: 54%
Sauna rel.hum.: 3.0%

SUBJECT: R.L. DATE: MARCH 22-75

LEAN BODY WEIGHT:

1- 5.4mm (chest)

2- 7.3mm (tricept)

3- 8.0mm (subscapular)

4- 4.4mm (supra iliac)

5- 7.6mm (abdomen)

6- 7.3mm (front thigh)

% total body fat = 40.0mm x 0.097+3.64 = 7.52%

FAT WT = 69.51Kg x 0.0752 = 5.23Kg

LBW = 69.51Kg - 5.23Kg = 64.28Kg

Condition: RH-100% % dehydration: 3.90%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1482.99	996.00	1081.55	1124.76	1180.18	1208.99
Blood G mg%	151.46	125.24	117.86	110.68	103.88	121.17
Weight Kg	69.51	67.00	67.51	68.08	68.55	68.87
Liq in ml		627.5	627.5	627.5	627.5	
(O2)	0.1550	0.1609	0.1634	0.1664	0.1632	0.1628
(CO2)	0.0449	0.0422	0.0415	0.0391	0.0428	0.0425
Gas Temp.	25C	24.8C	25.4C	24.8C	24.4C	24.3C
VATPS li/min.	40.795	44.907	43.731	50.459	48.905	47.369
VSTPD li/min.	35.300	39.028	37.563	43.911	42.577	41.416
R.Q.	0.7809	0.8334	0.8710	0.8768	0.9002	0.8829
VO2 li/min.	2.013	1.962	1.777	1.943	2.010	1.979
True O2	5.703	5.028	4.730	4.425	4.721	4.780

Bar press.: 741.6mmHg
Time start: 6:00A.M.
Time D.H.: 3.75Hrs
Time finish: 2:45P.M.

Room Temp.: 20C
Sauna Temp.: 70C
Room rel.hum.: 42C
Sauna rel.hum.: 3.1%

NAME: R.L.

AGE: 18years old.

PRETEST: PHYSICAL WORK CAPACITY 150

1. 1227.24 Kp.m./min.
2. 1967.94 Kp.m./min.
3. 1675.44 Kp.m./min.
4. 1654.04 Kp.m./min.

Mean: 1631.16 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: None.

100% Rehydration: The subject only completed a 3.9% lean body weight dehydration because of a headache which desappeared after the second set of tests.

NAME: B.G.

AGE: 29years old.

PRETEST: PHYSICAL WORK CAPACITY 150

1. 1962.52 Kp.m./min.
2. 1854.88 Kp.m./min.
3. 1873.87 Kp.m./min.
4. 1887.94 Kp.m./min.

Mean: 1894.80 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: 4.5 hrs of sleep.

100% Rehydration: 5 hrs of sleep.

SUBJECT: B.G. DATE: MARCH 21-75

LEAN BODY WEIGHT:

1-	4.4mm	(chest)
2-	6.9mm	(tricept)
3-	11.4mm	(subscapular)
4-	7.2mm	(supra iliac)
5-	10.0mm	(abdomen)
6-	9.8mm	(front thigh)

% total body fat = 49.7mm x 0.097+3.64 = 8.46%

FAT WT = 83.72Kg x 0.0846 = 7.08Kg

LBW = 83.72Kg - 7.08Kg = 76.64Kg

Condition: RH-50% % dehydration: 4.07%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	2234.56	1772.95	1890.16	1955.55	2197.07	2225.71
Blood G mg%	120.71	124.57	121.14	122.86	125.71	135.71
Weight Kg	83.72	80.60	80.77	81.02	81.11	81.40
Liq in ml		390	390	390	390	
(O2)	0.1542	0.1598	0.1568	0.1571	0.1572	0.1596
(CO2)	0.0460	0.0403	0.0438	0.0449	0.0434	0.0432
Gas Temp.	25C	25C	26C	26C	25C	25C
VATPS li/min.	46.461	51.987	47.919	50.363	48.338	50.232
VSTPD li/min.	40.160	44.915	41.060	43.138	41.628	43.247
R.Q.	0.7914	0.7667	0.7887	0.8203	0.7888	0.8305
VO2 li/min.	2.318	2.343	2.363	2.345	2.275	2.234
True O2	5.775	5.217	5.512	5.437	5.464	5.166

Bar press.: 740.5mmHg
Time start: 6:00A.M.
Time D.H.: 2.25Hrs
Time finish: 1.15P.M.

Room Temp.: 22.5C
Sauna Temp.: 70C
Room rel.hum.: 33%
Sauna rel.hum.: 3.2%

SUBJECT: B.G. DATE: MARCH 28-75

LEAN BODY WEIGHT:

1- 5.2mm (chest)

2- 7.3mm (tricept)

3- 12.4mm (subscapular)

4- 8.2mm (supra iliac)

5- 10.8mm (abdomen)

6- 10.5mm (front thigh)

% total body fat = 54.4mm x 0.097+3.64 = 8.92%

FAT WT = 83.39Kg x 0.0892 = 7.44Kg

LBW = 83.39Kg - 7.44Kg = 75.95Kg

Condition: RH-100% % dehydration: 4.35%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1583.12	1206.13	1260.00	1296.82	1340.27	1351.66
Blood G mg%	125.27	120.16	117.03	121.06	123.75	119.20
Weight Kg	83.39	80.08	80.55	81.15	81.84	82.44
Liq in ml		827.5	827.5	827.5	827.5	
(O2)	0.1602	0.1560	0.1576	0.1591	0.1601	0.1600
(CO2)	0.0403	0.0448	0.0441	0.0437	0.0421	0.0410
Gas Temp.	24C	25C	25C	26C	26.5C	26.5C
VATPS li/min.	57.480	55.505	55.270	58.586	63.240	62.795
VSTPD li/min.	51.856	49.788	49.577	52.261	56.267	55.871
R.Q.	0.7742	0.7977	0.8119	0.8302	0.8145	0.7867
VO2 li/min.	2.679	2.778	2.675	2.726	2.887	2.890
True O2	5.161	5.579	5.395	5.216	5.132	5.173

Bar press.: 768mmHg
Time start: 6=00A.M.
Time D.H.: 2.00Hrs
Time finish: 1:00P.M.

Room Temp.: 23C
Sauna Temp.: 70C
Room rel.hum.: 29%
Sauna rel.hum.: 3.4%

NAME: M.R.

