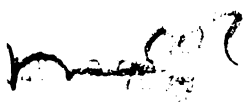
# AN INVESTIGATION OF THE EFFECTS OF EXERCISE (BASKETBALL) ON BLOOD SUGAR CONCENTRATIONS

Thesis for the Degree of M. A.

MICHIGAN STATE UNIVERSITY

Rev. Bruno Masotti O. S. B.

1960



# AN INVESTIGATION OF THE EFFECTS OF EXERCISE (BASKETBALL) ON BLOOD SUGAR CONCENTRATIONS

By

Rev. Bruno Masotti C. S. B.

AN ABSTRACT

Submitted to the College of Education of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

Year 1960

Approved Henry J. Montgomery

REV. BRUNO MASOTTI O. S. B. ABSTRACT

Title of Study

An investigation of the effects of exercise (basketball) on blood sugar concentrations.

Statement of Problem

The principle question to be examined in this investigation is "What effect has exercise on blood sugar levels?" The secondary aspects of the study concern the effect of duration of exercise and the effect of rest following exercise on blood sugar levels.

Need for Study

In recent years there has been an increased use of supplementary sugar in all types of athletic contests. The results ofthis study will furnish data to aid in the determination of the advisability or value of such practice in a contest such as basketball.

Review of Literature

The reported research in the area concerning blood sugar and exercise falls into four general categories; three major areas deal with the effect of emotion or excitement on blood sugar; the effect of diet and sugar supplements and effect of various types of exercise. A fourth group is made

up of various topics which refer in some way to this study.

Almost without exception, studies of the effects of emotion on blood sugar reported an increase in sugar concentration when emotion was present as a stimulus.

The majority of data involving sugar supplements concludes that additional ingestion of sugar is valuable in prolonged and strenuous physical exhertion such as marathon races. In less exhausting activities such as football or basketball sugar taken prior to or during a contest has little effect. Any increase over the normal expected rise with excitement and physical activity is probably psychological.

In general, studies relating types of exercise to blood sugar levels show an increase in blood sugar as activity is increased. As subjects show signs of approaching exhaustion the trend is reversed.

Additional topics significant to this study deal with the effects of training, the effect of exercise in animals, and the effect of fasting on blood sugar concentrations and recovery following exercise.

Design of Experiment

The subjects involved in this experiment were twelve boys selected from the freshmen and varsity basketball teams of St. Bernard High School in Cullman, Alabama.

A sample of blood was obtained from each subject twenty to thirty minutes prior to and immediately following each contest. Periodically these tests were purposely delayed for the intention of determining the effect of rest following activity on blood sugar. Several fasting specimens were obtained to determine the blood sugar levels of each subject.

The method used in blood sugar determinations was designed by the LaMotte Chemical Products Company and was of sufficient accuracy for clinical purposes in blood sugar studies.

Significant Findings

1. Post-game blood sugar levels were elevated significantly in every game.
2. Post-game blood sugar levels returned to below pre-game levels after a delay in sampling of thirty to forty minutes.
3. There was no significant correlation between blood sugar change and time in the game.

4. The factor of age was not a significant variable in pre and post-game samples.
5. Emotion or excitement increases blood sugar levels during or prior to exercise.
6. In the light of the results and the corroborating evidence of writings regarding the rise of blood sugar with exercise, it is concluded that the practice of ingesting sugar prior to or during a contest like basketball is of little value.

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## ACKNOWLEDGEMENTS

The author wishes to express his gratitude to the following persons who helped make this study possible: Dr. Henry J. Montoye, of the Department of Health, Physical Education and Recreation of Michigan State University; Rt. Rev. Bede Luibel, Abbott of Saint Bernard Abbey; individual members of the Saint Bernard Prep Basketball Team; Mr. David Rueff, Saint Bernard College; Mr. Dale Metts, basketball coach at West Junior High School, and his wife, Betty, who so patiently typed this thesis.

The author also wishes to express special appreciation to Rt. Rev. Msgr. Jerome V. MacEachin, Pastor of Saint Thomas Aquinas Church and his parishoners.

P. B. E. M.

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# CHAPTER I

## INTRODUCTION

In the past forty years there has been a growing awareness of a relationship between the blood sugar level of a competing athlete and his performance. Research has shown that athletes, especially those in less-than-top condition, experience a definite drop in blood sugar levels as the point of exhaustion is approached.[5] This had led to various theories concerning training diets, pre-contest measures, supplements and training procedures.

### Statement of the Problem

The principle question to be examined in this investigation is "What effect has exercise on blood sugar levels?" The secondary aspects of the study are the effect of duration of exercise and the effect of rest following exercise on blood sugar levels.

### Purpose of the Study

It was the purpose of the study to investigate the differences, if any, between pre-game and post-game samples of blood sugar. A secondary purpose was to question the

advisability of giving athletes sugar as an aid to increased performance in activities that do not lead the athlete to complete or near complete exhaustion.

## Need for the Study

It has been brought out by other investigators that there is often an appreciable drop in the blood sugar level of marathon and distance runners during a contest.[6] It is the belief of the writer that this information has led coaches of less exhausting sports to give athletes sugar as a counter agent to this condition. It is hoped that this study might show the actual need for supplementary sugar in contests of shorter duration. It is a fact that many coaches are relying upon data that may not be applicable to their particular situation and it is hoped this will clarify the questions concerning the value of such procedures.

## Limitations of the Study

It is a recognized fact that anxiety can and does affect the blood sugar level. It was impossible for the writer to ascertain the conditions that made one contest more important than another for each individual. Many factors such as home contests, tournament games, private motives and a myriad of other things quite probably influenced,

to some degree, the blood sugar level of each athlete in certain situations.

Another element that was not taken into consideration in this study was the fact that some contestants had a longer rest period than others between the time of actual competition and the blood sugar check. This was true because our facilities did not allow us to check each athlete at precisely the same moment and also because some finished their individual active competition prior to the end of a game.

# CHAPTER II

## REVIEW OF LITERATURE

### Introduction

It has been pointed out that observations made by different investigators in the field of blood sugar and its relationship with physical exercise have not been entirely in agreement. When one considers the many factors that influence the concentrations of sugar in the blood, some easy to control, some more difficult to control, this lack of agreement is not surprising.[17]

### Effect of Emotional Stimulus on Blood Sugar During Exercise

A great deal of emphasis has been placed on the fact that emotion or excitement alters blood sugar levels.[9,13] Edwards, Richards and Dill[17] observed that hyper-glycemia is uncommon in exercise with little or no emotional stress. They also reported peak levels of blood sugar in football players when the game was half over. In their study of football players they noted that two subjects performing a task in a game situation showed a rise in blood sugar concentration while these same two men performing the identical task under laboratory conditions registered a drop

in blood sugar.

Steter[26] reported that the emotionally stimulated rise of blood sugar is a phenomena not limited to human beings. Trained race horses experience a condition commonly known as "starting fever," a rise in blood sugar. This is assumed to be brought on by previously known images such as saddling, bridling, etc. In a similar group of regularly ridden, but not systematically trained horses, this condition did not occur.

Several studies of athletes competing in Olympic contests showed a general marked rise in blood sugar levels prior to competetion.[6]

## The Effect of Sugar Supplements

Karpovich[5] reported data that was very significant to this work. It was his conclusion that strenuous and prolonged activity, like a marathon race, caused a gradual fall in blood sugar while contests of a less exhausting nature, such as basketball and football games, show a general rise in blood sugar concentration. The study emphasises the importance of carbohydrate in the energy metabolism of the muscles. There was no evidence that candy and other sweets should be restricted during training unless they diminished the appetite and thus reduced the food intake at regular meals. Since prolonged and exhausting exercise is required to lower blood

sugar, Karpovich felt that there was no practical value in the administration of sugar prior to or during most athletic contests. He indicated that any apparent resulting increase is probably psychological in origin. He felt that it might be of value in a contest like a marathon race where the exhaustion of glycogen reserves and the consequent lowering of blood sugar level may be a dominant factor in bringing about complete exhaustion.

