Evaluation of Citrus Bioflavonoid as an Aid in Prevention and Treatment of Athletic Injuries.

Martin J. Broussard
Louisiana State University and Agricultural & Mechanical College

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EVALUATION OF CITRUS BIOFLAVONOIDS AS AN AID IN PREVENTION AND TREATMENT OF ATHLETIC INJURIES

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Education in The Department of Health, Physical and Recreation Education

by
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B.S., Louisiana State University, 1954
M.S., Louisiana State University, 1960
August, 1967
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ABSTRACT

The specific purpose of the study was to evaluate the benefits of citrus bioflavonoid as an aid in the prevention and treatment of athletic injuries such as sprains, pulled muscles and contusions.

Members of the varsity football team at the Louisiana State University during the 1962 season were used as subjects in this study. Forty-eight players, including thirty-five members of the varsity squad and thirteen members of the scout squad, were placed at random into two groups on a matched player basis. Throughout the pre-season practices and during the regular season, each player received three gelatin capsules daily—two before the noon meal and the third at suit-up time. Capsules containing 300 mg. of lemon-orange flavonate glycoside (a citrus bioflavonoid complex) were dispensed to Group B. The capsules dispensed to Group A contained 300 mg. of lactose, a placebo formulation.

A detailed description of all the injuries was recorded according to nature, severity and treatment. A comparison of the injuries and treatment received by Group A and Group B was made. All injuries were described as to location, type, and severity at the time of occurrence. The results of the study were:

1. Thirteen players were injured in Group A, and fourteen players were injured in Group B.

2. Group A subjects received twenty-seven contusions, whereas
the subjects in Group B received twenty-three contusions.

3. In the sprain category, Group A received twenty-eight injuries, and Group B received fourteen injuries.

4. Group A received nine sprains and sixteen contusions during the month of September, whereas Group B received four sprains and six contusions during the same month.

5. Group A received sixteen sprains and six contusions during October, whereas Group B received nine sprains and ten contusions.

6. Group A received three sprains and five contusions in November, whereas Group B received one sprain and seven contusions.

The extent of the severity of the injuries was approximately the same in both groups. In the sprain category for Group A, 36 per cent of the injuries fell in the minimal or mild classifications, and 64 per cent of the injuries fell in the moderate and severe classifications. In Group B, 50 per cent of the sprains were of the minimal and mild classifications, and 50 per cent were of the moderate and severe classifications.

The average number of treatments per injury was greater in Group A than in Group B for both contusions and sprains. The average number of treatments for the contusions in Group A was 4.2; in Group B, it was 3.8. For the sprain category, the average number of treatments
received by Group A was 5.8. The average number of treatments in Group B was 4.2.

In making analyses by using totals, it appeared that the experimental group received some benefit from the citrus bioflavonoid; however, when this analysis was made in terms of specific injuries, it became apparent that the injuries to only a few subjects influenced the average a great deal.

Within the limits of this study, it was concluded that:

1. Citrus bioflavonoid has no effect on the number of players injured.
2. Citrus bioflavonoid will aid slightly in reducing the total number of injuries.
3. Citrus bioflavonoid supplementation has only a slight effect, if any, on reducing the severity of football injuries.
4. Citrus bioflavonoid may show a slight advantage in the reduction of recovery time from traumatic injuries received in football.
5. Players injured once are more likely to be injured a second time.
CHAPTER I

INTRODUCTION AND STATEMENT OF PROBLEM

1. INTRODUCTION

Increased requirements of essential nutrients during stress and physical exertion necessitate adequate dietary intake and supplementation. We now know that the addition of citrus bioflavonoids to the normal diet has many beneficial effects. Muscular and ligamentous injuries occur less frequently, injury recovery rate is much more rapid, muscular cramps are non-existant and swelling caused by contusions or joint injuries is minimal and subsides rapidly. These observations are very important in caring for athletic injuries.

More than two hundred chemical compounds have been identified in both the orange and lemon fruit. These include Vitamin C, eight B-complex factors, seventeen carotenoid pigments, four of which have Vitamin A activity, enzymes and more than fifty aromatic flavoring compounds. The interrelationship of these apparently is the key to adequate nutrition and health. An improper balance of diet nutrients may have a detrimental effect because strong interrelationships exist between dietary essentials. The presence of all essential nutrients is required for maximum tissue growth and proper metabolism.

The inclusion of citrus in the diet provides an important natural source of many of these vital essentials and supplies many of
the factors which potentiate and enhance nutritional substances present in the total diet.

Bioflavonoids, more commonly known as flavonoids, are a class of organic substances found in citrus, principally in the pulp. Working in conjunction with Vitamin C and other nutrients, they contribute to the maintenance of the integrity of the capillary and vascular systems. While there is no disease entity specifically known as "weakened capillaries," many organic diseases are affected by such a condition.

Of great significance is the role of the bioflavonoids in potentiating other nutritional factors, especially Vitamin C. This relationship between Vitamin C and the bioflavonoids has been the subject of numerous reviews which emphasize their value in blood capillary and vascular functions. An apparent relationship also has been indicated between the bioflavonoids and several of the B-complex factors. Recent preliminary findings indicate the bioflavonoids in citrus potentiate Vitamin A by increasing its absorption and utilization.

II. STATEMENT OF PROBLEM

The purpose of this study was to investigate the effects of citrus bioflavonoids in minimizing the incidence, the severity, and the duration of athletic injuries in football players during a complete football season.
CHAPTER II

REVIEW OF LITERATURE

The first part of the review of literature deals with material related to food supplement in minimizing the incidence and severity of athletic injuries. The second part of the review deals with related material to food supplement and their effect on health and fitness. The third part deals with incidence of injuries to football players at Louisiana State University over a four-year period.

1. STUDIES REVIEWED REGARDING INTAKE OF CITRUS BIOFLAVONOIDS IN REDUCING INCIDENCE AND SEVERITY OF ATHLETIC INJURIES

Cragin\(^1\) investigated the effects of citrus bioflavonoids on reducing the incidence and severity of athletic injuries. Athletes at San Jose State College were used in the study. The football, soccer, and judo teams were given coated citrus bioflavonoid with and without ascorbic acid, ascorbic acid alone, or a placebo. A double-blind technique was used with all athletes except with the basketball team. The study extended throughout the entire training season, with an equal number of men from each sport receiving the formulation with

ascorbic acid, without ascorbic acid, or the placebo. At the end of
the season, the injury records were reviewed and each player was
interviewed.

In basketball the double-blind study was not followed. Only
those players who had received injury or who did not respond to normal
treatment were used. One-half of the group was given the citrus
bioflavonoids and the other half was given the ascorbic acid formula-
tion. Evaluation and tabulation of results was accomplished at the
completion of each period.

Cragin concluded from this study:
1. The occurrence of muscle injuries was approximately one-half
   as frequent in these groups as in the ascorbic acid,
   pectin or corn starch control groups.
2. The recovery rate from muscle injuries was twice as rapid
   as that of the controls.
3. Muscle cramp (Charley Horse) is no longer a factor.
4. Swelling, usually a result of trauma, contusion or joint
   injury, was minimal and disappeared rapidly.

The addition of citrus bioflavonoids to the accepted treatment
of soft tissue injuries caused a significant recovery response. There
was no change in the recovery time of ligament and joint injuries when
bioflavonoids were prescribed.

Harrison et al., in a study at Texas A&M College, investigated the

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R. H. Harrison, R. H. Harrison, III, C. E. Harper, and C. R.
possible role of water soluble citrus bioflavonoid compound in minimizing the severity of superficial injuries in athletes. The study was started at the beginning of the 1956 football season. Sixty varsity players were evenly divided, according to position, into three groups and treated as follows: (1) twenty players were given one capsule containing water soluble citrus bioflavonoids and ascorbic acid two times a day, (2) twenty players received two capsules two times a day, and (3) the remaining twenty players served as untreated controls. Voided urine was collected and examined before the fall practice season opened and each week following a mid-week game scrimmage. Bruises were measured; hematomas, strains, sprains, broken bones, lacerations, and all forms of trauma were evaluated daily by one of the staff members.

Because the results obtained during this short study period indicated that the athletes were afforded significant protection, the study was extended to cover the four-week 1957 spring training season. During that time the entire football squad received the higher dosage of four capsules daily, two capsules twice a day.

Harrison concluded from this study:

1. Data on the effectiveness of a water-soluble bioflavonoid compound in controlling hematuria due to trauma is insufficient to draw conclusions. No appreciable effect in reducing morbidity in cases of lacerations and fractures was demonstrated.
2. As a prophylactic measure, its administration is effective in preventing and minimizing the severity of superficial injuries such as bruising, hematomas in skin and muscles, sprains and strains resulting in early restoration of many injured players to the active playing lists.