AGE: 21years old.

PRETEST: PHYSICAL WORK CAPACITY 150.

1. 1712.37 Kp.m./min.

2. 1733.32 Kp.m./min.

3. 1733.40 Kp.m./min.

4. 1761.99 Kp.m./min.

Mean: 1735.27 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: Subject had only 3 hrs of sleep and got drunk the night before. On the sixth set of tests the subject was tested with a different belt, since the previous had broken, therefore his physical work capacity 150 and gas exchange were recorded but not included in the analysis of data because the new belt showed no reliability to the previous one.

100% Rehydration: Subject has only 2.5 hrs of sleep and got drunk the night before.

SUBJECT: M.R.   DATE: MARCH 28-75

LEAN BODY WEIGHT:

1- 3.7mm (chest)

2- 4.7mm (tricept)

3- 6.3mm (subscapular)

4- 4.7mm (supra iliac)

5- 6.4mm (abdomen)

6- 5.9mm (front thigh)

% total body fat = 31.7mm x 0.097+3.64 = 6.71%

FAT WT = 78.04Kg x 0.0671 = 5.24Kg

LBW = 78.04Kg - 5.24Kg = 72.89Kg

Condition: RH-50%   % dehydration: 4.00%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1182.04	1029.27	1146.54	1077.24	1137.17	1949.84
Blood G mg%	146.00	133.45	139.38	136.45	140.16	142.11
Weight Kg	78.05	75.12	75.38	75.70	75.85	75.92
Liq in ml		365	365	365	365	
(O2)	0.1577	0.1591	0.1589	0.1618	0.1586	0.1610
(CO2)	0.0454	0.0449	0.0439	0.0417	0.0438	0.0408
Gas Temp.	26C	27C	26.5C	26.5C	26.5C	24.5C
VATPS li/min.	48.539	48.006	47.264	52.537	48.513	36.291
VSTPD li/min.	43.326	42.603	42.053	46.744	43.163	32.633
R.Q.	0.8433	0.8603	0.8373	0.8402	0.8225	0.8016
VO2 li/min.	2.317	2.208	2.201	2.303	2.277	1.649
True O2	5.348	5.184	5.236	4.927	5.276	5.052

Bar press.: 768mmHg
Time start: 6:30A.M.
Time D.H.: 2.5Hrs
Time finish: 2:30P.M.

Room Temp.: 23C
Sauna Temp.: 70C
Room rel.hum.: 29%
Sauna rel.hum.: 3.4%

SUBJECT: M.R. DATE: MARCH 22-75

LEAN BODY WEIGHT:

1- 4.0mm (chest)

2- 4.9mm (tricept)

3- 6.7mm (subscapular)

4- 4.6mm (supra iliac)

5- 6.2mm (abdomen)

6- 6.0mm (front thigh)

% total body fat = 32.7mm x 0.097+3.64 = 6.81%

FAT WT = 76.74Kg x 0.0681 = 5.22Kg

LBW = 76.74Kg - 5.22Kg = 71.52Kg

Condition: RH-100% % dehydration: 4.10%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1568.15	1261.29	1351.38	1371.95	1390.33	1515.95
Blood G mg%	139.80	137.86	118.45	118.64	129.90	145.63
Weight Kg	76.74	73.81	74.50	74.96	75.48	75.95
Liq in ml		732.5	732.5	732.5	732.5	
(O2)	0.1575	0.1580	0.1609	0.1590	0.1573	0.1592
(CO2)	0.0474	0.0452	0.0422	0.0468	0.0471	0.0490
Gas Temp.	24.2C	24.0C	24.9C	26.2C	25.2C	26C
VATPS li/min.	42.110	44.837	42.501	44.959	44.942	43.868
VSTPD li/min.	36.663	39.122	39.530	38.802	39.097	38.502
R.Q.	0.8853	0.8447	0.8333	0.9094	0.8954	0.9619
VO2 li/min.	1.951	2.079	1.984	1.997	2.044	1.949
True O2	5.320	5.315	5.028	5.146	5.228	5.063

Bar press.: 742mmHg
Time start: 6:15A.M.
Time D.H.: 2.25Hrs
Time finish: 1:00P.M.

Room Temp.: 20C
Sauna Temp.: 70C
Room rel.hum.: 42%
Sauna rel.hum.: 3.1%

NAME: K.I.

AGE: 18years old.

PRETEST: PHYSICAL WORK CAPACITY 150.

1. 1181.54 Kp.m./min.

2. 1025.28 Kp.m./min.

3. 1033.96 Kp.m./min.

4. 1056.25 Kp.m./min.

Mean: 1076.76 Kp.m./min.

SPECIAL COMMENTS:

50% Rehydration: Subject slept only 3 hrs and had a headache after dehydration which desappeared after the first rehydration.

100% Rehydration: Subject slept 3.5 hrs the night before.

SUBJECT: K.I. DATE: MARCH 29-75

LEAN BODY WEIGHT:

1- 4.1mm (chest)

2- 5.6mm (tricept)

3- 6.7mm (subscapular)

4- 4.0mm (supra iliac)

5- 7.0mm (abdomen)

6- 6.6mm (front thigh)

% total body fat = 33.8mm x 0.097+3.64 = 6.92%

FAT WT = 60.12Kg x 0.0692 = 4.16Kg

LBW = 60.12Kg - 4.16Kg = 55.96Kg

Condition: RH-50% % dehydration: 4.29%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	1090.59	613.49	613.16	692.66	670.50	683.94
Blood G mg%	118.42	120.98	121.43	135.15	146.62	141.35
Weight Kg	60.12	57.72	57.87	58.12	58.27	58.47
Liq in ml		300	300	300	300	
(O2)	0.1549	0.1589	0.1578	0.1544	0.1545	0.1540
(CO2)	0.0481	0.0441	0.0446	0.0570	0.0454	0.0445
Gas Temp.	23C	25C	25C	25C	27.5C	26C
VATPS li/min.	28.487	30.075	32.017	28.680	32.015	30.285
VSTPD li/min.	24.911	26.915	30.613	25.656	28.223	26.880
R.Q.	0.8489	0.8374	0.8270	0.7886	0.7840	0.7569
VO2 li/min.	1.403	1.408	1.640	1.477	1.623	1.570
True O2	5.630	5.230	5.356	5.757	5.753	5.840

Bar press.: 741.6mmHg
Time start: 6:00A.M.
Time D.H.: 3.00Hrs
Time finish: 1:30P.M.