Best and Taylor[2] discussed the effects of a moderately high carbohydrate diet and conditioning on marathon runners. In the 1924 Boston Marathon there was a close correlation between the physical condition of the runners at the finish and the order in which they placed. The winner had a comparatively normal blood sugar and was in excellent condition. Four of the runners had 50, 49, 47, and 45mlgs. respectively. Two of them were completely exhausted and another unconscious. Before a similar race in 1925 the diet of the runners was carefully controlled. They were advised to eat moderately large amounts of carbohydrates before the race and were supplied sugars during the race. At the finish their blood sugar was practically normal and their physical condition far better than after the race of the previous year.[10]

Morehouse and Miller[6] also noted the correlation between a pre-contest carbohydrate diet, the ingestion of candy, and the blood sugar levels and physical condition

of marathon runners. They pointed out that the outstanding symptoms of extreme physical exhaustion such as in co-ordination of movements, collapse and unconciousness, are referable, not to the muscles, but to the central nervous system. The brain, unlike skeletal muscles, has no available carbohydrate stores and cannot fall back on the metabolism of other substances when its glucose supply is curtailed. It depends from moment to moment on the glucose brought to it by the blood. When the blood glucose level falls, brain function is depressed and unconciousness usually occurs when this concentration falls below 40 mlgs.[5]

## The Effects of Various Types of Exercise

Burger and Martens[6] reported conflicting data on the effects of one hour of gymnastics or one hour of boxing on the blood sugar levels of fasting men. The results being, some increase, some no change and some decrease.

D. B. Dill,[4] in a study of the effects of exercise on blood sugar, showed that during light exercise the ordinary rate of delivery of glucose to the blood from the storage depots adequately balanced the rate of glucose utilization by the muscles. Thus no change is apparent in blood sugar levels. As exercise in increased, especially with the accompanyment of excitement, the secretion of adrenalin becomes excessive and glucose is added to the blood at a

faster rate than the metabolic activities of the contracting muscles require. The result is a rise in blood sugar concentration. Dill also observed a more pronounced effect in intermittent exercise than in continuous exertion.

## Additional Data

There are numerous articles and studies that relate in some degree to this topic.

Robinson and Harmon,[21] seeking the effect of training on blood sugar found, while blood sugar was raised significantly in the initial experiments, it declined with training and was only slightly above basal value in final tests.

By measuring the rate of blood flow through the liver and the sugar concentration in the blood, Soskin[24] calculated the amount of blood entering and leaving the liver in a given time unit. In fasting animals the liver was found to liberate glycogen into the blood at a constant rate. When glucose was administered interveinously, the blood sugar rose and the liver stopped putting out sugar and started taking in glycogen in large amounts. After the period of reduced output, the liver again began supplying sugar to the blood at the original rate. This experiment therefore demonstrated that one function of the liver is action as a reservoir from which the blood sugar level may

be maintained while glucose, lactose or fructose is not entering the blood from other sources.

In a study of the sugar and oxygen relationships in the blood of dogs, Scott and Hastings[22] found the sugar concentration declined steadily during exercise.

In the Canadian Journal of Research, Hans Selye[23] describes the effect of fasting on the recovery period following intense muscular exercise of rats. The fasting animals have an extremely low blood sugar concentration during the first twenty four hours of rest. At this time there began a rise which gradually reached that of the control group. The control group was fed normally during this recovery period and showed an actual increase in blood sugar over the initial value at the end of twenty four hours.

# CHAPTER III

## GENERAL EXPERIMENTAL PROCEDURE

### Testing Environment

The subjects involved in this experiment were twelve boys selected from the varsity and freshman basketball teams of St. Bernard High School in Cullman, Alabama. Their ages ranged from 15 years to 18 years, 4 months. The individual weights varied from 125 to 170 pounds. It is apparent that these subjects may be viewed as a sampling of typical American high school athletes in regard to age and body development.

The boys were housed in the same dormitory with sleeping hours regulated. They ate a common diet at training table. Their recreational activities were similar and so far as can be ascertained their level of physical condition was very nearly equal. The testing was carried on over twenty basketball games. Previous investigators have described the effect of emotion on blood sugar. In this regard, it should be pointed out that the contests involved in the testing ran the gamut of emotional possibilities. There were non-league games, local rivalries, county and district tournament games.

The writer was fortunate in the degree of controlled experimental environment that was afforded in this boarding school. The above mentioned factors of similar diet and training conditions undoubtedly were influential in producing a clearer picture than would have been experienced with high school basketball teams.

## Procedure for Experiment

A sample of blood was obtained from each subject twenty to thirty minutes prior to each contest. At the same time urine specimens were taken and weights recorded. No nutrients or water were ingested after this time.

The identical procedure was again followed immediately after each contest. Periodically these tests were purposely delayed for the intention of determining the fall in blood sugar concentration with time, following a sontest. However, this time lapse did not exceed forty minutes.

The method used in blood sugar determination was one designed by the LaMotte Chemical Products Company[9] and was of sufficient accuracy for clinical purposes in blood sugar studies. It was essentially the method of Folin Wu.

The principle of the method depends upon the simple reduction of potassium ferricyanide by the sugar present in the blood, and the colorimetric determination of the ferricyanide formed as Prussian Blue. No colorimeter is

required, since the special comparator block and the blood sugar color standards were provided with the apparatus used.

The LaMotte Blood Sugar Method is a relatively new method, and is primarily designed for the testing of capillary blood as obtained direct from a small finger puncture. However, the test will give equally satisfactory results with oxalated venous blood. For the sake of clarity, a detailed description of the method used is as follows:

A test tube for each blood specimen was filled to a 10 ml mark with a Tungstic Acid solution made up of 16cc of .083N. Sulfuric acid added to 80 cc of distilled water. Then 2 cc of 10% sodium tungstate solution was added to the mixture and the solution was shaken thoroughly.

Using a 0.1 ml capillary pipette, 0.1 ml of blood was taken from the small finger puncture and discharged into the tungstic acid solution. The solution was drawn up into the pipette several times to get all the blood out of the pepette. The test tube with the blood and Tungstic Acid solution was then stoppered and shaken for a minimum of five minutes. This precipitated the red blood cells and left the blood serum and Tungstic Acid in solution.

A piece of No. 1 reagent grade paper was then placed into a funnel and washed thoroughly with distilled water, some of which was allowed to filter through the paper. This procedure was done as a precautionary measure to prevent any of the loose paper fibers from reacting with

any of the reagents to be added, and thus giving an inaccurate reading of the sugar content in the blood.

The funnel with washed filter paper was then placed into a clean test tube, and the mixture of blood and Tungstic Acid was filtered. The precipitate which was the formed elements of the blood was discarded, while the filtrate was collected in entirety.

The filtrate was then poured into a large test tube to the four ml mark. Following this, 0.5ml of Potassium Ferricyanide Solution and 0.5ml of Alkaline Cyanide Solution was added separately. The Potassium Ferricyanide solution was made up by dissolving 1gm of chemically pure Potassium Ferricyanide in distilled water and diluted to a volume of 250cc. This solution was kept in a brown bottle to prevent the oxidation of the Ferricyanide by light. The Alkyl Cyanide solution was made up by transferring 8gms of anhydrous sodium carbonate to a 500cc volumetric flask and adding 40-50cc of water and shaken to enable the substance to go into solution rapidly. Then with a cylinder 150cc of freshly prepared 1% solution of sodium cyanide was added and the mixture was diluted to the volume of 500cc with distilled water. After the Potassium Ferricyanide Solution and Alkaline Cyanide Solution was added, the mixture of these and blood was immersed in boiling water for exactly eight minutes.

After the solution had boiled for the entire eight minutes the tube was removed, and while still warm, 3ml of Ferric Solution was added from a special 3ml pipette. It was mixed by twirling the tube, cooled and diluted to a 25ml mark with distilled water. Comparison was then made with standards provided by the LaMotte Chemical Company.

