AN INVESTIGATION OF THE RELATIONSHIP BETWEEN GRIP STRENGTH AND ACHIEVEMENT IN PHYSICAL EDUCATION

Thesis for the Degree of M. A.

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Wayne Franklin Tinkle

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A THESIS

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

MASTER OF ARTS

Department of Health, Physical Education, and Recreation

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W. F. T.

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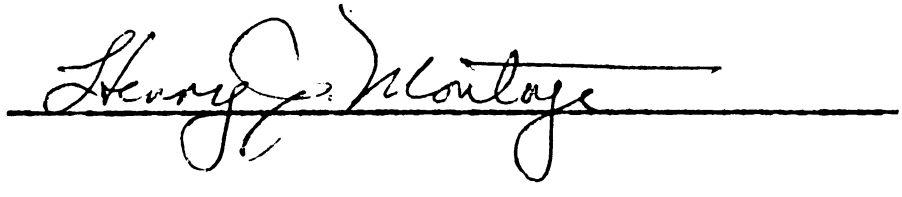
Approved 

WAYNE FRANKLIN TINKLE ABSTRACT

Many studies have indicated that grip strength is an important factor in physical fitness, athletic ability, general strength, and general organic vigor. It was the purpose of this investigation to correlate grip strength with achievement in physical education among college men. The subjects for this experiment were six hundred and thirty-five college freshmen and sophomore men who were participating in physical education activities. Their right and left grip strength were measured, together with age, height, and weight. Grip strength was then correlated with the final letter grade received in physical education. Pertinent intercorrelations of these measurements were investigated.

Conclusions

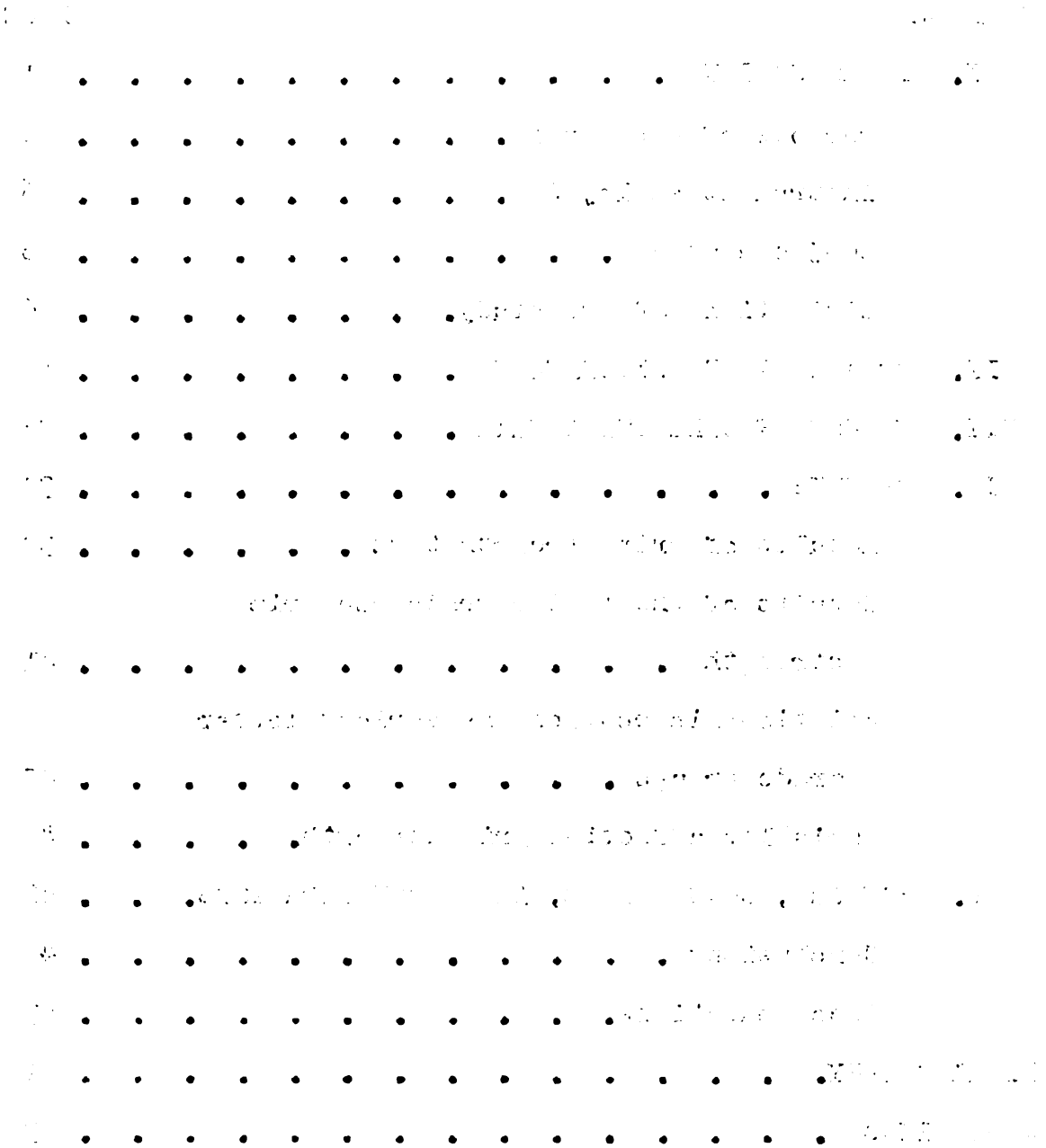
After a statistical analysis was made, the following conclusions appear justified:

1. Grip strength is important to achievement in physical education at Michigan State University.

2. Right grip strength is highly correlated with left grip strength.

3. A significantly larger proportion of left handed men have stronger right hands, as compared to right handed men with stronger left hands.

4. College students who are physically weak could benefit from a course to improve strength.



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CHAPTER I

INTRODUCTION

The practical problems of everyday physical activities are the concern of everyone. It is not only the athlete or the student of physical education who is affected by varying degrees of speed, endurance, strength, and skill during work or play. Every person is vitally affected by the capacity and limitations of his body, the most effective ways of relieving or delaying fatigue, and the possible techniques for improving physical fitness and efficiency.

One of the most important elements in any muscular contraction or correlation is strength. Activities such as weight-lifting or wrestling demand more muscular effort during each contraction than does walking or jumping out of the path of a car. The reasons for their extra muscular effort is that large muscle groups are used vigorously. The strength of a muscle and the amount of work it can do depends upon its cross section construction, which can be increased by exercise.[1] As muscle fibers are unable to

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[1]Peter V. Karpovick, Physiology of Muscular Activity (Philadelphia and London: W. B. Saunders Co., 1953), p. 13.

reproduce, any increase must be due to changes within the fibers present, such as thickening and toughening of the sarcolemna and increase in the amount of connective tissue within the muscle. In every muscle there are latent or unused fibers and fibers that are small from lack of use. These muscles will develop in response to the increased demand made upon them.[2]

The actual gain in power of a muscle as a result of use, however, is out of all proportion to its gain in size; therefore, the quality of the contraction is improved. Such factors as the following account for this change: fuel is made more available and in greater amounts; oxygen is more abundant, owing to improved circulation of blood through the muscle; and better coordination of the action of the individual muscle fibers and more complete use of all fibers are realized. Functionally, the strength and effectiveness of the stimulus are an important factor in the actual realization of muscle power. Exercises involving strong muscular contractions, repeated until fatigue sets in, contribute to the development and coordination of these factors,

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[2] Ibid., p. 5-6.

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and results in the increased strength of muscles and the ability to apply muscular power effectively.[3]

These are some of the reasons why body strength must always be a paramount concern to the physical educator, as upon it depends the individual's ability to learn physical skills, to maintain body vigor, and to resist fatigue. Moreover, endurance is based upon strength. No one can be expected to take an active role in physical education activities if he is physically weak and inefficient.

In "competitive" activities, educational objectives and precepts of fair play will be realized most completely only when the powers of opposing teams or individuals have been equalized.[4] There are, of course, many viewpoints concerning equalization of competition. Rogers[5] lists the following as educational values of equality:

> 1. Present health is best protected and promoted when opponents are equal. Players enjoy the game more: joy is a great immediate health tonic. It is even possible that the total effects on health and vitality of a game of checkers played with intense enjoyment

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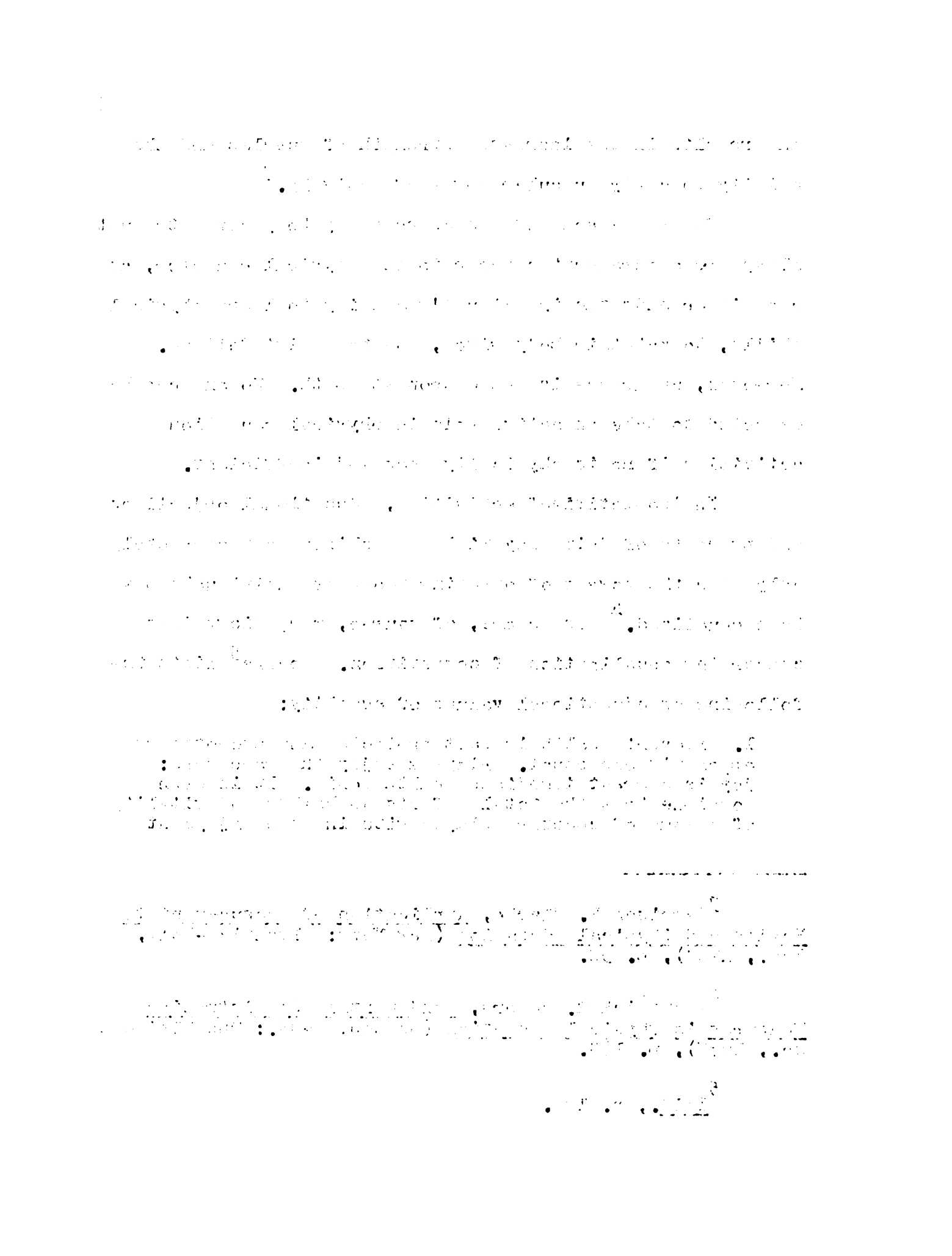
[3]Harrison H. Clarke, Application of Measurement to Health and Physical Education (New York: Prentice-Hall, Inc., 1950), p. 58.

[4]Frederick R. Rogers, Fundamental Administrative Measures in Physical Education (Newton, Mass.: The Pleiades Co., 1937), p. 130.

[5]Ibid., p. 133.



will be more beneficial than a basketball battle "played" under protest in a spirit of rebellion and hate. On the other hand, when opponents are badly matched, especially in physical strength, the weaker player will be harmed or will harm himself physically. It is a curious fact that scholastic players often forget that joy and satisfaction are always keenest when opponents are equally matched.

2. Enjoyment also leads to habits of playing. Such habits serve to assure future health. If opponents are badly matched, especially in physical power, there will be less desire to renew the contest or to repeat the experience with others.

3. Courage and perseverance may be acquired by meeting, without flinching, the many new and dangerous situations which team game events provide. But satisfaction must attend if courage or perseverance is to be strengthened. It is essential that the situation not be too difficult for the strength, physical or moral, of the student.

4. Self-respect and self-confidence may be learned if satisfaction attends activities. If shame attends there will be learning, but it will be self-pity, an inferiority complex and perhaps worse qualities.

5. Fair play can only be inculcated by teaching students to refuse to give or receive advantages. A habit of bullying will result if students are taught to accept and take advantage of opponents' weaknesses.

6. Cooperation will be learned when players derive satisfaction through submerging their egos in group accomplishment. The team game situation is an ideal one in which to learn this equality.

7. Courtesy and sympathy may be learned by actually thinking of "the other fellow." When a team wins today and loses tomorrow (this is the rule only when opponents are nearly equal) generous sympathy for losers and proper respect for winners may be learned. It must be apparent that the foregoing values or objectives in some respect coincide with most physical educators' philosophy toward this field.

Ability grouping is an important pedogogical procedure. There is doubt in the minds of experienced physical educators that class instruction is more efficient when the abilities of groups are similar. Heterogeneous grouping presents a serious problem in class instruction, as class work is usually geared to the ability of the less able pupils. Instruction adapted to the ability of the average student becomes too difficult for the poor performers and too easy for the good ones. Equating, however, brings together students of equal ability, all of whom are ready for instruction on the same level.

It is stated in H. Harrison Clarke's text, Application of Measurement to Health and Physical Education[6], that homogeneous grouping may also be far more important in physical education than in scholastic phases of the educational program. The manner of an individual's participation in many physical activities is dependent to a large extent upon what he does and how he reacts to the actions of those with whom he is participating. For example, the greatest football player cannot catch a forward pass if the ball is thrown badly. Correlative and oppositive efforts of this sort are not required in English, mathematics, or other academic classes.

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[6]Clarke, op. cit., p. 222.

Purpose of the Study It is the purpose of this study to ascertain the correlation between a single test of strength and the achievement of a group of college men participating in a physical education activity program. If a high correlation is forthcoming, the strength test used may be of real value to physical education for use in classifying heterogenous groups.

Instrument Employed The Narragansett hand dynomometer apparatus was selected for the testing instrument. Because of its economical and expedient value, the hand dynomometer was believed by the writer to be one of the most practical measuring instruments obtainable by schools interested in conducting a program of classification within their physical education department.

Subjects Used The answer to the question proposed by this study was obtained through analysis of the data gathered on six hundred and thirty college freshmen and sophomores. These men were taking part in a required program of physical education activities at Michigan State University.

Limitations of the Study One limitation that might be significant is the procedure used in testing the subjects. The tester was granted permission to be present when certain physical education classes were in session. He then

went from squad to squad giving the grip strength test. Each group received a single explanation and was then tested for grip strength. In the event that a subject's hand or fingers slipped, he was retested at the end of that testing period. Only two tests were taken with each hand. It was, therefore, felt by the tester that the students who were tested again may have had some advantage because of a practice attempt and were more highly motivated in that they wanted to score higher on the second test. It should, however, be made clear that only very few received a second test.

The only motivational factor was an individual's desire to surpass the score of the others in his squad. This may have been a limitation if some of the men felt they were weak and therefore did not exert maximum effort. It is also feasible that this single motivating factor could produce maximum effort on the part of all the men tested.

Although this writer presents no evidence of the influence of the time of day on physological output, it may have been a factor in this study. Since these tests were given during the regular class periods, testing was in progress from eight o'clock in the morning until five o'clock in the afternoon.

Another limitation which could affect this study is the week within the school term in which the men were tested.