Room Temp.: 20C
Sauna Temp.: 70C
Room rel.hum.: 54%
Sauna rel.hum.: 3.0%

SUBJECT: K.I. DATE: APRIL 1-75

LEAN BODY WEIGHT:

1- 4.7mm (chest)

2- 6.2mm (tricept)

3- 7.5mm (subscapular)

4- 5.0mm (supra iliac)

5- 7.8mm (abdomen)

6- 7.8mm (front thigh)

% total body fat = 39.0mm x 0.097+3.64 = 7.42%

FAT WT = 59.92Kg x 0.0742 = 4.45Kg

LBW = 59.92Kg - 4.45Kg = 55.47Kg

Condition: RH-100% % dehydration: 4.09%

	6AM	0hrRH	1hrRH	2hrRH	3hrRH	4hrRH
PWC 150kpm/min.	985.66	571.08	644.64	709.41	715.78	769.05
Blood G mg%	125.83	123.17	119.17	105.00	112.50	115.83
Weight Kg	59.92	57.65	58.11	58.59	59.04	59.34
Liq in ml		554	554	554	554	
(O2)	0.1530	0.1563	0.1575	0.1559	0.1563	0.1585
(CO2)	0.0499	0.0466	0.0473	0.0488	0.0487	0.0464
Gas Temp.	25C	25.5C	26C	25.5C	25.5C	25.5C
VATPS li/min.	30.680	32.654	32.095	30.853	31.650	30.853
VSTPD li/min.	27.010	28.706	28.139	27.104	27.851	27.086
R.Q.	0.8518	0.8429	0.8830	0.8842	0.8901	0.8831
VO2 li/min.	1.573	1.577	1.498	1.487	1.514	1.414
True O2	5.823	5.493	5.323	5.485	5.438	5.220

Bar press.: 754mmHg
Time start: 6:30A.M.
Time D.H.: 3.00Hrs
Time finish: 2:00P.M.

Room Temp.: 22C
Sauna Temp.: 70C
Room rel.hum.: 22%
Sauna rel.hum.: 2.8%

Figure 8

Individuals % Changes in PWC-150.

50% Rehydration= ▲

100% Rehydration= ●

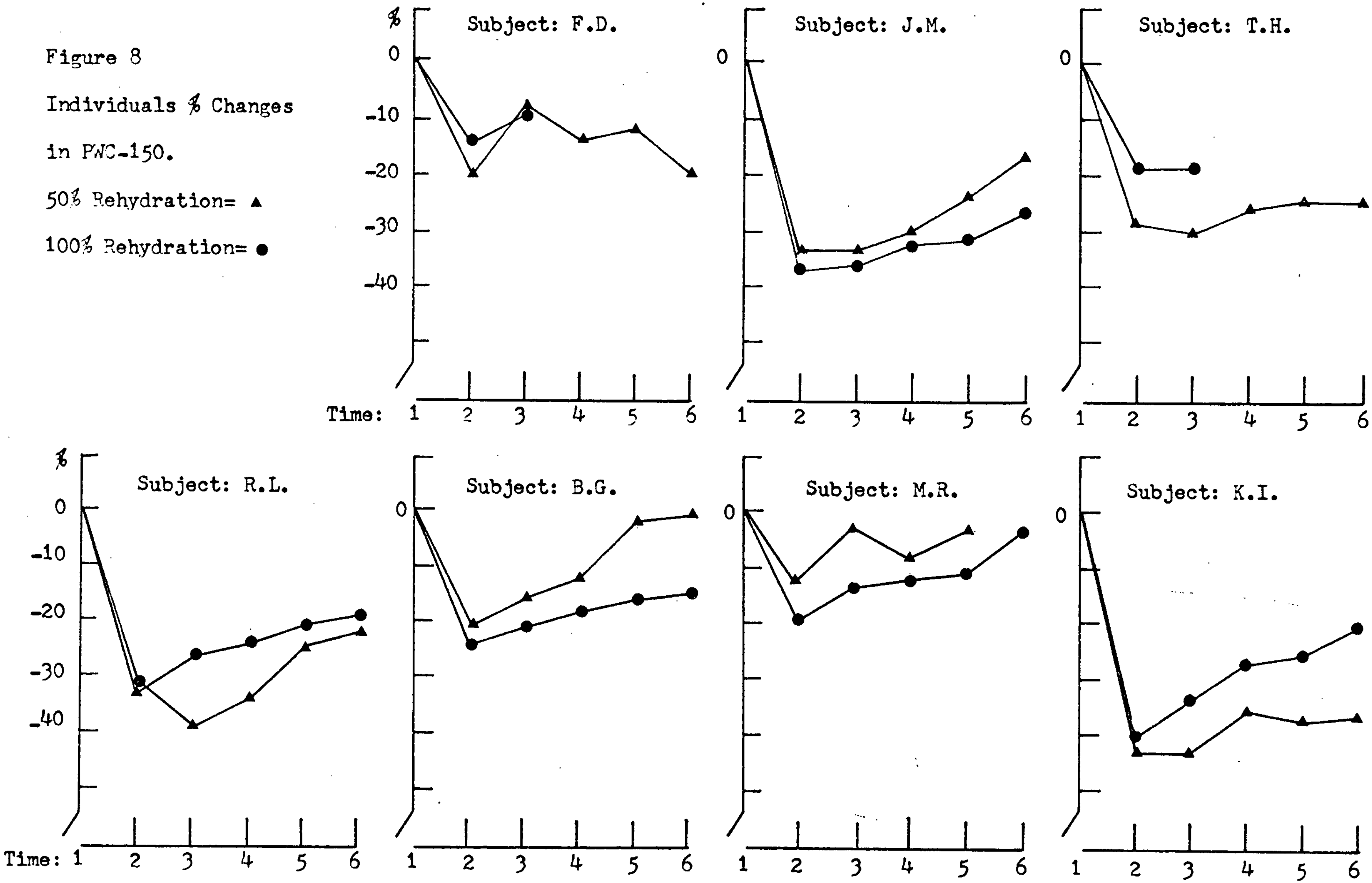


Figure 9

Individuals % Changes in Blood Glucose.