The Ferric Solution was make by filling a liter cylinder with distilled water and suspending 20gms of Gum Ghatti on a wire screen of copper or galvanized iron, and left overnight. After the ghatti had been suspended just below the surface of the distilled water, it was removed and the liquid was strained through a double layer of clean laboratory towels. Then 5 grams of anhydrous ferric sulfate and 75cc of 85% solution of phosphoric acid in a 250cc beaker which contained 100cc of water, was mixed and dissolved by heating. This solution was cooled and added while stirring, to the Gum Ghatti solution. Finally, 15cc of a 1% Potassium Permanganate Solution was added, and a slight turbidity existed which disappeared after a few days.

In making the blood sugar determination, a test tube was filled to 10ml and placed in the middle hole of a three-hole comparator block. On the holes on either side of the test sample, two consecutive color standards, for example, 75 and 100mg, seem to most nearly match the color of the test sample. The three tubes were then viewed

through the comparator slots by holding the etched glass toward a source of bright light. The standards were changed if necessary, until the color of the test sample exactly matched one of the standards, or lay between the colors of two consecutive standards. If an exact match was obtained, the value was read directly from the standards on either side of it, the value was taken as the average of the two.

In case the test solution showed a color deeper than that of the highest standard, the test would be resumed, filling the large tube to the 2ml mark with the filtrate, and then proceeding exactly as outlined before. The reading must be multiplied by two to obtain the sugar content of the blood in this case.

In the case of the urinalysis, the specific gravity of the urine was tested by a standard urinometer. The acid-alkaline reaction was checked by commercial ph litmus paper. The glucose and albumin content was tested with Uristix, a commercial product that works on the basis of enzymatic reaction. A routine non-centrifuged microscopic examination was performed, and the findings reported per high-powered field.

At the end of the first week, again after the fourth week, and at the end of the season, a fasting specimen was obtained to determine the blood sugar levels of each subject under investigation. At approximately 6:30 A.M., subjects

were roused from sleep and specimens drawn. These fasting specimens ranged from 100 to 130 mg per 100 ml of blood.

Each subject recorded on a diet sheet the actual amounts of each kind of food he consumed each day. Carbohydrated, proteins and number of calories were tabulated by Georgia State Department of Public Health.

# CHAPTER IV

## PRESENTATION AND DISCUSSION OF DATA

### Introduction

The analysis of this data may most conveniently be divided into two parts. The preliminary phase consists of viewing various variables in the study to determine the effect, if any, they may have on the results. The major problem is concerned with a test for significance of the effect of exercise on blood sugar concentrations. The possible fluctuations in blood sugar levels with rest following exercise will also be viewed.

### Results of Preliminary Phase

Age. The subjects were taken from two groups, St. Bernard High School varsity and freshman basketball teams. The ages of the players on the reserve squad ranged from 15 years to 16 years 8 months. The ages of the varsity players spanned 16 years 10 months to 18 years 4 months. Figure #1 indicates that age was not a significant variable.

Point Difference. There is a great amount of data showing the positive effect of emotion on blood sugar levels. It was felt by the writer that the difference in score of the