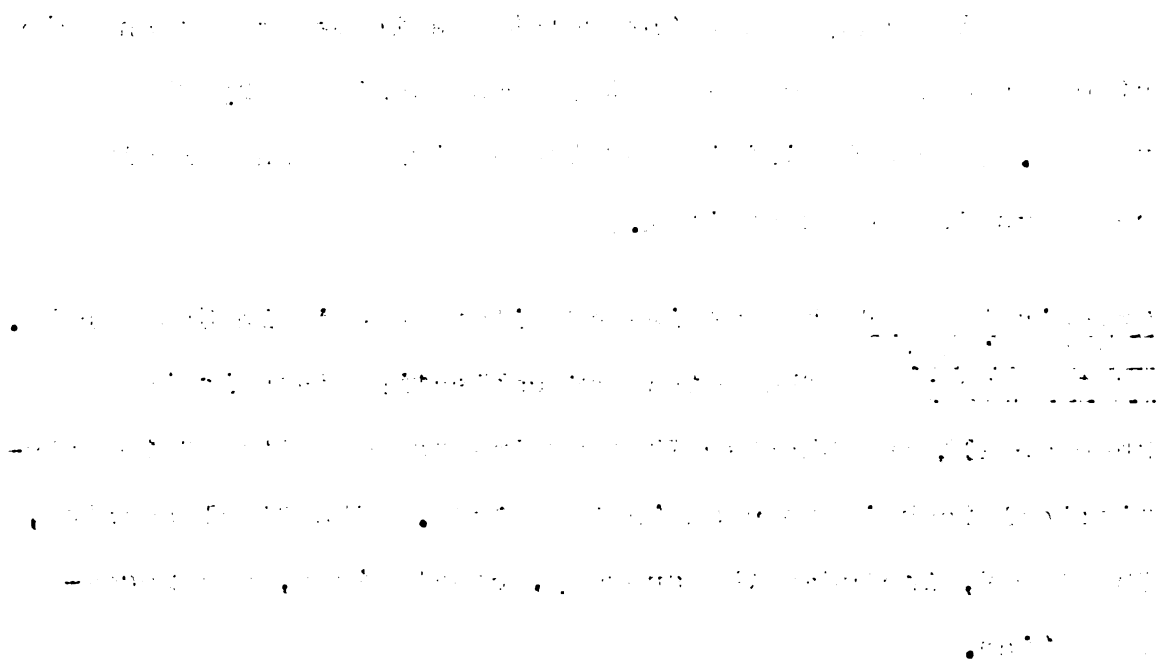
In testing six hundred and thirty-five men during regular classes, it was impossible to cover all the classes in one day or even one week. Consequently, some men may have had an opportunity to improve their grip strength by participating longer in physical activities than some of the others tested.

The results of this study could also have been affected by the differences in the individuals grading the subjects for their test. Even though a similar grading scale was used [See Appendix A], individual instructors will grade differently. This one possible limitation could, however, be one of the most positive factors in this study, for if the grip strength scores correlate highly with the letter grade received, regardless of the grader, it would apparently be a good test of the relationship of grip strength to achievement measured by a letter grade in physical education activity courses. The courses selected are defined in Appendix A.

The apparatus used in this study may have been a limitation. The measuring scale of the Narrogansett Grip Strength Measuring Instrument was calibrated from 0 to 200 pounds. In calibration, no error greater than one pound was observable, yet one limitation of this instrument is that it cannot be adjusted to better fit the hand size of the different men being tested. This would make it possible for the men whose hands fit the instrument to be measured more accurately.

This study shows the relationship between mean grip strength scores and the letter grade achieved by the men tested. [For a definition of the activities and grading scale used, see Appendix A.]

Organization of the Remainder of the Study The review of literature is in Chapter II. The method of collecting data is in Chapter III, and Chapter IV contains the results of the statistical techniques used in the study. The final chapter, Chapter V, includes the summary, conclusions, and recommendation.



CHAPTER II

REVIEW OF THE LITERATURE

A great many physical educators indicate increasing interest in finding a test that will measure objectively the fitness of the body as a whole; a test, according to Clarke[1], that will be sensitive to the effects upon the organism of lack of exercise, of faulty health habits, and of organic drains; a test that can be understood, interpreted, and used by individuals trained in physical education. Not only is a test needed for evaluating the physical fitness benefits of the physical education program, but such a test is needed also to select those boys and girls who are deficient in this essential quality, so that their particular needs may be studied and improved.

Strength tests, although they do not measure all aspects of fitness as physical educators view the problem, do deal with a basic element of the individual's general physical status. They have been used successfully in practical field situations, both as a means of selecting

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[1]Harrison H. Clarke, Application of Measurement of Health and Physical Education (New York: Prentice-Hall, Inc., 1950), p. 58.

students for remedial and developmental classes and for general classification in physical activities.

If it were possible to isolate an individual muscle used in any skill, the measured strength test of that muscle would be the best general measure of particular skills, short of repetition of the skills themselves. The pianist has strong forearms; the archer strong extensor muscles in the left upper arm, strong flexor muscles in the right forearm and upper arm, also strong back muscles. The swimmer is well developed throughout his body. The runner has strong legs, etc. This, of course, says Rogers[2], is due to the constant use of the muscles involved.

Rogers[3] also states that as a general measure of all-round skill, probably no measures have higher validity than those of strength. Dynamometers are reliable, objective, economical, and interesting measuring devices. Consequently, strength tests by means of dynamometers are among the most useful for measuring general skill.

Although strength is very important to general motor performance, it is not an end in itself.(2) Riedman[4], in her

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[2]Frederick R. Rogers, The Fundamental Administrative Measures in Physical Education (Newton, Mass.: The Pleiades Co., 1937), p. 38.

[3]Ibid., p. 39.

[4]Sarah R. Riedman, The Physiology of Work and Play (New York: The Dryden Press, 1950), p. 173.

book The Physiology of Work and Play, illustrates in fact that development of strength for its own sake may have distinctly harmful effects. As an objective, the mere development of the size and power of the muscles has no meaning. Bulging muscles and weight-lifting power may have "stunt" value, but do not necessarily add to the effectiveness of motor ability or endurance. Strength, however, is essential as a requisite for successful participation in physical activity, for learning new skill, and for maintaining the support of the trunk and internal organs.

The positive and very high correlation of muscular strength to general health, physical fitness, or capacity for activity can hardly be questioned. With no strength there can be no physical activity; moreover, when muscular strength is low, all other life functions are handicapped. Physical educators are coming increasingly to recognize, therefore, that the development of muscular strength is of prime importance in any rational physical education program, although there are limits beyond which it is improper to go in the improvement of any particular individual's physical power.[5]

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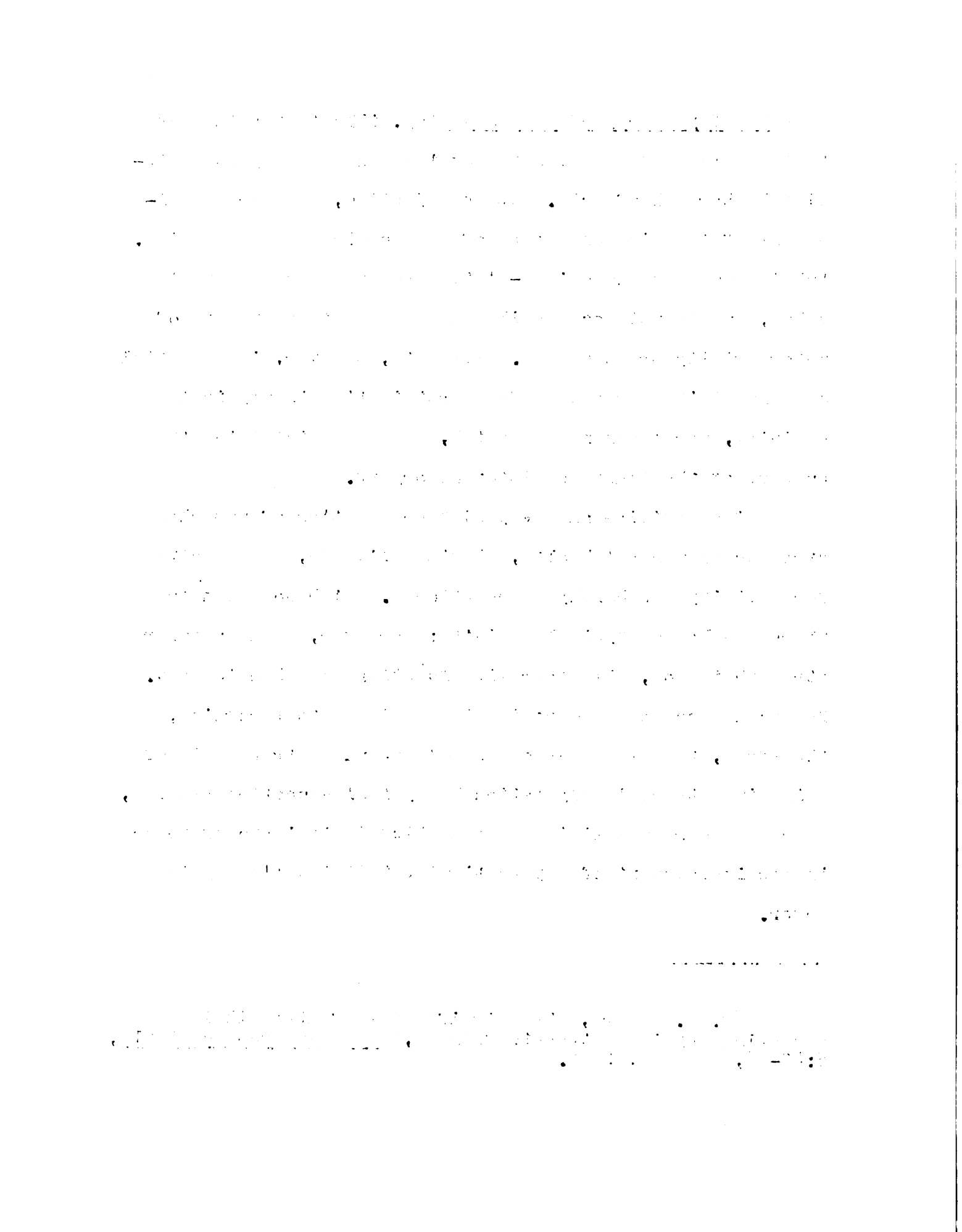
[5] F. R. Rogers, "The Significance of Strength in Revealing Physical Strength Fitness," The Research Quarterly, 5:43-46, October, 1934.



In the latter connection, the training curve obtained by Karpovick and Pestrecov[6] on inmates of a county jail and of college students is significant. The subjects worked on stationary bicycles five days a week, pedaling as long as possible, until exhaustion supervened. The investigators discovered that "training curves" were not the same for the different men. The reason given for this dissimilarity was the great difference in the relative strength of the men.

The stronger men among both the jail inmates and the students increased in endurance, and more rapidly than did the weak ones. When the experiment began in the jail, certain men had such poor physical strength that four weeks were spent in general body-building exercise. Strength was shown definitely to be of importance in developing endurance.

The importance of muscular system in education is stated uncompromisingly by J. M. Tyler in Growth and Education:[7]

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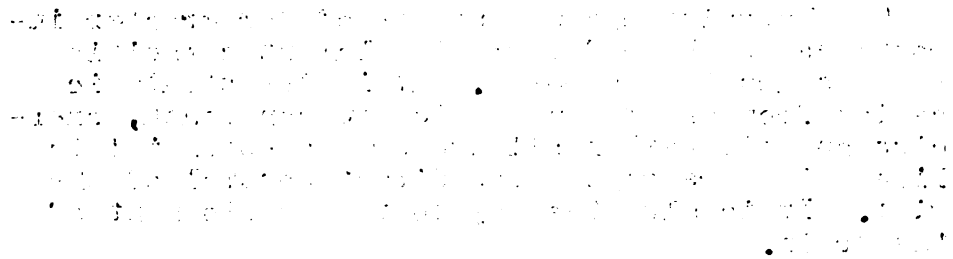
[6]Clarke, op. cit., p. 59.

[7]John Mason Tyler, Growth and Education (New York: Houghton Mifflin Co., 1907), p. 39.

> The Muscular System must be of far greater importance and have far greater latent capacities than we usually supposed. It is the strategic center from and through which we can reach, exercise and strengthen all the organs essential to life which are beyond the direct control of the will. It is also the key to the development of the brain.

The development and proper use of the muscular system is considered the key-note to successful program of physical education; therefore, physical educators have spent much time, energy, and effort to develop tests that would indicate the degree of development or the potential of the muscular system. It is apparent that tests of qualities such as locomotion, manipulation, transportation, coordination, and strength are valid measures of physical capacity. Specifically, any strains or drains of the physical structure will be reflected in weaker musculature and any deficiencies of structure or function will also be reflected.

The best proof of the validity of strength tests as measures of physical capacity is yielded by observations available to anyone. When activity is restricted by disease, the patients lose their strength rapidly. The muscular weakness of invalids is proverbial. Their fitness for "purposeful physical activity" is admittedly low. It is interesting, by comparison, to observe the rapid improvement in the strength of convalescents. We observe their muscles gaining power by use. Again, health and strength are highly correlated. If one were to speak with a trainer



of any athletic team, he could supplement the above observations with many others. A common cold is reflected by weaker musculature; sprained joints have great effect on performance. Even fatigue and undernourishment are reflected in the disease of efficiency in body performance.

It is possible to find a great many tests dealing with strength in physical education literature. All of these tests are important to the physical educator in that they furnish him with the physiological factors that determine the reactions of his students to the program. Physical measures such as lung capacity, grip strength, back strength, leg strength, arm strength or combinations of all these are usual tests administered by physical educators.

The tests mentioned do not measure all voluntary muscles, or even all the larger muscles generally considered to be of paramount importance to physical activity. A large sample of these is measured, however, including practically all of the more important muscle groups. Moreover, the relationship between the strength of various muscle or muscle groups must be fairly high, because it would be almost impossible to exercise one muscle or a group of muscles without involving other parts of the anatomy, as it would be to grade a part of a student's performance.

The instructor who wishes to rank his pupils by objective tests must be certain that the tests have a

coefficient of reliability of at least .8. Unless the tests have that degree of reliability, the instructor cannot be sure that he is ranking his pupils accurately. In selecting tests, the choice should be made when possible from those which give proof of acceptable reliability. In reading the literature on physical education tests, the student will find that much of the early work was done without consideration of reliability, and that tests have been devised and used without a check for this essential element. The work which is based on such tests is as likely to be inaccurate as would be the measuring time with which a watch if the watchmaker put his instrument together and placed it on the market without checking its accuracy.[8]

To determine the general and specific purposes which should underlie the physical education programs in our schools, many tests have been developed and used. Some, of course, have been more useful to the field of physical education than others. One of the methods of measuring general skill or athletic ability is by sampling and testing specific representative skills. An excellent example of

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[8] G. M. Rusch and G. D. Stoddard, Tests and Measurements in High School Instruction (Yonkers-on-Hudson, New York: World Book Company, 1927), p. 57.

this type is the Cozens' "Measure of General Athletic Ability for College Men."[9] It consists of seven tests, scored by multiplying the tests made, and by adding the resulting scores. The test is conducted as follows: the instructor counts the number of dips on parallel bars times 6, plus baseball throw per distance [12 inch ball] times 1.5, plus football punt for distance times 1.0, plus standing broad jump times 1.0, plus quarter mile run times 1.2, plus long dives times 7, plus a dodging run times 1.0.

Though the validity and reliability of this test is higher than that of the strength index, it is expensive in time and apparatus. As yet no norms have been developed for weight and age.

A number of other tests of general athletic ability have been devised. These usually include tests of running and jumping, and the handling of balls. In 1905 Meylan[10] set up a general measure by combining strength tests with physicians' health ratings, an endurance test, and four tests on gymnastic apparatus. Points were assigned on an arbitrary basis, but no reliable norms were established.