Accordingly, it was decided to continue the routine prophylactic administration to all members of the Texas A&M football squad and to advocate its use for athletes engaged in contact sports.

In a preliminary controlled study on intercollegiate wrestlers, Miller\(^3\) found that the incidence and severity of injuries were significantly reduced by citrus bioflavonoid supplementation. Thirteen intercollegiate wrestlers were placed on two capsules, three times daily for one week, then maintained on one capsule, three times daily, thereafter. Each capsule contained 200 mg. of ascorbic acid and 200 mg. of soluble bioflavonoids. A control group of fourteen wrestlers was placed on placebos with the same dosage schedule. All participants in the study had approximately equal periods of contact in practice but not in meets. All injuries occurred during practice and were evaluated by staff members each day.

In the preliminary test, three impressions were received:

1. Muscular injuries resulting in the tear of muscle tissue appeared to have similar degree of severity and required

\(^3\)M. J. Miller, "Injuries to Athletes," Medical Times, 88:313, 1960.
the comparable amount of time for healing in both test and control group.

2. The control group on placebos had a high percentage of facial and soft tissue hematomas, which were conspicuously absent in the test group.

3. The vast majority of injuries which did occur in the test group were of the strain and sprain variety, and the subjects who initially appeared to have sustained moderately severe injuries were able to return to contact activity more rapidly.

Miller conducted another study using an intercollegiate 150-pound football team. At the onset of this study a daily examination was planned to note and evaluate relatively asymptomatic injuries which the player might not bring to the attention of the physician; however, the time schedule of the athlete precluded this. Thus, the only injuries evaluated were those which were severe enough to warrant medical consultation. The following results were observed:

The prophylactic use of hesperidin-ascorbic acid has been found to reduce the incidence and severity of contusions sustained by football players.

The massive hemorrhagic effusion usually observed in cases of knee injuries was found to be reduced in those patients treated prophylactically with hesperidin-ascorbic acid.

Our experiences and observations in the prophylactic use of hesperidin-ascorbic acid confirm the conclusion that this combination is of value in the conditions described.

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4 ibid. 5 ibid.
Lichtman conducted an extensive study on the influence of citrus bioflavonoids on traumatic injuries in prize fighters. He noted that ocular trauma, blockage, and other bruises subsided in one to three days instead of ten days to two weeks (prior to the present treatment).

Three hundred and fifty traumatic injuries were treated with hesperidin and ascorbic acid. The results were classified as excellent in 231 cases, 66 per cent; good in 87 cases, 25 per cent; fair in 18 cases, 5 per cent; and as failures in 14 cases, 4 per cent. The fourteen failures sustained injuries resulting in ruptured vessels and were obviously beyond the scope of nutritional or enzymatic treatment.

He concluded that the use of hesperidin and ascorbic acid, orally, and the use of enzyme (trypsin) are adequate aids to nature in the management of bruising injuries.

Much can be accomplished to minimize tissue injuries by good nutrition, attention to capillary system, mental attitude, and adequately caring for the problems of fatigue and injury when they occur.

The vast capillary system of the human body, so often overlooked, must be considered as perhaps a functional organ of human physiology.

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7 Ibid.
The "capillaries" are the so-called "fields of labor" where the essential activities of the circulatory system are carried out. The importance of the heart, arteries and veins cannot be minimized, however, their sole function is to maintain an adequate rate of blood flow through the capillary beds. Alterations in the function and permeability of the capillaries seriously affect the normal physiological processes by interfering with the transfer of nutrients or by permitting micro-molecules or other abnormal materials to pass the capillary barrier into the tissues.

The integrity of the capillary system is affected by numerous complex factors that may be generalized as stress conditions. A broad scope of the causative agents, such as stress conditions, nutritional, physical, environmental and disease affect the integrity and function of the capillary system and result in capillary damage. Stresses may be classified as:

1. **Nutritional**: malnutrition; vitamin deficiencies; enzyme deficiencies; toxic factors (chemicals, foods and drugs); pregnancy; growth.

2. **Physical**: injury or trauma (bruises, sprains); surgery (wound healing); burns; exhaustion (overexertion, fatigue).

3. **Environmental**: freezing; atmospheric pressure changes; heat and humidity; allergic factors; physiological.

4. **Disease states**: infections (viral, bacterial); endocrine disturbances; splenic dysfunctions; malignancies.
The pattern of capillary damage includes increased permeability, seepage of blood and plasma constituents into the tissues, followed by inflammatory reaction. The inflammation may be localized at the site of the injury or may extend throughout the body in such tissues as brain, nerves, heart, liver, lungs, spleen, adrenals, muscle and the intestinal tract on a generalized basis. 8

Various bioflavonoid materials have been evaluated for their effect upon the capillary. The degree of capillary fragility has been determined by numerous procedures.

The therapeutic rationale of combining hesperidin or other citrus bioflavonoids with ascorbic acid or other therapeutic agents is based on the premise that capillary weakness may be a contributing factor to the disease state and that capillary integrity should be maintained. Citrus bioflavonoids in conjunction with ascorbic acid appears to enhance the efficacy of other therapy and aid in controlling such factors as infection, stress and nutritional deficiency even in cases which do not manifest capillary weakness. 9

Tissue repair, wound healing and the reversal of the inflammatory process are dependent upon accelerated cellular metabolism. Increased requirements of Vitamin C, citrus bioflavonoids and other nutrients, hormones (corticosteroids), enzymes and other factors are


9 Ibid.
essential. In addition, Vitamin C and the citrus bioflavonoids are important as adjuvants to the therapeutic regimen in controlling or reversing the extension of inflammatory processes.

The mechanism of the citrus bioflavonoids in the prevention and reversal of the inflammatory processes may be considered on a multiple basis by:

1. Capillary action (maintenance of integrity; decreased permeability).

2. Cellular metabolic processes (inhibition of Hyaluronidase, which is the spreading factor in tissues; potentiation of corticosteroids; stabilizing effects on the reticuloendothelial cells of the adrenal gland; and sparing action and synergism with Vitamin C).

3. Direct anti-inflammatory action.

4. Elevation of plasma corticosteroid level.

Pre- and post-surgical citrus bioflavonoid treatment of five hundred thirty tonsillectomies significantly reduced the need for clamp and the procedures to control oozing of blood from the cut surfaces. In thirty-five head and neck surgical procedures treated with citrus bioflavonoids, the need for sutures or nasal packings was definitely decreased, and post-operative swelling receded sooner than expected from previous experience.

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11 Ibid.
12. STUDIES REVIEWED REGARDING INTAKE OF CITRUS BIOFLAVONOID AND EFFECT ON HEALTH AND FITNESS

Simonson, Baer, and Enzer\textsuperscript{12} studied the effect of a large surplus of Vitamin B Complex (6 mg. Thiamin, 80 mg. Nicotinamide, 8 mg. Riboflavin, 0.3 mg. Pyridoxine, 80-120 units filtrate factor a day) given for six to ten weeks after a preliminary period of three weeks to twelve healthy subjects as compared with a control group of eleven subjects. No effect of Vitamin B intake was seen in five different types of muscular work: (1) dynamic work (endurance and recovery), (2) static work (endurance and recovery), (3) maximum frequency of finger movements, (4) absolute muscle force, and (5) fatigue of maximum muscular effort. The increase and recovery of pulse rate in dynamic and static work was not changed. In eight of twelve subjects, there was a pronounced increase of the fusion frequency of flicker (which is intimately related to fatigue of the central nervous system) beginning after three weeks intake and reaching the maximum after five weeks intake. The fusion frequency dropped to the initial values during the four to six-week period after cessation of intake. The placebos given to the control group had no effect. All twelve experimental subjects and only one of the control group felt improvement of subjective working capacity. Therefore, a favorable

\textsuperscript{12}E. Simonson, A. Baer, and N. Enzer, "The Influence of Vitamin B (Complex) Surplus on the Capacity for Muscular and Mental Work," \textit{Federation Proc.}, 1:81, 1942.
influence on the capacity for all types of work with prevailing fatigue of the central nervous system might be expected in the majority of normal people from the intake of considerable Vitamin B-complex surplus.

