WISCONSIN STATE UNIVERSITY--LA CROSSE

GRADUATE SCHOOL

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I recommend acceptance of this seminar paper to the Graduate school in partial fulfillment of this candidate's requirements for the degree of Master of Science. The candidate has completed his oral seminar report.

January 16, 1967
Date

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This seminar paper is approved for the Graduate School:

January 17, 1968
Date

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AN ANALYSIS OF AN APPARATUS EMPLOYED TO APPRAISE THE "READINESS" OF A DEFENSIVE CHARGE IN FOOTBALL

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ABSTRACT

This study was made to determine if practice of a defensive charge on a sled would improve the "readiness" of high school football linemen to respond with consistently faster defensive charges, as measured by a timing device.

Veteran and new linemen were divided into two seperate groups, with backs forming a third group which acted as a control. Only line candidates practiced daily with the sled.

Data was recorded by all three groups at the beginning, middle, and end of the football season with a timing device, which had a starting signal light connected to the base of the sled. The flash of the light activated the timing hand and signaled the subjects to start their trial. From a defensive stance, the subjects reacted to hit a padded surface on the face of the sled, depressing a plunger which stopped the timing hand.

Analysis and comparisons of group data seems to indicate that linemen improve their "readiness" by practice on the sled.

AN ANALYSIS OF AN APPARATUS EMPLOYED TO APPRAISE THE "READINESS" OF A DEFENSIVE CHARGE IN FOOTBALL

A Seminar Report

Presented to

The School of Graduate Studies

Wisconsin State University at La Crosse

Submitted in Partial Fulfillment

of the Requirements for the Degree

Master of Science in Physical Education

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by

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January, 1967

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CHAPTER I

INTRODUCTION

STATEMENT OF THE PROBLEM

This study was made to ascertain if the practice of a defensive charge on a sled will increase the "readiness" of football linemen to respond to a stimulus, thus manifesting itself in consistently faster defensive starts as measured by a timing device.

ANALYSIS OF THE PROBLEM

Investigators have shown that nerves carry action potentials, or nerve impulses, at constant speeds, depending on their structures and cross sections. These speeds range from a few meters per second for non-myelinated fibers to about a hundred meters per second in the thickest myelinated sheaths found in the sensory and motor fibers concerned with body balance and fast reflex movements.[1]

Muscles also respond to stimuli and contract at a constant speed, following the "all or none" principle that is also true for nerves. However, an increase in the number of stimuli brought to a muscle will increase the number of muscle fibers responding,

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[1]Bernhard Katz, "How Cells Communicate", Reprint from Scientific American, (San Francisco, California: W. H. Freeman and Company, September, 1961). p. 6.

and results in more powerful muscle contraction.[2] Practice in this area would result in an increase in force but not in speed. Intensity of volitional effort results in an increase of nerve impulses to muscles and an increase in the strength of muscle contraction.[3]

Thus it seems that, under normal circumstances, any increase in response to a stimulus would be due to "readiness" or the subject's concentration to respond quickly. However, under emotional stress, an increase of epinephrine in the blood from the medulla of the adrenal glands increases a subject's awareness of an environment and facilitates reflex responses.[4]

While it is possible for a subject to react just as fast without practice as with practice, it is the purpose of this study to find out if practice with the sled will result in consistently quicker "readiness" to respond; a conditioned reflex that will respond faster more often with practice.

PURPOSE OF THE STUDY

In high school defensive play the speed of the defensive

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[2]H. E. Huxley, "The Mechanism of Muscular Contraction", Reprint from Scientific American, (San Francisco, California: W. H. Freeman and Company, December, 1965). p. 2.

[3]W. W. Tuttle and Byron A. Schottelius, Textbook of Physiology, (Saint Louis: The C. V. Mosby Company, Fifteenth Edition, 1965) p. 79.

[4]Ibid., p. 385.

charge is essential to success, but an apparatus for developing this skill is not in general use. While the light sled has been used at Aquinas High School, La Crosse, Wisconsin, for over twenty years, there was no evidence, except subjective opinion, to indicate that it was doing what it was designed to do.

A demonstration of a timing device by Dr. Ernest Gershon of Wisconsin State University--La Crosse inspired an attempt to measure the use of a light sled as an instrument for developing a "readiness" for increasing the speed of the defensive charge of high school linemen at Aquinas High School. Obviously, if reliable data could be gathered to show that the sled practice improved the speed of the defensive charge, its continued use would be a great asset in a football practice schedule; if not, then the time spent on it could be questioned.

DELIMITATIONS

Subjects in this study consisted of boys enrolled at Aquinas High School, in grades ten to twelve, and scholastically eligible to compete under the rules of the Wisconsin Inter-scholastic Athletic Association and Aquinas High School. Age, height, and weight were not considered in the groupings of the subjects. All were certified as physically fit for football by doctors of their own choice. Membership to, or severance from the football squad is entirely voluntary. No one is personally invited to participate and a no-cut policy is followed, except for serious disciplinary reasons.

LIMITATIONS

The timing device was designed by Peter and Tim Hulick and built by Peter Hulick. Both are experts in electronics. The timer is powered by batteries, which were changed every five days of use to insure adequate power for reliable readings. The timing device has a rheostat which regulates the speed of the timing hand or pointer. For accuracy, the timing device was carefully calibrated each day of use by checking it with a track stop-watch before and after recording data.

While the physical and mental condition of the subjects during the readings could be a factor, it was visibly ascertained that each subject was in no way handicapped by injury or bruises which might have an effect on the recordings. Competition with each other for better recordings insured motivation for each subject to give his best effort on each trial. Emotional problems, if any, were beyond our control.

While teaching methods of stance and start were uniform, individual variations during trials resulted in readings from relatively poor mechanical body positions.

False starts were called when observed and the trial repeated.

Temperature, humidity, and field conditions might have had some effect, although no data was recorded during rain, even a slight drizzle.

DEFINITION OF TERMS

Sled - a wooden apparatus with skids on the bottom, designed to slide on the ground when hit or pushed. The face of the sled is thirty two inches high and padded with sponge rubber. Subjects hit the padded surface hard with the heels of their hands and drive the sled forward.

Timer - a gear-driven device powered by batteries which turn a hand or pointer around a clock-like face which is marked at equidistant intervals. There are 100 markings around the face. When the rheostat is adjusted to make the hand or pointer revolve exactly two revolutions per minute, each marking will have a value of 1/200 of a second.

Reading or Recording - a trial at the sled during which data is recorded.

Subjects - football players engaged in recording data.

Experienced Group - linemen that had practice on the sled the previous year, made up mostly of boys in the eleventh and twelfth grades.

Inexperienced Group - linemen with no previous practice on the sled, composed mostly of boys in the tenth grade.

Control Group - varsity backfield candidates, many with game experience, who do not practice on the sled.