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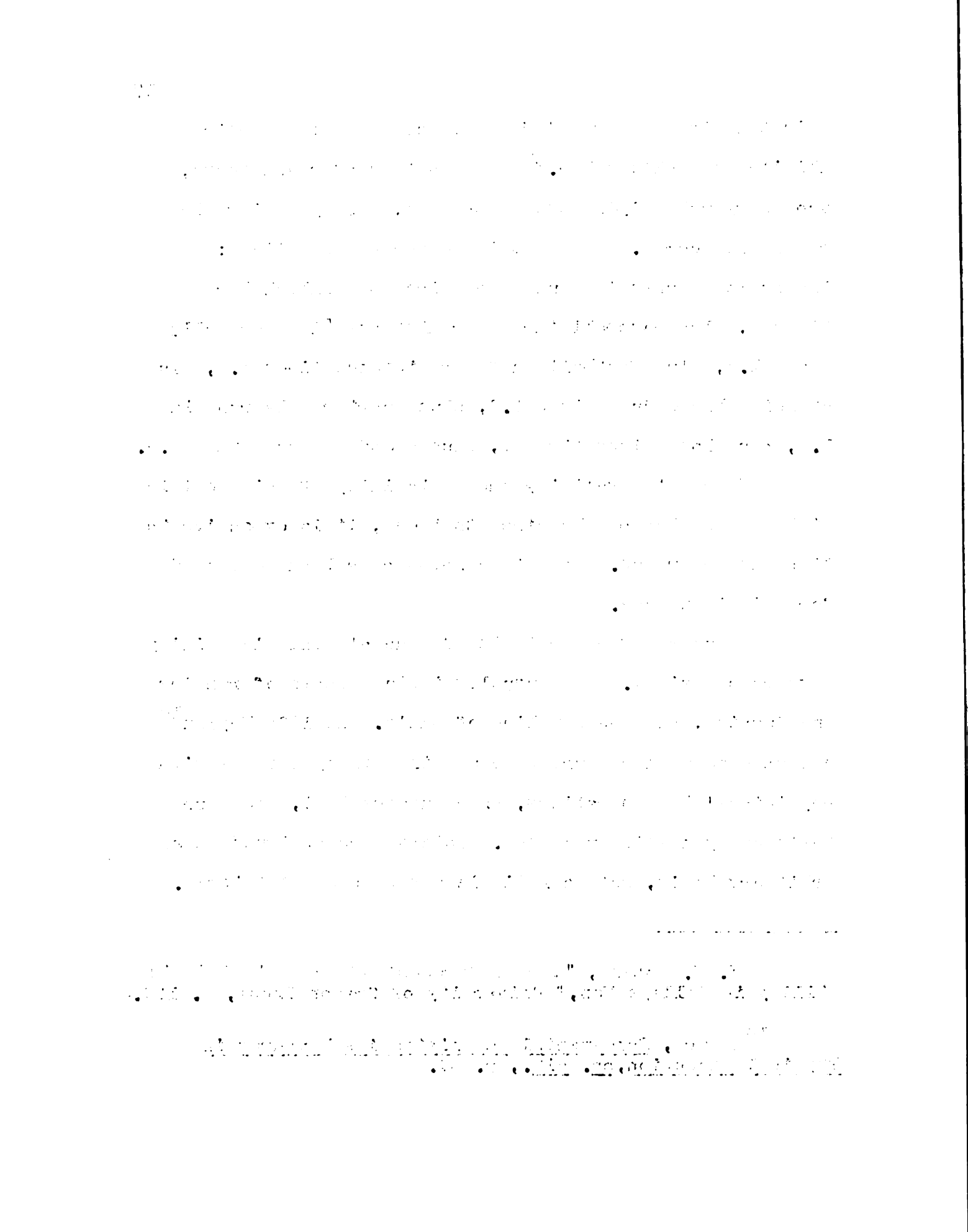
[9]F. W. Cozens, "The Measurement of General Athletic Ability in College Men," University of Oregon Press, p. 129.

[10]Rogers, Fundamental Administrative Measures in Physical Education, op. cit., p. 39.



Other tests followed. The "Sargent Physical Test of Man"[11] has some possibilities as a single measure of "general athletic ability" and has been the subject of several experiments. But it also lacks reliability. Consequently, its validity is low as a measure of any function. In this test the subject jumps vertically as high as possible. The jump is measured by a variety of means devised by Sargent, Schwiger, Engelhardt, Bovard, and Cozens and J. H. McCurdy.[12]

Using shadows and great care in observations McCurdy[13] was able to secure fair reliability by having each subject repeat the test several times on three different occasions and by using the best record. No norms are available for sex, weight, or age, and the test has not been used to determine programs or to measure achievement.

In a discussion of some of the tests for athletic ability, the Brace Test[14] of motor ability should be included. This test was the first of its kind, and at the time it was published it was intended for use as a measurement of general motorability. It was composed of twenty

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[11] Ibid., p. 39.

[12] Ibid., p. 39.

[13] Ibid., p. 40.

[14] David K. Brace, Measuring Motor Ability (New York: A. S. Barnes and Company, 1927), p. 171.

stunts, each of which was scored in terms of success or failure. The number of successive stunts was interpreted in the form of a T score. This test is still regarded as good, but since it was intended to be a test of general motor ability, some stunts were included which were primarily dependent upon strength, and other elements were included which were not particularly related to what is termed motor ability.

General athletic ability is more than skill. In fact, skill by itself is of minor importance in competitive athletic activities, especially where bodily contact, endurance, and supreme efforts are necessary. The most skillful tennis player would be impotent even when opposed to a beginner if the expert were too weak to stand. In other words, muscular strength is the "sine qua non" for athletic performance. Indeed, it is the most important single quality contributing to successful performance in most of the athletic activities of American school boys and college students.[15]

The majority of the tests mentioned thus far have been concerned with general motor ability. Another facet of physical education measurement is that of physical capacity. The individual measures adopted for the "Strength Index" battery are generally called physical capacity tests.

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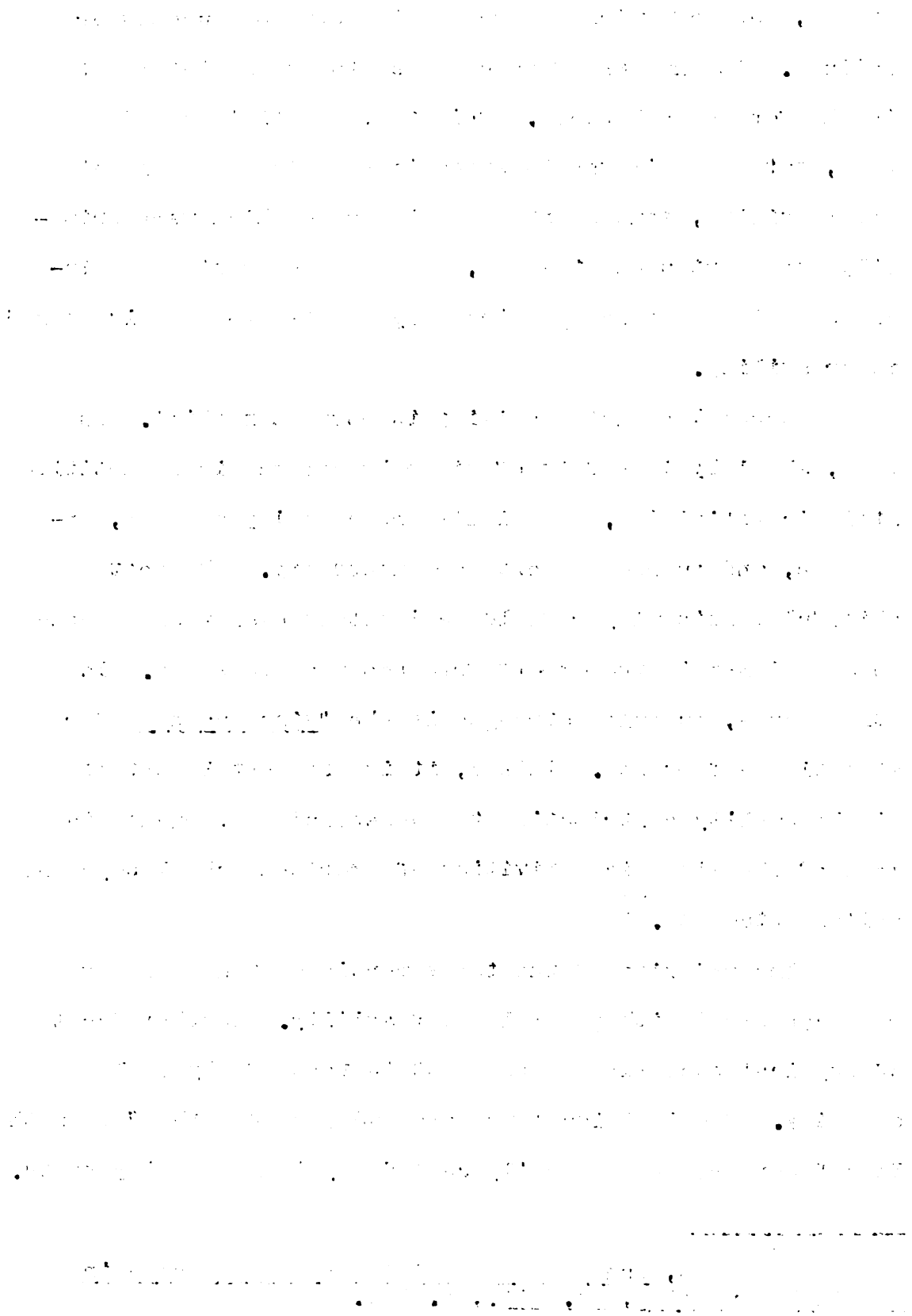
[15]Rogers, Fundamental Administrative Measures in Physical Education, op. cit., p. 136.



They were selected as the most objective, reliable, and valid of a great many strength tests which might have been chosen.

The Physical Capacity test[16] consists of measures of lung capacity, strength of right and left grip, back strength, leg strength, and arm strength. The last is measured by the number of dips and pull-ups scored by a formula which takes weight and height into consideration. The initial purposes of this test were (1) to find a method of classifying boys for athletic competition, and (2) to find a measure of physical fitness.

The author found the test elements to be highly reliable with r's which range from .86 to .97. Only leg strength and back strength were below .9. These reliabilities are high--much higher than the majority of tests in use in physical education. To prove the validity of the measure as an indicator of athletic ability, the scores on the Physical Capacity tests were correlated with an Athletic Index. The Athletic Index consisted of the 100 yard dash, the running broad jump, the running high jump, and the bar vault. These were combined in a single score in which

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[16] Ruth B. Glassow and Marian R. Broer, Measuring Achievement in Physical Education (Philadelphia and London: W. B. Saunders Company, 1943), p. 272.

running was given a weight of 10; high jump, 5; broad jump, 1. The bar vault was omitted from the test, and the shot-put and a measure called skill were added. Skill was "computed by adding points in baseball and football throw [accuracy] tests to 5 times the number of basketball goals scored."[17] In this group, dash, high jump, and shot-put were weighted two and the other elements were weighted one.

Rogers[18] found for high school boys, a correlation of .81 between the Athletic Index and the Physical Capacity Test. Using the measures which are commonly used for classification, age, height, and weight, Rogers found a correlation coefficient of .62. He concludes that the physical capacity score is a better basis for classification for athletes than is the best combinations of age, height, and weight.

The correlation coefficients and Predictive Indices of the computed Athletic Index with physical measures are reported in the table on the following page.

The product-moment correlation coefficient between the Strength Index and the criterion Index of Athletic

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[17] Ibid., p. 272.

[18] Rogers, Fundamental Administrative Measures in Physical Education, op. cit., p. 273.

[illegible]

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Ability was .76. The correlation-ratio was 184. It should be noted here that these correlations are nearly three times as high as the correlation between weight and athletic ability, and nearly twice as high as the correlation between athletic ability and the best theoretical combination of age, height, and weight.

TABLE I

CORRELATIONS AND PREDICTIVE INDICES: ATHLETIC INDEX WITH PHYSICAL MEASURES[19]

Athletic Index With	r	P. I.
Age	.50	.134
Height	.50	.134
Weight	.51	.140
Lung Capacity	.59	.193
Right Grip	.68	.267
Left Grip	.68	.267
Back Lift	.66	.267
Leg Lift	.64	.232
Pushups	.67	.158
Pullups	.59	.193

While studying Rogers'strength norms, Cureton[20] found that the actual computed Pearson r by the scattergram method was r = .321. The data appeared to be quite rectilinear. Age is neglected because age is not closely

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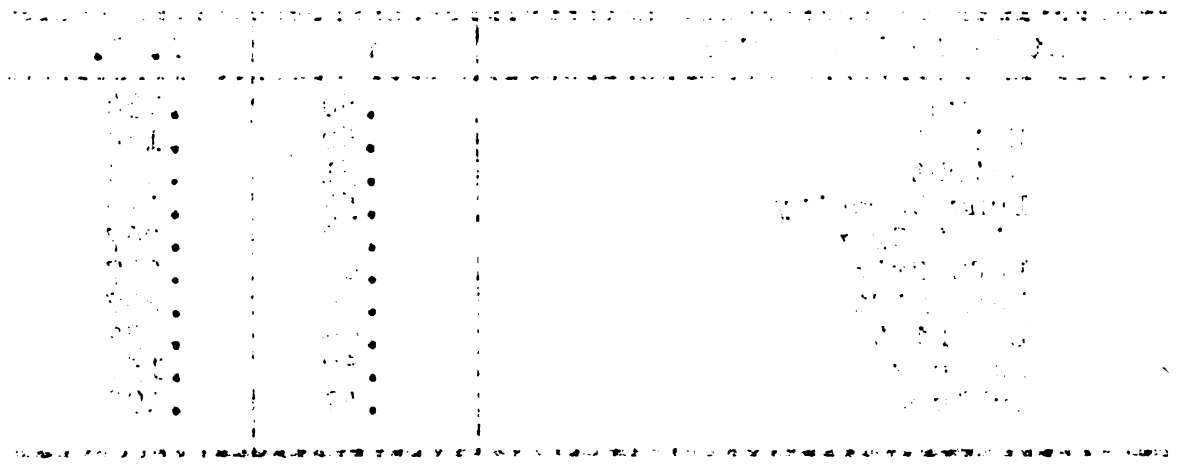
[19] Ibid., p. 137.

[20] T. K. Cureton, Physical Fitness Appraisal and Guidance (New York: The C. V. Mosley Company, 1947), p. 378.



correlated with the Strength Index [r = .1347] in these data. Rogers assumed a perfect correlation with weight, whereas the best line of regression was only a correlation of .321. A multiple regression solution combining height and weight to predict the Strength Index correlated .321. Since age correlates .134 and height correlated .199, weight alone is indicated as the important base for norms within the age span of these college men.