50% Rehydration=▲

100% Rehydration=●

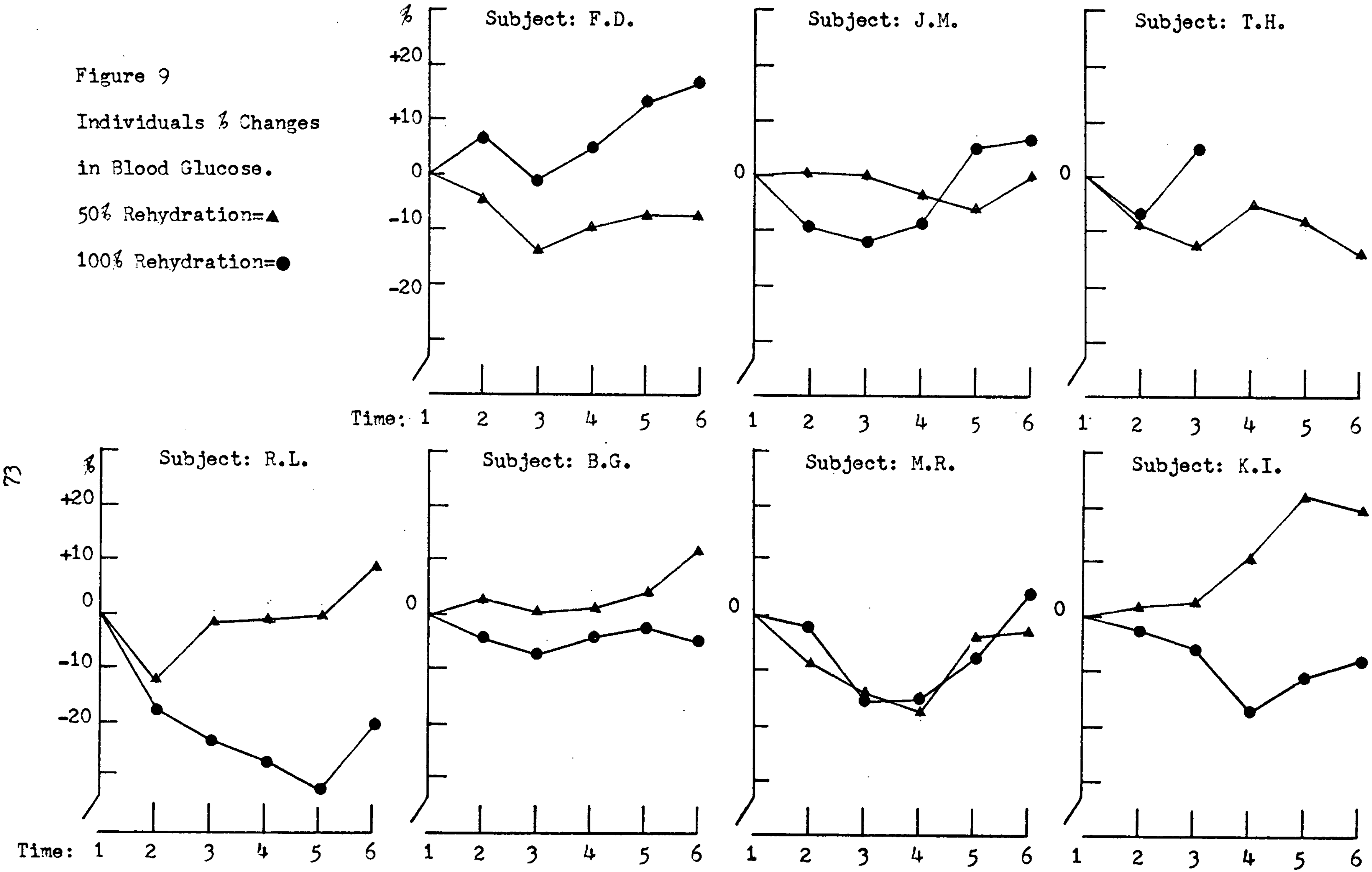


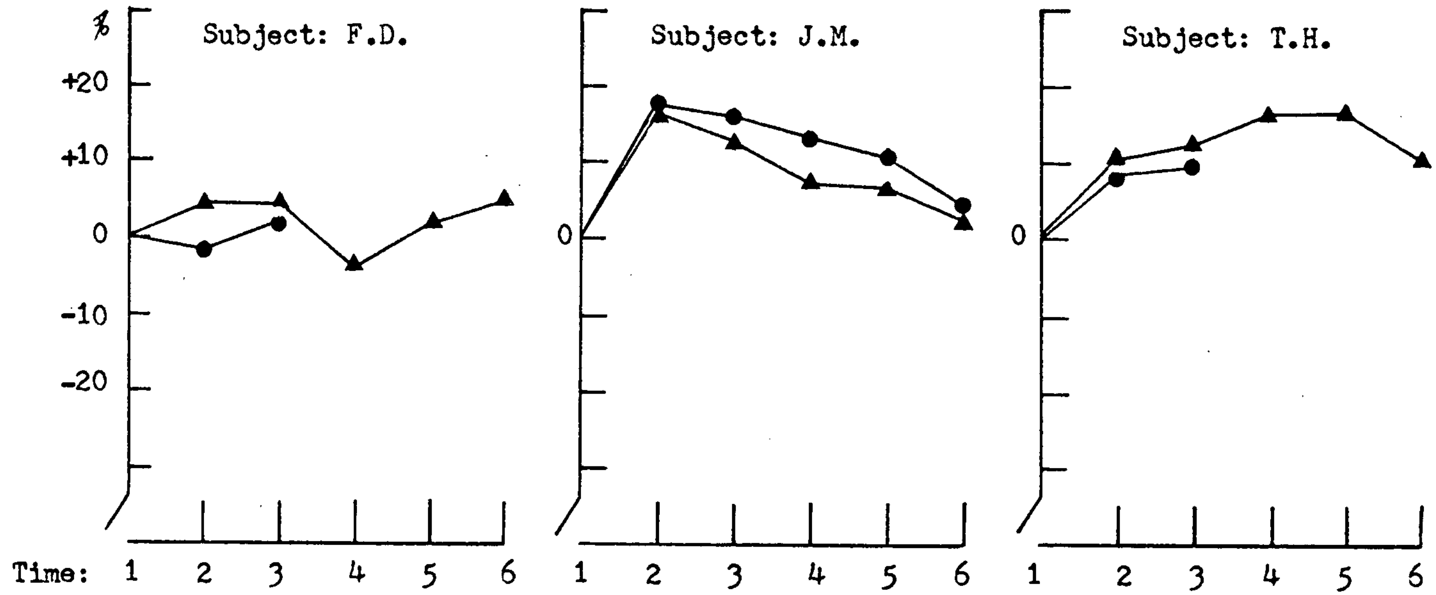
Figure 10

Individuals % Changes

in Volume STPD.