Defensive stance - a crouched position with legs shoulder-width apart, back straight, head up, knees bent, buttocks in line with the shoulders, and the knuckles of either hand on the

ground in line with the head.

"Readiness" - the intense concentration of attention of the subject to respond as fast as possible to an external stimulus.

Starting signal - a light bulb, connected to and powered from the timer, which lights up simultaneously with the start of the timing hand.

Plunger - a small metal device with a metal projection which, when pushed, stops the hand of the timer. It is mounted behind the right padded board of the sled. Contact of hands on the padded board pushes the projection inward and stops the hand of the timer; when pressure is released, the projection moves outward and the hand can resume movement.

CHAPTER II

REVIEW OF RELATED LITERATURE

Every coach has his own ideas on what should be done to develop the skills used in football. Various machines and pieces of apparatus have been designed and built for this purpose and used in many different ways. One of the oldest pieces of apparatus used was the sled, and the purposes for its use varied with the ideas of each coach: to teach the use of the hands on defense, the forearm shiver, to develop leg drive and strength, to teach proper body position, and to work against great resistance. But these sleds were generally very heavy and hard to move. None were designed especially to develop the speed of a defensive charge.

It is generally recognized by football coaches that "getting off the ball" is of prime importance in a football game. The team, especially the linemen, which can respond quicker to the snap of the ball have the initial advantage both on offense and defense.

The relative importance attached to a fast charge in football may be seen by the amount of time and emphasis used by leading coaches in developing this phase of the game. Bierman[1]

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[1]Bernie W. Bierman, Winning Football (New York: McGraw-Hill Book Company, 1937).

Crisler,[2] Leahy,[3] and "Biggy" Munn[4] considered the effectiveness of line play to be based on a fast "take-off".

Rockne's[5] teams were famous for their quick starts and his innovation of the shift from the "T" to the Notre Dame box formation was designed for a quick start. The resultant controversy over the fast start generated by the shift caused the football rules committee to legislate a full second stop before the snap of the ball for all eleven men on the offensive team. Waldorf,[6] in his coaching philosophy, strongly emphasized quick starts.

While attempts have been made to measure the speed of a response in many ways: by Nakamura[7] and Westerlund[8] in track,

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[2]H. O. Crisler, Practical Football (New York: McGraw-Hill Book Company, 1934).

[3]Frank W. Leahy, Notre Dame Football -- T Formation (New York: Prentice-Hall, Inc., 1949).

[4]Clarence B. Munn, Michigan State Multiple Offense (New York: Prentice-Hall, Inc., 1953).

[5]Knute K. Rockne, Coaching - The Way of a Winner (New York: Devin-Aire, 1930).

[6]Lynn O. Waldorf, This Game of Football (New York: McGraw-Hill Book Company, 1952).

[7]H. Nakamura, "Experimental Study of Reaction Time of the Start in Running a Race," Research Quarterly Supplement, 5: 33-45, 1934.

[8]J. H. Westerlund and W. W. Tuttle, "Relationship Between Running Events in Track and Reaction Time," Research Quarterly, 2: 95-100, October, 1931.

by Atwell[9] in male high school students, and Slater-Hammel,[10] Sills,[11] and Wendler[12] on light stimuli and limb response, comparatively few researchers, like Elbel[13] and Manolis[14] have attempted to study the speed of a charge in football.

Elbel's[15] study was on the speed of the charge and the force exerted. He attempted to find out if there was any relationship between the speed of the charge and force generated. He found no relationship between the two. Manolis[16] looked for the relationship of charging speed to blocking performance in football. He timed speed by using a buzzer as a starting signal and a target, twelve inches away from the subjects' helmet, which

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[9]Wm. O. Atwell and Edwin R. Elbel, "Reaction Time of Male High School Students in 14-17 Year Age Groups," Research Quarterly, 19: 22-29, March, 1948.

[10]A. T. Slater-Hammel, "Comparisons of Reaction Time Measured to Stimulus and Arm Movements," Research Quarterly, 26: 82-87, March, 1955.

[11]Frank D. Sills, "Reaction Time and Multiple Response Time," Physical Education Research Laboratory, State University of Iowa, Research Methods, (Washington, D. C.:American Association for Health, Physical Education, and Recreation, 1959). p. 158.

[12]A. J. Wendler, "Choice Response Time," Physical Education Research Laboratory, State University of Iowa, Research Methods, (Washington D. C.: American Association for Health, Physical Education, and Recreation, 1959). p. 158.

[13]Edwin R. Elbel and others, "Measuring Speed and Force of Charge of Football Players," Research Quarterly, 23: 295-300, October, 1952.

[14]Gus G. Manolis, "Relation of Charging Time to Blocking Performance," Research Quarterly, 26: 170-178, May, 1955.

[15]Elbel, op. cit., p. 300. [16]Manolis, op. cit., p. 177.

swung when hit and stopped his timing device. Data from this work, used in conjunction with game films of his subjects, led him to conclude that there were pronounced individual differences in speed of charging.

No satisfactory study has been made to measure the effect of practice on an apparatus such as a sled for improvement of "readiness" of response in a defensive charge.

CHAPTER III

PROCEDURE

The linemen on the football squad were divided into two groups; those with previous experience were designated as the Experienced Group and those with no previous experience as the Inexperienced Group. All returning backfield candidates formed the Control Group. The purpose of the study and the data gathering procedure was explained to all the groups, and practice trials were taken with the timer in operation to familiarize them with the procedure. However, no data was recorded on this first day.

Apparatus

The sled is made of wood, 32" high, and wide enough for two subjects to work side by side with comfort. The striking surfaces consist of two detachable padded boards, 1" by 12" by 40" each, and the sponge rubber padding is held snugly by a covering of vinyl. In front of the sled is an extension having a steel rod running the width of the sled and measuring 28" from the face of the sled. Knuckles placed on the ground inside of the rod, with wrists touching it, assures the same starting position for all of the subjects.

An attachment containing a light bulb is mounted at the middle base of the sled. Wires leading to the timing device from the bulb simultaneously flash the light and start the pointer

on the timer. The signal light approximates the position of a football on the line of scrimmage and its flash acts as a starting signal.

The device for stopping the timer, called the plunger, is mounted solidly behind the right padded board with its projection barely touching the board. Contact on the pad depresses the projection and stops the timer. When the pressure on the pad is released, a spring returns the projection back to its original position and the hand on the timer can resume moving.

The timer is carried along the right side of the sled during recorded trials. Wires from the timer lead to the signal light and to the plunger, with sufficient length allowed to enable the operator to walk along side the sled during the trials without interfering with either the subjects or the timing device. Switch buttons on the face of the timer enable the operator to start the signal, hold the time recorded, and to reset the hand on the clock-face.