In all studied where strength is a variable, weight seems to be an important factor. In his study on arm strength and athletics, McCloy thought weight was so important that it should be subtracted from strength index formulas. In the use of strength tests the individual's actual strength is decided by the average strength for those of his age and weight.[21] In a person of good muscular development, the muscles constitute approximately forty per cent of the body weight. Increase in weight due to training, would develop the particular muscle weight faster than the entire body weight. Therefore, strength would increase faster than load; and increase in height would be accompanied by an increase in weight.[22] Hence, from a

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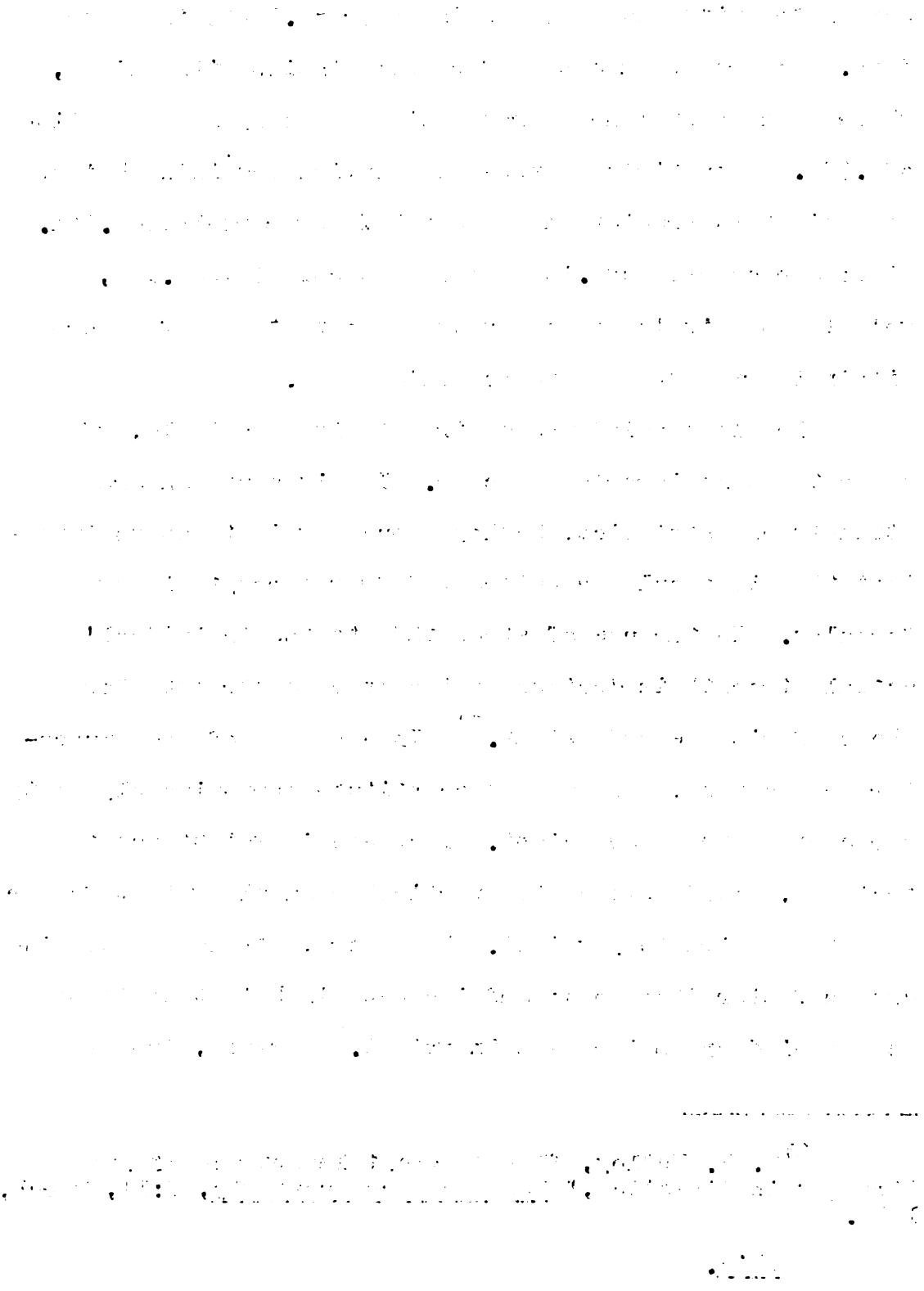
[21]C. H. McCloy, "The Apparent Importance of Arm Strength in Athletics," The Research Quarterly, 2:11, March, 1934.

[22]Ibid.



purely theoretical, mechanical point of view, height alone would seem to have little influence on performance, aside from the accompanying increase in weight.[23]

The correlation between a strength index determined from the test items explained, and a Strength Index derived from any other group of tests measuring other important muscle groups, must be very high--probably above .90 to .90. Intercorrelations among individual tests used in the Strength Index battery are printed in Table II.

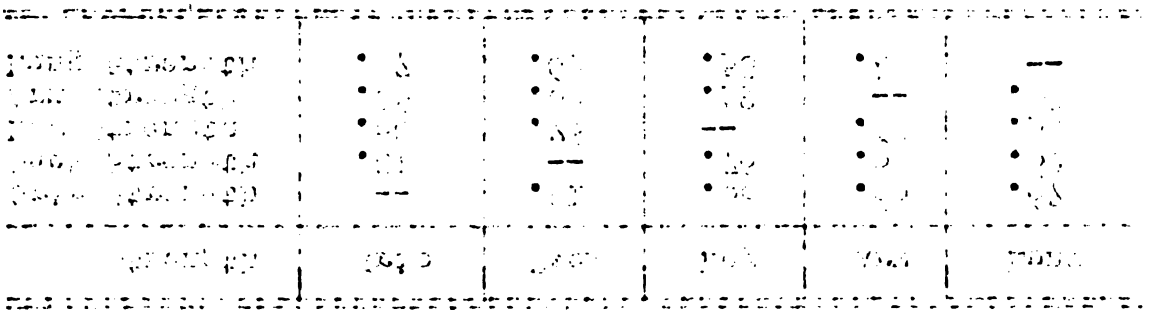
TABLE II

INTERCORRELATIONS OF PHYSICAL CAPACITY TESTS[24]

Strength	Grip	Back	Leg	Arm	Lung
Grip Strength	--	.81	.68	.66	.67
Back Strength	.81	--	.76	.60	.69
Leg Strength	.68	.76	--	.59	.58
Arm Strength	.66	.60	.59	--	.48
Lung Strength	.67	.69	.58	.48	--

[23] C. H. McCloy, Tests and Measurements in Health and Physical Education (New York: Appleton-Century-Crofts, Inc., 1942), p. 26.

[24] Ibid., p. 39.



Strength tests were the earliest and are, perhaps, the most fundamental measures of physical health and vitality available. Certainly they measure functions which are indispensable to normal human life; functions, however, whose improvement yields increased health and happiness to individuals. They are, perhaps, the most fundamental of all measures for physical educators, whose duty is to change behavior "by means of or through large muscle activity."

Another area that has received a great deal of attention has been the testing of physical fitness. Physical fitness can be defined to mean the capacity for purposeful physical activity, not to be identified entirely with physical health. General physical fitness depends predominately on muscular efficiency obtained through exercise. The beneficial effects of exercise are commonly attributed to the development of muscle alone; however, the most significant contribution of rational exercise to body fitness is the effect exercise has in developing the organs of the body. In fact, exercise is the best known means by which we may effect such development.[25]

Objective proof that strength tests measure general physical fitness is illustrated by Smiley.[26] An experimental ??

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[25]Peter V. Karpovick, Physiology of Muscular Activity (Philadelphia and London: W. B. Saunders Co., 1953), p.28.

[26]D. F. Smiley and C. W. Chamberlain, "Functional Health and the Physical Fitness Index," The Research Quarterly, March 1931, p. 193-198.

[illegible]

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sixty-five Cornell Students was chosen at random, each student of whom was given a complete physical examination by the University staff examining physicians, and was rated by Smiley into one of three categories in terms of functional health: If in the opinion of the physician the subject was handicapped in any way that would likely impair his normal efficiency he was rated "C"; those subjects who were in average functional health, and whose defects, if any, were present, were not of a sufficient magnitude to impair their normal functions, were rated "B"; those who were markedly superior, who were free from defects, whose health habits were such that they would likely be in an efficient state day in and day out, were rated "A." The data used to determine health ratings included thirty-seven items.

Following the medical examinations Chamberlain gave strength tests and rated each student as A, B, or C according to the Physical Fitness Index.

The two sets of ratings were then compared. The results are summarized below:[27]

1. The P.F.I. rating agreed with the medical rating in 36 out of 42 average subjects.
2. The P.F.I. rating agreed with the medical rating in 3 out of 5 superior cases.

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[27] Ibid., p. 193.

3. The P.F.I. rating agreed with the medical rating in 13 out of 19 handicapped cases.

4. In the entire group the two ratings agreed in 52 out of 65 cases--an average 80 per cent agreement.

5. The correlation coefficient was .60.

Rogers[28] illustrates the validity of strength tests as measures of general physical fitness by examples of strength tests revealing deficiencies which had not been discovered by medical examination until poor strength test indicated a strain.

These examples by Smiley[29] and Rogers[30] appear to present obvious relationships between strength measures and general physical fitness. The relationships found are of fundamental importance to both the individuals and the physical educator because they correlate higher with personal success and the success of the physical-educator program. The results of physical examination for duty with the Armed Services in each of the World Wars has brought to the front a need for emphasis of the general physical fitness of American males. Physical educators with well-conducted programs of physical education are in a position to carry part

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[28]Rogers, Fundamental Administrative Measures in Physical Education, op. cit.,p.126.

[29]Smiley, op. cit., pp. 193-198.

[30]Rogers, Fundamental Administrative Measures in Physical Education, op. cit., p. 126.

of this responsibility to increase the physical efficiency of American youth.

The tests of primary importance to this study are those concerned with grip strength. Grip strength is concluded to be the earliest and one of the best forms of dynamometer tests used for testing specific muscle groups.[31] The majority of research on grip strength has been in reference to its use as a measure of growth and development and as a test in a battery of tests relative to physical fitness or motor ability.

Rogers,[32] in the original investigation of grip strength as a measure of changing bodily condition, reports a study performed on an adult male subject who, after being trained in the grip-test technique, tested himself once daily or oftener. His findings were as follows:

A. His grip strength dropped 30 points (from 170 to 140) before he was aware of approaching influenza.

B. An unusually fatiguing day (90 holes of golf and a barn dance) resulted in no change in grip strength at bed time, but a drop of 30 points was recorded the following morning.

C. Exhausting fatigue of the forearms caused drops of 35 to 60 points, depending upon the degree of exhaustion induced, with corresponding delay in return to normal.

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[31] W. P. Brown, Applied Anatomy and Kinesiology (Philadelphia: Lea and Febiger, 1949), p. 36.

[32] Frederick Rand Rogers, "The Significance of Strength Tests in Revealing Physical Condition," Research Quarterly, V, 3 (October, 1934), p. 43.

Wylie[33] reports the grip history of a forty year old male subject. His normal grip strength, determined after repeated tests, was 125. For reasons unsuspected at the time, his grip steadily dropped six pounds in three weeks. Diagnosed as afflicted by intestinal parasitism, he was hospitalized and a seven foot tapeworm was removed. During the next eight weeks, the subject's grip rose to 145.

Blakeman, Jackson, and Rogers[34] concluded from a study they conducted that grip tests are likely to prove invaluable to athletic coaches in selecting players and substitutes for any game involving large muscle activity and in deciding when and whether or not to return tired players to games.

The following findings are of special significance to physical education:

1. As compared with "dynamic" strength [dash, broad jump, jump and reach, distance throw], static cynamometric strength is more closely associated with biological growth, suggesting a dependence upon constitutional factors expressed in physical measurements and in physical education.

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[33]James A. Wylie, "1938 Case Reports of Physical Ailments and Grip Strength Tests," (Boston: Boston University, 1938). (Mimeographed.)

[34]Frederick Rand Rogers, "The PFI Analogue and Complement of the I.Q.," School and Society, Vol. 50, No. 1296, (October 28, 1939), p. 546.

2. Among boys, a positive relationship of strength to "prestige" traits is apparent, which is regarded as evidence of the role of physical prowess in the adolescent value system. This relationship is not so definite for girls.

3. Superior strength in boys is a part of a complex physical characteristics valued highly during the adolescent period. The absence of this trait is a handicap whichcan be overcome only by strongly compensating personal traits in other areas also highly valued.

4. (a) Strong boys: A tendency was evidenced for strength to be associated with a good physique, physical fitness, early maturation, social prestige,and social stimulus value and an apparently satisfactory level of personal adjustment.

(b) Weak boys: These boys had a pronounced tendency toward an asthenic physique, later maturation, poor health record, social difficulties and lack of status, feelings of inferiority and personal maladjustment in other areas.

5. (a) Strong boys: These boys were also high in adjustment in most categories, except that of school adjustment. In general they showed an improvement with age.

(b) Weak boys: These boys were poorly adjusted and in general their ratings were marked by downward trends.

Their social reactions tended to be stereotyped either in withdrawal or in extroversion attention-seeking.

Despite the use of meager strength-testing procedures, the Berkley study clearly indicates the importance of physical abilities, especially strength, in the social and psychological adjustment of adolescent boys. Therefore, it becomes obligatory for the physical educator who wished to meet the individual social needs of his boys to consider the adequacy of their basic strength and to take appropriate steps to improve the status of those who are physically weak.

A study by Bookwalter[35] exemplifies the comparative closeness between increases in grip strength and increases in physical growth and development, illustrated by body weight. There were only three prominent irregularities in grip strength growth patterns pointed out. There was a deviation of this growth pattern and grip strength increase at 100--120 pound interval and also a definite drop in grip strength growth or increase after the 200 pound weight interval was reached. In the majority of the sampling there was little increase in grip strength beyond the physical growth of 200 pounds of body weight. The third deviation in the

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[35]Karl W. Bookwalter, "Grip Strength Norms for Males," The Research Quarterly, 50:249, October, 1946.

growth pattern between body weight and grip strength is the difference in acceleration of increased strength of the right and left hand. The left mean grip strength of males from nine to twenty-four years of age and up tends to increase with age. The rate of increase is slow from nine to fourteen; there is a speeding up in the rate of increase of grip strength growth between fourteen and seventeen years of age. The greatest increase in grip strength appears between sixteen and seventeen. A few small irregularities appeared in the mean grip strength scores between seventeen and twenty-four and up, where the rate of growth begins to slow down.

The right grip strength of males also increases between nine and twenty-four years of age. The rate of increase is slow and regular between nine and fourteen years of age. The rate of increase is more rapid between fourteen and seventeen with the greatest increase coming at sixteen years of age. Increase in grip strength is slower beyond sixteen, but regular through twenty-three, with a rise occurring at twenty-four years of age. However, a plateau appears at sixteen, which is less pronounced than that of the left hand. Right hand mean grip strength by age has shown less irregularity than the left hand.

According to Bookwalter's[36] study on grip strength norms for males, it is illustrated that left grip strength

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[36]Bookwalter, op. cit., p. 249.

is consistently lower than the right grip strength, but is more regular in its growth progression. The right grip strength shows more erratic growth progression in that it increases more rapidly at any given body weight intervals than does the left hand. The right grip strength can be from three to thirteen pounds greater than the left grip strength.

Another interesting feature in relation to handedness and growth is that in the American male beyond the age of fifteen, there is about 3 kg. difference in the average grip strength of the right and left hand. Whereas for the Australians the difference was less than 1.5 kg. This fact would indicate that American people who live in a mechanical age are not called upon to be ambidexterous. Likewise, the absence of a marked dextrality in Australians is perhaps the result of social habits and a motion of tool users having a tendency to become more unidexterous.

What is known as ambidexterity[37] is, to a large extent, the result of a social conformity of the naturally left handed individuals. Smidley,[38] in his studies on handedness, also reports the fact that there is a correlation between height and weight and physical measurements. Grip

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[37]Ira S. Wite, Handedness: Right and Left (Boston: Lothrop, Lee and Shepard, Co., 1934), p. 61.

[38]Ibid., p. 190.

strength is correlated between .2 and .3 with height and between .4 and .5 with weight.

Schwartz, Britton, and Thompson[39] in 1928 used grip strength measurements in their investigation of the physical development and posture of school children and adults between the ages of three and sixty-five years. They found that grip strength increased rapidly up to approximately age twenty, but did not reach its maximum until about the age of thirty. After age thirty there was a gradual decline in strength.

In a recent study conducted by Burke, Tuttle, Thompson, Janney, and Weber,[40] data relative to maximum grip strength and grip strength endurance as related to age were collected from 311 male subjects ranging in age from twelve to seventy-nine. The data indicated the following: There is a rapid increase in both maximum grip strength and grip strength endurance from twelve to twenty-five years of age. After the twenty-fifth year there is a gradual decrease in both maximum grip strength and grip strength endurance up

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[39] L. L. Schwartz, R. A. Britton, and L. R. Thompson, Public Health Bulletin No. 179 (Washington: U. S. Public Health Service, 1928), passim.

[40] W. E. Burke, W. W. Tuttle, C. W. Thompson, D. C. Janney, and R. J. Weber, "The Relation of Grip Strength and Grip Strength Endurance to Age," Journal Applied Physiology, 5:628, 1953.

to the age of seventy-nine years. The maximum grip strength and the grip strength endurance of the seventy-five to seventy-nine year age group was approximately equal to that of the twelve to fifteen year old group. The study also suggests that the individuals with the greatest maximum grip strength have a greater grip strength endurance index. These studies point out specific information that show a significant relationship between grip strength and physiological growth and development.

CHAPTER III

METHOD OF COLLECTING DATA

The data for this study were collected during regular sessions of Physical Education activity classes at Michigan State University. The testing began during the second week of the term and continued for the next eight weeks.

In an effort to secure a more complete indication of the relationship of grip strength to general physical achievement, the investigator selected students from various activity courses to be tested. These included appratus stunts, badminton, beginning swimming, beginning tumbling, fencing, trampoline, and wrestling. An explanation of these courses can be found in Appendix A. This variety of courses was also selected as insurance against a specific experience in physical education that might tend to increase or develop grip strength.

