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The use of a repeated carbohydrate loading diet upon the swimming performance of male albino rats

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THE USE OF A REPEATED CARBOHYDRATE LOADING DIET UPON THE SWIMMING PERFORMANCE OF MALE ALBINO RATS

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TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This thesis was designed to study the effects of a repeated carbohydrate loading diet upon the swimming performances in male albino rats.

STATEMENT OF THE PROBLEM

The problem was to study the effects, if any, on the repeated utilization of a carbohydrate loading diet and the swimming performances of untrained adult male albino rats.

DEFINITIONS

For use in this Thesis, the following terms have been defined:

Carbohydrate Loading Diet

A diet manipulated into two distinct phases. First, a high protein diet for three days: the high protein diet contained the following nutritional mixture - Twenty-Three grams of proteins, Ten grams of carbohydrates, Five and One-Half grams of lipids, and Ten and One-Half grams of fillers. Secondly, a high carbohydrate diet for Three days: The high carbohydrate diet contained the following nutritional mixture - Four grams of Proteins, Twenty-Eight grams of carbohydrates, Two grams of lipids, and Sixteen grams of fillers.

Control Diet

A normal nutritional mixture of Fifteen grams of proteins, Ten grams of carbohydrates, Thirteen grams of lipids, and Twelve grams of fillers contained in a standard rat's diet.

Proteins

Any of a class of complexed nitrogenous substances occurring in all animals and found in animal diets (Webster, 1969).

Carbohydrates

Any of a class of organic compounds composed of carbon, hydrogen, and oxygen found in animal diets (Webster, 1969).

Lipids or Fats

Any of a class of glyceryl esters containing fatty acids which are insoluble in water and contained in animal diets (Webster, 1969).

Fillers

Any minerals, vitamins, or other substances found in animal diets.

Swimming Performance

The total swimming time of an adult male albino rate until complete exhaustion. Complete exhaustion resulted when the rat remained Ten full seconds below the surface of the water. (McArdle and Montoye, 1966).

Swimming Rat

An adult male albino rat with Five percent body weight attached to the lower abdominal (Hardin and Kelly, 1970; McArdle and Montoye, 1966).

DELIMITATIONS

The study was delimited to the following:

1. Untrained Adult male albino rats.

2. The use of Four water baths with a height of Twenty-Seven inches and a diameter of Twenty inches. The water in the water baths was warmed to a constant Thirty-Two degrees Centigrade and maintained at a depth of Eighteen inches.

LIMITATIONS

The study was limited to the following:

1. The environmental conditions of the Physiology laboratory in the Robin's Center at the University of Richmond.

2. Any uncontrollable factors common to the life expectancy of the adult male albino rat which may influence the study.

PURPOSE OF THE THESIS

The purpose of the thesis was to examine if the extra fuel supply of a repeated carbohydrate loading diet could physiologically be incorporated and utilized by the untrained adult male albino rat during a swimming bout.

METHODOLOGY

The study employed Three aspects of methodology - Class of Inquiry, Internal Validity, and External Validity.

Class of Inquiry

A Four Cell study was utilized (McGrath, 1970). The Two groups employed were the Experimental and Control. Each group was pre-tested and post-tested, as well as weekly tested, on swimming performance during a Three week period.

Internal Validity

The internal validity consisted of a swimming test pre-validated by the preliminary pilot study. Standard procedures were utilized prior to and during each swim test. Each rat was fed and watered *ad libitum* daily. Each rat was individually weighed on the same pre-set scale prior to each and every swim test. The scale allowed for accurate measurements in the Five percent body weight to the nearest Tenth of a gram. The rats were not handled by the experimenter, except during the actual swimming test. The rats were entrusted into the hands of Two laboratory assistants.

External Validity

The external validity was not crucial to this study. The results only applied to the population of the study, therefore, the control of external validity was not necessary.

HYPOTHESIS

The null hypothesis was assumed. Based upon all accumulated information in the review of literature, no significant differences were expected to be found from pre-test to post-test in the swimming performances of untrained adult male albino rats exposed to a repeated carbohydrate diet regimen.

POPULATION

The population was Eighteen untrained adult male albino rats.

INSTRUMENTATIONS

The instrumentations were limited to the following:

1. A standard gram scale.
2. A standard centigrade thermometer.
3. A Twelve hour light switch.
4. Two standard sweep second stop watches of identical make and model.

CHAPTER 2

REVIEW OF LITERATURE

This review has been limited to the physiological areas which pertain to the effects of diet upon prolonged exercise. Four physiological areas have been deemed essential to the rat or the rat's physiology during or prior to an exercise bout. The Four areas are Swimming and the Rat, Diet and Exercise, Diet and Non-Exercise, and Muscle Glycogen and Exercise. Throughout the Four areas specific attention has been directed toward the carbohydrate loading diet and its effect upon the swimming performance of albino rats.