Recording of Data

Since the sled was designed for two subjects to work simultaneously and has two seperate pads for hitting, the subjects worked in pairs both in practice and during recordings. However, only the right pad could record data.

The subjects lined up single file in front of the right pad. The first subject took his recorded trial and moved over to the left side for a practice trial with the second subject who

was being recorded. The second subject then moved to the left pad as the third subject advanced for his trial. Thus each subject was getting a recorded trial and a practice trial before dropping out and going to the end of the line.

Instructions to the subjects were simple. At the command of "ready" the subjects assumed their defensive stances with their hands inside the extension rod and the wrists touching the rod. When the signal light flashed they charged and hit the padded surface as hard and fast as they could with their hands and kept driving. On the command of "change" the subjects stopped driving and changed positions, according to routine procedure. Again at "ready" the whole process was repeated.

The device for timing was operated by the writer throughout the study, being carried alongside the sled during trials. When the subjects were ready a switch button was pushed to flash the starting signal and start the timing hand. As soon as contact was made and the plunger stopped the hand, a switch button was pushed to hold the time recorded. The data was called out verbally to assistant coach Marvin Sammartano, who wrote the readings in their proper places for each subject. A manager on the opposite side of the sled assisted in observing for false starts.

Three recordings a day were taken for five days within the first two weeks of the football season and designated as Early Season data; three recordings a day were taken for five days within the sixth and seventh weeks of the season and were

designated as Mid-Season data; and the final three times a day recordings taken for five days within the last two weeks of the season and are called End-of-Season data. The football season is twelve weeks in length. All linemen practiced on the sled daily except on days when games were scheduled or when football practice was not scheduled.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

It was assumed at the beginning of the study that if enough time recordings were made during all three parts of the season, the average of the recordings would give a good indication of the progress of each individual as well as each group and give a better picture of their development of increased "readiness" to respond in terms of faster times in the recordings.

To make sure that any increase in "readiness" by the linemen was not due entirely to the drills and routine of practice other than the sled, a control group was necessary for purposes of comparison. To select linemen for a control group would deprive them of practice on the sled, which we felt was important to their progress. Backfield men seemed to offer the best kind of a control group, since speed and quickness are qualities demanded by their positions. Also, they would participate in daily drills and practice routines designed to improve their speed and response to the snap of the ball, but would not practice on the sled except when recording data. Backfield men selected for the control group were all returnees from the previous season, most of them with game experience.

All data recorded is in terms of 1/200 of a second.

ANALYSIS OF THE EXPERIENCED GROUP

Early Season. As expected, the examination of individual data of all groups (Tables I, IV, and VII) showed the experienced group with the best results, since they were familiar with work on the sled from the previous year. Their 83.6 average was better than the 88.1 average of the Control Group, who had seen the sled in use the previous year and whose members had tried it occasionally on their own initiative from time to time. The Inexperienced Group, using the sled for the first time, had a 92.1 recording.

This data, taken in five days of the first two weeks of the season, showed the eighteen subjects of the Experienced Group with a distribution range of average time from a low score of 79.6 to a high score of 90.4 (Table XIV), with thirteen subjects scoring in the 80.0 to 84.9 range.

Mid-Season. Comparison with Early Season data indicates an improvement of +4.4 for the entire group (Tables II, X, and XIII). Several individuals made substantial improvement but the gains for the rest of the subjects were comparatively small. But the Mid-Season data shows a consistency of performance lacking in the Early Season readings.

A look at the distribution range of scores (Table XIV) finds the low score as 75.6 and the high score as 82.6, with the Mid-Season average at 79.2. Consistency of performance is indicated by thirteen of the subjects being in the 75.6 to 79.9

range and five subjects in the 80.0 to 82.6 range. Also, the Mid-Season Group average of 79.2 is better than the Early Season individual low score of 79.6 (Table XIV).

End-of-Season. Comparison of individual averages with those of Mid-Season shows that half the group, eight subjects, as having improved their scores 5.0 to 13.4 during that period while the rest of the group, with two exceptions, had comparatively smaller gains. Two of the subjects had very slight losses from their Mid-Season average. However, the average of the whole group improved +6.3 from Mid-Season to the End-of-Season. (Tables X and XIII).

The distribution range of scores is more illuminating. The individual low score of the End-of-Season recordings was 63.4, while the high score was 78.8. The End-of-Season group average of all eighteen subjects was 72.9, and was better than the Mid-Season individual low score of 75.6.

The consistency of the whole group at the end of the season is evidenced by their final averages (Table XIV). Ten of the subjects scored in the 70.0 to 74.9 range and six were in the 75.0 to 78.8 range, or a total of sixteen of the eighteen subjects being in the 70.0 to 78.8 range. The remaining two subjects had average scores of 63.4 and 64.8 (Table X).

Comparing with the Early Season data (Tables X, XIII, and XIV), an improvement of +10.7 in group average time is noted. Also, the End-of-Season group average of 72.9 and the individual

high score of 78.8 Is better than the low individual score of 79.6 in Early Season data.

The group improved +4.4 the first half of the season, but increased their gain to +6.3 in the second half.

ANALYSIS OF THE INEXPERIENCED GROUP

Early Season. The Inexperienced Group of fourteen subjects registered a low score of 84.4 and a high score of 98.6, with eight subjects in the 90.0 to 94.9 range (Tables V and XV). At this time they had no training or coaching in the technique of a defensive charge as used in working on the sled. They simply assumed a defensive stance and as the signal light flashed, hit the sled pad as fast as they could. Their three trials a day for five days furnished an average that was a good representation of their responses at this time.

Middle Season. A comparison with Early Season data shows a +7.7 improvement as a group. But a look at their individual data (Tables V, XI, and XIII) indicates a wide variation of individual improvement or lack of it, -2.6 to 16.4. These variations are the result of coaching this group in the correct technique of a defensive charge, with emphasis not only on a fast start but a hit on the pad with force and power, followed by a driving follow through. While Early Season data for this group showed only how quick they could hit the pad from a defensive stance, disregarding form and technique, their Mid-Season data showed their time recordings while trying to use the correct

stance, charge, and hit with force. Since the learning time of these techniques vary with each individual, some subjects showed negligible gains or losses while others showed substantial improvement. The distribution range of scores indicates a low of 78.8 and a high of 93.8, with thirteen of the fourteen subjects scoring in the 78.8 to 93.8 range (Table XV). Their Group Mid-Season average of 84.4 is also better than their Early Season individual low score of 86.0. So the Inexperienced Group, as a group, showed not only an increase in speed but an improvement in the proper execution and hit of a defensive charge.

End-of-Season. The last half of the season showed a consistency of performance for most subjects in their daily average readings and in the averages for the five days (Tables VI and XI). The average improvement of speed for this part of the season, +7.9, was almost matched by the increase of +7.7 for the first half of the season, and the net gain of +15.6 for the whole season, especially with good execution, was significant. Table XIII also reveals that the End-of-Season average for this group, 76.5, was better than the Mid-Season average of 79.2 made by the Experienced Group.