It was not the plan of the writer to use grip strength as a competitive tool between classmates, but rather as a measure to use in comparison with the letter grade received in that physical education activity course.

For this reason the tests were given, while classes were in session, but in small groups whenever possible.

The test was administered in the following manner:

1. Magnesium carbonate was put on the hand to insure that the hand was dry.

2. The tester set the indicator on zero and placed the dynamometer face down in the palm of the student's hand, with the larger concave pressing edge to heel of palm. This was done to prevent fingers from hindering the movement of the indicator and to allow the instrument to best fit the student's hand.

3. To prevent the fingers from slipping over the edge, the convexedge of the dynamometer is placed against the fingers rather than the palm.

4. The students were instructed to keep their hand away from the body when making the test.

5. Each student was given two tests with each hand, alternating right and left with a ten second interval between each test.

6. The score was read to the nearest pound. The tests were all given at the same time to reduce the possibility of practice or improved grip strength.

7. Each student was checked to see if he had control of the apparatus. If a student's hand did slip the test was disregarded and repeated after the other men in that group had been tested.

For each student tested the writer was the recorder, reading and recording the grip strength score to the nearest

pound. The following data were recorded on a prepared work sheet: student's name, class, birthday, present age [to the closest month], height to closest inch, weight to closest pound, handedness--right or left, and grip strength score. [See Appendix B for these data.]

So the students would not have opportunity to practice, all the testing was completed in a single class period. The two scores of each hand were recorded, but the better score of each hand was selected to be used in this study.

At the end of the term the investigator was permitted to use all the class records and recorded on the prepared work sheet the letter grades received by each student.

CHAPTER IV

RESULTS

Results of the Grip Strength Test. In an effort to analyze the grip strength test itself, the various trails were intercorrelated. The resulting coefficients appear on Table III.

TABLE III

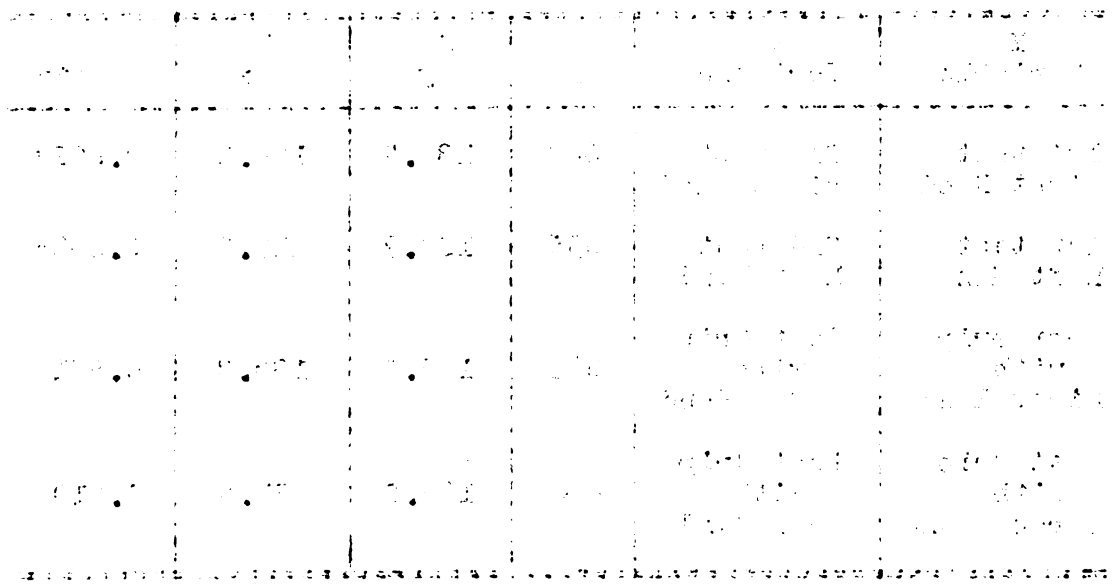
CORRELATION COEFFICIENTS BETWEEN VARIOUS GRIP STRENGTH TESTS

Y Variable	X Variable	N	M y	M x	r**
1st test Right Hand	2nd test Right Hand	642	130.7	128.3	0.802*
1st test Left Hand	2nd test Left Hand	655	120.7	117.7	0.838*
Best Grip with Right Hand	Best Grip with Left Hand	648	129.2	133.3	0.581
Best Grip with Strong Hand	Best Grip with Weak Hand	646	133.2	121.5	0.810

*Coefficient of reliability

**All of these values are significant at a probability of less than 0.001.

The correlation coefficients when computed illustrated that there was close interrelationship between all the variables compared. Although the correlation of the two tests



on the left hand was highest r =0.838, it was felt by the investigator that this indicated a small strength decrement between these two tests. This would lead one to assume that the left hand reaches a point of maximal output. The test with the right hand shows, however, that the right hand can be expected to show a greater difference in subsequent tests. In this investigation where most of the subjects were right handed, the correlation coefficient was r = 0.802.

The relatively low coefficient correlation of the best right hand grip strength test and best left hand grip strength indicated that it would be impractical to arbitrarily select just one hand in measuring grip strength. It was necessary to select the measures that would give us the most inclusive information on both the strong and the weak hand.

The correlation selected to be compared with letter grade was the combination of the best score with the strong hand and the best score with the weak hand. This comparison was indicative of the similarity of grip strength of strong individuals. Although the mean scores illustrate a 12.7 difference in pounds, the correlation coefficient was r = 0.810. This correlation coefficient shows that the strong individuals are strong with both hands when compared with the weaker subjects tested in this investigation.

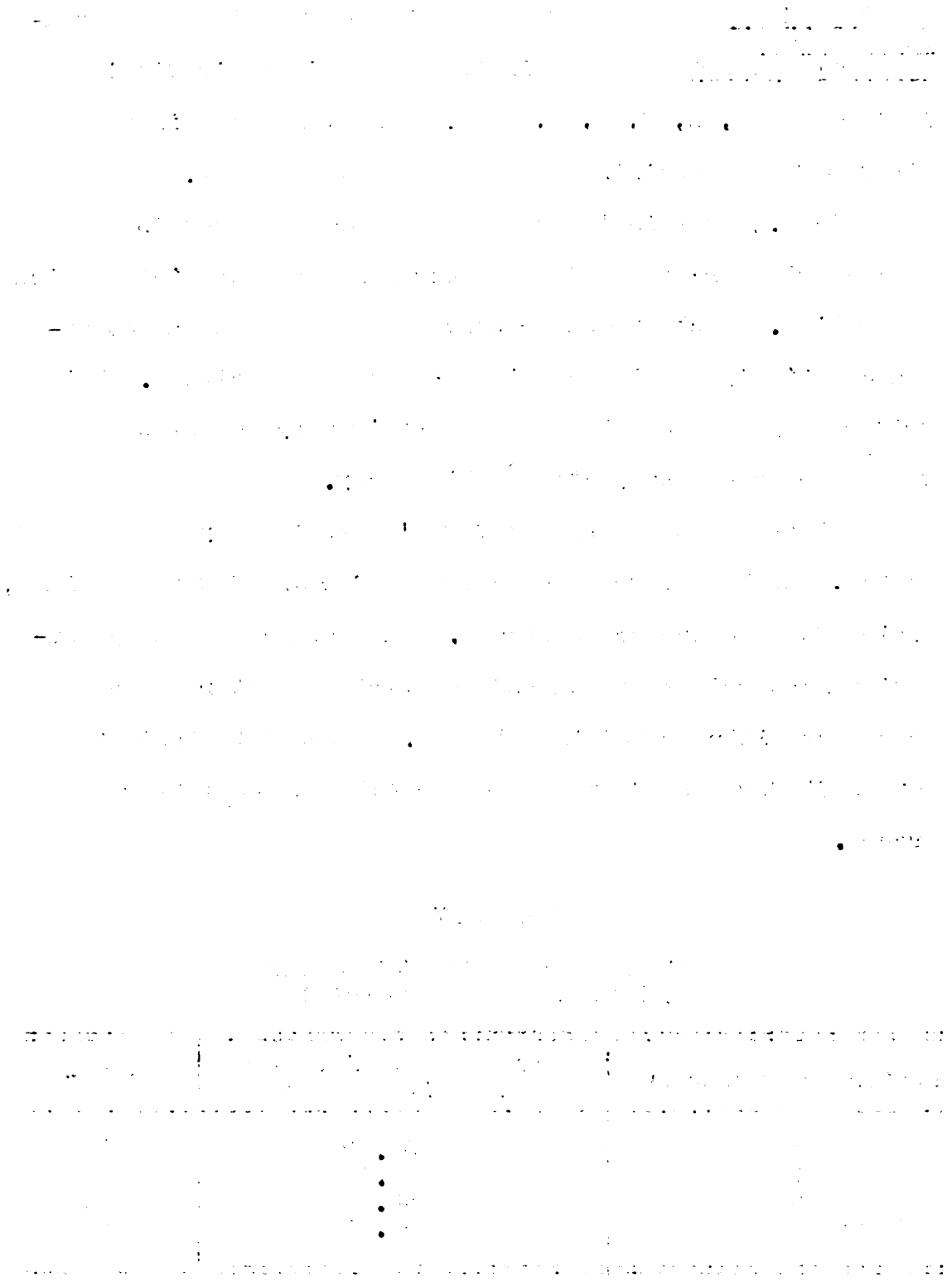
Results of the Letter Grade and Grip Strength The measure of achievement for the students in this study is their final letter grades, A, B, C, D, or F. The scale used in the classes for determining letter grade are similar. [See Appendix A.] The individual instructor was never informed of the grip strength and hence could not use the information in grading. Each student received a grade that was determined entirely by his work in the course activities. This writer only saw the final grade received by the students who had been his subjects in this study.

Because there were so few F's received by the students tested, the letter grade catagories of D and F were combined, giving four letter grade groups. The data obtained by comparing mean grip strength and the various letter grade groups are illustrated in Table IV. These data indicate a marked difference of grip strength between the letter grade groups.

TABLE IV

MEAN GRIP STRENGTH SCORES FOR VARIOUS LETTER GRADE GROUPS

Letter Grade Groups	Sum of Best Right and Left Grip Strength	Number
A	264.27	144
B	260.39	250
C	250.59	196
D and F	244.73	45



Relationship Between the Various Letter Grade Groups

Table IV illustrates that a significant difference occurred between all letter grade groups. A comparison of the mean grip strength score and the letter grade grouping clearly points out that the stronger students, as measured by grip strength, received the higher grades.

In addition, critical ratios of the differences between all letter grade groups were calculated. The results in Table V verify that differences in the mean grip strength of each letter grade group is more significant than could be attributed to chance alone. This indicates still further the relationship between grip strength and the achievement of the subjects in this investigation.

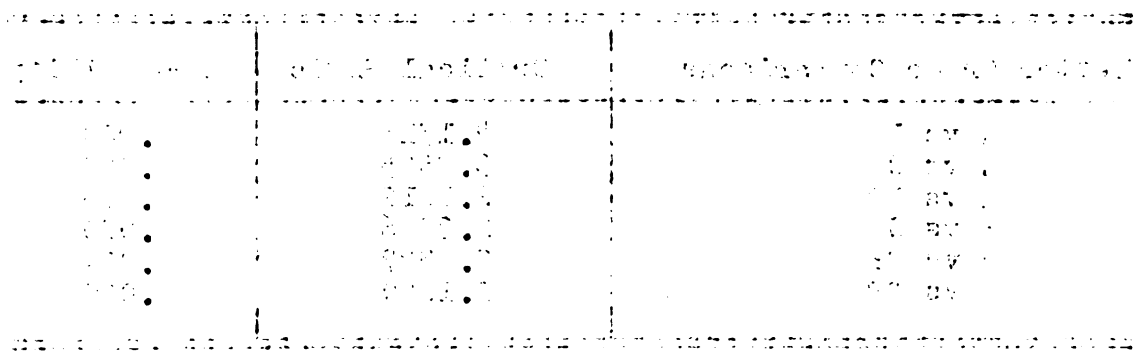
TABLE V

CRITICAL RATIOS FOR THE COMPARISON OF MEAN GRIP STRENGTH AMONG VARIOUS LETTER GRADE GROUPS

Letter Grade Comparisons	Critical Ratio	Probability
A vs B	4.1318	.000
A vs C	3.2575	.002
A vs DF	2.7812	.006
B vs C	2.3266	.020
B vs DF	2.8377	.004
C vs DF	2.1820	.029

Variables Affecting Grip Strength

No marked relationship is readily discernible between age, height and weight, and grip strength. However, there is an apparent



relationship between one of these variables, weight and grip strength. In order to establish the influence of each of these three variables on mean grip strength, a correlation coefficient was computed. In this correlation the mean of these variables for all the subjects tested was compared with the mean grip strength scores, as was indicated from the raw data weight was the most significant r = 451, results are illustrated in Table VI.

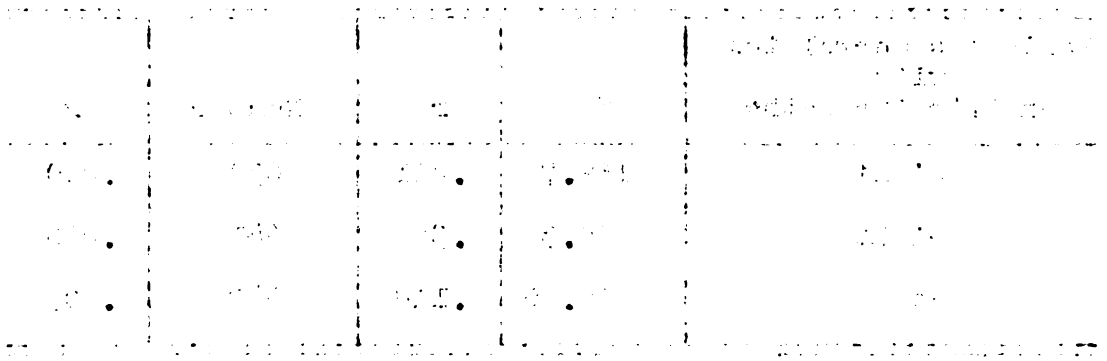
TABLE VI

CORRELATION COEFFICIENTS BETWEEN GRIP STRENGTH AND OTHER VARIABLES

Variables Correlated with Mean Grip Strength*	M	r	Number	P
Weight	159.7	.451	639	.000
Height	70.3	.326	641	.000
Age	19.06	.118	642	.003

*Mean grip strength for all classes in this investigation are in Appendix C.

To supplement the data obtained from the results of the above correlation, a partial correlation was computed. It was possible with this statistical procedure to eliminate the effect any one variable had upon the other in respect of mean grip strength. Although there was a correlation of r = 0.637 between weight and height, weight was the most



prominent factor. The partial correlations are shown in Table VII. Because age-and-weight and age-and-height had such low correlation coefficients, r= 0.028 and 4 = 0.047 respectively, further analysis of age did not appear necessary.

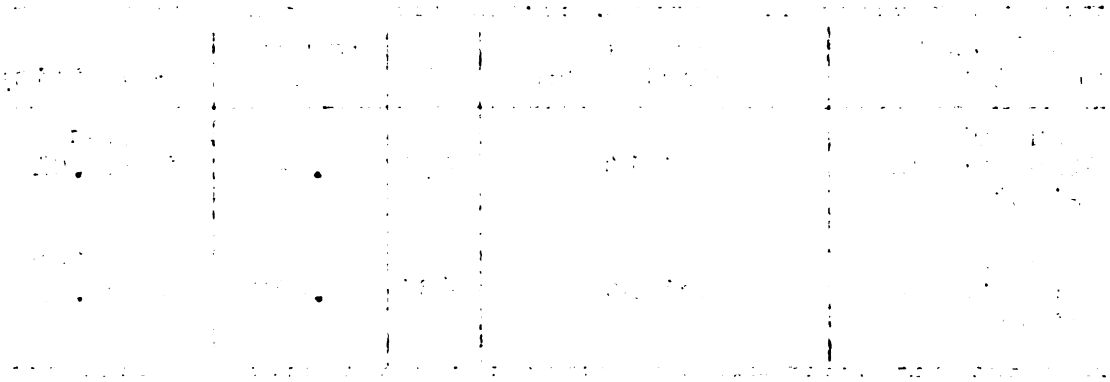
TABLE VII

PARTIAL CORRELATION COEFFICIENT BETWEEN VARIABLE HEIGHT AND WEIGHT AND GRIP STRENGTH

Variables Correlated	Variable Partialed Out	N	Partial r	Probability
Mean Grip Strength and Weight	Height	635	.34	less than .01
Mean Grip Strength and Height	Weight	635	.057	greater than .05

It was assumed from the analyses of the data collected that weight could be an important factor in the predicting of mean grip strength scores. Consequently, residuals were computed using the following line of regression derived from data collected on weight and grip strength; Y = .76X + .36. Where Y = predicted grip strength in pounds; X = weight in pounds.