In the First section, Swimming and the Rat, the knowledge gained pertaining to the rat's swimming ability insured that the best conditions in relationship to the rat were obtained for the swimming bout. Dietary manipulations were considered in direct relationship to exercise within Diet and Exercise. The dietary manipulations of various diets during a non-exercise phase was then shown to influence exercise or the quality of exercise within Diet and Non-Exercise. The knowledge gained from both Diet and Exercise and Diet and Non-Exercise insured a complete comprehension of all nutritional factors both during and prior to an exercise bout. Finally, the Fourth area on the role of Muscle Glycogen and Exercise was then considered with regard to Carbohydrate Loading. This section on muscle glycogen or the effect of the carbohydrate was then linked directly to the swimming performances of the rat.

SWIMMING AND THE RAT

Recently, there has been an increase in the utilization of small laboratory animals for physiological studies. Several studies have incorporated various types of exercise bouts and various small laboratory animals. Treadmill runs (Issekutz, 1965) cold water swims (Baker, 1964; Wilber, 1963) warm water swims (Baker, 1964; Hardin, 1970; McArdle, 1967; Weber, 1964) and long distance runs (Johnson, 1973; Karlson, 1971; Rennie, 1974) have been utilized as exercise upon the laboratory animals. Dawson and Horvath (1970) have collected Two Hundred and Fifty-Four articles pertaining to the exercising of laboratory animals, primarily to the swimming of albino rats.

McArdle, in a recent study (1967), concentrated on the swimming rat. The experimenter maintained the water bath temperature between Thirty-Two and Thirty-Four degrees Centigrade or within normal body temperature ranges of the rats. Baker and Horvath (1964), in a Three phased study found that rats produced the longest swim times in water at approximately rectal temperature. In view of this information Thirty-Two degrees Centigrade was selected as the water temperature for the swimming bout.

Weber (1963) noticed another factor pertaining to the swimming of rats. The rats were found to have a nocturnal activity pattern and during alteration of this pattern normal swimming performances were observed to change while the ingestion of food and water was reduced. Later, Weber (1963) concluded that the amount of food and water ingested was the major factor in the poorer swimming ability not the alteration *per se* in the nocturnal activity pattern. Therefore, the proper regulation of food and/or the light cycle seems to be an important aspect of prolonged exercise at least in the rat species.

Several Physiologist (Weber, 1963; McArdle and Montoye, 1966; McArdle, 1967; Hardin and Kelly, 1970) have noted swimming abilities of rats with attached weights. Weber (1963) considered adding the weights to the lower abdomen in order to stress the animal's metabolic system. McArdle and Montoye (1966) attached between Two and Seven percent body weight slugs to the rat's tail prior to swimming bouts. In both studies the added weights were noticed to force the rats to swim at full capacity to remain above water. However, at times drowning occurred when the rats had reached a state of total exhaustion. The problem of when to retrieve the exhausted rats was resolved later in the study when a high correlation (r=.99) with total exhaustion was found when the rats remained below the surface of the water for Ten full seconds.

Handin and Kelly's study (1970) incorporated repeated swimming bouts over a period of many weeks. In the study, some rats were fitted with Five percent body weights prior to swimming bouts. The weighted rats were found to be more exhausted on the average than non-weighted rats in otherwise identical exercise bouts. Therefore, Five percent body weight attachments were found to be very satisfactory for swimming tests involving rats.

Most researchers agree that an exhaustive state in most cases can be quickly obtained when attached weights are applied to the rat's abdomen. Five percent attachments seems to be the ideal weight to add in the case of any swimming test.

DIET AND EXERCISE

In some physiological studies exercise has been considered in regard to dietary modifications. A few of these studies (Daniel, 1975, Means, 1974; Mirkin, 1973; Russek, 1972; Johnson, 1973; Schanfani, 1972) have dealt exclusively with the effects of a carbohydrate regime on laboratory animals.

Johnson and Rennie (1973) concentrated on the effects of a high carbohydrate regimen and its relationship to the Free Fatty Acids (FFA) fuels during exercise. In relationship to the role of FFA during high carbohydrate diets, the researchers found an obvious alteration in the normal utilization pattern of the fat derived fuels during prolonged exercise. Also, the study found an increase in the ability of muscles to exercise during prolonged exercise bouts from both carbohydrates and FFA.

In another FFA study, Russek and Stevenson (1972) found that the FFA concentration of the blood increased due to the intensity and duration of an exercise bout. This study noted that the changes in the FFA role during exercise was in direct relationship with the physiological fitness of the animals. The study concluded that the more fit the animal, the greater the efficiency in the FFA turnover during exercise. Therefore, FFA may increase the working muscle's endurance if a more efficient manner of FFA release from adipose tissue could be obtained.

However, in a later study, Russek and Stevenson (1973) did not believe that the FFA fuels are extremely important in very prolonged exercise. The experimenters noted that muscle cells became impermeable to the FFA during very prolonged exercise bouts. So, FFA may aid in exercise, but the key during prolonged exercise seems to be related intrinsically to the availability of carbohydrates to the working muscle cells.