The distribution range of scores show a low of 70.0 and a high of 85.6. The greatest gain was in the consistency of scores within the 70.0 to 79.9 range, where twelve of the fourteen subjects had averages within this area (Table XV). A study of the distribution range of scores for the whole season indicates

that not only did the wide variation between scores in the Early and Mid-Season narrow considerably, but there was a great deal of improvement through the season by the whole group, from a 92.1 average to a 76.5 average.

ANALYSIS OF THE CONTROL GROUP

Early Season. For this group no teaching of a defensive charge was attempted nor did they practice on the sled, except to take their trials. This group consisted of eleven backfield men, whose trials consisted of trying to hit the pad as fast as possible on the starting signal from a stance.

With few exceptions, the daily averages for this group were pretty consistent with their five day averages, although throughout the season some of the daily averages of various individuals fluctuated. Tables VII, VIII, and IX show these individual inconsistencies occuring through the whole season.

Table XVI indicates a low score of 84.4 and a high score of 98.6, with an Early Season average of 88.1. The distribution range of scores have a bunching of eight of the eleven subjects in the 85.0 to 89.9 range.

Mid-Season. The group made a gain of +1.7 from the beginning of the season (Tables XII and XIII), and a comparison with Early Season individual averages reveal mostly slight gains and a few slight losses in average scores. One subject had a considerable increase of +14.6 from his previous average.

Table XVI exhibits a low score of 81.2 and a high of 93.2, with a Mid-Season average of 86.4. While the average scores of the subjects were better than in the Early Season, the distribution of these scores were spread out, with five subjects in the 81.2 to 84.9 range, three subjects in the 85.0 to 89.9 range, and three in the 90.0 to 93.2 area.

End-of-Season. A comparison of individual averages with those of the Mid-Season show increases or losses among the individual members to be slight, with none over 5.0 and only two over 4.0. Three subjects showed slight losses. One subject revealed a slight loss both in Mid-Season and at the End-of-Season recordings. The gain from Mid-Season was +1.8 for the whole group, almost identical with the +1.7 increase from Early Season to Mid-Season. The total improvement for the whole season was +3.5 (Tables XII and XIII).

Table XVI indicates that the low score of 81.6 and the high score of 93.6 to be almost identical with those of Mid-Season. The End-of-Season average of 84.6 is only slightly better. Eight of the subjects were bunched in the 81.6 to 84.9 range. The overall improvement for six of the subjects was very slight, all being below +4.0.

CHAPTER V

SUMMARY AND CONCLUSIONS

The intention of this study was to compare each group with itself in three divisions of the football season, designated as the Early, Mid-Season, and End-of-Season. The objective was to note if there was any increase in "readiness" of response to a stimulus with a fast-hitting defensive charge, if practice on the sled would increase this response, and what parts of the season would be most fruitful. The Control Group would serve as a check to see if any increase in response was due to practice on the sled and not to the routine activities of daily practice drills. Any comparisons between the groups were intended to indicate progress check-points from one part of the season to another for one of the groups.

What part mental or emotional conditions played in the daily recordings and daily averages of individual subjects can only be theorized. It was noted, however, that some individuals were sharper and quicker on some days than on others during the recording of trials. Informal conversations with some of the subjects about their recordings and fluctuations in scores on certain days confirmed that some subjects felt better on some days than on others.

Summarizing the results of the Experienced Group first, their Early Season average was the best of the three groups.

Previous training in the defensive charge and familiarity with the use of the sled would account for their better group average, although abstinence from athletic activity during the summer months for some of the subjects resulted in variations in the daily trials and averages in Early Season recordings. The variations of individual averages ranged from a low score of 79.6 to a high score of 90.4, but these variations leveled off at the Mid-Season readings, which registered a low of 77.6 and a high of 82.6. This tendency of the scores to cluster together within a narrow range would indicate that practice on the sled during the first half of the season resulted in sharpening up the responses of those who were inactive during the summer, bringing them in line with those who were active. At any rate, the consistency of the scores at Mid-Season would be a good indication of the state of "readiness" of response for all these subjects at this part of the season.

Contrary to expectations, the most improvement was made by this group in the second half of the season, a +6.3 gain compared to the +4.4 of the first half. The total improvement of +10.7 for the season is satisfactory, considering that retraining rather than learning was needed for this group.

Summarizing the results of the Inexperienced Group data, the Early Season readings would merely reflect this group's "readiness" of response for this time, without any regard for form, technique, or force of the hit from a defensive charge.

After a half of a season of practice, during which the subjects were taught the form and technique of a defensive charge while the hit was continuously stressed, the Mid-Season readings were a good indication of their progress in learning to charge and hit with speed and power. In fact, their average time of 84.4 at this point is almost as good as the 83.6 average compiled by the Experienced Group at the start of the season.

Their improvement of +15.6 for the season was almost equally divided between the first half, +7.7, and the second half of the season, +7.9. But significantly, the final group average of 76.5 was registered with an acceptable form and technique of a defensive charge and a hit with force.

A study of the data of the Control Group leads to the conclusion that this group was pretty much the same at the end of the season as it was at the beginning, as far as their "readiness" of response could be measured by the sled and timing device. The +3.5 improvement for the whole season could be due to natural development of response during the routine of daily practice. The natural conclusion is that practice on the sled daily does improve the "readiness" of response in the speed of a defensive charge.

Daily practice with the sled seems indicated for all linemen, experienced or inexperienced. Experienced linemen would increase their "readiness" to respond quickly with a fast charge and hit, while inexperienced boys would learn the form and tech-

nique of a defensive charge while also improving their response.

To determine the statistical significance of the study, the Mann-Whitney[1] test was administered, using the null hypothesis of no difference. Each group was compared with itself through the three parts of the season and then with each other, using the End-of-Season results.

With the Experienced Group, a comparison of the Early Season with the Mid-Season, the Mid-Season with the End-of-Season, and the Early Season with the End-of-Season data indicates that the null hypothesis of no difference is to be rejected and that the results were significant at better than the .01 per cent level of confidence.

The same procedure with the Inexperienced Group, also comparing the data of all parts of the season, rejects the null hypothesis and indicates that the results are significant at better than a .01 per cent level of confidence.

With the Control Group, a comparison of data between the Early Season and Mid-Season resulted in a slightly better than .20 per cent level of confidence, and the Mid-Season and End-of-Season comparison was beyond the .20 per cent level. In both cases the null hypothesis of no difference would have to be accepted. The comparison of Early Season with the End-of-Season

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[1]Merle W. Tate and Richard C. Clelland, Non Parametric and Short Cut Statistics (Danville, Illinois: The Interstate Printers and Publishers, Inc., 1957), p. 137.

was significant at the .01 per cent level and the null hypothesis is rejected.