Twenty-six soldiers maintained on standard U.S. Army garrison rations were repeatedly subjected to standardized severe exercise in a study by Keys and Henschel. The exercise consisted of marching for a definite period on the motor-driven treadmill at a constant speed of 3.85 miles per hour and a 12.5 per cent angle of climb in the first series and 10 per cent in all subsequent series. Circulatory, metabolic and blood chemical responses were measured. The exercise room was maintained at 78°F with relative humidity between 40 and 60 per cent saturation. The exercise was severe enough to be somewhat beyond the capacity of the average untrained college student.

In four series of studies involving 256 experiments, large daily supplements of thiamine chloride, riboflavin, nicotinic acid, pyridoxine, pantothenic acid, and ascorbic acid were administered over periods of four to six weeks, alternating with equal periods of placebo administration.

In neither brief extreme exercise nor in prolonged severe exercise and semi-starvation were there indications of any effects, favorable or otherwise, of the vitamin supplementation on muscular

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ability, endurance, resistance to fatigue, or recovery from exertion. Healthy young men expending an average of 3700 to 4200 calories per day are not benefited by a daily supply of more than 1.7 mg. thiamine chloride, 2.4 mg. riboflavin, and 70 mg. of ascorbic acid.

In a study by Darling and others,\textsuperscript{14} twenty-four volunteers were selected from the personnel of a Civilian Public Service Camp, who continued on the work regime of the camp and ate their meals at special tables in the regular mess halls. At the start of the study, each subject was given a thorough physical examination, clinical laboratory examination of blood and urine and blood chemical examination of NPN, protein and A/G Ratio. Throughout the study, frequent check-up physical examinations were held and the estimations of blood NPN and protein were repeated weekly along with a measurement of the nitrogen in a 24-hour specimen of urine. Assessment of physical fitness each week was by means of the so-called "Pack Test." In this test the subject, wearing a rucksack weighted to approximately one-third his body weight, stepped up onto a 16-inch platform and back down onto the floor once each 2 seconds (hand-rails at shoulder height were used as an aid). The stepping exercise was terminated at five minutes if the subject could carry on that long; after stopping, the pulse was counted for three periods: 1 to 1\frac{1}{2} minutes, 2 to 2\frac{1}{2} minutes.

minutes, and 4 to 4½ minutes of the recovery period. From these data a numerical score was calculated as:

\[
\frac{\text{Duration of exercise in seconds}}{2 \times \text{Sum of pulse beats counted in the three periods}}
\]

This test had been found previously to correlate with physical ability in athletes and to parallel improvements with training and deterioration accompanying proven inadequate diets. In order to have an additional index of recuperative powers, the test was administered twice on each occasion with only a fifteen minute rest period between the two.

The dietary test program consisted of three periods: two weeks preliminary control; eight weeks of modified diet; and two weeks of final control. The twenty-four subjects were divided in three groups of eight—each group including a rough cross-section of the whole in respect to occupation and physical fitness. All groups ate the regular camp diet for the first two weeks and one of the groups of eight continued thus throughout. A second group, called restricted protein group, changed their diet at the end of the first control period to one which allowed no meat, cheese, eggs, nuts, legumes and only up to one-half cup of milk daily. Bread was the only other food allowed the restricted protein group which contained animal protein (milk). This was limited in amount to this group so that not more than 2½ gm. of milk protein was furnished daily in this form and not more than five gm. of animal protein in the entire daily diet (the other 2½ gm. or less in top milk on cereals). Unlimited amounts of
low protein foods were furnished this group and they, like the other
groups, were urged to fully satisfy their appetites. During the final
control period, this group was given a high protein diet. The third
group, called the high protein group, was furnished with large
amounts of high protein foods and allowed only restricted amounts
of low protein foods. All groups were given daily 5 gm. of yeast
extract fortified with additional riboflavin to forestall any
possibility of Vitamin B deficiency.

Each subject had a special record book with a page for each
day in which he noted the amounts of each article of food eaten during
the day on one side of the sheet and the day's activities hour by
hour on the other side. The proper analytical figures for protein,
fat and calories were entered in these books periodically by the
dietician's staff.

The work of the subjects included office, kitchen, laundry,
farming, and forestry work (including work on trails, clearing
forest ground and repair of roads). The daily caloric expenditure,
depending on the subject's job, ranged from 2400 to 5000 calories,
with an average of approximately 3300.

It was found that even with the severe restriction of high
protein foods, the daily protein intake was rarely below 50 gm. and
averaged 53 gm. When the caloric intake was above 4000 calories, the
protein was usually nearer 60 gm. It is apparent from this that to
choose a low protein diet from commercial articles of diet is
difficult, provided caloric balance is maintained. When sufficient calories are given for hard physical labor, a fairly respectable level of protein is automatically included.

In general, all the subjects in the restricted protein group believed they were getting enough food. It was their observation, however, especially those doing the heaviest work, that they became unusually hungry and felt a little weak late in the morning and late in the afternoon. There was an average weight loss during the 8-week period of 0.9 kg., a good part of which could be logically explained by the fact that several of the group started on a regime of much heavier outdoor work than was customary to them. A weight loss of similar magnitude was found in the group on the normal diet.

None of the subjects complained of unusual symptoms other than late morning and afternoon hunger. The pack test data confirmed the impression that they show no deterioration. In spite of some irregularities, it was found that both the group on normal diet and restricted protein diet improved slightly. A few improved strikingly, undoubtedly due chiefly to the physical training from their active work regime. The irregularities of scores are in some cases due to changes in motivation on different days; in other cases to local disabilities arising from minor injuries. The relative scores on the two consecutive tests on the same day did not yield any additional information. It was an unexplained fact that the relationship of the second to the first score was largely characteristic of the individual.
The blood chemical and hematological findings were completely negative.

In the final control period when high protein diet was given, no change in physical performance or chemical findings was evident aside from the increased amount of nitrogen in the urine.

In the high protein diet group, the weekly averages of daily protein intake ranged from 157 to 192 gm. compared to 95 to 113 gm. in the normal group (4-week average). The less active men in this group tended to feel overfull and sleepy after meals. Not all this effect was necessarily due to the high protein per se. Among the available common foods, high protein is associated with considerable fat. As a result the total caloric intake in this group tended to be higher than necessary. The average gain in weight was 1.0 kg. No other unusual symptoms were experienced. The physical fitness tests showed a tendency to gradual improvement as in other groups, which was likewise explainable by training.

The urinary excretions of nitrogen expressed as equivalent protein are 138 gm. and 142 gm. daily for the two 4-week periods. The only change in chemical findings was a tendency to slightly higher NPN which was probably not very significant.

It was concluded that manual work must be limited to results appearing within the time limit of the tests, namely eight weeks of the modified diet. The practical implications are that under emergency conditions, a diet supplying about 50 gm. of protein,
chiefly from potatoes and grain products, is not compatible with the health of physically active young men.

Pitts and others\textsuperscript{15} studied the effects of water, salt, and glucose, with principal emphasis upon attainment of the best possible performance. Experiments were performed in the late fall or winter in a heated room under hot, dry (100°F, 30 per cent relative humidity) and hot, moist conditions (95°F and 90°F, 83 per cent relative humidity). Six healthy fully acclimatized young men marched at least three times a week at 3 mph. Depending upon the severity of the temperature and humidity, which were constant in individual series of experiments, they marched anywhere from one to six hours with a ten-minute rest in each hour.

They found that the best performance of fully acclimatized young men on a good daily diet, performing intermittent hard work in the heat, was achieved by replacing hour by hour the water lost in sweat and that any amount of water considerably less than this leads in a matter of hours to serious inefficiency and eventually to exhaustion. When water is available, it should not be forbidden on the traditional ground that during work it is bad for one, but men should be encouraged to drink to capacity. Even the toughest, best acclimatized men suffer serious inefficiency in a few hours while

working hard without water. A case of true exhaustion from dehydration has been observed in a man marching for six hours at -20°F.

Replacement of salts hour by hour under such circumstances had no demonstrable advantage. The best performance of intermittent work in the heat is achieved by replacing salt loss meal by meal. The serum chloride remained remarkably constant in prolonged work in the heat, even in spite of profuse sweating provided the over-all daily intake of salts with the meals was adequate.

Administration of glucose was of little, if any, advantage when compared with the great benefit of large amounts of water. With small doses of glucose (25 gm. of glucose dissolved in about 30 ml. of water) there was a small but definite advantage over experiments when no water was permitted. This could have been due to the small amounts of water in which the glucose had to be dissolved before ingestion.

Four series of experiments on six different subjects, living during the experiments on a diet poor in protein, were made by Krogh and Lindhard\(^\text{16}\) to study the relative value of fat and carbohydrate as a source of muscular energy. All the series agreed in showing that work is more economically performed on carbohydrate than on fat. When the work was sufficiently severe, the subjects performed it with greater difficulty on fat than on carbohydrate and became much more tired. The difference was thought to be due to the waste of some energy from fat.