In summary, FFA and Protein were noted to effect the quality and quanity of exercise, however, the key to prolonged exercise was found to be the availability and permeability of glucose and other carbohydrates into the working muscle cells. The availability of glucose was found linked both to the Hepatic release and the muscle storage of the carbohydrate. The permeability of glucose was found related to the fitness of the subject being tested.

DIET AND NON-EXERCISE

A few select experiments dealing with dietary modification have not been structured with the interrelationship of the effects of a diet upon exercise. However, a number of these studies have dealt with the effect of diet and non-exercise studies (Daniel, etal, 1975; Schanfani, 1973; Simson and Booth, 1973) can indirectly be related to prolonged exercise.

In situations of fasting (Daniel, Pratt and Sparso, 1975) a shift in the normal nutritional factors being utilized for body functions can be noted. Forty-Five percent of the glycogen for normal body functions were obtained by the breakdown of lipids into lesser FFA. Means and Mendell (1974) concurred, however, in very long fasts FFA was noted to play the predominant nutritional role with a noted increase in the utilization of proteins. This increased role of FFA was found related to the effects of insulin within the adiopocytes of fat cells. The adiopocytes seem to degrade more rapidly with higher levels of insulin while allowing more fuel to be utilized by the body. While, during the same time, the autoregulation of insulin increased the body cells permeability to the new gluconeogenetic derived glucose.

This effect of insulin (Daniel, Love, and Pratt, 1975) as the autoregulator of blood sugar and FFA levels are or at least seem to be logically linked to the diet or lack of diet. However, other factors may be involved within the autoregulation of insulin. These other effects may be related to physical characteristics, growth and the ability to exercise. Nevertheless, not all of these effects may be healthful to the body (Mirkin, 1973).

To sum up, if carbohydrates, proteins and FFA are not properly utilized during non-exercise, many dysfunctions may occur within the body. More specifically, if the autoregulation of the glucose titer is offset a heart attack may occur (Mirkin, 1973). So, the amount of carbohydrates should be controlled because the carbohydrates may influence general body functions during non-exercise and exercise.

MUSCLE GLYCOGEN AND EXERCISE

Wilber (1963) was interested in the internal chemistry of exhausted rats. The rats were swum to exhaustion and a noted reduction in the muscle glycogen level was noticed.

Similar results were obtained in humans by Bergstrom and Hultman (1967). The muscle glycogen level fell toward Zero during prolonged exercise in distance runners. The working muscle exercise capability was noted to decrease as the muscle glycogen and blood sugar level approached Zero. In relationship to the blood sugar decrease, the liver was found to increase the release of stored sugars during the later stages of exercise. However, the liver could not offset the metabolic imbalance if the exercise bout continued.

Hultman (1967) investigated the role of carbohydrates, fats and proteins during exercise. The Three nutritional factors were manipulated and controlled experimentally over the period of many weeks. First, low carbohydrate diets or diets low in glucose content were studied. These glucose-free diets were high in fats and/or proteins. Then, diets high in carbohydrates or diets low in fats and/or proteins were studied. The results of the study showed that the low carbohydrate diets were found to decrease the normal muscle glycogen levels. This fact decreased the time spent in an exercise bout significantly. The diets high in carbohydrate were noticed to increase normal muscle glycogen levels but only slightly. However, very high muscle glycogen levels were noticed to occur following a low carbohydrate diet for a few days then followed by a high carbohydrate diet for a few days. This "diet" increased the time spent in an exercise bout significantly. This procedure of increasing muscle glycogen storage was termed the Carbohydrate Loading Technique.

The Carbohydrate Loading Technique (Hultman, 1967) was then coupled with various exercise bouts. Hultman found, through the use of the technique, exercise could be prolonged without total fatique. This fact then encouraged many other researchers to investigate the role of glucose in other forms of prolonged exercise.

Rennie and Johnson (1974) in a metabolic study found that carbohydrates were the key to exercise in prolonged states. In prolonged runs it was shown that glycogen-enhanced or high carbohydrate diets improved the overall ability of runners to complete very long runs.

In an earlier study Karlson and Statin (1971) shows that the speed of runners on glycogen-enhanced diets increased as opposed to the speed of runners on a normal diet during prolonged runs. The slowest Ten mile run times were recorded following repeated normal diet regimes, while the fastest Ten mile run times were recorded following repeated high carbohydrate diet regimes. This study showed that the speeds of the runners increased progressively in the middle to later stages of the run as opposed to the primary stages. Therefore, it seems as if the endurance physical fitness of conditioned distances runners was enhanced by the repeated carbohydrate diets.

Daniel, Love, and Pratt (1975) stated that the increased ability to exercise via high carbohydrate diets has an end point. The study noted that the liver, during very prolonged exercise, offset the lowered blood sugar levels to some degree. Nevertheless, the muscle cells could not seem to utilize this new energy. This inability of the muscle cells to utilize the new energy was related to the permeability of the muscle cell membranes. Low insulin was found the key to the impermeability. Therefore, the controlling factor pertaining to both the blood sugar level and muscle cell permeability seems to be insulin levels.