Both the Experienced and Inexperienced Groups, when compared with the Control Group data, showed better than a .01 per cent of confidence and here again the null hypothesis of no difference is rejected. But a comparison of the End-of-Season results between the Experienced and Inexperienced Groups shows a significance level of .10 per cent and the null hypothesis of no difference between these groups is accepted.

Recommendations for Further Study. It would be informative to follow up the Inexperienced Group next season and compare their End-of-Season data with that compiled by this season's Experienced Group.

Our practices on the sled stongly emphasize the force of the hit as well as the speed of the charge. A measurement of speed response "readiness" together with the development of the force of the hit in inexperienced linemen through the season would be interesting.

BIBLIOGRAPHY

BIBLIOGRAPHY

Atwell, Wm. O., and Edwin R. Elbel, "Reaction Time of Male High School Students and 14-17 Year Age Groups," Research Quarterly, 19: 22-29, March, 1948.

Bierman, B. W. Winning Football. New York: McGraw-Hill Book Company, 1937.

Crisler, H. O. Practical Football. New York: McGraw-Hill Book Company, 1934.

Elbel, Edwin R., and others. "Measuring Speed and Force of Charge of Football Players," Research Quarterly, 23: 295-300, October, 1952.

Huxley, H. E. "The Mechanism of Muscular Contraction," Reprint from Scientific American, San Francisco, California: W. H. Freeman and Company, December, 1965.

Katz, Bernhard. "How Cells Communicate," Reprint from Scientific American, San Francisco, California: W. H. Freeman and Company, September, 1961.

Leahy, Frank W. Notre Dame Football -- T Formation. New York: Prentice-Hall, Inc., 1949.

Manolis, Gus G. "Relation of Charging Time to Blocking Performance," Research Quarterly, 26: 170-178, May, 1955.

Munn, Clarence B. Michigan State Multiple Offense. New York: Prentice-Hall, Inc., 1953.

Nakamura, H. "Experimental Study of Reaction Time of the Start in Running a Race," Research Quarterly Supplement, 5: 33-45, 1934.

Rockne, Knute K. Coaching - The Way of the Winner. New York: Devin-Aire, 1930.

Sills, Frank D. "Reaction Time and Multiple Response," Physical Education Research Laboratory, State University of Iowa, Research Methods. Washington, D. C.: American Association for Health, Physical Education, and Recreation, 1959.

Slater-Hammel, A. T. "Comparison of Reaction Time Measures to Stimulus and Arm Movements," Research Quarterly, 26: 82-87, March, 1955.

Tate, Merle W. and Richard C. Clelland. Non Parametric and Short Cut Statistics. Danville, Illinois: The Interstate Printers and Publishers, Inc., 1957.

Tuttle, W. W. and Byron A. Schottelius. Textbook of Physiology. St. Louis: The C. V. Mosby Company, Fifteenth Edition, 1965.

Waldorf, Lynn O. This Game of Football. New York: McGraw-Hill Book Company, 1952.

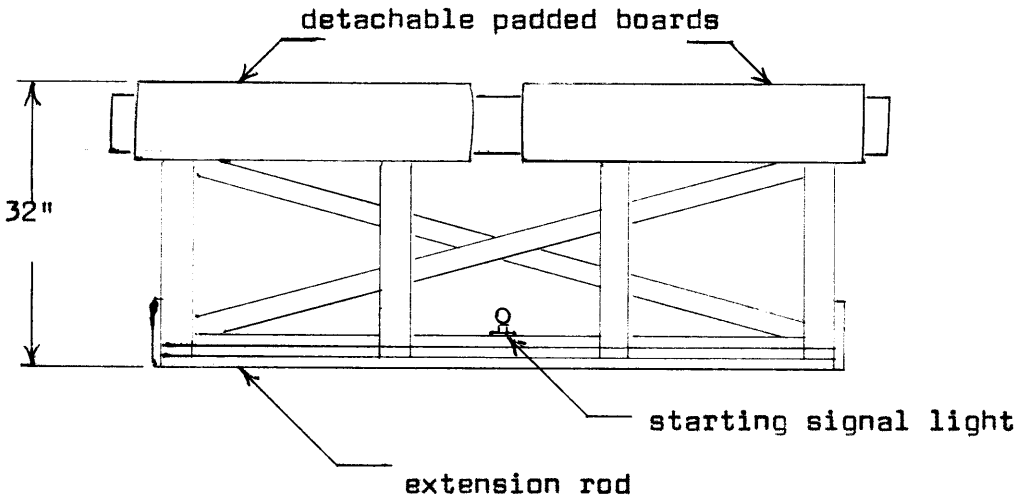
Wendler, A. J. "Choice Response Time," Physical Education Research Laboratory, State University of Iowa, Research Methods. Washington, D. C.: American Association for Health, Physical Education, and Recreation, 1959.

Westerlund, J. H. and W. W. Tuttle, "Relationship Between Running Events in Track and Reaction Time," Research Quarterly, 2: 95-100, October, 1931.

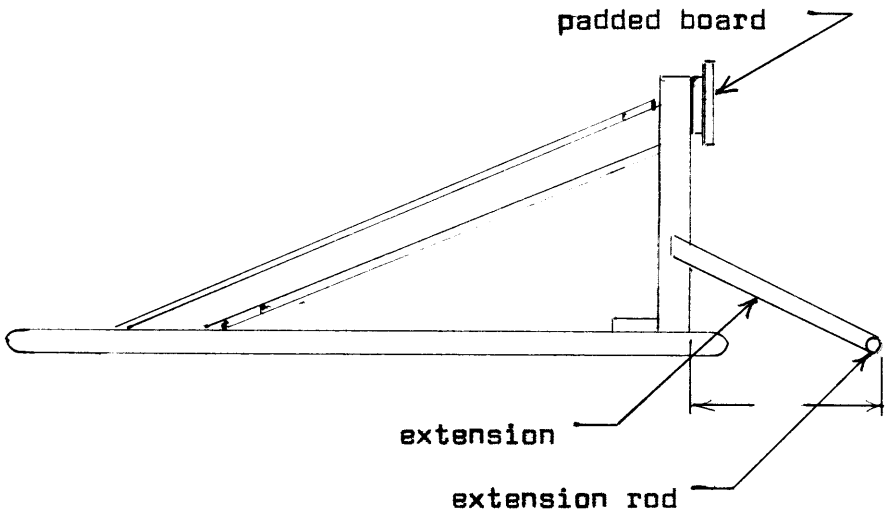
APPENDIX

DIAGRAM OF SLED

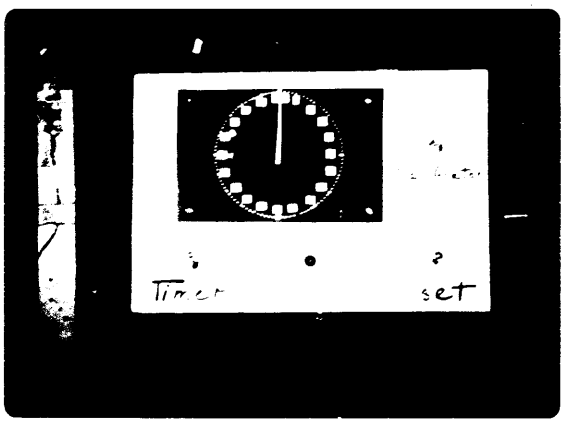
FRONT VIEW



SIDE VIEW



TIMING DEVICE



Clock Face.