Predicted grip strength and actual grip were compared, and if the sum of the two best grip strength scores was lower than the predicted grip strength, a minus residual was recorded for that student; if the predicted grip strength



score was below the actual sum of the two best grip strength scores, a plus residual was recorded. This tabulation was done for each student in all the classes tested. [See Appendix B for all data on residuals.] The final results were compared with the four letter grade groupings in Table VIII.

TABLE VIII

GRIP STRENGTH RESIDUALS FOR EACH LETTER GRADE

Letter Grade Achieved Groups	Mean Grip Residuals	Number
A	+6.06	144
B	-1.72	250
C	-3.45	196
D and F	-11.59	45

In order to further define the residuals a critical ratio was computed. The critical ratios for A, B, and C letter grade groups were not significantly different from the residuals computed from the raw scores. However, when the critical ratios of the D and F groups were compared, the difference was more significant. This would indicate that as the men gained in weight, either by fleshiness or size beyond a certain point, their grip strength did not gain proportionately.

Table IX present this information, which further verifies the relationship of weight to grip strength.

TABLE IX

CRITICAL RATIOS FOR THE COMPARISON OF RESIDUALS AND THE VARIOUS LETTER GRADE GROUPS

Letter Grade Comparisons	Critical Ratio	Probability
A vs B	2.12	0.034
A vs C	3.07	0.002
A vs DF	6.66	0.000
B vs C	1.84	0.065
B vs DF	4.31	0.000
C vs DF	3.44	0.000

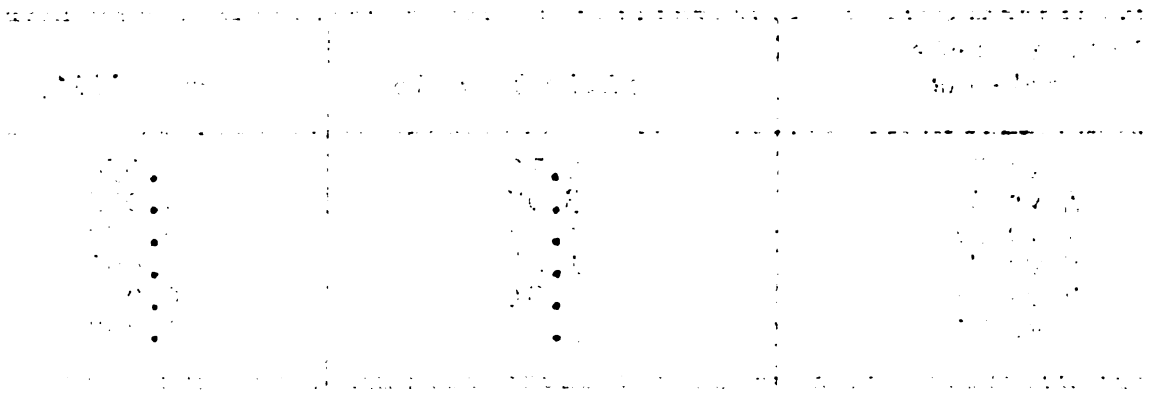
During the tabulation and recording of the results of this study, it was observed that some of the subjects who had stated that they were right handed had stronger left hands. Table X shows the number of subjects whose so-called opposite hands were stronger.

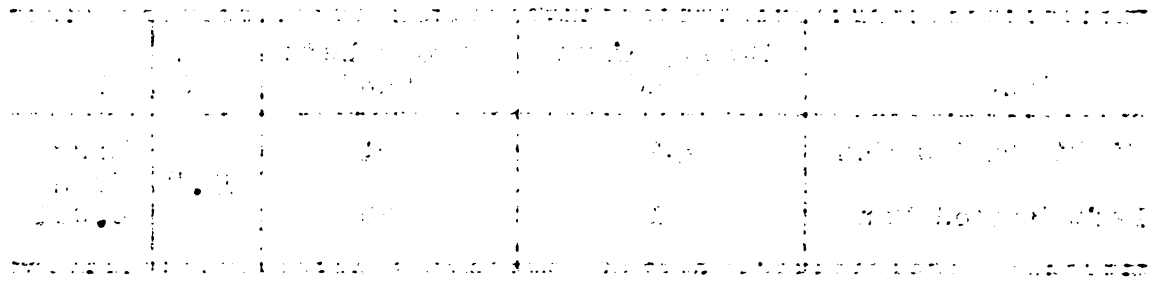
TABLE X

THE COMPARISON OF GRIP STRENGTH SCORES AND HANDEDNESS

Men	Strong Right Hand	Strong Left Hand	X^2	P
Right Handed Men	452	51	35.7	Less Than 0.001
Left Handed Men	21	26		

The ratio of left-handed men with strong right hands was so great, as compared to right-handed men with strong left hands, that several assumptions were made. The influence of a right handed society has so channeled the





muscular experiences of naturally left-handed people that there is very little difference between grip strength and handedness. This ratio also illustrates that continued use does develop muscular efficiency.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Many studies have indicated that grip strength is an important factor in physical fitness, athletic ability, general strength and general organic vigor. It was the purpose of this investigation to correlate grip strength with achievement in physical education among college men. The subjects for this experiment were six hundred and thirty-five college freshmen and sophomore men who were participating in physical education activities. Their right and left grip strength were measured, together with age, height, and weight. Grip strength was then correlated with the final letter grade received in physical education. Pertinent intercorrelations of these measurements were investigated.

Conclusions After a statistical analysis was made, the following conclusions appear justified:

1. Grip strength is important to achievement in physical education at Michigan State University.
2. Right grip strength is highly correlated with left grip strength.
3. A significantly larger proportion of left handed men have stronger right hands, as compared to right handed men with stronger left hands.

4. College students who are physically weak could benefit from a course to improve strength.
5. An individual's weight is more closely correlated with grip strength than either his height or age.
6. The statistical analysis of the data demonstrated that raw grip strength scores are nearly as accurate in predicting achievement, as are tests that consider weight in the evaluation. Although as you compare the A, B, and C student with the D and F students, weight is more significant.

Recommendations The following recommendations are made for additional investigation with grip strength:

1. A similar investigation using female college subjects might prove interesting.
2. An investigation in which achievement was predicted from grip strength scores would present additional data.
3. A study to ascertain the length of time needed to increase strength enough to improve achievement in physical education would prove advantageous.
4. A study could be conducted correlating grip strength and personality with college success.

5. Another investigation that might be significant would be to establish at what age strength becomes important to physical education achievement.
6. An experiment that compared grip strength to success in various sports could be given some thought.

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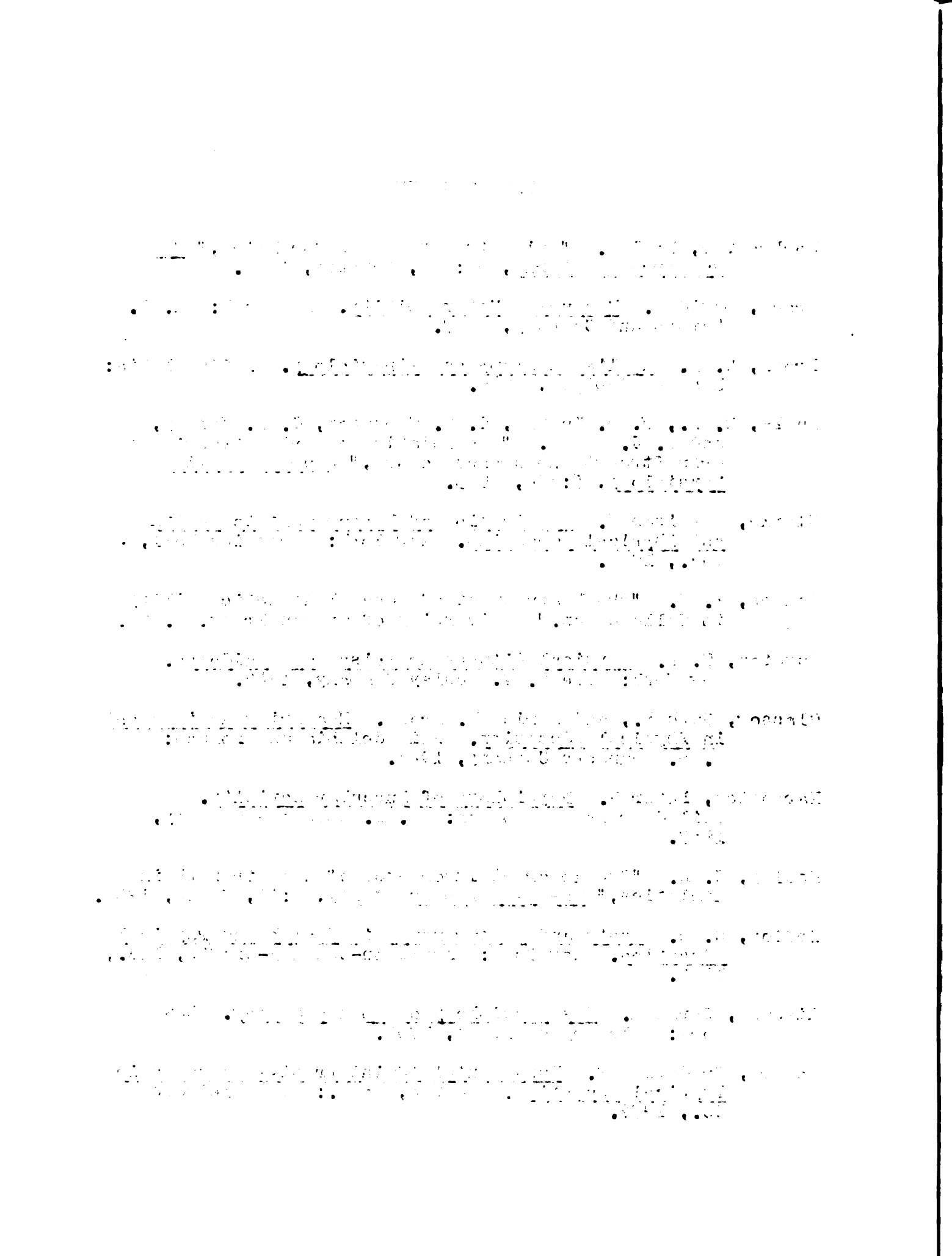

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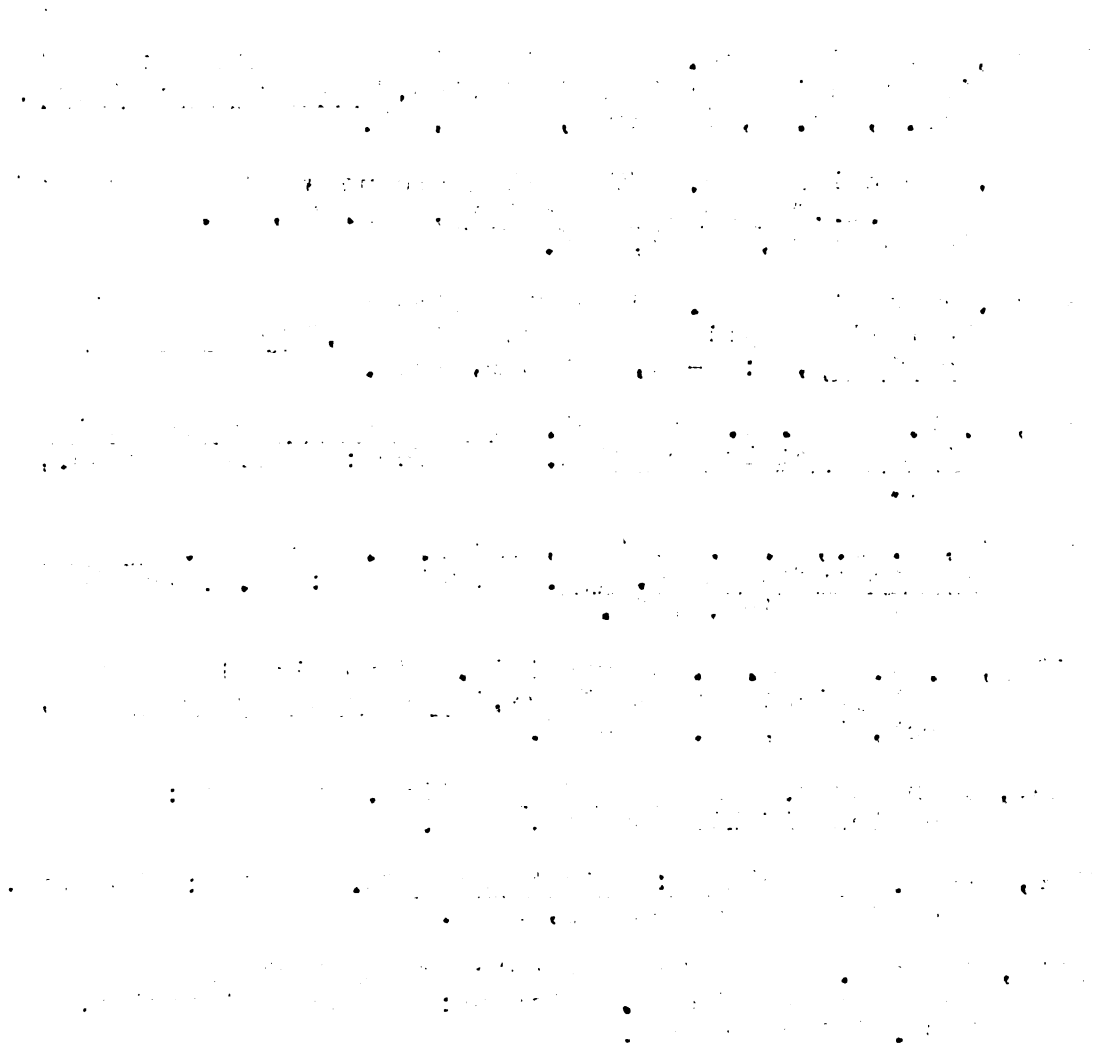


APPENDIXES

APPENDIX A

Definition of Courses Selected for this Study from the Service Curriculum Syllabus of Courses in Physical Education for Men Michigan State University

Educational Philosophy

This physical education curriculum is based upon the thesis that one of mankinds basic needs is the desire for expression in physically wholesome and mentally stimulating activities. To that end, we offer a program of instruction and guidance in a wide range of skills fundamental which can satisfy basic needs and will contribute to socially efficient living.

Curriculum Organization

The service curriculum in physical education for men consists of five general areas, namely: Aquatics, conbatives, games, stunts, and adapted sports for the physically handicaped. There are a total of twenty-seven courses represented in all the areas.

Physical Education Requirements

Physical education is required of all men students during the freshman and sophomore years, or until completion of six quarters of physical education unless excused by the Health Service. Veterans of the armed forces are exempt from physical education. Students who have reached their 30th birthday are exempt from physical education. Exemption certificates must be secured by the student from the Registrar and presented at enrollment. If for any reason, a course is deferred, it must be made up.

Grade Scale

The grade scale for all courses except those in the aquatic series is standard. The range is listed as follows: 90 or more points, A; 80 to 89 points, B; 70 to 79 points, C; 60 to 69 points, D; 59 points or less, F.

The grades on this scale are considerably lower than a standard scale used for academic courses at Michigan State, and this discrepancy should probably be explained. This scale was arrived at following considerable debate at a meeting of the Department committee chairmen. The general feeling expressed indicated that because of the lack of good physical

education programs at the secondary level, boys have not had adequate activity experiences and are not advanced as much in a physical sense as they are academically. This point, of course, is open to debate and probably will not be settled until the extended use of this scale has supplied information for further study.