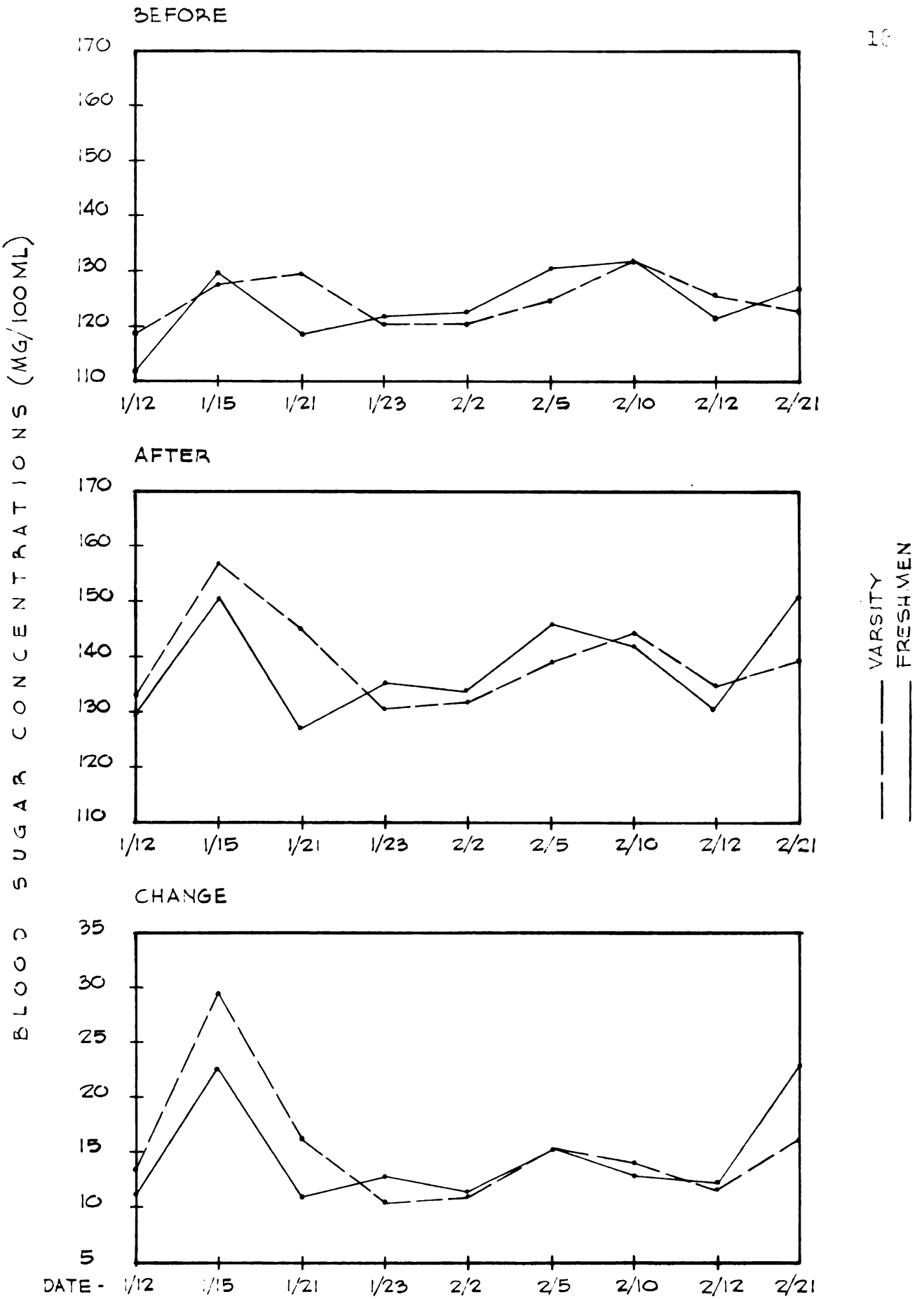



FIG. 1 - BLOOD SUGAR CONCENTRATION BEFORE AND AFTER GAMES (TEAM AVG.). COMPARISON OF VARSITY AND

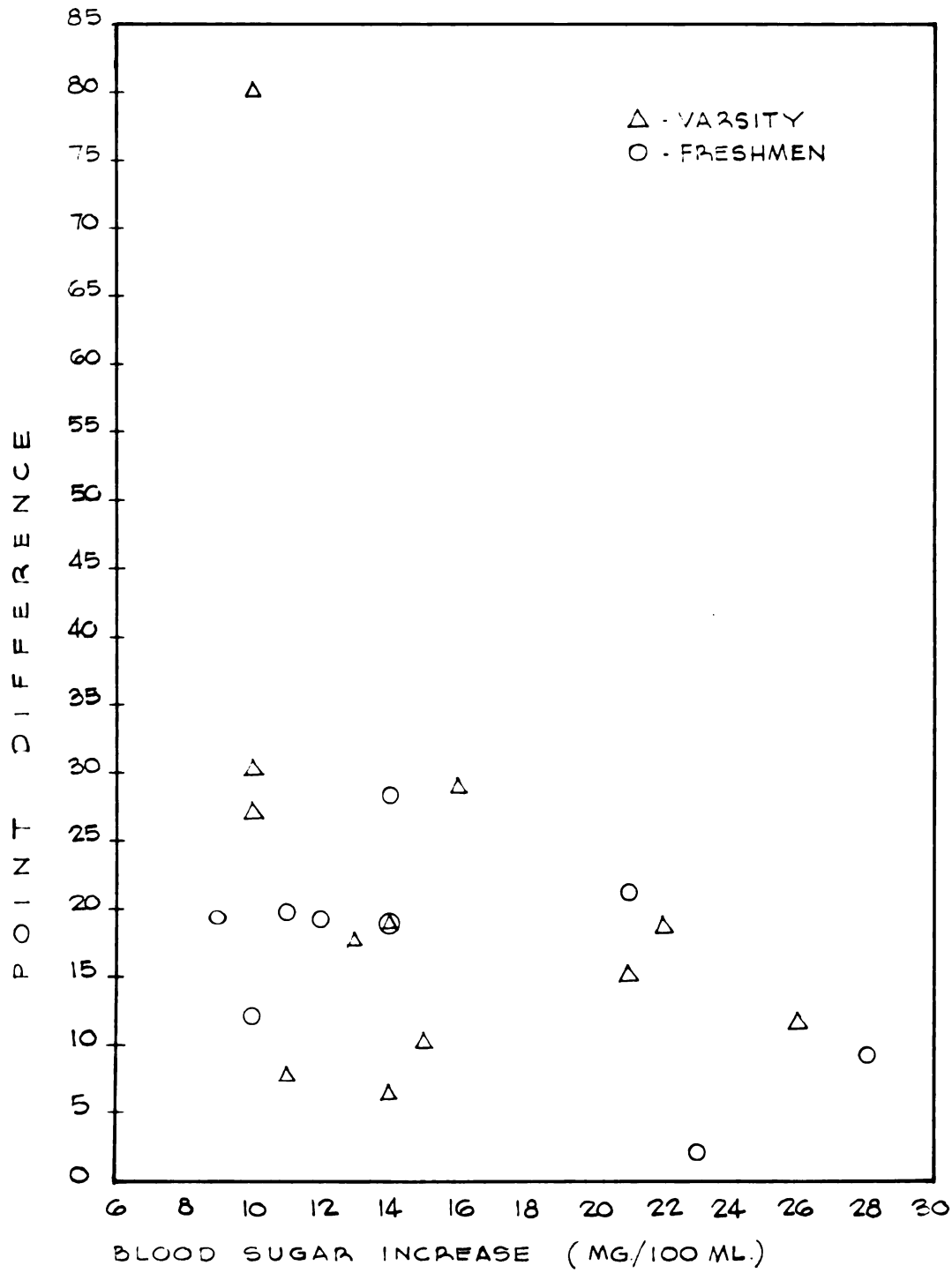



FIG. 2 - CORRELATION OF AVERAGE BLOOD SUGAR INCREASE AND GAME POINT DIFFERENCE

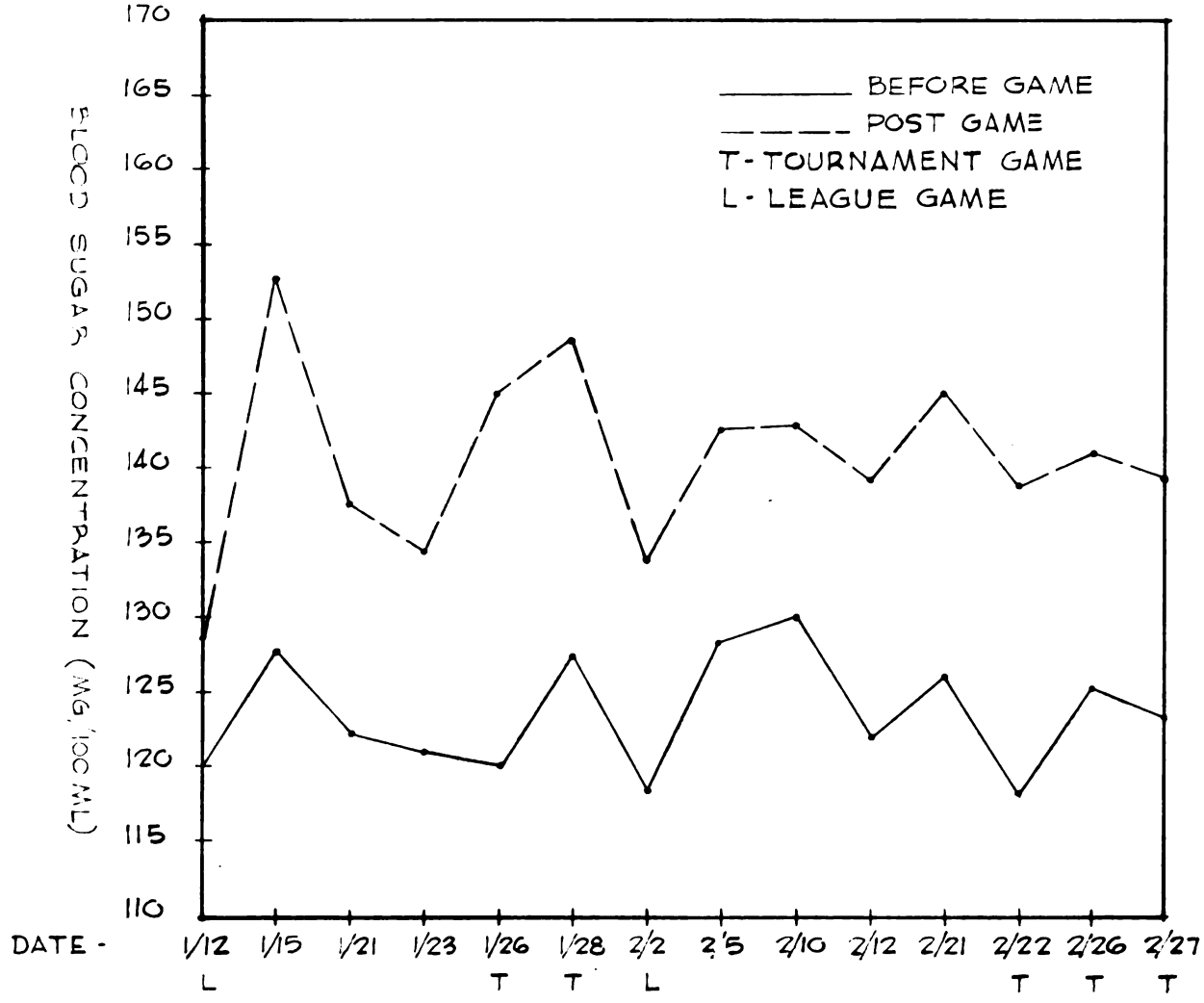



FIG. 3 BLOOD SUGAR BEFORE AND AFTER GAMES

two teams might change the results in some way. There was no statistically significant difference in mean blood sugar levels between games with a large point spread and close games. Examination of Figure #2, however, indicates a definite trend toward higher blood sugar levels in closer games.

Tournament, League and Non-league Contests. The various types of contests too, were examined to see if the emotional stresses of so called important games altered the blood sugar concentration more in comparison to other contests not thought to be so emotionally charged. Figures #3 and #5 show a trend toward higher blood sugar levels in the more important games such as league and tournament contests.

Training Effects. It might be expected that blood sugar concentrations would gradually fall through the physical stresses of a seasons play. As can be noted in Figures #1 and #3, the blood sugar fluctuates throughout the experiment showing that the expected longitudinal effect did not occur.