Marked off with 100 equidistant raised dimples. A colored dimple and a number are placed at intervals of every five markings.

Starting Signal Light.

At the left of the Timer in photograph. It is mounted to the middle base of the sled.

Plunger.

At right of the Timer in photograph. Attached behind the right padded board of the sled. When the projection is pushed in it stops the hand of the clock.

Controls.

Calibrator -- regulates the speed of the hand. At two revolutions per second, each marking on the clock-face has a value of 1/200 of a second.

Reset -- used to get the hand or pointer back to zero.

Timer -- switch for simultaneously flashing the light for the starting signal and starting the Timer.

TABLE I

EARLY SEASON DATA - EXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	84.0	80.3	77.0	79.3	81.3	80.4
2.	79.3	76.0	80.0	81.0	85.6	80.4
3.	86.6	90.3	87.3	87.6	83.3	87.0
4.	75.0	83.0	81.6	79.3	78.6	79.6
5.	95.0	94.0	84.6	92.0	86.6	90.4
6.	80.3	80.3	88.0	84.3	82.0	83.0
7.	84.6	81.3	81.6	82.0	83.6	82.2
8.	74.0	87.3	88.0	82.6	86.0	83.6
9.	78.0	84.6	87.0	86.3	87.0	84.4
10.	76.3	80.0	86.3	81.0	83.3	81.4
11.	79.6	83.0	84.0	89.0	81.0	83.2
12.	77.3	90.3	88.3	80.3	86.3	84.4
13.	76.0	87.0	87.3	82.0	81.0	82.6
14.	79.6	86.3	87.3	81.3	85.3	84.0
15.	79.6	87.6	84.6	82.6	96.0	86.0
16.	82.3	80.6	87.3	89.3	82.6	84.4
17.	75.0	84.0	86.3	80.0	86.0	82.2
18.	82.3	85.6	88.6	88.3	84.0	85.8
						83.6

Group Average - Early Season - 83.6

Table II indicates the average time for three trials recorded each day. The five day average for each subject is the average time for fifteen trials.

This Early Season data will be compared with Mid-Season and End-of-Season recordings of this Experienced Group.

TABLE II

MID-SEASON DATA - EXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	78.6	81.0	75.6	81.0	71.6	77.6
2.	81.0	77.0	77.0	81.6	74.6	78.0
3.	79.6	75.0	79.6	81.3	83.0	79.6
4.	75.0	72.3	74.6	78.3	78.0	75.6
5.	77.6	76.6	81.6	81.3	79.3	79.2
6.	82.0	87.0	84.6	78.6	80.6	82.6
7.	75.0	80.6	82.3	83.3	73.3	79.0
8.	80.0	79.3	74.0	85.3	73.6	78.4
9.	82.3	77.6	79.6	70.3	81.0	78.2
10.	79.3	74.6	82.6	84.0	71.0	78.2
11.	81.3	79.0	79.3	75.3	87.0	80.4
12.	81.0	81.0	83.0	79.3	85.6	82.0
13.	84.3	81.0	84.0	80.3	81.3	82.0
14.	82.6	79.6	79.0	84.3	74.6	80.0
15.	81.6	78.0	78.3	76.6	77.0	78.2
16.	85.3	80.6	76.3	79.3	74.0	79.0
17.	77.6	78.6	73.6	83.3	80.3	78.6
18.	78.6	75.6	75.6	83.6	77.6	78.2
						79.2

Group Average - Mid-Season - 79.2

Table II indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This Mid-Season data will be compared with Early Season and End-of-Season recordings of this Experienced Group.

TABLE III

END-OF-SEASON DATA - EXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	72.0	62.0	73.0	76.0	70.3	70.6
2.	76.6	59.3	77.6	72.6	75.0	72.2
3.	82.6	73.6	74.6	81.3	73.3	76.8
4.	77.3	68.0	76.6	78.6	80.3	76.2
5.	82.6	71.3	80.6	75.6	77.6	77.6
6.	70.6	60.0	79.3	68.0	77.3	71.0
7.	65.6	50.3	72.3	62.6	66.6	63.4
8.	68.0	60.6	79.0	80.3	80.6	73.6
9.	71.6	72.0	79.0	83.0	83.0	77.8
10.	70.0	71.3	80.6	50.6	51.6	64.8
11.	77.0	69.3	86.3	81.0	80.6	78.8
12.	66.3	58.3	78.6	80.6	71.0	70.8
13.	73.3	65.3	71.6	70.3	74.3	70.8
14.	73.6	70.6	79.3	72.3	84.3	76.0
15.	78.3	69.3	71.6	74.3	77.6	74.4
16.	72.6	65.3	70.6	74.3	68.6	70.2
17.	73.6	57.0	79.3	79.3	74.0	72.6
18.	71.0	67.6	78.3	75.3	79.0	74.2
						72.9

Group Average at End-of-Season - 72.9

Table III indicates the average time for three trials recorded each day. The five day average for each subject is the average time for fifteen trials.

This End-of-Season data will be compared with Early Season and Mid-Season recordings of this Experienced Group.

TABLE IV

EARLY SEASON DATA - INEXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	85.0	91.3	93.6	88.0	80.3	87.6
2.	99.0	89.6	96.0	89.0	91.0	93.0
3.	100.0	90.6	97.3	88.3	92.3	93.6
4.	83.6	100.0	92.6	78.0	86.3	88.0
5.	89.0	95.6	94.3	85.0	80.6	88.8
6.	92.3	98.6	97.3	91.0	83.3	92.4
7.	102.3	92.3	98.3	90.6	81.0	92.8
8.	92.6	87.3	91.6	94.3	90.6	91.2
9.	95.6	90.3	86.3	93.3	93.0	91.6
10.	95.6	82.6	79.6	87.0	85.6	86.0
11.	107.6	97.3	104.3	88.3	95.3	98.6
12.	98.3	110.0	94.6	87.0	95.0	97.0
13.	99.6	96.3	92.0	89.6	92.0	93.8
14.	98.0	96.6	110.0	88.3	78.6	94.4
						92.1

Group Average - Early Season - 92.1

Table IV indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This Early Season data will be compared with Mid-Season and End-of-Season recordings of this Inexperienced Group.