In another study by Pitts, Consolazio, and Johnson, three healthy young men were subjects. The experiment covered four successive periods of at least six weeks in winter and six weeks in spring, 1942-1943. The diets were nutritionally complete but varied from period to period with respect to level of protein. Observation in each period fell into three distinct categories: (1) observations on diet and nutritional state, (2) observation on physical fitness for work in both temperate and hot environments, and (3) observations on metabolism.

Total caloric intake was not restricted. Control observations were made in October and November with the subjects on their customary normal diet. From November 30 to January 11, the diet was high in first-class proteins with corresponding reduction in carbohydrate. From January 12 to March 6, the diet was sharply restricted in first-class proteins with corresponding increase in carbohydrate. During this period, to avoid the possible ill effects of B-complex deficiency, 10 gm. of Fleischman's dried brewers' yeast was supplemented twice a week. After March 6, the subjects returned to their customary diet. Specimens of urine were collected frequently over 24-hour periods for estimation of nitrogen excretion. Samples of blood were drawn periodically from the subjects before breakfast for estimation of plasma protein.

In each dietary period physical fitness for hard work was tested both under temperate and under simulated desert and tropical conditions. A fourth subject subsisting at all times on a normal diet was included in all physical fitness measurements as a control against the effects of training and acclimatization.

(a) Temperate environment. In this test of stamina and cardiovascular fitness the subject ran on a motor-driven treadmill at 7 mph. up an 8.6 per cent grade either until he was exhausted or, if not exhausted, for five minutes. The environmental conditions used to assess physical fitness were 75°F temperature, 50 per cent relative humidity and 0 mph. wind velocity. On the basis of duration of effort and the sum of three pulse rates during recovery, a score in arbitrary units was calculated. A change in score of about three or four points is significant. Each subject was given two such tests in each dietary period.

(b) Hot environment. Performance in the heat was tested by prolonged marches on a treadmill. Moist, tropical conditions were simulated at 95°F, 85 per cent relative humidity, and 5 mph. wind velocity. The subjects spent ten to twelve hours a week in the heated room. In all tests of physical fitness in the heat the grade was 2.5 per cent, the speed 3.5 mph. and the length of performance 1 hour and 20 minutes. The maximal length of marching in one day was five hours. Salt intake was adequate at all times. Water intake was constant for each subject from experiment to experiment and was at a
level which had been found to satisfy thirst at all times during the preceding normal period. Fitness was judged from terminal pulse rate and rectal temperature, equal weight being placed on each of these factors.

The effects of dietary protein level on respiratory metabolism were studied by a separate set of experiments in each dietary period under temperate (75°F, 50 per cent relative humidity, and 0 mph. wind) and tropical (95°F, 85 per cent relative humidity, and 5 mph. wind) conditions. For each set of observations, the subject came to the laboratory in a fasting state and rested while lying down for at least one-half hour in the appropriate room. His respiratory exchange was measured while reclining, standing, and marching (after reaching a steady state) on a motor-driven treadmill at 3.5 mph. In order to make the physiological stresses on the heat dissipating mechanisms comparable, a grade of 8.6 per cent was used in the temperate room and a grade of 2.5 per cent in the hot, humid room. Nitrogen in the urine during the periods of reclining, standing, and marching was determined. After completing the morning march, the subject ate a late breakfast followed by lunch at the usual time. These meals were appropriate in protein content to the particular dietary period and contained approximately two-thirds of the protein intake for the day. One and a half hours after lunch, the subject lay down again in the same room as in the morning and the exact procedure of the morning was repeated. The total respiratory exchange and non-protein R. D. were calculated.
It was noted that the average protein intake during the low protein period was 76 gm. per day. This was called "low protein diet" because the subjects averaged over 100 gm. per day during both normal periods. Since the subjects were consuming 3,000 calories per day and with this caloric intake it was very difficult to reduce protein intake much below 76 gm. per day without resorting to highly artificial diets. Urinary nitrogen excretion was highest during the high protein period and lowest during the low protein period. Changes in weight were small but maximal weight was attained during the high protein period.

Physical fitness under temperate conditions showed no changes attributable to dietary protein level. Two subjects and the control showed a steady improvement from the start of the observations through the low protein period and this was believed to be a training effect resulting from the high level of the physical activity of the subjects.

All subjects in the hot environment showed an improvement in performance during the first two or three periods and this was believed to be the residual acclimatization process. There were no changes in performance at either 95°F and 85 per cent humidity, or 110°F and 25 per cent humidity, which are attributable to dietary protein level. In other words, dietary protein may be maintained at any level between 75 and 150 gm. per day for periods of at least six weeks without affecting performance in a physical test which may
increase the pulse rate by sixty or more beats per minute and raise the rectal temperature by three or more degrees Fahrenheit.

Metabolism while reclining and while standing was not significantly different in the high and low protein periods. Metabolism while marching was slightly lower in the low protein period but as judged by actual performance in the heat, this was a physiologically insignificant change.

For periods of at least six weeks, dietary protein level may vary widely (from 75 to 150 gms. a day) without affecting physical fitness for intermittent work either under temperate or under hot conditions. Since a high protein diet is preferred by most workmen, it should not be prohibited on the basis of effects on physical fitness or heat dissipation. However, in the special case where water supply is limited, a high protein diet is contra-indicated.

Barborka, Foltz and Ivy\textsuperscript{18} studied the "Relationship Between Vitamin B-Complex Intake and Work Output in Trained Subjects." Four subjects who had been existing on a controlled, adequate diet and who had been trained on the bicycle ergometer for from nine months to one year were placed on a diet deficient principally in the vitamin B-complex. The recommended daily allowances for the various dietary essentials (prescribed by the Food and Nutrition Board of the National Research Council) were set up to serve as a guide for planning

adequate nutrition for the civilian population of the United States. They used in adequate controlled diets (during the training period and establishment of the plateau level of work output) 1.8 mg. of thiamine and 2.7 mg. of riboflavin, which are recommended daily amounts of these special nutrients for moderately active men in health.

The deficient diet was composed of common food and the menus were such as might be found on the tables of about one-third or more of the population of the United States. The deficient diets used contained approximately 0.65 mg. of thiamine and 0.94 mg. of riboflavin which is about one-third of the recommended daily requirement.

During the eighty-two days on the deficient diet, the subjects developed irritability, easy fatigability, lack of pep, anorexia, and increased in leg pain during the work periods, but at no time did they develop any objective physical signs of vitamin B-complex deficiency.

Subjective symptoms of fatigue, irritability, lack of pep, anorexia, and leg pains all disappeared and work output returned to normal or better within a few days following supplementation of vitamin B-complex (yeast concentrate).

Vitamin B-complex supplementation added to a vitamin B-complex inadequate diet restored work output to efficient levels.

In a study by Wald, Brouha and Johnson, after thirty days of high

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vitamin A nutrition (75,000 I.U. daily), five young men were maintained on a diet extremely low in vitamin A for a period of about six months. After the subjects had been on the deficient diet for three to four and a half months, their ability to perform moderate and heavy muscular exercise was determined with the standard fatigue laboratory treadmill test: 15-minute walk at 3.5 mph. on an 8.6 per cent grade; ten minutes rest; run to exhaustion or up to five minutes at 7 mph. on an 8.6 per cent grade; and recovery followed for 20 minutes after the run. At the close of the period on the vitamin A-low diet, the subjects returned to a normal diet supplemented with vitamin A. After at least six weeks of this, they were tested on the treadmill as before.

In measurements of reaction to moderate muscular work (walking), while the subjects were on the vitamin A-low diet, no significant differences from normal appeared either during or following mild muscular work. Specifically there was practically no difference between these and the post-deficiency measurements with respect to heart rate during and after the walk; blood pressure after the walk; and ventilation, oxygen consumption, respiratory quotient and blood lactate during the walk.

The deficient diet appeared to have no significant effect on the ability to perform exhausting exercise of short duration (running). Specifically, there were no definitely significant differences between the deficiency and post-deficiency measurements of duration of effort; heart rate during and after the run; ventilation, oxygen consumption
and respiratory quotient during the run; and blood lactate immediately after the run.

Athletic trainers have long been besieged with the age-old problem of what to feed their athletes before a contest. The so-called stand-by meal consisting of a beef pattie or steak, a baked potato, dry toast and tea, has brought complaints from the athletes about being sluggish during the game, becoming over-tired quicker than normal, and being nauseated. During recent years, there has been considerable success reported with the use of liquid nutrition as a substitute for the pre-game meal in all sports.