50% Rehydration=▲

100% Rehydration=●



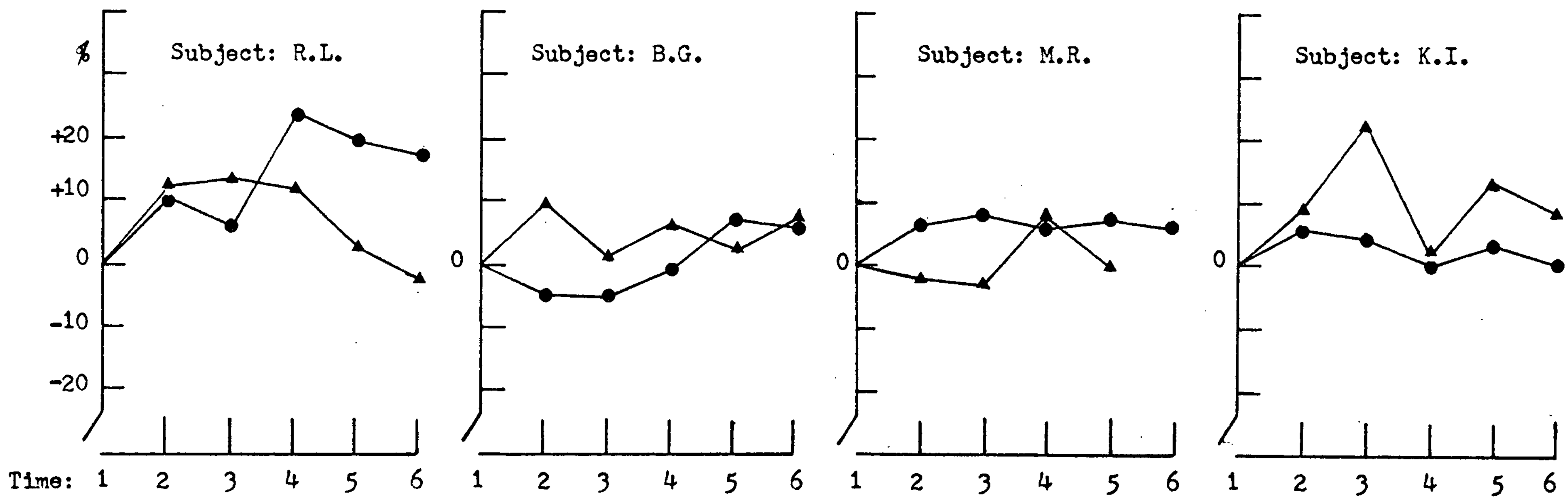


Figure 11

Individuals % Changes in R.Q.

50% Rehydration=▲

100% Rehydration=●

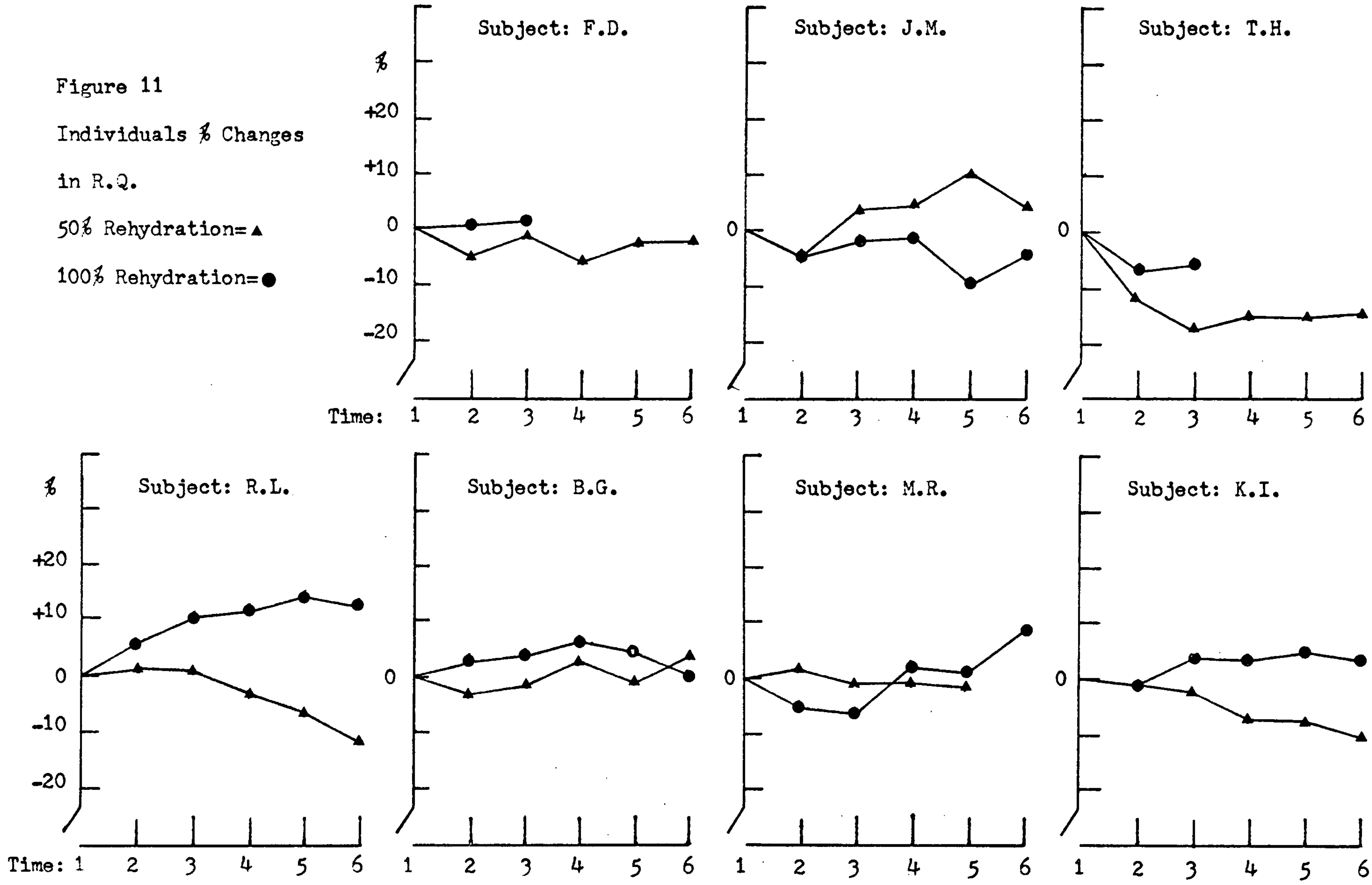


Figure 12

Individuals % Changes

in True O_2.