TABLE V

MID-SEASON DATA - INEXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	93.3	84.0	83.0	92.0	86.3	87.8
2.	88.6	88.6	87.0	86.6	93.3	88.8
3.	78.6	74.3	82.6	81.6	77.3	78.8
4.	76.0	76.0	82.3	78.3	78.3	78.4
5.	92.0	83.3	84.0	86.6	89.3	87.0
6.	80.3	74.3	83.0	79.6	82.3	79.8
7.	81.6	80.6	91.3	86.0	77.3	83.4
8.	95.0	94.0	90.3	93.6	96.6	93.8
9.	82.3	92.6	90.6	89.0	90.3	89.0
10.	73.6	76.6	86.0	78.6	90.0	81.0
11.	79.6	74.0	85.0	87.0	85.0	82.2
12.	80.3	91.3	89.6	94.0	82.3	87.4
13.	79.6	82.3	76.3	78.3	81.6	79.6
14.	80.3	84.6	81.0	86.6	86.6	83.8
						84.4

Group Average - Mid-Season - 84.4

Table V indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This Mid-Season data will be compared with Early Season and End-of-Season recordings of this Inexperienced Group.

TABLE VI

END-OF-SEASON DATA - INEXPERIENCED GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	87.3	83.0	78.6	70.6	75.6	79.0
2.	87.3	84.3	87.3	86.3	83.0	85.6
3.	72.3	83.3	78.6	64.6	69.3	73.6
4.	63.0	77.6	74.3	72.6	67.0	71.0
5.	82.3	78.3	74.0	79.3	66.3	76.0
6.	77.3	79.3	72.3	71.0	73.6	74.6
7.	72.3	74.3	79.3	78.6	73.3	76.0
8.	77.0	84.3	74.6	76.6	73.3	77.0
9.	82.6	83.0	73.6	68.6	74.0	76.3
10.	69.3	72.6	74.0	69.0	65.0	70.0
11.	81.3	84.3	83.6	84.6	85.6	83.8
12.	81.6	76.0	83.0	79.6	75.3	79.0
13.	80.6	66.0	78.3	75.0	60.3	72.0
14.	79.3	77.6	72.0	81.0	75.3	77.0
						76.5

Group Average - End-of-Season - 76.5

Table VI indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This End-of-Season data will be compared with Early Season and Mid-Season recordings of this Inexperienced Group.

TABLE VII

EARLY SEASON DATA - CONTROL GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	85.6	93.6	90.0	87.6	84.0	88.2
2.	89.6	96.0	92.6	89.6	89.3	91.4
3.	88.3	92.6	81.3	83.0	83.0	85.6
4.	88.6	89.6	83.6	87.0	86.3	87.0
5.	93.6	89.3	90.6	86.3	87.6	98.6
6.	95.0	95.6	93.3	82.0	85.3	90.2
7.	93.6	99.3	82.6	86.3	85.3	89.4
8.	98.0	90.0	84.0	84.0	88.6	88.8
9.	82.3	88.0	89.6	80.3	82.3	84.4
10.	89.6	91.6	83.3	83.3	85.6	86.6
11.	92.6	99.6	86.0	80.3	88.0	89.2
						88.1

Group Average - Early Season - 88.1

Table VII indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This Early Season data will be compared with Mid-Season and End-of-Season recordings of this Control Group.

TABLE VIII

MID-SEASON DATA - CONTROL GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	93.6	83.0	103.6	85.3	89.0	91.0
2.	89.0	95.3	96.0	82.0	93.0	91.0
3.	87.6	77.3	85.3	87.3	84.6	84.4
4.	90.0	84.0	85.6	83.0	81.6	84.8
5.	83.3	82.0	83.6	86.0	85.6	84.0
6.	98.3	92.5	98.6	86.6	90.3	93.2
7.	88.0	82.0	85.6	91.6	86.6	86.8
8.	84.0	76.6	79.6	85.0	87.3	82.4
9.	76.3	78.0	81.6	85.3	85.0	81.2
10.	94.3	84.3	81.0	79.6	89.6	85.8
11.	89.3	78.3	95.6	86.3	81.6	86.2
						86.4

Group Average - Mid-Season - 86.4

Table VIII indicates the average time for three trials recorded each day. The five day average for each subject is the average time for fifteen trials.

This Mid-Season data will be compared with Early Season and End-of-Season recordings of this Control Group.

TABLE IX

END-OF-SEASON DATA - CONTROL GROUP

Subject #	1st day ave.	2nd day ave.	3rd day ave.	4th day ave.	5th day ave.	Average for 5 days
1.	85.6	93.3	85.3	80.6	86.3	86.2
2.	92.0	91.6	85.6	78.0	85.3	86.6
3.	77.3	78.6	83.6	80.6	89.0	81.8
4.	83.6	86.0	82.3	80.6	86.3	83.6
5.	78.6	86.3	84.0	84.3	86.3	83.2
6.	92.0	98.6	85.6	96.6	95.3	93.6
7.	82.0	84.3	87.3	79.6	89.6	84.4
8.	81.0	78.3	86.3	84.0	84.3	82.8
9.	83.6	82.0	69.0	88.6	85.0	81.6
10.	83.3	80.6	87.3	87.6	84.0	84.6
11.	82.0	89.0	83.0	73.0	88.3	83.0
						84.6

Group Average - End-of-Season - 84.6

Table IX indicates the average time for three trials recorded each day. The five day average for each subject is the average time of fifteen trials.

This End-of-Season data will be compared with Early Season and Mid-Season recordings of this Control Group.

TABLE X

COMPARISON OF DATA - EXPERIENCED GROUP

Subject #	Early Season Average	Compare Early Season and Mid-Season	Mid-Season Average	Compare Mid-Season and End-of-Season	End-of-Season Average	Compare Early Season and End-of-Season
1.	80.4	+2.8	77.6	+7.0	70.6	+9.8
2.	80.4	+2.4	78.0	+5.8	72.2	+8.2
3.	87.0	+7.4	79.6	+2.8	76.8	+10.2
4.	79.6	+4.0	75.6	-0.6	76.2	+3.4
5.	90.4	+11.2	79.2	+1.6	77.6	+12.8
6.	83.0	+0.4	82.6	+11.6	71.0	+12.0
7.	82.2	+3.2	79.0	+15.6	63.4	+18.8
8.	83.6	+5.2	78.4	+4.8	73.6	+10.0
9.	84.4	+6.2	78.2	+0.4	77.8	+6.6
10.	81.4	+3.2	78.2	+13.4	64.8	+16.6
11.	83.2	+2.8	80.4	+1.6	78.8	+4.4
12.	84.4	+2.4	82.0	+11.2	70.8	+13.6
13.	82.6	+0.6	82.0	+11.2	70.8	+11.8
14.	84.0	+4.0	80.0	+4.0	76.0	+8.0
15.	86.0	+7.8	78.2	+3.8	74.4	+11.6
16.	84.4	+5.4	79.0	+8.8	70.2	+14.2
17.	82.2	+3.6	78.6	+6.0	70.6	+9.6
18.	85.8	+7.6	78.2	+4.0	74.2	+11.6
	83.6	+4.4	79.2	+6.3	72.9	+10.7