The conventional meal mentioned earlier is not completely balanced in regard to our nutritional tables. There are several shortcomings, especially in the provision of fats and thus fat-soluble vitamins. This type of meal will provide between 450 and 500 calories of energy for body use when it is digested. The digestive process for a meal of this type will require approximately eight to twelve hours. This, in turn, means that the athlete will have an increased blood flow to the digestive tract for this period of time and, of course, a decreased blood supply to the rest of the body. Also, with the conventional meal, the subject runs the danger of nausea due to the extra time needed for digestion of solid food.

In the case of liquid nutrition, most of the objectionable features of the solid meal are removed. By using this type of nutrition, the athletes receive a well-balanced diet of 400 to 420
calories which provides more than 33 per cent of the day's nutritional needs. It is also a meal which is easily digested. The solid meal takes eight to twelve hours to digest, whereas, the liquid meal is digested and moved out of the digestive tract in about one-half of this time.

Andrews did a study to determine if a basic liquid diet which reduced the total caloric intake of the individual would have any effect on the strength, steadiness, pulse rate after exercise, and number memorization of a group of boys, aged fourteen to eighteen. In an attempt to discover what effects a basic liquid diet would have on the physiological and mental capacities of the boys, a reduced caloric intake of 1,595 calories was prescribed for 21 days, or until such time as discipline, health, or unforeseen maladies might attack the experimental group.

The experimental group consisted of 23 boys picked at random from voluntary groups of 303 individuals, and a control group was picked from the remaining volunteers.

The number of calories used in this dietary study was determined by the number of calories contained in the liquid diet used. Each can of liquid nutrition contained 418 calories. It was suggested by the company producing the liquid diet that roughage be supplemented to guard against constipation. Five dietary crackers, one orange, one

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apple and two carrots per day were used as roughage. Three cans of the liquid diet produced 1,254 calories, with the roughage upping the total intake to 1,579—well within the safe caloric content limit indicated by research.

The major muscles, cardiovascular and nervous systems were tested. In addition, number memorization was assessed in an attempt to determine the effects restricted diet might have on the individual's responses in this area.

The two groups were tested before the study actually began and there were no significant differences between the two groups in the factors being studied. After twenty-one days of the control diet, the two groups were re-tested for the same variables and it was found that there were significant differences between the two groups. It was concluded that the significant changes experienced during the study were due to the difference in the diet. The experimental group using the liquid diet performed significantly better than the control group in all factors tested.

Dr. Ken Rose, in a research study with the University of Nebraska football team found Sustazen, a liquid nutrient produced by Mead Johnson Laboratories, an ideal substitute for the traditional pre-game meal. Sustazen beverage taken several hours before game time was digested before opening kick-off, providing the players with

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benefits of this nutritionally complete food. It was reported that
muscle cramps and pre-game and game time vomiting were eliminated.
Weight remained constant; strength and endurance were improved. It
appeared that a liquid, calorie-rich pre-game meal is physiologically
sound, and it is recommended for use by all athletes.

III. REVIEW OF STUDY REGARDING INCIDENCE OF INJURIES
TO FOOTBALL PLAYERS AT LOUISIANA STATE UNIVERSITY
OVER A FOUR-YEAR PERIOD

The author did a four-year study, 1955 through 1958, for his
Master of Science thesis, on the incidence of treatment to injured
varsity football players at the positions of end, interior lineman,
and backfieldman. 22

The data were obtained from the records of Trainer's Office
at Louisiana State University, Baton Rouge, Louisiana. All treatments
of injuries of a major nature to football players were recorded. Minor
injuries such as treatment of blisters, small abrasions, minor bruises
and minor strains were not recorded.

The varsity traveling squad at Louisiana State University was
classified into three groups according to the positions of end,
interior lineman, and backfieldman. One hundred fifty-one subjects

22 Martin J. Broussard, "Incidence of Treatment of Injuries to
University, Baton Rouge, 1960).
took part in the study over a four-year period with a total of 4,397 treatments given. The total number of times over a four-year period the ends received treatment, the total number of times the linemen received treatment, and the total number of times the backfieldmen received treatment were recorded. These totals were used as the basis of comparison of the incidence of treatment of injuries for the various positions.

It was concluded that there was no proportional difference in the incidence of treatment of injury. No one position received any more treatment for injuries in proportion to the number of players participating than any other position over a four-year period. The number of treatments for injuries for any one season may be out of proportion to the total number of players participating. There is a relationship between the incidence of treatment to injuries and the number of games won. There are fewer treatments given to players during a winning season than during a losing season.
CHAPTER III

PROCEDURE AND COLLECTION OF DATA

1. INTRODUCTION

To evaluate the benefits of citrus bioflavonoid as an aid in preventing and treatment of athletic injuries, a double-blind study was conducted during the 1962 football season at the Louisiana State University.

Forty-eight varsity football players at Louisiana State University during the 1962 season were used in the study. Thirty-five were playing members of the varsity squad; thirteen participated in every practice but did not play in games. The subjects were arranged randomly into two groups on a matched player basis. Throughout the pre-season practices and during the regular season, each player received three gelatin capsules daily, two before the noon meal and the third at suit-up time. Capsules containing 300 mg. of lemon-orange flavonate glycoside (a citrus bioflavonoid complex) were dispensed to Group B. The capsule dispensed to Group A contained 300 mg. of lactose, a placebo formulation.

A detailed description of the nature of the injury, the severity and the treatment was recorded. A comparison of injuries and treatment received by Groups A and B was made. All injuries were described as to location, type and severity at the time of occurrence.
II. PROCEDURE

Representatives of Sunkist Growers, Pharmaceutical Products, Ontario, California were contacted to furnish the formulations for the study. Dr. Francis Drury, major professor, Dr. Louis Rusoff, minor professor, Dr. Harold Voss, Team Physician, and the author met with representatives to organize the study.

The procedure included the selection of subjects, medication dosage and dispensing, experimental period, and recording of injuries.

III. SELECTION OF SUBJECTS

This study was conducted during the football season starting September 1, 1962 and ending November 24, 1962. Subjects used were forty-eight male students from the sophomore through the senior classes inclusive, enrolled at Louisiana State University. They were all active participants of the varsity football squad; thirty-five were members of the traveling squad. The remainder were members of the scout squad (also varsity squad members) who did not participate in any games. The study included sixty-eight practice sessions and ten games. There was equal distribution in the number of ends, tackles, guards, etc. in each group. The forty-eight players were arranged on a matched player position basis.

IV. PROCEDURE FOR ADMINISTRATION OF BIOFLAVONOID AND PLACEBO

A student trainer dispensed the capsules with a cup of water
(8 oz.) to make certain each player took the formulation. Throughout the pre-season practices and during the regular season, each player received three soft gelatin capsules daily—two before the noon meal and the third at suit-up time. The only person having a knowledge of the chemical composition given the players was Dr. Louis Rusoff. All data were collected and analyzed before Dr. Rusoff revealed the composition of the two capsules. This was done to prevent any biased opinions affecting the description and treatment of the injuries.

V. COMPOSITION OF CITRUS BIOFLAVONOIDS AND PLACEBO

Capsules containing 300 mg. of lemon-orange flavonate glycoside (a citrus bioflavonoid complex) were dispensed to Group B. The capsules dispensed to Group A contained 300 mg. of lactose, a placebo formulation. Both capsules were similar in appearance and taste.

VI. COLLECTION OF DATA

All injuries were described as to location, type and severity at the time of occurrence and recorded on injury forms. Each football player received a thorough physical examination one day before the start of the football season. Records of physical examinations were available and studied but were not used in the study. The purpose of the study was to evaluate citrus bioflavonoid as an aid in the prevention and treatment of athletic injuries. The
evaluation was made through three types of observations. The first
type of observation involved checking all players for minor injuries
(skin abrasions, blisters, muscle cramps, etc.), after each practice
and recording the findings. (See Appendix A.) Diagnosis of a minor
injury was recorded along with the nature of treatment and severity
of injury. The second type of observation dealt with injuries which
needed considerable treatment. Description and prognosis of injury
were made at time of first examinations. (See Appendix B.) The
third type of observation was made where the daily treatment and
prognosis of the more severe injuries was recorded as in observation
two. (See Appendix C.)

In order to increase reliability of the various observations,
a descriptive vocabulary was developed. Other than those injuries
in which bones were fractured, all injuries were classified as either
a contusion or a sprain, or a combination of both. All injuries were
described as to type and severity.