The amount of available insulin to exercising muscle, however, may not be the only key to the impermeability of fatigued muscle cells to glucose (Hultman, 1967). The levels of Nitrogen in the body, related to gluconeogenesis, may influence the cells utilization of glucose during exercise (Munro and Waterlow, 1969). During exercise many available glucose stores are utilized while FFA and/or protein molecules are broken down by gluconeogenesis and converted into sugars. This breakdown of protein increases the nitrogen levels in the blood while the increased levels of Nitrogen seems to decrease the permeability of muscle cells to glucose. However, Waterlow states that only approximate answers can be expressed concerning the advantages and disadvantages of proteins during exercise, but to date the findings seem to show that proteins are more helpful after exercise as opposed to during exercise.

In another metabolic study, Kelmen, et al (1975), studied the effects of blood lactate production upon prolonged exercise bouts. Three dietary regimes were examined while their respective effects on the blood lactate level were studied. The First regimen considered a diet with normal amounts of carbohydrates, the Second a high carbohydrate diet, and lastly a low carbohydrate diet. The blood lactate level was found highest during a high carbohydrate diet, however, no significance was found in the increased levels, except maybe a decrease in the muscle cells permeability to glucose.

Simson and Booth (1973) in a related feeding study, observed that feeding decreased when amino acid levels in the body were found to be high. The increase in the amino acid concentration caused a noted increase in the water consumption while the feeding decreased. The study also observed that the normal feeding and watering patterns did not occur until the levels of the amino acids decrease to near normal amounts.

All in all, Three major factors can be obtained from the literature concerning the effects of carbohydrates upon exercise bouts. One, the availability of blood sugar to the muscles cells was found to be controlled by the liver and pancreas and not to a great extent by the diet. The blood levels of glucose was found to be fairly constant during all stages of exercise from onset to near exhaustion. However, the blood sugar level was noticed to fall when the subject neared total exhaustion. Two, the physiological fitness of the subject seems to be related to the utilization of the nutritional fuels during exercise, that is the more fit the subject the more he was found to utilize both carbohydrates and FFA. On the other hand the less fit subject was found primarily to utilize carbohydrate and very little FFA. Three, the Carbohydrate Loading Technique (Hultman, 1967) increased muscle endurance by somehow increasing the muscle glycogen level, however, the exact reason behind the increased titer was not completely understood or stated.

In summary, a study pertaining to the repeated carbohydrate diet (Hultman, 1967) and the swimming performance of laboratory rats (Dawson, 1970) did not seem to be recorded in the physiological literature to date. Therefore, more information may be added to the literature by more intensive studies in carbohydrates because as Mirkin (1973) notes, that if carbohydrates are not utilized properly the body may function abnormally. Mirkin believed that this abnormality could cause heart problems in athletes while practicing the Carbohydrate Loading Technique. Regardless, if abnormalities occur or not, more information can be added to the literature by a study involving rats and repeated carbohydrate loading.

CHAPTER 3

PROCEDURES

The adult albino male laboratory rats for the study were ordered from a commercial supply company. The rats were ranked by their pre-test swimming performance then selected for the Experimental or Control groups. The Experimental and Control groups were selected and matched in the following manner: the Control group was the First, Fourth, Sixth, Eighth, Tenth, Twelfth, Forteenth, Sixteenth, and Eighteenth ranked rat; the Experimental group was the Second, Third, Fifth, Seventh, Ninth, Eleventh, Thirteenth, Fifteenth, and Seventeenth ranked rat. The procedures for the study were divided into Four main areas and were identified as the Preliminary Period, Pre-Test Period and Procedures, Experimental Period, and Post-Test Period.

PRELIMINARY PERIOD

All rats were individually caged. Each rat was fed a control diet and watered *ad libitum*. The animal control room was lighted each day from Twelve o'clock noon until Twelve o'clock midnight (Weber, 1963). This lighting cycle was maintained until the end of the Experimental period.

PRE-TEST PERIOD AND PROCEDURES

1. The pre-test, as well as all swimming tests, followed standard procedures.

2. The Pre-test began October Twenty-Third, 1976, at Twelve o'clock noon.

3. The Four water baths were prepared and maintained at a constant temperature throughout the test.

4. The assistants individually weighed each rat. The rats' Five percent body weight was then attached to the lower abdomen.

5. After weighing and attachments were complete, the rat was handed to the experimenter who systematically swam the rat. The rat was observed at all times by both the experimenter and the assistant.

6. Thw swimming rat remained in the water bath until complete exhaustion. The experimenter retrieved the rat when the animal had remained under the surface of the water for Ten full seconds.

7. The swimming performance of the retrieved rat was recorded and the assistant then removed the attached weight and dried the animal.

8. The rat was then placed in its cage by the assistant. The assistant then prepared another rat for swimming until all rats had completed the swimming test.