50% Rehydration=▲

100% Rehydration=●

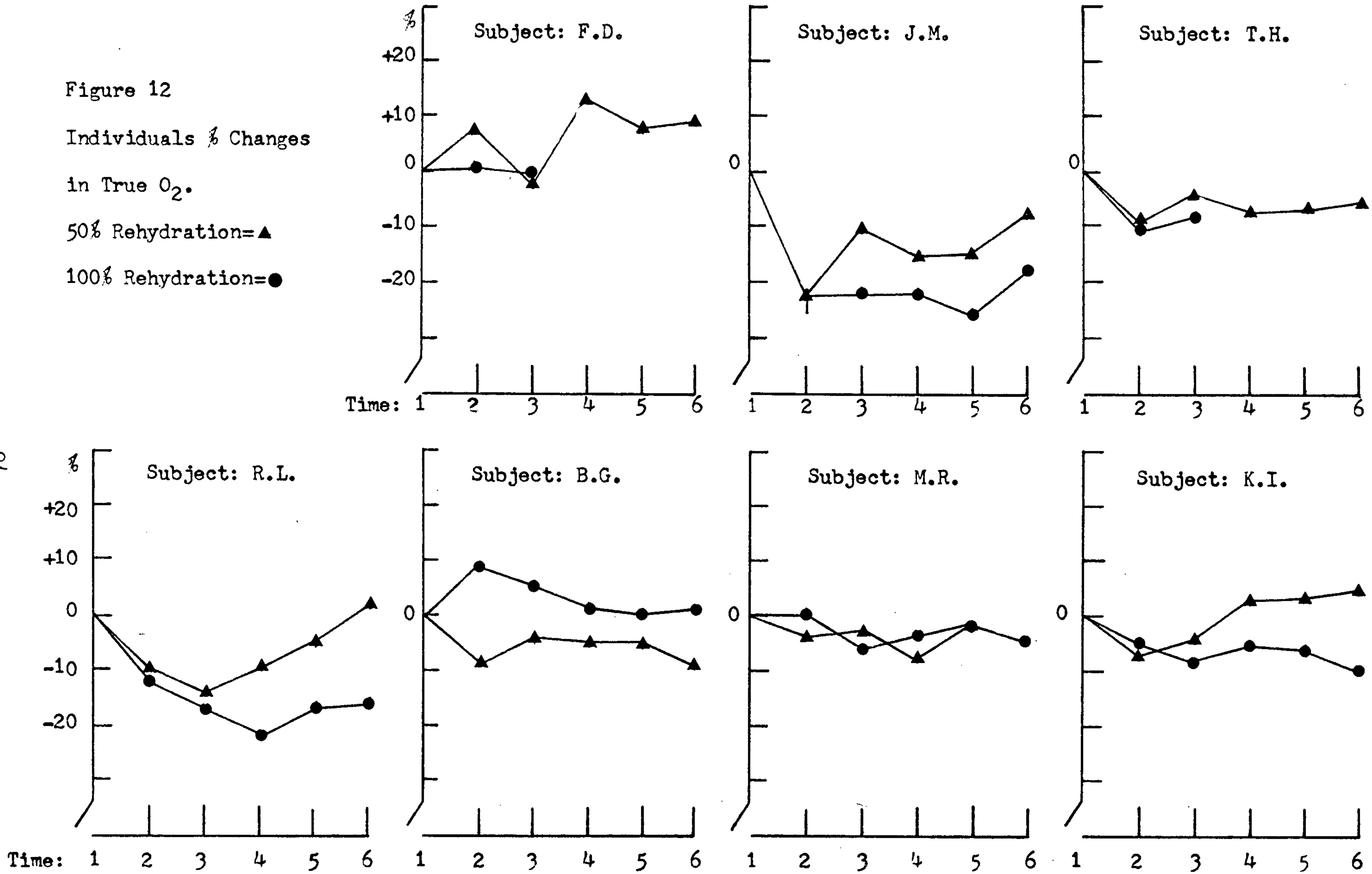
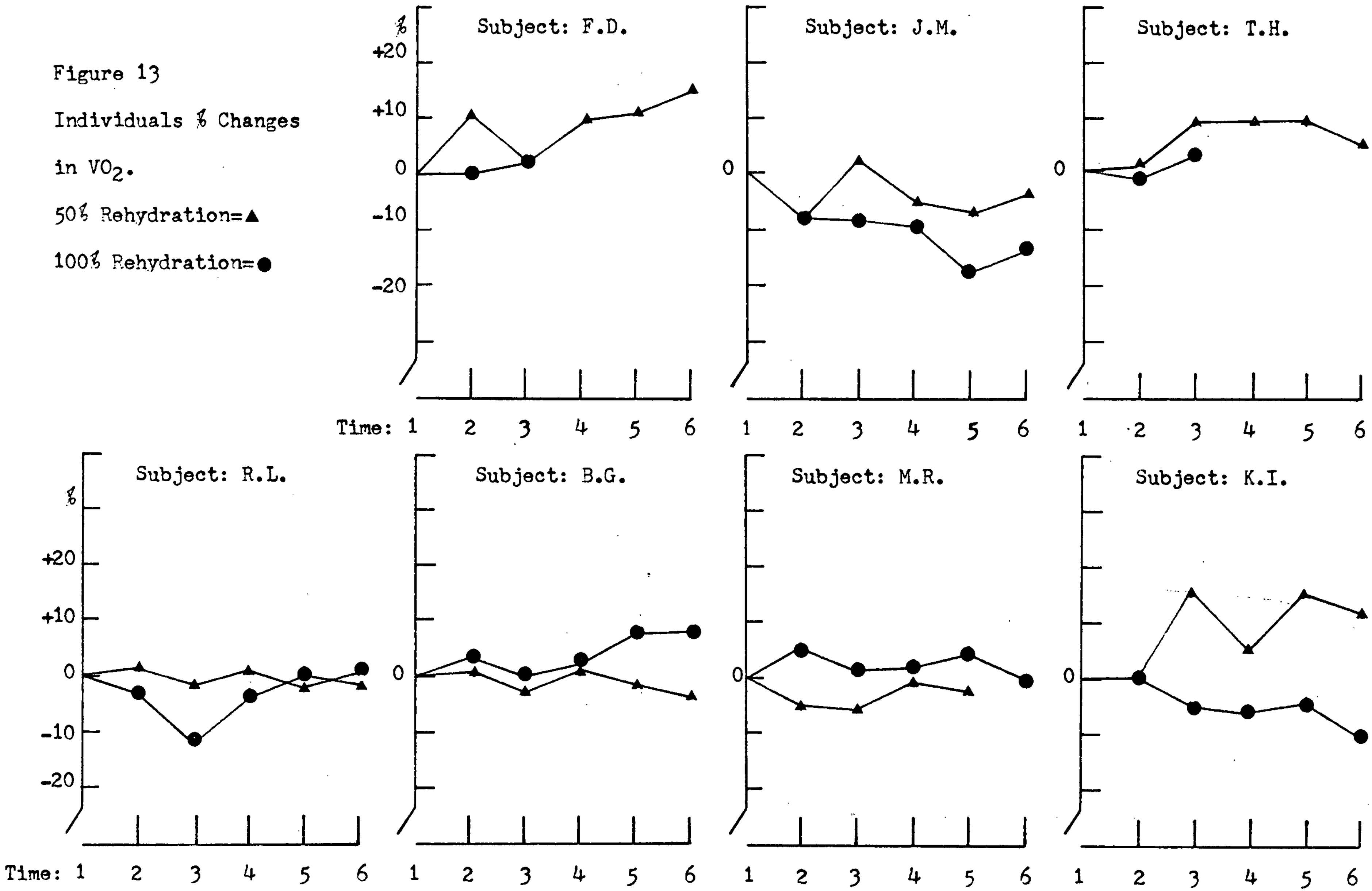