A contusion can be defined as an injury to tissues without
breakage or laceration of the skin—a bruise. This type of injury
results in capillary or vascular rupture and in infiltrative type of
bleeding followed by edema and inflammation. The resulting local
swelling may be superficial or deep, depending on the nature of the
blow and the location of the injury.

In this study degrees of contusion injuries are described by
the following vocabulary:
1. **Minimal.** Very slight swelling, very little pain, possible slight discoloration and limited capillary damage.

2. **Mild.** A little swelling, slight pain, a little discoloration and a little more than minimal capillary damage.

3. **Moderate.** Noticeable swelling, injured area tender and painful, more discoloration with some subcutaneous hemorrhage and moderate tissue damage.

4. **Severe.** Considerable swelling, very painful, extensive vascular damage, and subcutaneous hemorrhage with extensive tissue discoloration.

A sprain can be defined as the abnormal stretching or partial rupture of joint ligaments or their attachment caused by wrenching or twisting and resulting in effusion, pain, swelling, and disablement of the injured joint. Abnormal motion beyond the elastic limit of a ligament will cause a sprain.

In this study, degrees of sprain injuries are described by the following vocabulary:

1. **Minimal.** Very little swelling, slight pain, possibly some discoloration but no loss of joint function.

2. **Mild.** Local tenderness, limited swelling, slight discoloration and some hemorrhage within the joint. In this degree of sprain, a few ligament fibers have been torn but without functional loss.

3. **Moderate.** Very tender joint, quite painful, diffused
swelling, a rise in local temperature, inflammation, considerable discoloration and limited movements. Generally, a ligament is torn and some degree of functional loss is evident.

4. **Severe.** Extreme tender joint, very painful, extensive swelling, elevated local temperature, considerable discoloration and complete or nearly complete loss of function.

5. **Muscle pulls.** The term applies to an injury to the muscle when the muscle is forced beyond its expansion limitation.

In this study the degrees of a pulled muscle are described by the following:

1. **Minimal.** No swelling, slight pain but no loss of functional locomotion.

2. **Mild.** Local tenderness, limited swelling, slight discoloration and some hemorrhage around injured area. In this degree of "pull" a few muscle fibers are torn without functional loss.

3. **Moderate.** Very tender area, swelling, rise in local temperature, considerable discoloration and limited function. Generally, a considerable number of muscle fibers have been torn and nearly complete loss of function to the muscle results.

4. **Severe.** Extreme tender area, very painful, extensive
swelling, elevated local temperature, considerable
discoloration, and complete loss of muscle function
is evident. Many muscle fibers have been torn.

Using the descriptive vocabulary each time the player reported
for treatment, a description of the nature of injury was recorded as
well as the treatment. After the season had been completed, all the
observations were classified, totaled, and recorded on a master
chart. (See Appendix D.)
CHAPTER IV

ANALYSIS OF DATA

Two analyses of the data were made. In the first analysis, the total number of days lost for each group, total number of contusions and sprains, total number of treatments, and the total number of injuries in each severity classification were analyzed. In the second analysis, the data were grouped according to the nature, location, the month the injury occurred and the days lost from practice for each injury. No attempt was made to draw conclusions until both analyses were made, and then the conclusions or generalizations were based upon a subjective analysis of the complete project.

Data gathered on forty-eight members of the varsity football squad at Louisiana State University during the 1962 season were used in this study. In the treatment of data, every player who participated in varsity football during the 1962 season and who made the traveling squad was considered as one subject. The injury data were compiled from the record forms. The types of injuries were tabulated. The number of injuries and the duration of the injuries in days was also tabulated for both Groups A and B. The number of players involved in each injury category was also totaled. Injuries occurring in November were treated until completely recovered, thus the study was carried out until all subjects were recovered and not stopped immediately after the last game which took place November 24, 1962.
A total of forty-eight subjects took part in the 78-day study. Group A contained twenty-four subjects and did not receive a supplement of citrus bioflavonoid. Group B contained twenty-four subjects and received 900 mg. of citrus bioflavonoid daily. Six hundred (600) mg., two capsules, were taken at the noon meal and 300 mg., one capsule, was taken one-half hour before practice or before ball game time.

Table I shows the number of possible subject football days. A subject football day is either a practice or a game day. The number in the first column was derived by multiplying the number of subjects (24) by the number of practice days plus game days (78). Because of a number of severe injuries that occurred to several subjects in both groups, the investigator felt that it would not be practical to use 1872 as the total subject days. The nature of these severe injuries was such that no type of food supplementation would have prevented these injuries. The days that these severely injured subjects took part in practice and games prior to their injury were used in the study.

The total number of subject days, shown in column two of Table I, was used as the base figure in the computation of percentages for the analysis of the data.

Column three in Table I shows the number of subject days lost due to severe injuries. No attempt will be made to compare the two groups by means of these figures because the investigator felt that these injuries were too severe to be influenced by any diet supplement.
TABLE I

NUMBER OF SUBJECT FOOTBALL DAYS FOR FOOTBALL SEASON AND NUMBER OF SUBJECT FOOTBALL DAYS LOST FROM FOOTBALL SEASON DUE TO SEVERE INJURIES OF VARSITY FOOTBALL PLAYERS DURING 1962 FOOTBALL SEASON

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Possible Subject Football Days</th>
<th>Total Subject Days</th>
<th>Days Lost Due to Severe Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N=24)</td>
<td>Control</td>
<td>1872</td>
<td>1746</td>
</tr>
<tr>
<td></td>
<td>Bioflavonoid</td>
<td>1872</td>
<td>1809</td>
</tr>
</tbody>
</table>

| B (N=24) | Control                              | 1872               | 1746                             | 126                              |
|         | Bioflavonoid                          | 1872               | 1809                             | 63                               |
As indicated in Table I, the subjects who did not receive the supplement missed a total of 121 days more of practice and games than those who received it. The percentage of subject football days lost due to minor injuries in the experimental group was 5.1; whereas, 8.6 per cent of the subject football days were lost due to minor injuries in the control group.

TABLE II

NUMBER OF SUBJECT FOOTBALL DAYS LOST DUE TO MINOR INJURIES OF VARSITY FOOTBALL PLAYERS DURING THE 1962 FOOTBALL SEASON

<table>
<thead>
<tr>
<th>Group</th>
<th>Total Subject Days</th>
<th>Number of Days Lost Due to Minor Injuries</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N=24)</td>
<td>1746</td>
<td>151</td>
<td>8.6</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B (N=24)</td>
<td>1809</td>
<td>93</td>
<td>5.1</td>
</tr>
<tr>
<td>Bioflavonoid</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table III, the number of players injured was approximately the same for Group A and Group B, but the total number of injuries was considerably larger in Group A than those received in Group B. As to the difference in the nature of injuries, it appears that the subjects in Group A were more susceptible to sprains than the subjects in Group B. It had been accepted by the trainer and doctor that some boys are more prone to injuries than others. As also
indicated in Table III, the same trend seems to appear to a much lesser degree with the contusions.

**TABLE III**

**NATURE AND INCIDENCE OF INJURIES RECEIVED BY THE L.S.U. VARSITY FOOTBALL PLAYERS DURING THE 1962 SEASON WHO RECEIVED THE CITRUS BIOFLAVONOID AND THOSE WHO DID NOT RECEIVE THE CITRUS BIOFLAVONOID**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects Injured</th>
<th>Contusions</th>
<th>Sprains</th>
<th>Total Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N=24) Control</td>
<td>13</td>
<td>27</td>
<td>28</td>
<td>55</td>
</tr>
<tr>
<td>B (N=24) Citrus Bioflavonoid</td>
<td>14</td>
<td>23</td>
<td>14</td>
<td>37</td>
</tr>
</tbody>
</table>

Table IV shows the severity and number of injuries received by the two groups. Each injury was classified as being minimal, mild, moderate or severe, according to the terminology established prior to the study.