EXPERIMENTAL PERIOD

1. The experimental period began Sunday, October the Twenty-Third, 1976, upon completion of the pre-test.

2. The Control group was fed the control diet and watered ad libitum daily.

3. The Experimental groups was fed the carbohydrate loading diet. The protein aspect of the diet began Sunday, October the Twenty-Third, 1976, after the pre-test and ended Wednesday, October the Twenty-Seventh, 1976, at Twelve o'clock noon. The carbohydrates aspect of the diet began Wednesday, October the Twenty-Seventh, 1976, at Twelve o'clock noon and ended Saturday, October the Thirtieth, 1976, prior to weekly swim test One. The rats were fed and watered ad libitum during the entire experimental period.

4. Following weekly swim test One, week Two of the experimental period began. Identical procedures were followed for week Two and the days for Carbohydrate Loading Diet manipulations were Sunday and Wednesday. The same procedures, as in weeks One and Two, also applied for week Three.

5. All swim test, during the Experimental Period followed the identical procedures noted in the Pre-Test Period and Procedures section.

6. The Experimental period ended November Thirteenth, 1976.

POST-TEST PERIOD

1. The post-test swim began at Twelve o'clock noon Sunday, November the Thirteenth, 1976.

2. The post-test period ended following the swimming of the final rat.

CHAPTER 4

ANALYSIS OF DATA

The data collected and utilized for the study was from the pre-test swimming performances, the pre-test rats' weights, the post-test swimming performances and the post-test rats' weights. The Experimental and Control groups' data was compared and analyzed for both intergroup and intragroup relationships. Every relationship in the study was analyzed by the correlated means "t" test for small samples for a significant difference (Johnson and Nelson, 1974).

The small sample of rats used in the study necessitated the utilization of the "t" test for small samples as the statistical tool. Nevertheless, with a high degree of reliability, the "t" test analyzed the mean scores of both the Experimental and Control groups data. The examination of the mean scores then allowed for determination of significant differences between or within the Two groups used in the study.

The data analyzed by the "t" test in the study was divided into Six areas. The Six areas were the Control and Experimental Pre-Test Swimming Performances, the Control and Experimental Pre-Test Rats' Weights, the Control and Experimental Post-Test Swimming Performances, the Control and Experimental Post-Test Rats' Weights, the Experimental and Groups' Pre-Test and Post-Test Swimming Performances, and the Control Groups' Pre-Test and Post-Test Swimming Performances.

COMPARISON ONE

The First comparison was between the Controls and Experimentals Pre-test Swimming Performances.

Sample	Sample Size	Mean	Standard Deviation
Experimental	9	826.556	513.850
Control	8	810.625	545.547

The pooled standard deviation was 528.879. The "t" test result was 0.062. The probability of the "t" being equal to or longer than 0.062 is 48% at 15 degrees of freedom. No significant difference was found.

COMPARISON TWO

The Second comparison was between the Controls and Experimentals pre-test rats weights.

Sample	Sample Size	Mean	Standard Deviation
Experimental	9	212.344	16.1068
Control	8	204.900	23.9745

The pooled standard deviation was 20.164. The "t" test result was 0.759. The probability of the "t" being equal to or larger than 0.759 is 23% at 15 degrees of freedom. No significant difference was found.

COMPARISON THREE

The Third comparison was between the Controls and Experimentals post-test swimming performances.

Sample	Sample Size	Mean	Standard Deviation
Experimental	9	2582.78	2050.590
Control	7	535.00	412.563

The pooled standard deviation was 1573.45. The "t" test result was 2.583. The probability of the "t" being equal to or larger than 2.583 is 1% at 14 degrees of freedom. A significant difference at the .01 level was found.

COMPARISON FOUR

The Fourth comparison was between the Controls and Experimentals post-test rats weights.

Sample	Sample Size	Mean	Standard Deviation
Experimental	9	298.178	17.2536
Control	7	355.771	20.4705

The pooled standard deviation was 18.7. The "t" test result was 6.111. The probability of the "t" being equal to or larger than 6.111 is 0% at 14 degrees of freedom. A significant difference at the .01 level was found.

COMPARISON FIVE

The Fifth comparison was between the Experimental group pre-test and post-test swimming performances.

Sample	Sample Size	Mean	Standard Deviation
Experimental Pre-test	9	826.556	513.85
Experimental Post-test	9	2582.780	2050.59

The pooled standard deviation was 1494.82. The "t" test result was 2.49. The probability of the "t" being equal to or larger than 2.49 is 1% at 16 degrees of freedom. A significant difference at the .01 level was found.

COMPARISON SIX

The Sixth comparison was between the Control group pre-test and post-test swimming Performances.

Sample	Sample Size	Mean	Standard Deviation
Control Pre-test	8	810.625	545.547
Control Post-test	7	535.000	412.563

The pooled deviation was 488.688. The "t" test result was 1.089. The probability of the "t" being equal to or larger than 1.089 is 15% at 13 degrees of freedom. No significant difference was found.