Figure 13

Individuals % Changes in VO_2.

50% Rehydration=▲

100% Rehydration=●



APPENDIX B

TABLE VIII

ANALYSIS OF VARIANCE FOR CHANGES IN PHYSICAL WORK CAPACITY 150

N= 7

TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.60225	2	0.30112	34.98	0.000
ERROR	0.10329	12	0.00861		
PERCENT	0.00077	1	0.00077	0.27	0.621
ERROR	0.01709	6	0.00285		
TP	0.00161	2	0.00081	0.60	0.562
ERROR	0.01598	12	0.00133		

TABLE IX
ANALYSIS OF VARIANCE FOR CHANGES IN PHYSICAL WORK CAPACITY 150
N= 5
TIME= 1 TO 5

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.53443	4	0.13361	25.19	0.000
ERROR	0.08484	16	0.00530		
PERCENT	0.00007	1	0.00007	0.00	0.929
ERROR	0.003095	4	0.00774		
TP	0.00526	4	0.00131	1.12	0.380
ERROR	0.01870	16	0.00117		

TABLE X
ANALYSIS OF VARIANCE FOR CHANGES IN BLOOD GLUCOSE

N= 7
TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.03102	3	0.01034	5.65	0.007
ERROR	0.03293	18	0.00183		
PERCENT	0.01545	1	0.01545	1.13	0.329
ERROR	0.08203	6	0.01367		
TP	0.01319	3	0.00440	1.13	0.363
ERROR	0.06992	18	0.00388		

TABLE XI
ANALYSIS OF VARIANCE FOR CHANGES IN VOLUME STPD

N= 7
TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.05775	2	0.02887	9.91	0.003
ERROR	0.03495	12	0.00291		
PERCENT	0.00448	1	0.00448	1.32	0.293
ERROR	0.02022	6	0.00337		
TP	0.00230	2	0.00115	0.66	0.532
ERROR	0.02076	12	0.00173		

TABLE XII
ANALYSIS OF VARIANCE FOR CHANGES IN VOLUME STPD

N= 5
TIME= 1 TO 5

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.05451	4	0.01363	4.09	0.018
ERROR	0.05324	16	0.00333		
PERCENT	0.00000	1	0.00000	0.00	0.997
ERROR	0.02890	4	0.00723		
TP	0.01028	4	0.00257	0.95	0.457
ERROR	0.04295	16	0.00268		

TABLE XIII
ANALYSIS OF VARIANCE FOR CHANGES IN R.Q.

N= 7
TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.00267	2	0.00134	0.73	0.499
ERROR	0.02175	12	0.00181		
PERCENT	0.00323	1	0.00323	1.76	0.232
ERROR	0.01098	6	0.00183		
TP	0.00175	2	0.00088	1.15	0.349
ERROR	0.00914	12	0.00076		

TABLE XIV
ANALYSIS OF VARIANCE FOR CHANGES IN R.Q.

N= 5
TIME= 1 TO 5

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.00540	4	0.00135	1.91	0.157
ERROR	0.01129	16	0.00071		
PERCENT	0.00818	1	0.00818	0.80	0.420
ERROR	0.04059	4	0.01015		
TP	0.00549	4	0.00137	0.65	0.633
ERROR	0.03360	16	0.00210		

TABLE XV
ANALYSIS OF VARIANCE FOR CHANGES IN TRUE O2

N= 7
TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.04271	2	0.02135	4.74	0.030
ERROR	0.05401	12	0.00450		
PERCENT	0.00005	1	0.00005	0.01	0.894
ERROR	0.01583	6	0.00264		
TP	0.00253	2	0.00126	1.06	0.375
ERROR	0.01422	12	0.00118		

TABLE XVI
ANALYSIS OF VARIANCE FOR CHANGES IN TRUE 02

N= 5
TIME= 1 TO 5

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.05428	4	0.01357	4.17	0.017
ERROR	0.05199	16	0.00325		
PERCENT	0.00305	1	0.00305	0.35	0.583
ERROR	0.03439	4	0.00860		
TP	0.01248	4	0.00312	3.27	0.038
ERROR	0.01523	16	0.00095		