As shown in Table III, Group A received more injuries in both classifications than Group B, although the total number of subjects injured was approximately the same for both groups. This trend appears to be the same in the contusions classification as well as in the sprains classification. To further analyze this particular phenomenon,
TABLE IV

SEVERITY OF INJURIES RECEIVED BY THE L.S.U. VARSITY FOOTBALL PLAYERS DURING THE 1962 SEASON WHO RECEIVED THE CITRUS BIOFLAVONOID AND THOSE WHO DID NOT RECEIVE THE CITRUS BIOFLAVONOID

<table>
<thead>
<tr>
<th>Group</th>
<th>Severity of Injury</th>
<th>Contusions</th>
<th>Per cent of Total Number of Contusions</th>
<th>Sprains</th>
<th>Per cent of Total Number of Sprains</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N = 24)</td>
<td>Minimal</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Control</td>
<td>Mild</td>
<td>8</td>
<td>30</td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>19</td>
<td>70</td>
<td>17</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Totals:</td>
<td></td>
<td>27</td>
<td></td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>B (N = 24)</td>
<td>Minimal</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Bioflavonoid</td>
<td>Mild</td>
<td>9</td>
<td>39</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>13</td>
<td>57</td>
<td>6</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Severe</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Totals:</td>
<td></td>
<td>23</td>
<td></td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>
the data in Table IV were considered. This table shows that the nature of the severity of the injury did not vary much between the two groups, as did the incidence of injury. This would indicate to some extent that the large difference in the number of sprains between the two groups was probably due to either chance or injury prone subjects. Thirty per cent of the contusions received by Group A were either classified as minimal or mild, whereas 39 per cent of the contusions in Group B were classified as minimal or mild. In the moderate and severe category, Group A had 70 per cent, whereas Group B had 61 per cent of contusions classified as moderate and severe. Table IV, page 45, also indicates that 36 per cent of the sprains received by Group A were either classified as minimal or mild, whereas 50 per cent of the sprains in Group B were classified as minimal or mild.

There appears to be no advantage of citrus bioflavonoid Group B over placebo Group A in regard to the number of severe sprains. Extending the analysis further, in Group A 64 per cent of the sprains were classified as moderate or severe, whereas 50 per cent in Group B received a similar classification.

As an overall view of the data was taken, it appeared that there was little value in the citrus bioflavonoid supplementation in reduction of the severity of sprains and duration of treatment. The data indicate that there was a very slight advantage of the citrus bioflavonoid supplementation in prevention of injuries; however, when this advantage is analyzed in light of the effect on the severity of
injury, it appears that the big difference in the number of sprains received was influenced considerably by chance or injury prone subjects.

As shown in Table V, the average number of treatments was less for both contusions and sprains in the group that received the citrus bioflavonoid. The trend in favor of the supplementation seemed to be small but consistent. This is to be expected because Group A had more mild and severe injuries than Group B.

**TABLE V**

**DURATION OF TREATMENT RECEIVED BY THE L.S.U. VARSITY FOOTBALL PLAYERS DURING THE 1962 SEASON WHO RECEIVED THE CITRUS BIOFLAVONOID AND THOSE WHO DID NOT RECEIVE THE CITRUS BIOFLAVONOID**

<table>
<thead>
<tr>
<th>Group</th>
<th>Contusions</th>
<th>Average Number of Treatments Per Injury</th>
<th>Sprains</th>
<th>Average Number of Treatments Per Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N=24)</td>
<td>113</td>
<td>4.2</td>
<td>164</td>
<td>5.8</td>
</tr>
<tr>
<td>Control</td>
<td>(27)</td>
<td></td>
<td>(28)</td>
<td></td>
</tr>
<tr>
<td>B (N=24)</td>
<td>87</td>
<td>3.8</td>
<td>69</td>
<td>4.2</td>
</tr>
<tr>
<td>Bioflavonoid</td>
<td>(23)</td>
<td></td>
<td>(14)</td>
<td></td>
</tr>
</tbody>
</table>

The preceding analyses were based on total figures and no attempt was made to analyze effects of the citrus bioflavonoid on specific injuries. It is the writer's opinion that a truer picture
of the nature of the injuries could be developed by grouping the injuries according to location and time of the injuries.

The sprain category included those injuries in which there was tearing of the ligament and joint structure, tendon and muscle tissue. Contusions were limited to those injuries involving the rupture of blood vessels caused from a force or blow. This may involve muscle, tendon and bone tissues. No breakdown in the contusion category was made except for the time element.

Four categories were used in grouping the sprain injuries: (1) ankle and foot area, (2) knee area, (3) other joints of the body, and (4) pulled muscles.

The time of injury was determined by the month in which the injury occurred. The season was extended over three full months—September, October, and November.

In Table VI the number of injuries occurring each month and the nature and location of the injuries are shown. It appears that during the month of September the experimental group (Group B) taking the supplement received considerably fewer injuries than the control group. As the season progressed, however, this trend did not remain and in some instances the trend was reversed. In the contusion category, the experimental group received more injuries during October and November than did the control group. In October, the control group received three muscle pulls, but one of these injuries was a re-injury to a muscle that was pulled earlier in the season. It was interesting to
TABLE VI
INCIDENCE, NATURE, LOCATION AND MONTH OF INJURY RECEIVED BY THE LSU VARSITY FOOTBALL PLAYERS DURING THE 1962 SEASON WHO RECEIVED THE CITRUS BIOFLAVONOID AND THOSE WHO DID NOT RECEIVE THE CITRUS BIOFLAVONOID

<table>
<thead>
<tr>
<th>Month</th>
<th>Ankle Joint</th>
<th>Knee Joint</th>
<th>Other Joints</th>
<th>Muscle Pulls</th>
<th>Contusions</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A (N=24)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>October</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>November</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>12</td>
<td>4</td>
<td>4</td>
<td>27</td>
<td>55</td>
</tr>
<tr>
<td><strong>N = 13</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group B (N=24)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioflavonoid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>October</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>November</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>23</td>
<td>37</td>
</tr>
<tr>
<td><strong>N = 14</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
note that further analysis of the injuries indicated an increase in susceptibility to injury after the subject was once injured. This may be due to the subject favoring the injured part.

Two subjects in the control group injured both knees. In the experimental group one subject injured both knees and another subject injured both ankles. Each group had one subject who re-injured an ankle. In the experimental group, five of the six injuries occurring to the knee involved only two subjects and four out of the seven ankle injuries involved only two subjects. The concentration of injuries to so few subjects made it difficult to determine the effect of the supplement in determining the prevention of injuries.

In further comparison of the two groups in October and November, it appears that there was very little difference between the number and nature of the injuries received by the groups.

If the writer were to limit the analysis of the data to the month of September, it would appear that the supplementation of citrus bioflavonoid would be beneficial in reducing injuries. The control group sustained twenty-five injuries during September, whereas the experimental group sustained ten injuries in September. This trend continued, even though slight, during the month of October as the experimental group sustained nineteen injuries, and the control group received twenty-two injuries. During the month of November, both groups sustained eight injuries.

In analyzing the data in relation to the nature, location and
time of injuries, it appears that the supplementation of citrus bioflavonoid did not help in the prevention of injuries. Variation in the number of injuries could be by chance or by injury prone subjects rather than an effect of treatment.

To analyze the effects of the citrus bioflavonoid upon the number of days lost due to injuries was difficult. As the investigator studied the number of days lost by the individual players, it became apparent that a large percentage of the total days lost was accumulated by relatively few players. As shown in Table VII, over one-third of the total days lost due to knee injuries in Group A during the entire season was accounted for by one subject.

In analyzing the contusion category of Group A, the same problem existed but to a lesser degree, although there were considerably more injuries occurring during the month of September in Group A than in Group B. The average number of days lost by players in Group A was slightly less than the days lost in Group B. This trend reversed itself with regard to the average number of days lost during the last two months of the season.

As an over-all view of the data presented in Table VII was taken, it became apparent that totaling the data as was done in earlier analyses does not present an accurate picture as to the effects of the citrus bioflavonoid supplementation.
### TABLE VII

DAYS LOST PER INJURY IN RELATION TO THE MONTH IN WHICH THE INJURY OCCURRED TO THE L.S.U. VARSITY FOOTBALL PLAYERS DURING THE 1962 FOOTBALL SEASON WHO RECEIVED THE CITRUS BIOFLAVONOID AND THOSE WHO DID NOT RECEIVE THE CITRUS BIOFLAVONOID*

*Each number under the various injuries represents the number of days lost by a subject.