Time in Competition. The time each subject played in each game could not, of course, be kept constant. The coefficient of correlation was computed in order to determine the effect these differences in participation might have on change of blood sugar levels. The $r$ was computed to be .07. In 125 cases this $r$ is associated with a probability

greater than .05, showing no significant correlation. A scatter diagram was constructed which also showed similar results. [1,4]

## Major Problem

The determination of whether or not there is a significant difference between the means of the two sets of measurements; pre-game blood sugar levels and post-game blood sugar levels. The significance of the change in blood sugar concentration from before and after the game was determined by the *t* test for correlated values.[4] Consult Table #1 and Table #2.

TABLE I

INDIVIDUAL STATISTICAL SIGNIFICANCE OF CHANGE IN BLOOD SUGAR

| Subject | Mean Change | t Value | P. | Subject | Mean Change | t Value | P. |
|---|---|---|---|---|---|---|---|
| # 2 | 20.8 | 4.8 | .01 | # 8 | 5.4 | 2.2 | *.05 |
| # 3 | 16.2 | 9.0 | .01 | # 9 | 32.0 | 7.5 | .01 |
| # 4 | 13.6 | 4.0 | .01 | # 10 | 20.0 | 4.3 | .01 |
| # 5 | 18.8 | 3.2 | .01 | # 11 | 14.7 | 4.2 | .01 |
| # 6 | 20.0 | 8.5 | .01 | # 13 | 9.9 | 3.0 | .01 |
| # 7 | 16.1 | 3.4 | .01 | # 14 | 15.3 | 4.3 | .01 |

*Subject has a history of Brights Disease.

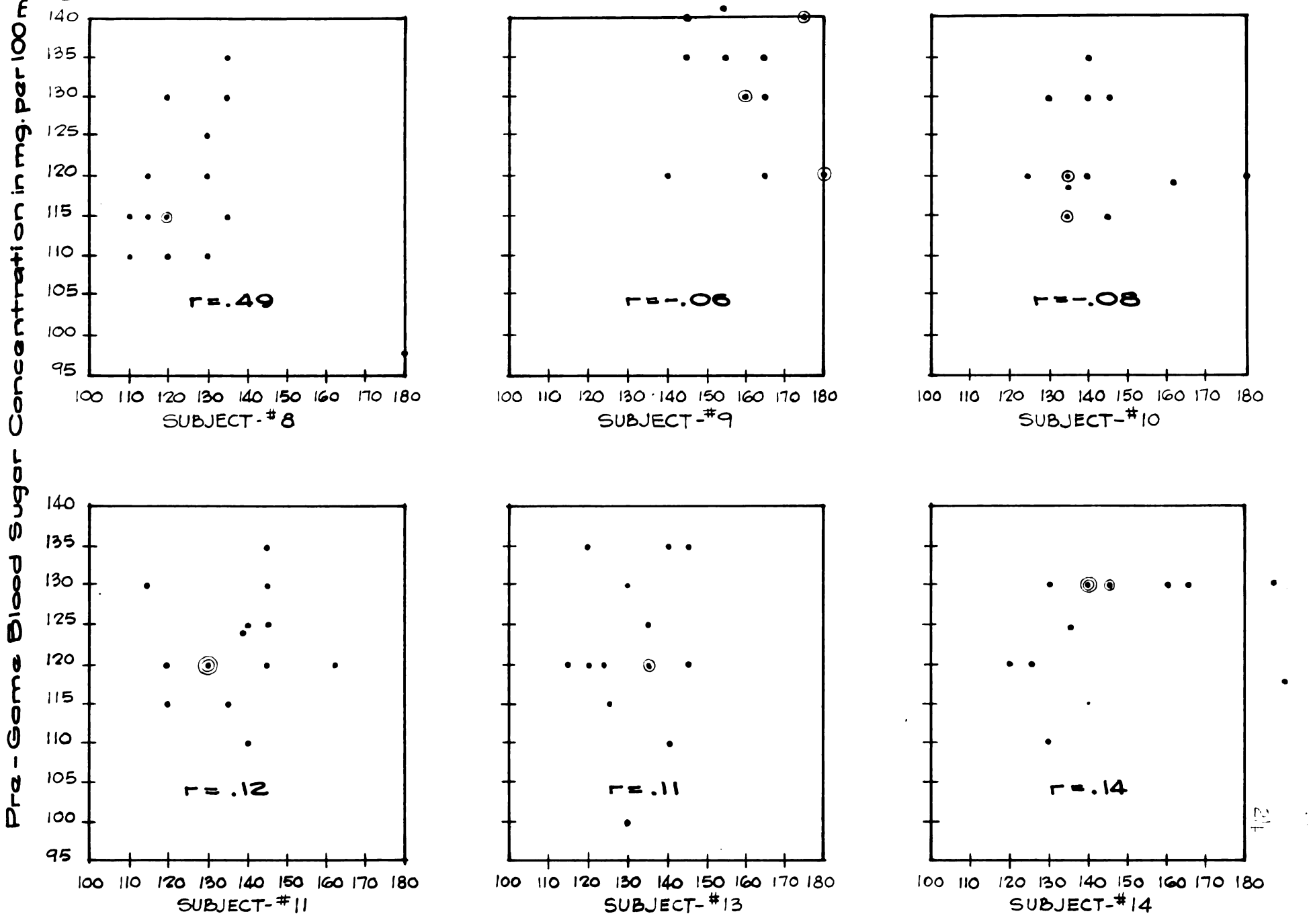
A coeffecient of correlation between blood sugar concentrations before and after competition was computed. The r for the group was .43 with a probability less than .01.[1] The coeffecient of correlation per each individual was also calculated. Coeffecients for three of the twelve subjects were significant at a .05 level. According to Wilkinson[28] these results would occur due to chance with a probability of less that .02. It may therefore be assumed that athletes with a higher pre-game blood sugar also show higher concentrations in their post game samples.