FIGURE 7

MEANS OF VO_2 EXPRESSED IN PERCENT FOR 50% REHYDRATION AND 100% REHYDRATION CONDITIONS

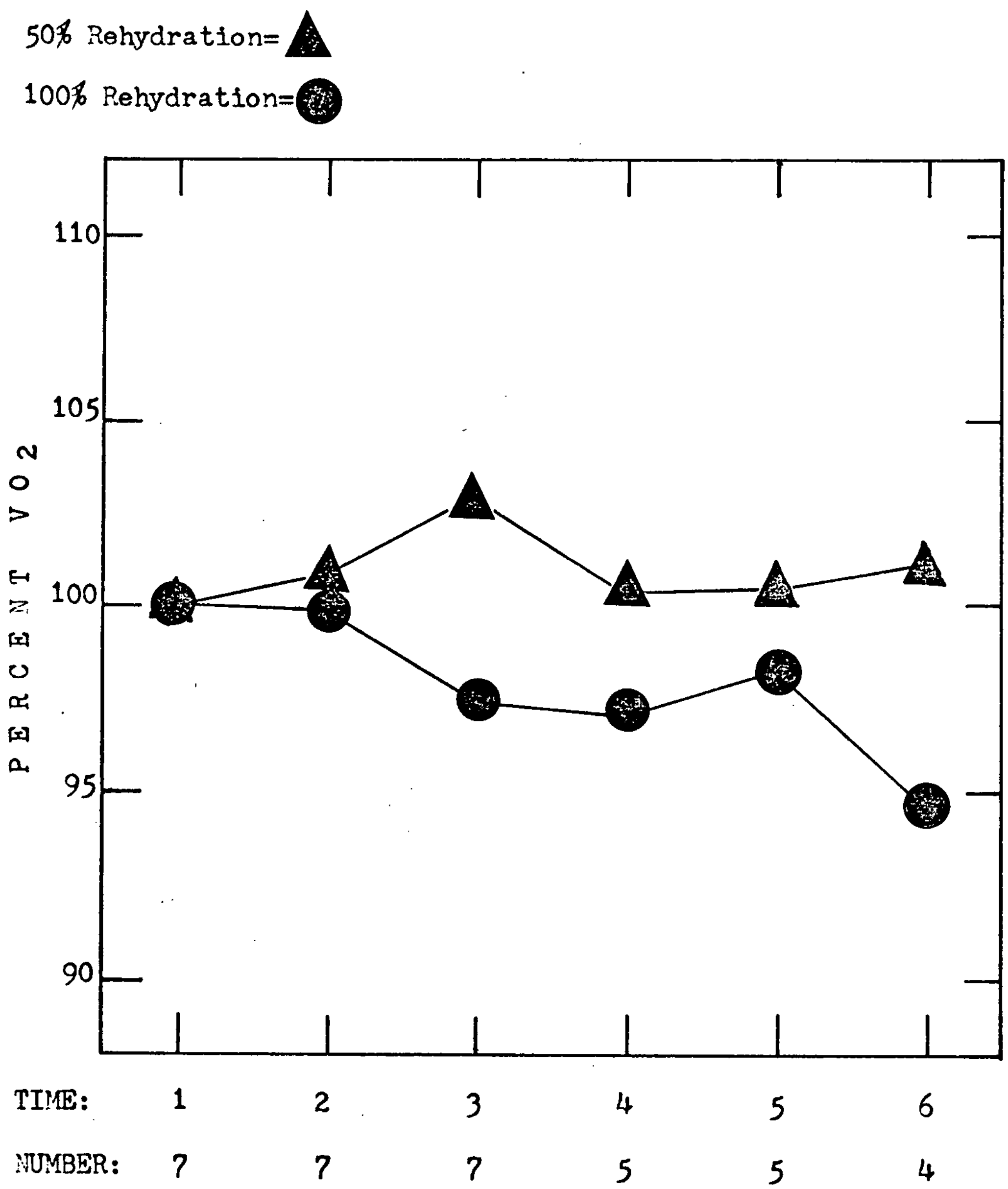


TABLE XVII
ANALYSIS OF VARIANCE FOR CHANGES IN VO2

N= 7
TIME= 1 TO 3

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.00007	2	0.00003	0.01	0.986
ERROR	0.02772	12	0.00231		
PERCENT	0.00485	1	0.00485	1.60	0.253
ERROR	0.01817	6	0.00303		
TP	0.00630	2	0.00315	1.54	0.254
ERROR	0.02451	12	0.00204		

TABLE XVIII
ANALYSIS OF VARIANCE FOR CHANGES IN VO2

N= 5
TIME= 1 TO 5

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	P
TIME	0.00118	4	0.00029	0.13	0.968
ERROR	0.03567	16	0.00223		
PERCENT	0.00554	1	0.00554	0.54	0.502
ERROR	0.04075	4	0.01019		
TP	0.01001	4	0.00250	1.48	0.252
ERROR	0.02687	16	0.00168		

TABLE XIX
ANALYSIS OF VARIANCE FOR CHANGES IN VO2

N= 4
TIME= 6

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	P
TIME	0.00158	5	0.00032	0.13	0.983
ERROR	0.03615	15	0.00241		
PERCENT	0.02156	1	0.02156	1.50	0.307
ERROR	0.04296	3	0.01432		
TP	0.01287	5	0.00257	1.30	0.315
ERROR	0.02966	15	0.00198		

APPENDIX C

SUBJECT INFORMATION AND INSTRUCTION

While the exact nature of this study cannot be revealed to you at this time, I am required to inform you of some pertinent details.

You will be asked initiallly, the week before the experiments, to perform several physical work capacity test with expiratory gas collection. You will then be familiarized with the rest of the equipment to be used.

This equipment will be used to determine your responses (heart rate, ventilatory and blood changes) to a pre set experimental design. You will be submitted to two experimental sessions which will consist of six (6); physical work capacity tests, finger tip blood samples and expiratory gas collections, distributed as follow: one after 4% lean body weight dehydration, and four, separated by one hour, during rehydration.

During dehydration you'll be able to go out of the sauna for five (5) minutes each 15 to 30 minutes. The dehydration should require two to four hours.

None of the information thus obtained will be identified as belonging to you, but will be pooled with results obtained from other subjects.

I, the undersigned, have read, understand the above information and know that the risks are minimal. I also keep the privilege to withdraw from the project at any time.