CHAPTER 5

RESULTS, CONCLUSIONS AND, DISCUSSION

No significant differences at the .05 level were found in the intergroup mean body weights or the pre-test swimming performances. However, experimental groups post-test mean swimming performances increased significantly at the .01 level. The experimental swimming performances increased significantly at the .01 level over and above the Controls' Swimming Performances. The Controls mean body weights increased significantly at the .01 level over the experimental mean body weights.

The rats at the time of the pre-test were statistically equal in both mean body weights and Swimming Performances. However, by the post-test, the Carbohydrate Loading Diet increased the Swimming Performances of the experimental rats significantly. The increased Swimming Performance produced by the Carbohydrate Loading Diet agreed with Hultman's (1967) findings. The increased Swimming Performances would seem to be related to the dietary differences between the groups and cause an increase in the deposit of glycogen in the muscle cells in the experimental group.

The rats on the Carbohydrate Loading Diet had an increased body weight but the mean body weight of the experimental group was significantly lower than the control group. In related data collected from the experiment (Kozub and Patton) it was shown that the ingestion of food by the experimental group was lower than the control group, 20 grams to 26 grams a day, respectively. Not only was the intergroup ingestion lower, but there was a noted difference between the protein and carbohydrate ingestion in the experimental group. The protein intake was the lowest with only 15 grams a day ingested while carbohydrate phase allowed a near normal 24 grams to be ingested daily. These results are in agreement with Simson and Booth (1973) who attributed this feeding phenomenon to the shunting of the "hunger signal".

The related data on water consumption (Kozub and Patton) showed that the control group consumed 37 ml. of water daily while the experimental group consumed 48 ml. a day. Again, there was a noted difference in the experimental intragroup watering between the protein and carbohydrate phases. During the protein phase the water intake was the highest with 54 ml. consumed a day while in the carbohydrate phase 42 ml. a day was recorded. These water consumption results could also be linked to Simson and Booth's (1973) study. Their amino acid - water phenomenon may be the factor which cause the increased water consumption during the protein phase. However, the reason for the increased water consumption results during the carbohydrate phases is not clear. The overingestion could be linked to the storage of muscle and/or Hepatic glycogen (Moorehouse and Miller, 1976), but the exact reason for the increased carbohydrate phase water consumption has to be left unanswered or at least partly unaccounted for.

All the above findings indicate that a Carbohydrate Loading Diet significantly improved the swimming performances of rats. However, in another aspect of the experiment (Eastman and Patton) the Carbohydrate Loading Diet seemed to have an effect on the body weights of the experimental rats in that the experimental group gained significantly less weight than the controls. The true nature, as mentioned above, remains unclear, but a question evolved: does this "decrease" in weight have an effect on the rats body.

In pursuit of the answer the adrenals were found to be smaller at the .10 level in the experimental group than the control group. The adrenals seemed to atrophy, possibly because of the hyperactivity of the glucocorticords incorporation within the storage aspect of the abundant glucose caused by the Carbohydrate Loading Diet. However, Leftwich (personal communication, 1976) noted that the experimental adrenals were a different color and texture from the control and/or normal rat adrenals. He seemed to think that the overactivity of the experimental rats' adrenals caused the atrophy while the control rats' adrenals for some unexplained reason, were not overstressed or at least not stressed above normal amounts. Nevertheless, no conclusions on this theory can be reached at this time.

In another aspect of Eastman and Patton's seperate study, it was noted that the repeated Carbohydrate Loading Diet produced an improvement in the Swimming Performances of the experimental rats weekly. The rats improved slightly by the first weekly swim test, more by the second swim test and significantly more by the post-test or third swim test. These results all agree with Hultman (1967).

In summary, the repeated Carbohydrate Loading Diet increased the Swimming Performance in the Laboratory Rats. However, certain evidence indicates the utilization of this diet may have hazardous side effects on the subjects body.

FUTURE RESEARCH

Based on the findings in this study, a future study in the excessive ingestion of water during the carbohydrate phase of the Carbohydrate Loading Diet is recommended. Another future study on the effects of the Carbohydrate Loading Diet on the physiological aspects of the adrenals and the adrenals atrophy is also recommended. Beyond any compromise, the study on the adrenals would determine if the utilization of the Carbohydrate Loading Diet is dangerous to athletes using this diet for better performances.

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APPENDIXES

APPENDIX A

TABLES

Table 1

Pre-Test Swimming Performance

Rank	Rat's #	Weight in Grams	Swimming Performance in Seconds
*First	7	188.4	1858
+Second	2	221.0	1635
+Third	3	224.5	1460
*Fourth	12	214.9	1383
+Fifth	1	229.5	1320
*Sixth	4	223.0	855
+Seventh	17	207.2	796
*Eighth	8	191.8	700
+Ninth	10	236.8	631
*Tenth	15	195.6	583
+Eleventh	14	194.0	571
*Twelfth	5	213.5	425
+Thirteenth	6	195.3	400
*Fourteenth	9	244.6	372
+Fifteenth	11	195.6	320
*Sixteenth	18	167.3	309
+Seventeenth	16	207.2	306