Group difference between Early and Mid-Seasons - +4.4

Group difference between Mid and End-of-Season - +6.3

Group difference between Early and End-of-Season - +10.7

TABLE XI

COMPARISON OF DATA - INEXPERIENCED GROUP

Subject #	Early Season Average	Compare Early Season and Mid-Season	Mid-Season Average	Compare Mid-Season and End-of-Season	End-of-Season Average	Compare Early Season and End-of-Season
1.	87.6	-0.2	87.8	+8.8	79.0	+8.6
2.	93.0	+4.2	88.8	+3.2	85.6	+7.4
3.	93.6	+14.8	78.8	+5.2	73.6	+20.0
4.	88.0	+8.6	79.4	+8.4	71.0	+17.0
5.	88.8	+1.8	87.0	+11.0	76.0	+12.8
6.	92.4	+12.6	79.8	+5.2	74.6	+17.8
7.	92.8	+9.4	83.4	+7.4	76.0	+16.8
8.	91.2	-2.6	93.8	+16.8	77.0	+14.2
9.	91.6	+2.6	89.0	+12.7	76.3	+15.3
10.	86.0	+5.0	81.0	+11.0	70.0	+16.0
11.	98.6	+16.4	82.2	-1.6	83.8	+14.8
12.	97.0	+9.6	87.4	+8.4	79.0	+18.0
13.	93.8	+14.2	79.6	+7.6	72.0	+21.8
14.	94.4	+10.6	83.8	+6.8	77.0	+17.4
	92.1	+7.7	84.4	+7.9	76,5	+15.6

Group difference between Early and Mid-Season - +7.7

Group difference between Mid and End-of-Season - +7.9

Group difference between Early and End-of-Season - +15.6

TABLE XII

COMPARISON OF DATA - CONTROL GROUP

Subject #	Early Season Average	Compare Early Season and Mid-Season	Mid-Season Average	Compare Mid-Season and End-of-Season	End-of-Season Average	Compare Early Season and End-of-Season
1.	88.2	-2.8	91.0	+4.8	86.2	+2.0
2.	91.4	+0.4	91.0	+4.4	86.6	+4.8
3.	85.6	+1.2	84.4	+2.6	81.8	+3.8
4.	87.0	+2.2	84.8	+1.2	83.6	+3.4
5.	98.6	+14.6	84.0	+0.8	83.2	+15.4
6.	90.2	-3.0	93.2	-0.4	93.6	-3.4
7.	89.4	+2.6	86.8	+2.4	84.4	+5.0
8.	88.8	+6.4	82.4	-0.4	82.8	+6.0
9.	84.4	+3.2	81.2	-0.4	81.6	+2.8
10.	86.6	+0.8	85.8	+1.2	84.6	+2.0
11.	89.2	+3.0	86.2	+3.2	83.0	+6.2
	88.1	+1.7	86.4	+1.8	84.6	+3.5

Group difference between Early and Mid-Season - +1.7

Group difference between Mid and End-of-Season - +1.8

Group difference between Early and End-of-Season - +3.5

TABLE XIII

SUMMARY OF DATA - ALL GROUPS

Experienced Group	
Early Season Average	83.6
Mid-Season Average	79.2
End-of-Season Average	72.9
Difference between Early and Mid-Season	+4.4
Difference between Mid and End-of-Season	+6.3
Difference between Early and End-of-Season	+10.7
Inexperienced Group	
Early Season Average	92.1
Mid-Season Average	84.4
End-of-Season Average	76.5
Difference between Early and Mid-Season	+7.7
Difference between Mid and End-of-Season	+7.9
Difference between Early and End-of-Season	+15.6
Control Group	
Early Season Average	88.1
Mid-Season Average	86.4
End-of-Season Average	84.6
Difference between Early and Mid-Season	+1.7
Difference between Mid and End-of-Season	+1.8
Difference between Early and End-of-Season	+3.5

TABLE XIV

DISTRIBUTION RANGE OF GROUP DATA

EXPERIENCED GROUP

Early Season (18 subjects)

Distribution Range of Scores

79.6 to 79.9	1
80.0 to 84.9	13
85.0 to 89.9	3
90.0 to 90.4	1

Low Score	79.6
High Score	90.4
Early Season Average	83.6

Mid-Season (18 subjects)

Distribution Range of Scores

75.6 to 79.9	13
80.0 to 82.6	5

Low Score	75.6
High Score	82.6
Mid-Season Average	79.2

End-of-Season (18 subjects)

Distribution Range of Scores

63.4 to 64.9	2
65.0 to 69.9	0
70.0 to 74.9	10
75.0 to 78.8	6

Low Score	63.4
High Score	78.8
End-of-Season Average	72.9

TABLE XV

DISTRIBUTION RANGE OF GROUP DATA

INEXPERIENCED GROUP

Early Season (14 subjects)

Distribution Range of Scores

86.0 to 89.9	4
90.0 to 94.9	8
95.0 to 98.6	2

Low Score	86.0
High Score	98.6
Early Season Average	92.1

Mid-Season (14 subjects)

Distribution Range of Scores

78.8 to 79.9	4
80.0 to 84.9	4
85.0 to 89.9	5
90.0 to 93.8	1

Low Score	78.8
High Score	93.8
Mid-Season Average	84.4

End-of-Season (14 subjects)

Distribution Range of Scores

70.0 to 74.9	5
75.0 to 79.9	7
80.0 to 84.9	1
85.0 to 85.6	1

Low Score	70.0
High Score	85.6
End-of-Season Average	76.5

TABLE XVI

DISTRIBUTION RANGE OF GROUP DATA

CONTROL GROUP

Early Season (11 subjects)

Distribution Range of Scores

84.4 to 84.9	1
85.0 to 89.9	8
90.0 to 94.9	1
95.0 to 98.6	1

Low Score	84.4
High Score	98.6
Early Season Average	88.1

Mid-Season (11 subjects)

Distribution Range of Scores

81.2 to 84.9	5
85.0 to 89.9	3
90.0 to 93.2	3

Low Score	81.2
High Score	93.2
Mid-Season Average	86.4

End-of-Season (11 subjects)

Distribution Range of Scores

81.6 to 84.9	8
85.0 to 89.9	2
90.0 to 93.6	1

Low Score	81.6
High Score	93.6
End-of-Season Average	84.6