<table>
<thead>
<tr>
<th>Group and Month</th>
<th>N</th>
<th>Ankle</th>
<th>N</th>
<th>Knee</th>
<th>N</th>
<th>Other Joints</th>
<th>N</th>
<th>Pulled Muscles</th>
<th>N</th>
<th>Contusions</th>
<th>Total Days Lost Due to Injuries</th>
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</thead>
<tbody>
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<td>A (N=24)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>4</td>
<td>35</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>16</td>
<td>5</td>
<td>2</td>
<td>140</td>
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<td>September</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>16</td>
<td>62</td>
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<tr>
<td>Total</td>
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<td>8</td>
<td>5</td>
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<td>1</td>
<td>4</td>
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<td>3</td>
<td>16</td>
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<td>140</td>
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<td>4</td>
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<td>33</td>
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<tr>
<td>Total</td>
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<td>5</td>
<td>18</td>
<td>2</td>
<td>14</td>
<td>3</td>
<td>12</td>
<td>6</td>
<td>20</td>
<td>85</td>
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<tr>
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<td>2</td>
<td>6</td>
<td>1</td>
<td>10</td>
<td>0</td>
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<td>6</td>
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<tr>
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</tr>
<tr>
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<td>1</td>
<td>18</td>
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<td>9</td>
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<td>4</td>
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<td>64</td>
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<tr>
<td>October</td>
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<td>3</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>10</td>
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<td>62</td>
</tr>
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<td>Total</td>
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<td>17</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>November</td>
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<td>8</td>
<td>0</td>
<td>0</td>
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<td></td>
<td></td>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
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<td>1</td>
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<td>0</td>
<td>7</td>
<td>22</td>
<td>30</td>
<td>3</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER V

SUMMARY, FINDINGS AND CONCLUSIONS

I. SUMMARY

The specific purpose of the study was to evaluate the benefits of citrus bioflavonoid as an aid in the prevention and treatment of athletic injuries. A double-blind study was conducted during the 1962 football season at the Louisiana State University.

Members of the varsity football team at the Louisiana State University during the 1962 season were used as subjects in this study. Forty-eight players, including thirty-five members of the varsity squad and thirteen members of the scout squad, were arranged randomly into two groups on a matched player basis. Throughout the pre-season practices and during the regular season each player received three gelatin capsules daily, two before the noon meal and the third at suit-up time.

Capsules containing 300 mg. of lemon-orange flavonate glycoside (a citrus bioflavonoid complex) was dispensed to Group B. The capsule dispensed to Group A contained 300 mg. of lactose, a placebo formulation.

A detailed description of all the injuries was recorded according to nature, severity and treatment. A comparison of the
injuries and treatment received by Group A and Group B was made. All injuries were described as to location, type, and severity at the time of occurrence.

Because of the limited number of subjects used in this study, no statistical technique was used to determine the differences between the two groups.

II. FINDINGS

The incidence of injuries was as follows:

1. Thirteen players were injured in Group A, and fourteen players were injured in Group B.

2. Group A subjects received twenty-seven contusions, whereas the subjects in Group B received twenty-three contusions.

3. In the sprain category, Group A received twenty-eight injuries, and Group B received fourteen injuries.

4. Group A received nine sprains and sixteen contusions during the month of September, whereas Group B received four sprains and six contusions in the same month.

5. Group A received sixteen sprains and six contusions during October, whereas Group B received nine sprains and ten contusions.

6. Group A received three sprains and five contusions during November, whereas Group B received one sprain and seven contusions.
The extent of the severity of the injuries was approximately the same in both groups. In the sprain category in Group A, 36 per cent of the injuries fell in the minimal and mild classifications. Sixty-four per cent of the injuries fell in the moderate and severe classifications. In Group B, 50 per cent of the sprains were of the minimal and mild classifications, and 50 per cent were of the moderate and severe classifications.

The average number of treatments per injury was greater in Group A than in Group B for both the contusions and the sprains. The average number of treatments for contusions in Group A was 4.2. In Group B it was 3.8. For the sprain category, the average number of treatments received by Group A was 5.8. The average number of treatments received by Group B was 4.2. In making analysis by using totals, it appeared that the experimental group received some benefit from the citrus bioflavonoid; however, when this analysis was made in terms of specific injuries, it became apparent that the injuries to only a few subjects influenced the average a great deal.

III. CONCLUSIONS

Within the limits of this study, it was concluded that:

1. Citrus bioflavonoid has no effect on the number of players injured.

2. Citrus bioflavonoid will aid slightly in reducing the total number of injuries.
3. Citrus bioflavonoid supplementation has only a slight effect, if any, on reducing the severity of football injuries.

4. Citrus bioflavonoid may show a slight advantage in the reduction of recovery time from traumatic injuries received in football.

5. Players injured once are more likely to be injured a second time.
SELECTED BIBLIOGRAPHY
A. PERIODICALS


**B. UNPUBLISHED MATERIAL**


APPENDIXES
APPENDIX A

PHYSICAL EXAM RECORD
(1962 Football Season)

NAME: ________________________________  CODE: __________

POSITION: ______________________________  HEIGHT: _________

DATE: ________________________________  WEIGHT: _________

Pre-season Physical Examination

Appearance (scars, previous injuries, etc.)

B.P.

Heart

Lungs

Pulse Rate (before exercise) _________  (after exercise) ________

Eye test __________________________________________________

Ear, Nose and Throat _______________________________________

Nerve reflexes ____________________________________________

Comments on general habits (use of aspirin) appetite, sleep habits, etc.

History of previous injury _____________________________________

History of colds and other minor respiratory infections ________
APPENDIX B

ATHLETIC INJURY STUDY
(1962 Football Season)

NAME: ____________________________  DATE: ____________________

POSITION: _________________________  TABLET CODE: __________

<table>
<thead>
<tr>
<th>Date</th>
<th>Game or Practice</th>
<th>Time (Min.)</th>
<th>Nature of Injury (Severity &amp; Duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
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<td>3.</td>
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<td>5.</td>
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<td>28.</td>
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<td></td>
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<tr>
<td>30.</td>
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</table>
APPENDIX C

ATHLETIC INJURY RECORD

ATHLETIC DEPARTMENT
LOUISIANA STATE UNIVERSITY

PLAYER ___________________________________________ FORMULATION CODE ______

POSITION __________________________ DATE ___________________

TYPE AND LOCATION OF INJURY (CONTUSION, SPRAIN, MUSCLE CRAMPS, KNEE INJURY, BRUISE, HEMATOMA OR OTHER).

TREATMENT RECOMMENDED

THERAPY APPLIED

RETURN TO PLAYING ROSTER

__________________________________________ M.D.

__________________________________________ TRAINER
<table>
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<th>Player</th>
<th>Position</th>
<th>Team</th>
<th>Injury Duration</th>
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</thead>
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<td>Chest</td>
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<td>Eye</td>
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<td>Elbow</td>
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<td>Face</td>
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<td></td>
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<td>Finger</td>
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<td>Wrist</td>
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</table>

**SUMMARY OF INJURIES**

**Formula B**

**APPENDIX D**
APPENDIX E

CODES USED

Medication and Treatment Code:

C. = Cast
EX. = Exercise
HT. = Hydrotherapy
IN. = Injection
N. = Novocaine
OE. = Oral enzyme
S. = Sonic
PT. = Physical therapy
T. = Tape
TR. = Traction

Anatomical Code:

A. = arm
Abd. = abdomen
Abr. = abrasion
An. = ankle
B. = back
Bl. = blister
Ch. = chest
E. = eye
El. = elbow
F. = face
Fi. = finger
Ft. = foot
Fu. = fungus
H. = head
Hl. = heel
Hp. = hip
I. = infection
K. = knee
L. = leg
Lo. = lower
L. = left
M. = muscle
Mo. = mouth
rt. = right
S. = shoulder
Sh. = shin
T. = tendon
Th. = thigh
To. = toe
u. = upper
W. = wrist
VITA

Martin J. Broussard was born in Abbeville, Louisiana on April 25, 1921. He attended primary and secondary school in Abbeville. While working toward a Bachelor's degree at Louisiana State University, he participated in varsity baseball and track. He is completing his twenty-second year as Head Trainer of Athletics at Louisiana State University. In 1946 he was Head Trainer at Florida University, and in 1947 he served in the same capacity at Texas A. & M. College.

He has served as President of the Southeastern Conference Trainers Association on three occasions. He has served on the Board of Directors of the National Trainers Association and also was a member of the Ethics Committee of the same organization.

In 1954 he was a member of the American training staff for the Pan American Olympics held in Mexico City, Mexico. He was a member of the American training staff for the XVII Olympiad held in Rome, Italy in 1960. He was recognized by the Rockne Foundation as the National Athletic Trainer of the Year in 1963.

He enrolled in Graduate School in June, 1957 and received his Master of Science degree from Louisiana State University in August, 1960. He received his Doctor of Education degree from Louisiana State University in August, 1967 by the Grace of God and the assistance of hundreds of L.S.U. friends.
EXAMINATION AND THESIS REPORT

Candidate: Martin J. Broussard

Major Field: Physical Education

Title of Thesis: Evaluation of Citrus Bioflavonoid As An Aid in Prevention and Treatment of Athletic Injuries

Approved:

[Signatures]

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

[Signatures]

Date of Examination:

July 12, 1967