*Control Rats
+Experimental Rats

Table 2

Experimental and Control Groups' Pre-Test
Swimming Performances and Body Weights

Rat's Number	Pre-Test Rank	Weight in Grams	Swimming Performance in Seconds
2	2	221.0	1635
3	3	224.5	1460
1	5	229.5	1320
17	7	207.2	796
10	9	236.8	631
14	11	194.0	571
6	13	195.3	400
11	15	195.6	320
16	17	207.2	306
Total	82.00	1911.100	7439.000
Experimental Mean	9.11	212.344	826.556

CONTROL

Rat's Number	Pre-Test Rank	Weight in Grams	Swimming Performance in Seconds
7	1	188.4	1858
12	4	214.9	1383
4	6	223.0	855
8	8	191.8	700
15	10	195.6	583
6	12	213.5	425
9	14	244.6	372
18	16	167.3	309
Total	71.00	1639.1	6485.000
Control Mean	8.87	204.9	810.625

Table 3

Pre-Test and Post-Test Swimming and Performance

Pre-Test				Post-Test		
Rank	Wt. in Grams	S. P. in Seconds	Rat's Number	Rank	Wt. in Grams	S. P. in Seconds
*First	188.4	1858	7	*Thirteenth	341.2	575
+Second	221.0	1635	2	+First	317.0	6040
+Third	224.5	1460	3	+Eighth	313.2	965
*Fourth	214.9	1383	12	*Tenth	347.8	836
+Fifth	229.5	1320	1	+Second	324.5	4610
*Sixth	223.0	855	4	*Twelfth	354.9	580
+Seventh	207.2	796	17	+Ninth	296.3	885
*Eighth	191.8	700	8	*Forteenth	362.0	190
+Ninth	236.8	631	10	+Fourth	278.0	3930
*Tenth	195.6	583	15	*Sixteenth	354.0	150
+Eleventh	194.0	571	14	+Eleventh	291.5	615
*Twelfth	213.5	425	5	*Fifth	333.5	1255
+Thirteenth	195.3	400	6	+Third	275.3	3995
*Forteenth	224.6	372	9	*Fifteenth	397.0	159
+Fifteenth	195.6	320	11	+Seventh	286.0	1020
*Sixteenth	167.3	309	18	Died		
+Seventeenth	207.2	306	16	+Sixth	301.8	1185

*Control
+Experimental
S.P.-Swimming Performance
Wt.-Weight

Table 4

Experimental and Control Pre-Test
To Post-Test Weights and Swimming Performances

EXPERIMENTAL

Pre-Test Rank	Pre-Test Wt. in Grams	Pre-Test S. P. in Seconds	Rat's Number	Post-Test Rank	Post-Test Wt. in Grams	Post-Test S. P. in Seconds	Increased or Decreased
Second	221.0	1635	2	First	317.0	6040	+
Third	224.5	1460	3	Eighth	313.2	965	-
Fifth	229.5	1320	1	Second	324.5	4610	+
Seventh	207.2	796	17	Ninth	297.3	885	+
Ninth	236.8	631	10	Fourth	278.0	3930	+
Eleventh	194.0	571	14	Eleventh	291.5	615	+
Thirteenth	195.3	400	6	Third	275.3	3995	+
Fifteenth	195.6	320	11	Seventh	286.0	1020	+
Seventeenth	207.2	306	16	Sixth	301.8	1185	+
Total Eighty-Two	1911.100	7439.0		Fifty-One	2684.60	23245	+
Mean 9.11	212.344	826.5		5.56	298.17	2582.7	+

CONTROL

Pre-Test Rank	Pre-Test Wt. in Grams	Pre-Test S. P. in Seconds	Rat's Number	Post-Test Rank	Post-Test Wt. in Grams	Post-Test S. P. in Seconds	Increased or Decreased
First	188.4	1858	7	Thirteenth	341.2	575	-
Fourth	214.9	1383	12	Tenth	347.8	836	-
Sixth	223.0	855	4	Twelfth	354.9	580	-
Eighth	191.8	700	8	Forteenth	362.0	190	-
Tenth	195.6	583	15	Sixteenth	354.0	150	-
Twelfth	213.5	425	6	Fifth	333.5	1255	+
Forteenth	244.6	372	9	Fifteenth	397.0	159	-
Sixteenth	167.3	309	18	Died			
Total Seventy-One	1639.1	6485		Eighty-Five	2490.40	3745	-
Mean 8.87	204.9	810.6		12.14	355.77	535	-