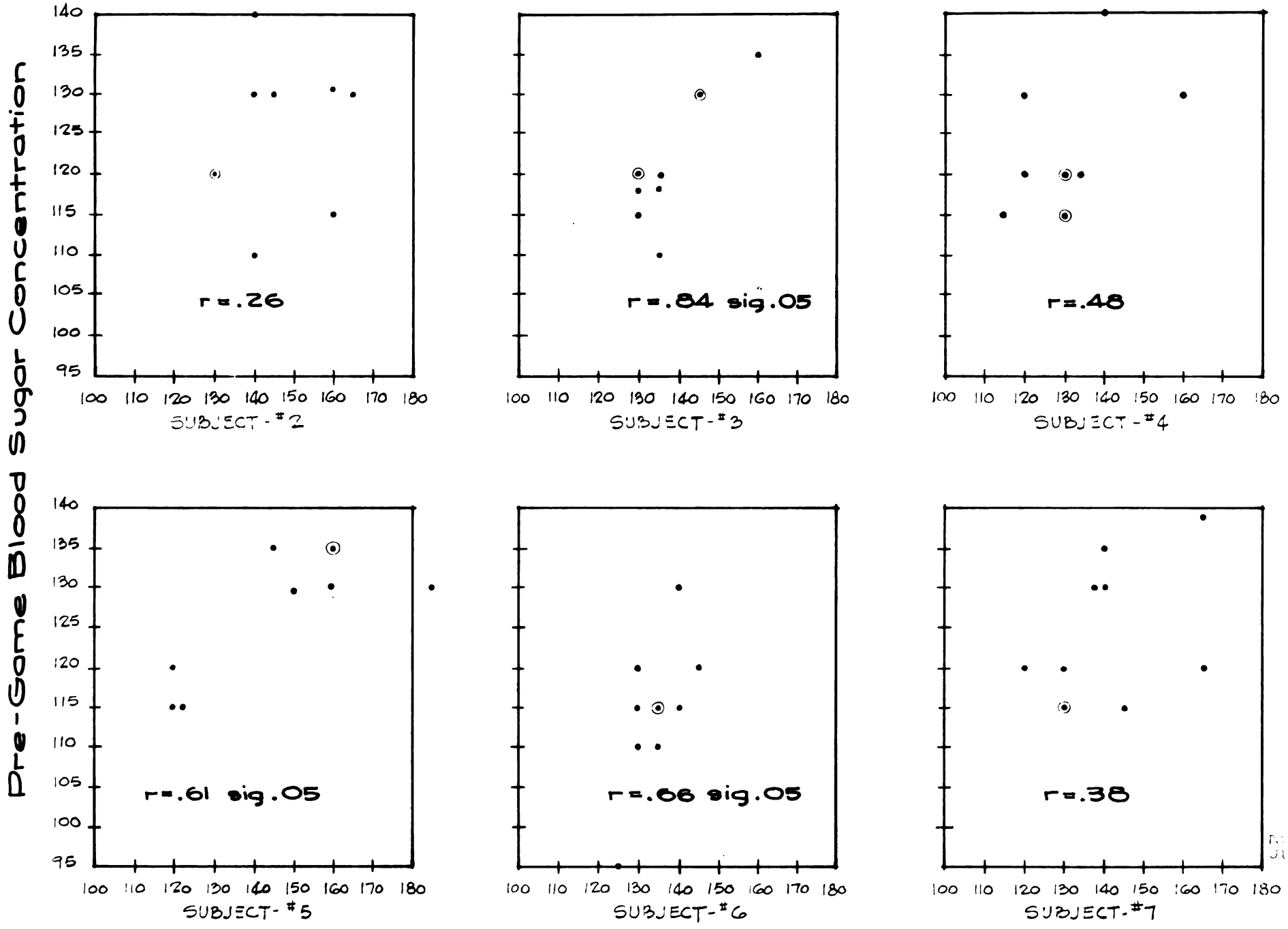
## Additional Data

Delay in Post Game Samples. In four contests the post-game sample was delayed 10, 20, 30, and 40 minutes. Figure V shows the return to pre-game concentrations and it also indicates that with rest the blood sugar concentration may fall below pre-game levels.

Weight Loss. The subjects were weighed prior to and immediately after each contest. The weight loss (average 2.05 pounds) was generally constant for individuals and was regularly regained by the following day, indicating fluid to be the chief source of the loss. Weights were maintained throughout the season pointing to the fact that physical condition was good and staleness or fatigue could not be considered factors in this study.

Figure 4A - Individual Correlation of Pre-Game & Post-Game Blood Sugar Concentration




Pre-Game Blood Sugar Concentration
140
135
130
125
120
115
110
105
100
95
100 110 120 130 140 150 160 170 180
r=.26
SUBJECT-#2
r=.84 sig.05
SUBJECT-#3
r=.48
SUBJECT-#4
r=.61 sig.05
SUBJECT-#5
r=.66 sig.05
SUBJECT-#6
r=.38
SUBJECT-#7
Post-Game Blood Sugar Concentration in mg. per 100 ml. Blood

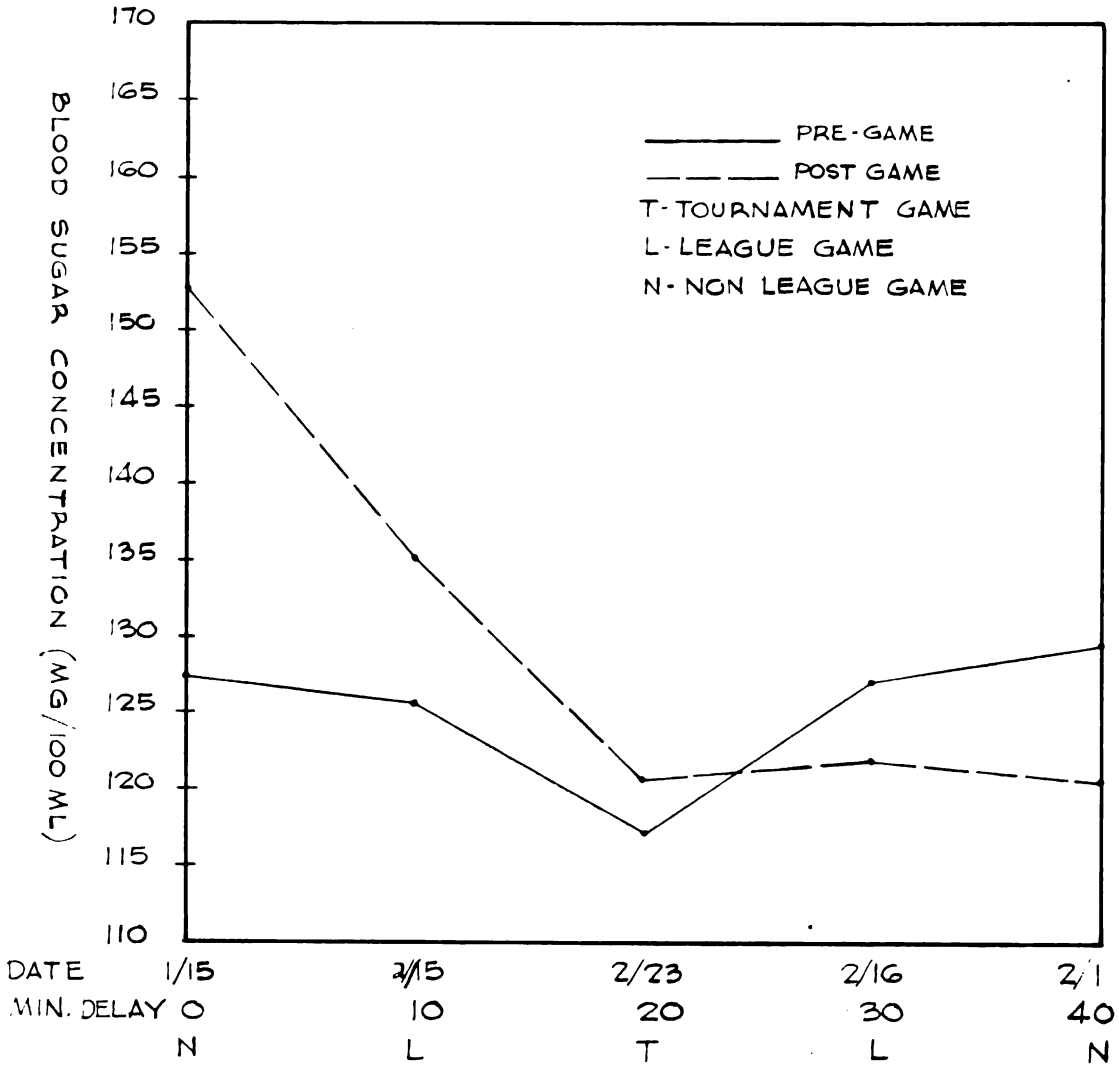



FIG. 5- BLOOD SUGAR CONCENTRATION RELATED TO TIME DELAY

The increase of blood sugar in the post game sample is significant in every subject. In Subject number eight at the .05% level, the remaining subjects have a P. value of .01.[1,4]

TABLE II

STATISTICAL SIGNIFICANCE OF CHANGE IN BLOOD SUGAR BEFORE AND AFTER EACH GAME

| Game Date | Mean Change Blood Sugar | t Value | P. |
|---|---|---|---|
| 1/12/60 | 11.6 | 4.3 | .01 |
| 1/15/60 | 25.2 | 5.0 | .01 |
| 1/19/60 | 43.5 | 7.6 | .01 |
| 1/23/60 | 12.0 | 4.7 | .01 |
| 1/26/60 | 25.0 | 3.9 | .01 |
| 1/28/60 | 21.6 | 3.4 | .02 |
| 2/2/60 | 15.8 | 4.4 | .01 |
| 2/5/60 | 15.0 | 3.8 | .01 |
| 2/10/60 | 10.0 | 3.1 | .02 |
| 2/12/60 | 10.0 | 5.3 | .01 |
| 2/19/60 | 9.5 | 3.0 | .01 |
| 2/21/60 | 17.4 | 3.7 | .01 |
| 2/26/60 | 15.8 | 3.8 | .01 |
| 2/27/60 | 10.8 | 1.9 | * .1 - .2 |

*.1 -.2 significance due to few subjects (5) sampled.