Tennis - PE 100c

1. Objectives:

   A. The conduct objective of this course is: playing tennis according to social and hygiene standards. The standard of achievement is - reasonably well.

   B. The control or immediate course objectives are:

      1. Service (simple alive)
      2. Forehand (grip and stroke)
      3. Backhand
      4. Net Play (volley - smash)
      5. Court Tactics (doubles play)
      6. Rules

2. Examination and Grading Plan:

		Points
A.	Skill performance	60
B.	Competition play	20
C.	Written examination rules and techniques	10
D.	Healthmanship and sportsmanship	10
		100

Badminton PE 100e

1. Objectives:

   A. The conduct objective of this course is: playing badminton according to social and hygiene standards. The standard of achievement is: reasonably well.

   B. The control of immediate course objectives are:

      1. Service (long-short)
      2. Forehand (clear - drop - rally)
      3. Backhand (clear - net - midcourt)
      4. Smach (deep - short)
      5. Court tactics (doubles play)
      6. Rules

2. Examination and Grading Plan:

	Points
1. Skill performance	60

		Points
B.	Competition Play	20
C.	Written examination on rules and techniques	10
D.	Healthmanship and sportsmanship	10
		100

Group Games PE 100F

1. Objectives:

   a. The conduct objective of this course is: Playing Group Games according to social and hygienic standards. The standard of achievement is: Reasonably well.

   b. The control or immediate course objectives are:

      (1) To acquire knowledge of various group games and relays.
      (2) To acquire techniques, skills and abilities in leading group games.
      (3) To develop poise, self-confidence and leadership abilities.
      (4) To learn to play and enjoy a variety of group games, to express yourself and to have fun.
      (5) To gain abilities and knowledge which will prove valuable to you later on as a parent, in raising your children, and as a leader in your community.

2. Examination and Grading Plan

   a. Individual Presentation . . . . . 30 points

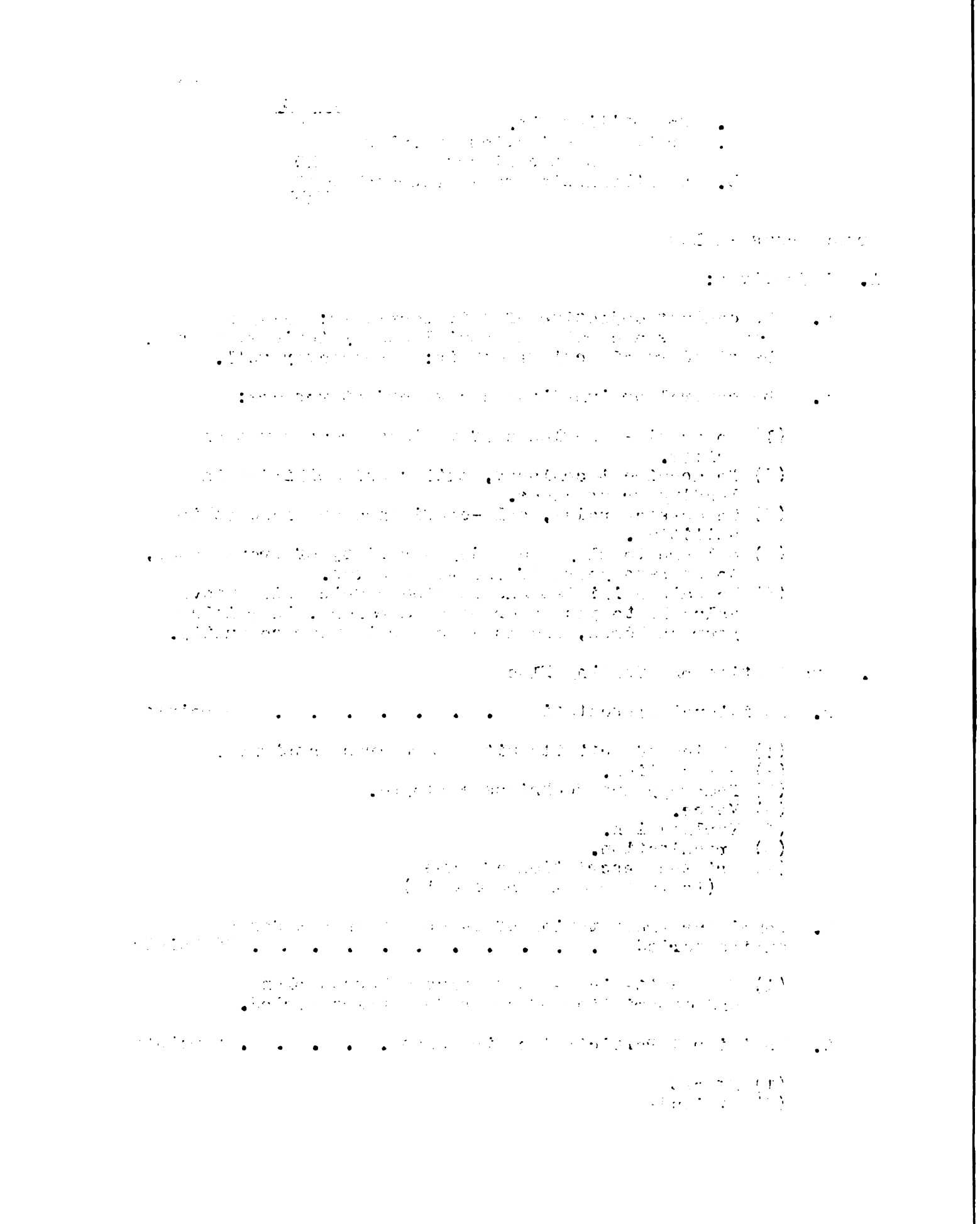
      (1) Choice of activity within age group assigned.
      (2) Preparation.
      (3) Pedagogy and Technique employed.
      (4) Voice.
      (5) Explanation.
      (6) Organization.
      (7) Written description of game (to be typed and handed in)

   b. Committee Presentation of Games and Relays for an entire period . . . . . 25 Points

      (1) Same criteria as above plus a lesson plan and description of games for entire period.

   C. Individual Participation in Games . . . . .25 points

      (1) Effort
      (2) Attitude



(3) Sportsmanship
(4) Healthmanship

d. Written examination on relays, games and rules . . . . . 10 Points

e. Healthmanship and Sportsmanship . . . . 10 Points

Total 100 Points

Handball PE 100i

1. Objectives

a. The conduct objective of this course is: Playing handball according to social and hygienic standards. The standard of achievement is: Reasonable well.

b. The control or immediate course objectives are:

(1) Be able to serve.
(2) Return serves and volley.
(3) Use placement shots
(4) Take a correct position on the court when playing

2. Examination and Grading Plan:

a.	Performance Test (Round Robin Scores). . . .	60 Points
b.	Demonstration Test (5 places,4 points each).	20 Points
c.	Written examination on rules and techniques.	10 Points
d.	Healthmanship and sportsmanship	10 Points
		100 Points

Bowling PE 100k

1. Objectives: The conduct objective of this course is: Bowling according to social and hygienic standards. The standard of achievement is: Reasonable well.

2. Teaching Procedure

a. Selecting a ball to fit your hand
b. How to hold a bowling ball
c. The stance
d. Foot work
e. Three, four or five step delivery
f. How to bowl straight, curve, or hook ball.
g. The pushaway
h. The back swing
I. How to slide
j. Bending versus stooping
k. How to make a strike
l. How to make a spare
m. How to score a game

3. Examination and Grading Plan

a.	Demonstration	40 Points
b.	Accuracy	40 Points
c.	Written examination.	10 Points
d.	Healthmanship.	5 Points
e.	Sportsmanship.	5 Points

Beginning Swimming 101A

1. Objectives:

   a. The conduct objective of this course is: Performing aquatic skills according to social and hygienic standards.

   b. The specific activities taught along with the standard of achievement for each are listed below:

   c. Activities on Skill Sheet

      (1) Crawl Stroke - 42 feet Minimum
      (2) Re-check - 75 feet Maximum
      (3) Elementary Back - 42 feet
      (4) Re-check - 75 feet
      (5) Breast Stroke - 42 feet
      (6) Re-check - 75 feet
      (7) Side Stroke - 42 feet
      (8) Re-check - 75 feet
      (9) Distance Swim - 42 feet
      (10) Distance Swim - 24 yards
      (11) Distance Swim - 50 yards
      (12) Distance Swim - 100 yds.
      (13) Sustained Swim - 1 minute
      (14) Sustained Swim - 2 minutes
      (15) Sustained Swim - 3 minutes
      (16) Sustained Swim - 4 minutes
      (17) Sustained Swim - 5 minutes
      (18) Sculling and Floating
      (19) Treading
      (20) Jumping and Diving
      (21) Underwater
      (22) Plunge Dive

Advanced Swimming 101b

1. Objectives:

   a. The conduct objective of this course is: Performing aquatic skills according to social and hygienic standards.

b. The specific activities taught along with the standard of achievement for each are listed below:

Activities	Grading Scale				
	A	B	C	D	F
Crawl Stroke	10	9	8	7	6
Breast Stroke	"	"	"	"	"
Side Stroke	"	"	"	"	"
El. Back Stroke	"	"	"	"	"

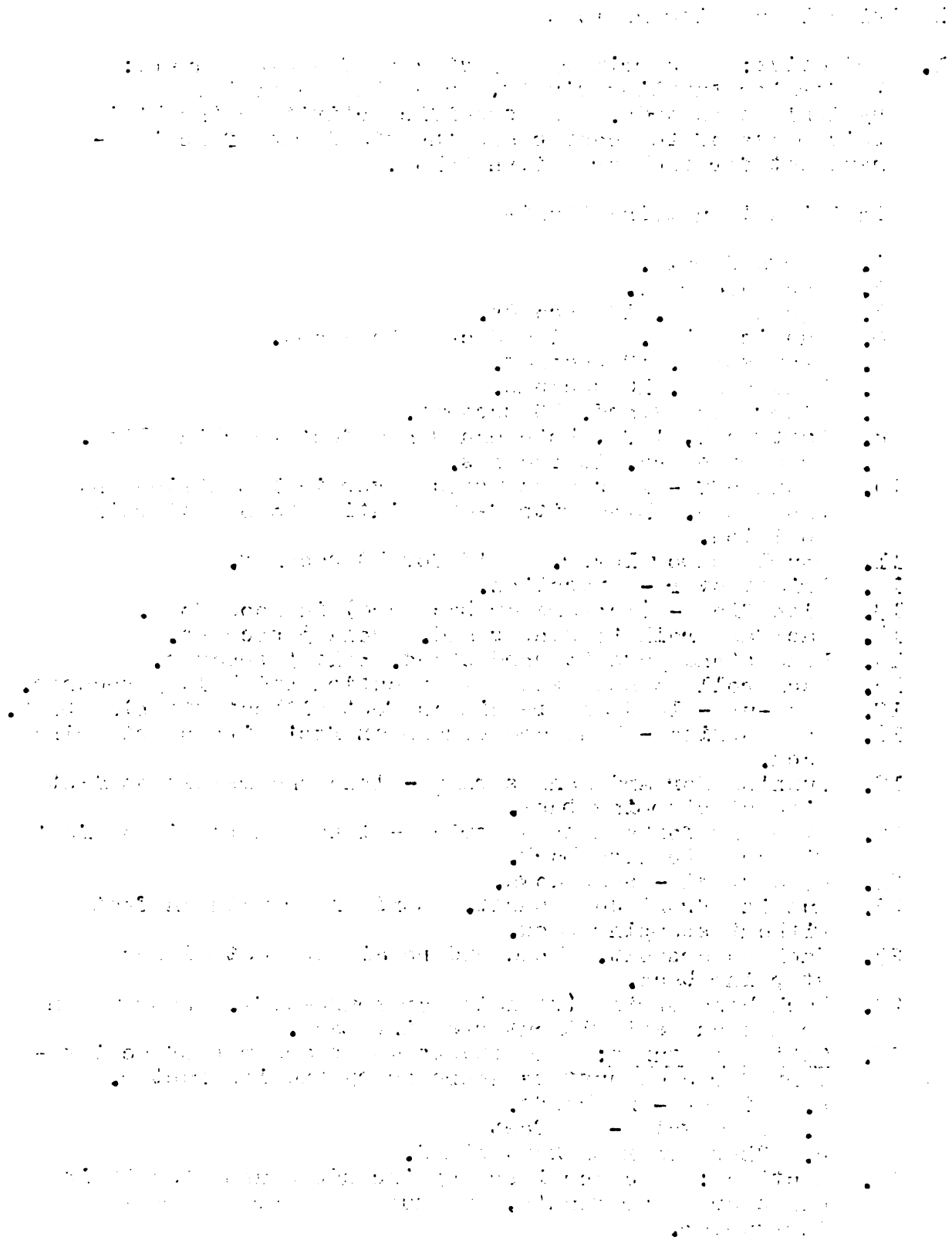
Distance Swim (1 mile - 27 laps)	Laps: 27 - 23	22 - 18	17 - 10	9 - 5	4-0	
Points Maximum Tot.	10	8	7	6	5	
Sustained Swim						
Time (Minutes)	30	29 - 25	24 - 20	19 - 15	14 - 10	
Points	10	8	7	6	5	
Maximum total	10 points					
Watermanship Skills						
Plunge Glide						
Distance	1 width	1st lane	2nd	3rd	4th	
Points	4	3	2	1	0	
Maximum Total	4 points					
Tread Water						
Time	15 min.	10 - 14	9 - 7	6 - 3	3 - 0	
Points	4	3	2	1	0	
Maximum Total	4 points					
Diving and Jumping (From Deck, low board, high board, surface)	4	3	2	1	0	
	A point for performing each event.					
Maximum total	4 points					
Underwater Swim						
Distance	1 length	20 yds.	15 yds.	10 yds.	5 yds.	
Points	4	3	2	1	0	
Maximum total of points for underwater swim of 4 points.						
Carries (Head, hair, cross chest tired swimmers)	1 length					
	4	3	2	1		
Maximum total--4	A point for each event					
Written Examination (On Rules, Techniques and Water Safety)	10	9	8	7	6	
Maximum Total	10 points					
Healthmanship and Sportsmanship						
Maximum Total	10 points					

Individual Tumbling PE 102a

1. Objective: The primary objectives of the course are: Performing tumbling stunts, according to social and hygienic standards. The specific activities taught in this phase of the course and the standards of achievement set for each are given below:

   Individual Tumbling Stunts

   1. Forward roll.
   2. Backward roll.
   3. Squat stand. 10 seconds.
   4. Running dive. Roll and come to stand.
   5. Head stand. 10 seconds.
   6. Hand stand. 10 seconds.
   7. Elbow head stand. 10 seconds.
   8. Cartwheel, left, both hands and feet touching line.
   9. Forearm stand. 10 seconds.
   10. Round off - legs pass through vertical position and snap down. Land with feet pointing toward starting position.
   11. Double elbow lever. Hold for 10 seconds.
   12. Bridge over - execution.
   13. Fish flop - (Forward or backward) in good form.
   14. Backward roll to hand stand. Hold 5 seconds.
   15. Head stand push to hand stand. Hold 5 seconds.
   16. Back roll to head stand - execution and hold 5 seconds.
   17. Snap-up - land and remain on feet without stepping back.
   18. Neck spring - land and remain on feet without stepping back.
   19. Running forward hand spring - land and remain on feet without stepping back.
   20. Standing forward head spring - land and remain on feet without stepping back.
   21. Hand stand - snap down.
   22. Running front somersault. Land and remain on feet without stepping back.
   23. Back somersault. Land and remain on feet without stepping back.
   24. Back hand spring (standing or round-off). Lansing and remain on feet without stepping back.
   25. <u>Optional Stunts</u>: The stunts and standards of achievement for each must be approved by the instructor.
       a. Kip up - no hands.
       b. Hand walk - 20 feet
       c. Chest rock to hand stand.
   26. Routines: The routines may include stunts taught in class or other stunts, and must be approved by the instructor.



a. Cartwheel - round off - back roll - back roll to head stand - push to hand stand.
b. Hand spring - round off - back roll - back extension.
c. Hand spring - dive roll - neck spring - back roll to hand stand.
d. Back roll - forward roll - neck spring.
e. Dive roll - forward roll - hand spring - head stand.
f. Round off - back roll to head stand - forward roll - neck spring.
g. Squat stand - head stand - head stand push to hand stand - snap down.