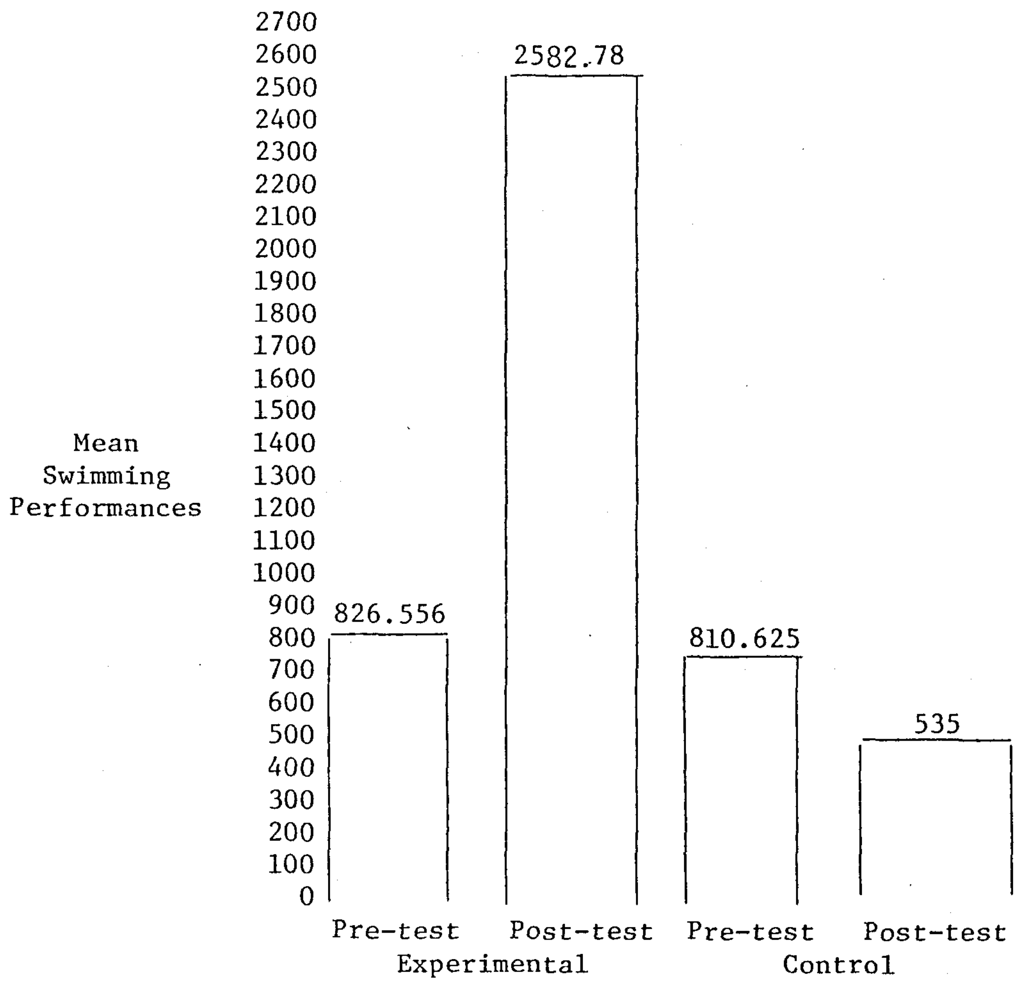
-Decrease
+Increase
S.P.-Swimming Performance
Wt. - Weight

APPENDIX B

FIGURES

Figure 1

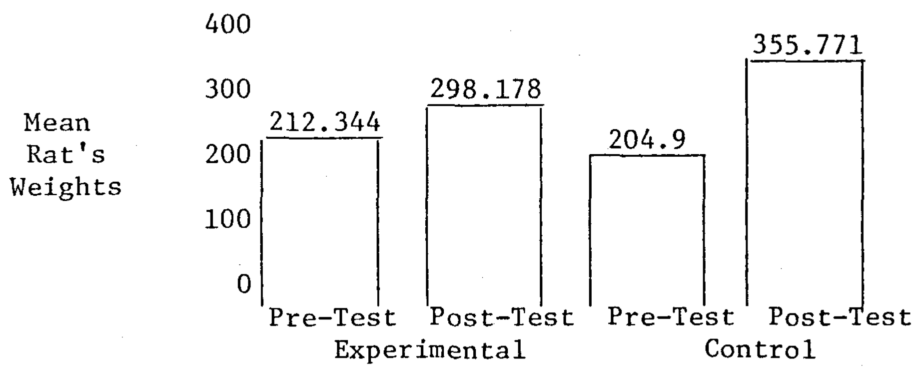
Experimental and Control Groups
Pre-Test to Post-Test Swimming Performances



There was a significant difference between Experimental and Controls Swimming Performances from pre-test to post-test with the Experimental over the Control.

Figure 2

Experimental Versus Control Groups
Pre-Test to Post-Test Rat's Weights



There was a significant difference between Control and Experimental Rat's Weights from Pre-Test to Post-Test with the Control over the Experimental.

VITA

Charles A. Patton was born on February 6, 1951, in War, West Virginia. He attended Public Schools throughout Florida, and was graduated from Oak Ridge High School in June of 1969. In June of 1974 he was graduated from Florida Technological University with a Bachelor of Arts in Biological and Physical Education. He completed the requirements for a Master of Science in Education, with emphasis in Physical Education and Exercise in Physiology, at the University of Richmond in December of 1976. Although a Ph.D in Exercise Physiology is sought, future plans are uncertain except for marriage to Mary Ann Brown.