Fasting Blood Sugar Levels. Fasting specimens were taken three times during the season to establish a basal blood sugar concentration for each individual.

TABLE III

INDIVIDUAL FASTING BLOOD SUGAR CONCENTRATIONS

| Subject | 1/14/60 | 2/4/60 | 2/29/60 | Mean |
|---|---|---|---|---|
| # 2 | 120 | 125 | 120 | 121.6 |
| # 3 | 120 | 115 | 115 | 116.6 |
| # 4 | 125 | 120 | 120 | 121.6 |
| # 5 | 120 | 120 | 120 | 120.0 |
| # 6 | 125 | 120 | 120 | 121.6 |
| # 7 | 118 | 115 | 125 | 119.3 |
| # 8 | 115 | 120 | 120 | 118.3 |
| # 9 | 130 | 125 | 130 | 128.3 |
| # 10 | 120 | 125 | 120 | 121.6 |
| # 11 | 100 | 120 | 115 | 111.7 |
| # 13 | 115 | 120 | 115 | 116.8 |
| # 14 | 115 | 125 | 120 | 120.0 |
| Total | 1425 | 1450 | 1440 | |
| Mean | 118.5 | 120.9 | 120.0 | 119.8 |

## Discussion

The results of this study and the data revealed in related books and articles lead to certain conclusions as to the causitive factors involved in the significant rise of blood sugar levels during exercise.

It would appear that emotion or excitement can definitely be classified as one of these factors. The rise which occurs commonly in both athletes and race horses prior to a contest would support this theory.

Close games and important contests were compared with other more average contests in an effort to rate the emotional factor as a causitive agent in blood sugar rise. A close scrutiny of Figures 2,3,and 5 will show that while not statistically significant there is a trend that would indicate a greater increase in blood sugar in the close or important games. Considering the amount of data in other studys that support the importance of emotion in blood sugar rise, it is the writers conviction that a more thorough testing of this point would have produced more pronounced results.

Tests which show a prominent increase in blood sugar concentration in exercise during competition before crowds, and little increase in the same exercise performed under laboratory conditions also indicated the importance of the

emotional factor.

It is obvious that emotion is not the only factor involved in this phenomenon. The overwhelming mass of evidence showing increased sugar concentration with vigorous exercise leaves no doubt that exercise itself is definitely a causitive agent. The variations in blood sugar rise which accompany different types, degrees and periods of exercise are indicative of its effect.

Long periods of fatiguing exercise which eventually bring about a drop in blood sugar along with external symptoms of exhaustion, point up the necessity of maintaining certain levels for physical efficiency. This also shows that while exertion effects a rise in blood sugar its prolonged effect is to deplete blood sugar stores.

In summary, it is the writers conviction that emotion and vigorous exercise are the important catalytic agents involved in stimulating the release of glycogen to the blood sugar.

# CHAPTER V

## SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

### Summary

A group of twelve high school athletes were examined prior to, and after twenty basketball games, over a period of eight weeks. At each examination the weight and blood sugar concentration was recorded and urine analyzed. Each subject was given forms on which he kept a written record of all food ingested. Periodically, blood samples were sent to a local hospital and analyzed. This was done as a check on the accuracy of the testing results. On three separate occasions blood samples were drawn during a fasting period to establish basal blood sugar concentrations of each subject.

The data was analyzed statistically. Correlations of time in game and change in blood sugar as well as pre and post game blood sugar concentrations were calculated for team and individual subjects. A t test for significance was computed on change in blood sugar concentrations.

In four contests post-game blood sugar sample was delayed ten, twenty, thirty and forty minutes.[4]

## Conclusions

On the basis of the experimental data obtained in this study, the following conclusions are offered:

1. Post-game blood sugar levels were elevated significantly in every game.
2. Post-game blood sugar levels returned to or below pre-game levels after a delay in sampling of thirty to forty minutes.
3. There was no significant correlation between blood sugar change and time in the game.
4. The factor of age was not a significant variable in pre and post game samples.
5. Emotion or excitement increases blood sugar levels during or prior to exercise.
6. In the light of the results and the corroborating evidence of writings regarding the rise of blood sugar with exercise, it is concluded that the practice of ingesting sugar prior to or during a contest like basketball is of little value.

## Recommendations

The following recommendations are made for further study in this area:

1. Although difference in ages had no apparent effect on the results of this study, a wider variation in age of subjects such as would be the case with junior high, high school and college athletes, might show age to be a significant factor.
2. It would be interesting and perhaps valuable in another study, to draw more blood samples with each contest; a series of tests beginning three to four hours prior to competition, at half time and periodic sampling after each game. A program such as this might give a clearer picture of emotional and other factors that appeared to be insignificant in this paper.
3. In order to distinguish the effect of emotion from the effect of exercise it seems advisable to draw blood sugar samples before and after practice sessions.
4. With the widespread use of sugar during contests it would seem worthwhile to concentrate a study on the value of such procedures.

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DEPARTMENT OF HEALTH, PHYSICAL EDUCATION AND RECREATION

GRADUATE STUDIES AND RESEARCH

# TABULATION SHEET

DATE OF TABULATION: July 1960

TOPIC: Blood Sugar Levels and Exercise

TABULATED BY: Rev. Bruno Masotti

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | Time in Game Min. |
|---|---|---|---|
| 1/12/60 | | | |
| #2 | 120 | 130 | 29.5 |
| #3 | 118 | 134 | 32 |
| #4 | 120 | 130 | 30 |
| #5 | 115 | 122 | 24 |
| #6 | 120 | 130 | 11 |
| #7 | 115 | 130 | 10.5 |
| #8 | 115 | 115 | 31.8 |
| #9 | 130 | 160 | 31.8 |
| #10 | 118 | 135 | 31.8 |
| #11 | 120 | 130 | 32 |
| #13 | 120 | 115 | 29.8 |
| #14 | 110 | 130 | 2.2 |
| 2/2/60 | | | |
| #2 | 110 | 140 | 26 |
| #3 | 110 | 135 | 32 |
| #4 | 115 | 130 | 23 |
| #5 | 135 | 160 | 32 |
| #6 | 95 | 125 | 30 |
| #7 | 120 | 120 | 25 |
| #8 | 115 | 120 | 29 |
| #9 | 135 | 145 | 32 |
| #10 | 115 | 145 | 32 |
| #11 | 115 | 135 | 32 |
| #13 | 120 | 120 | 16 |
| #14 | 120 | 120 | 2 |
| 1/19/60 | | | |
| #8 | 112 | NST | 30.5 |
| #9 | 120 | NST | 30 |
| #10 | 118 | 162 | 30 |
| #11 | 120 | 162 | 28 |
| #13 | 110 | 140 | 28 |
| #14 | 130 | 188 | 4 |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | Time in Game Min. |
|---|---|---|---|
| 1/15/60 | | | |
| #2 | 132 | 160 | 32 |
| #3 | 135 | 160 | 20 |
| #4 | 140 | 140 | 20 |
| #5 | 130 | 160 | 20 |
| #6 | 120 | 145 | 16 |
| #7 | 115 | 145 | 5 |
| #8 | 110 | 110 | 32 |
| #9 | 140 | 185 | 32 |
| #10 | 120 | 180 | 21 |
| #11 | 124 | 139 | 28 |
| #13 | 135 | 145 | 29 |
| #14 | 130 | 165 | 3 |
| 2/5/60 | | | |
| #2 | 140 | 140 | 30 |
| #3 | 130 | 145 | 30 |
| #4 | 120 | 130 | 17 |
| #5 | 160 | 160 | 30 |
| #6 | 115 | 135 | 30 |
| #7 | 120 | 165 | 30 |
| #8 | 120 | 130 | 32 |
| #9 | 130 | 165 | 32 |
| #10 | 115 | 135 | 32 |
| #11 | 120 | 145 | 32 |
| #13 | 130 | 130 | 32 |
| #14 | 130 | 130 | 0 |
| 1/28/60 | | | |
| #8 | 135 | 135 | 32 |
| #9 | 140 | 185 | 32 |
| #10 | 130 | 145 | 32 |
| #11 | 110 | 140 | 20 |
| #13 | 120 | 145 | 24 |
| #14 | 130 | 145 | 6 |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | Time in Game Min. |
|---|---|---|---|
| 1/21/60 | | | |
| #2 | 120 | 130 | 26 |
| #3 | 118 | 130 | 29 |
| #4 | 120 | 120 | 24 |
| #5 | 115 | 120 | 21 |
| #6 | 115 | 135 | 8 |
| #7 | 115 | 130 | 13 |
| #8 | 130 | 120 | 22 |
| #9 | 120 | 190 | 27 |
| #10 | 130 | 140 | 24 |
| #11 | 130 | 145 | 21 |
| #13 | 135 | 120 | 24 |
| #14 | 130 | 160 | 8 |
| 2/10/60 | | | |
| #2 | 130 | 165 | 21 |
| #3 | 130 | 145 | 21 |
| #4 | 130 | 120 | 6 |
| #5 | 135 | 145 | 21 |
| #6 | 130 | 140 | 21 |
| #7 | 135 | 140 | 21 |
| #8 | 125 | 130 | 30 |
| #9 | 145 | 165 | 30 |
| #10 | 135 | 140 | 32 |
| #11 | 135 | 146 | 31 |
| #13 | N.S. Sick | | |
| #14 | 130 | 140 | 5 |
| 2/22/60 | | | |
| #8 | 115 | 120 | 23 |
| #9 | 120 | 140 | 19 |
| #10 | 120 | 125 | 23 |
| #11 | 115 | 120 | 23 |
| #13 | 115 | 125 | 21 |
| #14 | 115 | 190 | 19 |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | Time in Game Min. |
|---|---|---|---|
| 1/23/60 | | | |
| #2 | 130 | 145 | 31 |
| #3 | 120 | 130 | 30 |
| #4 | 120 | 134 | 25.5 |
| #5 | 132 | 150 | 15.5 |
| #6 | 110 | 130 | 18 |
| #7 | 130 | 138 | 18 |
| #8 | 115 | 110 | 32 |
| #9 | 130 | 160 | 29 |
| #10 | 120 | 135 | 23 |
| #11 | 120 | 130 | 31.5 |
| #13 | 120 | 124 | 27 |
| #14 | 120 | 126 | 3.5 |
| 2/12/60 | | | |
| #2 | 130 | 140 | 24 |
| #3 | 120 | 135 | 24 |
| #4 | 115 | 115 | 8 |
| #5 | 120 | 120 | 24 |
| #6 | 115 | 130 | 24 |
| #7 | 130 | 140 | 24 |
| #8 | 110 | 120 | 32 |
| #9 | 140 | 155 | 29 |
| #10 | 115 | 135 | 29 |
| #11 | 120 | 120 | 29 |
| #13 | 120 | 135 | 8 |
| #14 | 130 | 140 | 0 |
| 2/26/60 | | | |
| #8 | 115 | 135 | 29 |
| #9 | 135 | 165 | 28 |
| #10 | 130 | 130 | 13 |
| #11 | 125 | 140 | 26 |
| #13 | 120 | 135 | 30 |
| #14 | 130 | 145 | 9 |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | Time in Game Min. | |
|---|---|---|---|---|
| 1/24/60 | | | | |
| #2 | 115 | 160 | 32 | |
| #3 | 115 | 130 | 32 | |
| #4 | 115 | 140 | 12 | |
| #5 | 130 | 185 | 32 | |
| #6 | 115 | 140 | 24 | |
| #7 | 120 | 130 | 0 | |
| #8 | 120 | 115 | 16 | |
| #9 | 120 | 190 | 32 | |
| #10 | 120 | 140 | 6 | |
| #11 | 120 | 130 | 32 | |
| #13 | 135 | 140 | 32 | |
| #14 | 115 | 140 | 16 | |
| 2/21/60 | | | | |
| #2 | 140 | 155 | 31.5 | |
| #3 | 120 | 130 | 23 | |
| #4 | 130 | 160 | 27.5 | |
| #5 | 135 | 160 | 23.5 | |
| #6 | 110 | 135 | 11.5 | |
| #7 | 138 | 160 | 21.5 | |
| #8 | 130 | 135 | 27.5 | |
| #9 | 135 | 155 | 32 | |
| #10 | 120 | 135 | 31 | |
| #11 | 125 | 145 | 29 | |
| #13 | 100 | 130 | 32 | |
| #14 | 124 | 135 | 3 | |
| 2/27/60 | | | | |
| #8 | 110 | 130 | 29 | |
| #9 | 120 | 165 | 29 | |
| #10 | (120) | (120) | DID NOT DRESS | |
| #11 | 130 | 115 | 29 | |
| #13 | 125 | 135 | 32 | |
| #14 | 130 | 140 | 24 | |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | |
|---|---|---|---|
| 1/15/60 | 0 | | |
| #2 | 132 | 160 | |
| #3 | 135 | 160 | |
| #4 | 140 | 140 | |
| #5 | 130 | 160 | |
| #6 | 120 | 145 | |
| #7 | 115 | 145 | |
| #8 | 110 | 110 | |
| #9 | 140 | 185 | |
| #10 | 120 | 180 | |
| #11 | 124 | 139 | |
| #13 | 135 | 145 | |
| #14 | 130 | 165 | |
| | 1531 | 1834 | |
| MEAN | 127.4 | 152.9 | |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | |
|---|---|---|---|
| 2/15/60 | 10 | | |
| #2 | 130 | 143 | |
| #3 | 125 | 134 | |
| #4 | 130 | 128 | |
| #5 | 125 | 144 | |
| #6 | 130 | 130 | |
| #7 | 120 | 136 | |
| #8 | 115 | 123 | |
| #9 | 135 | 153 | |
| #10 | 125 | 134 | |
| #11 | 120 | 133 | |
| #13 | 125 | 129 | |
| #14 | 125 | 138 | |
| | 1505 | 1625 | |
| MEAN | 125.4 | 135.4 | |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | |
|---|---|---|---|
| 2/23/60 | 20 | | |
| #8 | 120 | 125 | |
| #9 | 115 | 120 | |
| #10 | 120 | 130 | |
| #11 | 120 | 125 | |
| #13 | 115 | 110 | |
| #14 | 115 | 120 | |
| | 700 | 730 | |
| MEAN | 117 | 121.6 | |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | |
|---|---|---|---|
| 2/16/60 | 30 | | |
| #2 | 135 | 130 | |
| #3 | 135 | 130 | |
| #4 | 120 | 125 | |
| #5 | 120 | 125 | |
| #6 | 145 | 120 | |
| #7 | 105 | 120 | |
| #8 | 95 | 110 | |
| #9 | 140 | 115 | |
| #10 | | | |
| #11 | 130 | 120 | |
| #13 | 140 | 120 | |
| #14 | 135 | 130 | |
| | 1400 | 1345 | |
| MEAN | 127.2 | 122.2 | |

| Subject | Pre Game Blood Sugar mg/100 ml | Post Game Blood Sugar mg/100 ml | |
|---|---|---|---|
| 2/1/60 | 40 | | |
| #2 | 125 | 130 | |
| #3 | 130 | 135 | |
| #4 | 130 | 115 | |
| #5 | 120 | 120 | |
| #6 | 125 | 110 | |
| #7 | 130 | 120 | |
| #8 | 130 | 120 | |
| #9 | 140 | 130 | |
| #10 | 120 | 120 | |
| #11 | 135 | 125 | |
| #13 | 130 | 125 | |
| #14 | 135 | 120 | |
| | 1550 | 1451 | |
| MEAN | 129.1 | 120.8 | |