(These are suggestions. Others routines may be devised if preferred.)

2. Examination and Grading plan:

Performance test, 24 stunts, 3 points each	72 points
Performance test, 2 routines, 4 points each.	8 points

Each routine will be made up of five stunts which will not be repeated in the other routine. Performance tests will begin the fifth week and continue through the end of the term. Each student will receive four trials at each stunt and routine.

Written examination	10 points
Healthmanship and Sportsmanship.	10 points
Total	100 points

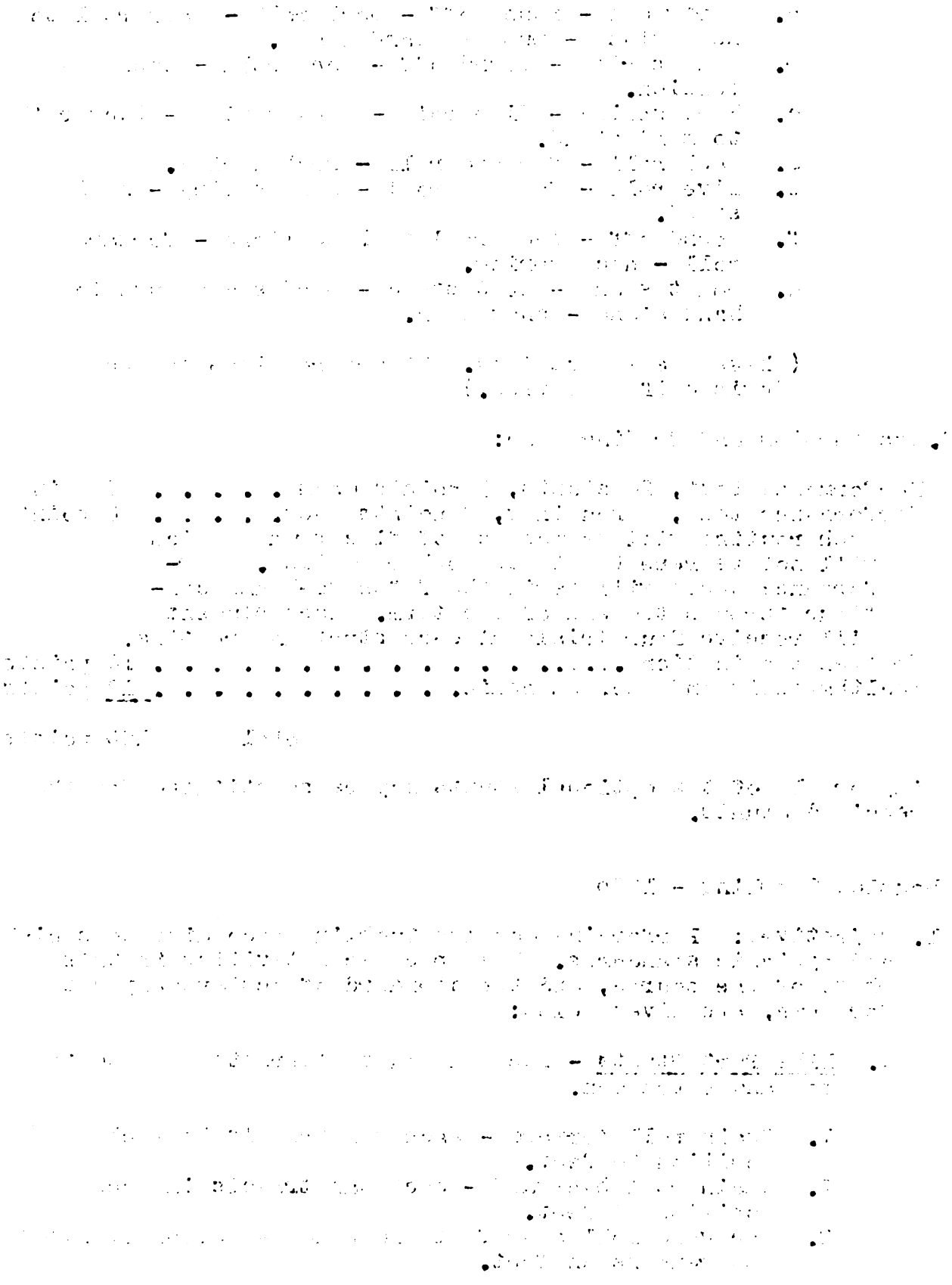
Any or all of the optional stunts may be substituted for the required stunts.

Doubles Tumbling - 102b

1. Objectives: Performing doubles tumbling according to social and hygienic standards. The specific activities in this phase of the course, and the standard of achievement set for same, are given below:

A. Like Part Stunts - Each man must alternate as a bottom man and a top man.

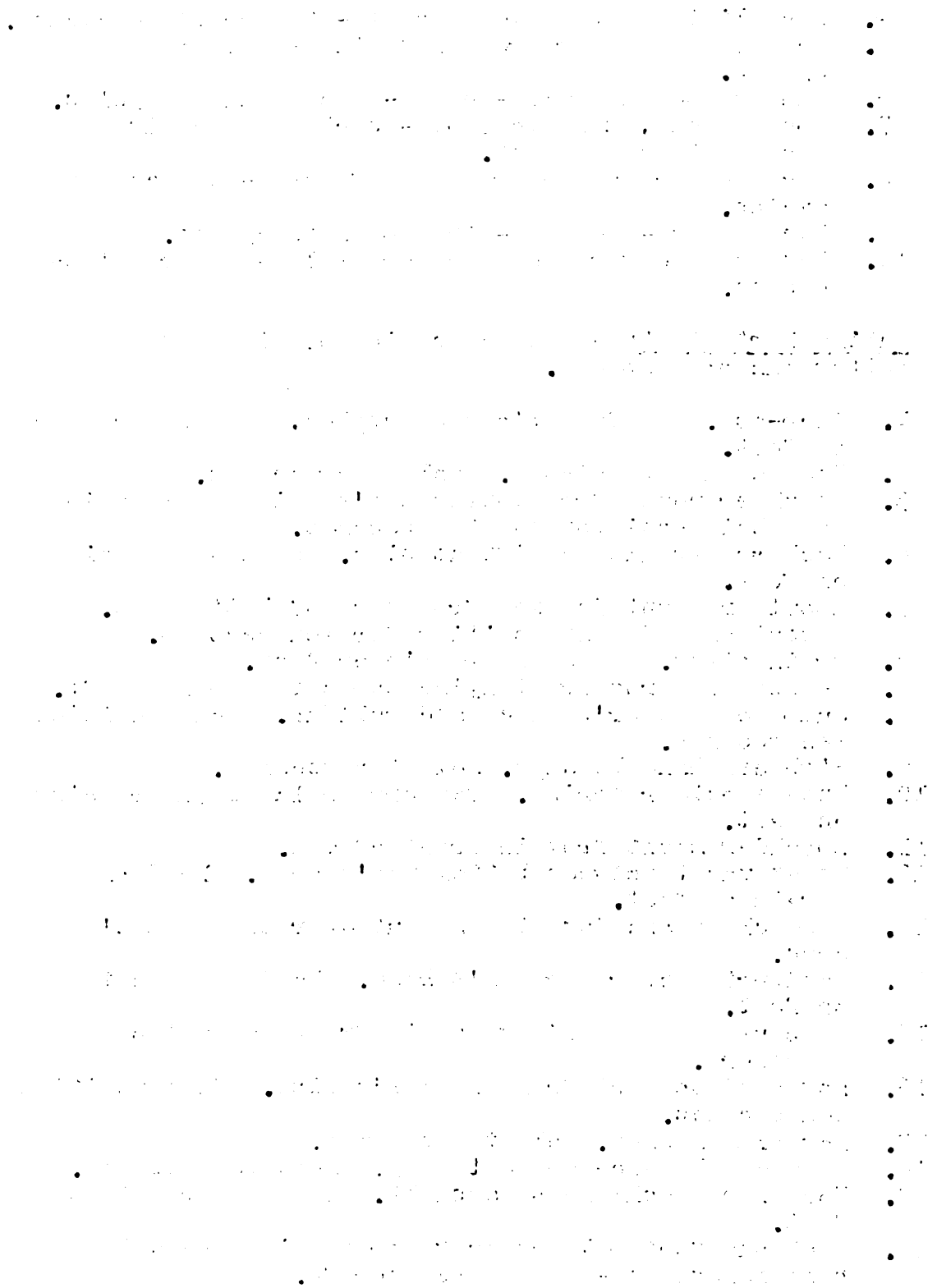
1. Chain roll forward - each man travels in each position 20 feet.
2. Chain roll backward - each man travels in each position 20 feet.
3. Backward roll over feet and hands - performer lands and remains on feet.



4. Neck lift and back somersault - two complete cycles.
5. Neck lift and forward handspring - two complete cycles.
6. Hand stand and pull - over - two complete cycles.
7. Double roll, hand to foot - each man travels in each position 20 feet.
8. Back to back and over and half turn - two complete cycles.
9. Back bends - double - two complete cycles.
10. Combined forward and backward roll - two complete cycles.

B. Unlike Part Stunts - Man has choice of either being a bottom man or a top man.

1. Snap-out. Performer's back arched, land and remain on feet.
2. Knee shoulder balance. Hold ten seconds.
3. Shoulder mount from bottom man's thigh - execution and hold position for ten seconds.
4. Back somersault by lift at side. Land and remain on feet.
5. Shoulder mount jumping from back of bottom man. Execution and hold position for ten seconds.
6. Groin pitch. Land and remain on feet.
7. Handspring from front lying support with leg lift.
8. Jump to thrower's knees and pull up. Hold position ten seconds.
9. High arm hand balance. Hold ten seconds.
10. Knee shoulder spring. Performaer lands and remains on feet.
11. Shoulder mount from in front of man.
12. Squat vault between bottom man's arms. Land and remain on feet.
13. Hand clasp and jump in and out over bottom man's arms.
14. Handspring over thrower's head. Land and remain on feet.
15. Snap up to thorwer's waist in front to seat on shoulders.
16. Low hand to hand from thrower's hips. Hold position ten seconds.
17. Low arm balance. Hold ten seconds.
18. Shoulder balance on feet only. Hold ten seconds;
19. Toe pitch backward somersault. Land and remain on feet.
20. Back and foot balance push top man into hand to hand handstand - hold five seconds.



2. Examination and Grading Plan:

Performance test - 10 like part stunts, 2 points each	.20 points
Performance test - 20 unlike part stunts, 3 points each	.60 points
Written examination	.10 points
Healthmanship and Sportsmanship	.10 points
Total points	100

Apparatus Stunts PE 102 c

1. Objectives: Performing apparatus skills according to social and hygienic standards. The specific activities taught in this phase of the course, and the standards of achievement set for each, are given below:

A. Harizontal Bar

1. Back hip pullover and underswing dismount.
2. Long underswing - dismount at end of backward swing.
3. Backward hip circle.
4. Knee swing up - other leg over and dismount to s tand.
5. Single knee circle backward.
6. Single knee circle forward.
7. Forward hip circle.
8. Glide kip.
9. Double knee circle backward.
10. Drop kip - underswing dismount.
11. Hock swing dismount.
12. Backward uprise.
13. Double knee circle forward.

Optional Stunts

1. Back kip.
2. Monkey hang.

B. Parallel Bars

1. Corkscrew mount.
2. Upper arm and roll forward.
3. Back roll layout.
4. Front vault dismount.
5. Rear vault dismount.
6. Back uprise.
7. Single leg cuts.
8. Kp from upper arm.
9. Handstand.

10. Glide kip.
11. Front uprise.
12. From flexed support - fast forward roll.
13. Double cut off and facing outward.

Optional Stunts

1. Rear vault 1/2 twist.
2. Swing into handstand.

C. Horse

1. a. Squat vault]
   b. Straddle vault]
   c. Flank vault] Perform 4 vaults
   d. Front vault] 1 point
   e. Rear vault]

2. Single leg circles or cuts in saddle - left leg over - left leg back - right leg over - right leg back. L - L - R - R

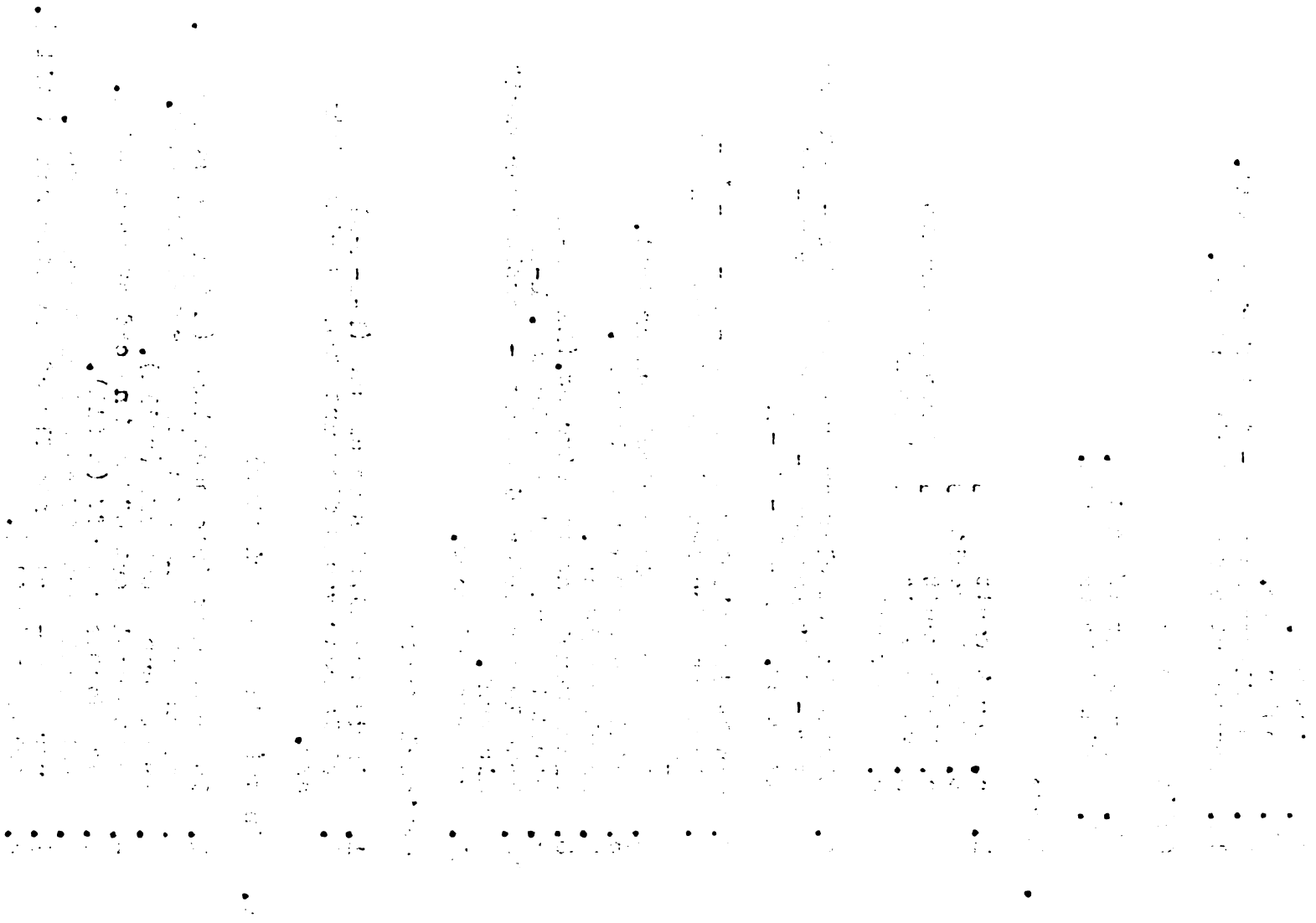
3. Single leg circles in saddle - L - R - L - R
4. Single and doubles circles in saddle L-R (LR) R-R
5. Right leg complete circle under left.
6. Feint and rear vault dismount.
7. Regular scissors.
8. Flank mount and leg circles.(LR) L-R
9. Straddle mount and leg circles. L-R
10. Both legs astride right arm - double rear vault dismount.
11. Reverse scissors.

Optional Stunts

1. Single leg circles on croupe (L-L-R-R)
2. Triple rear vault dismount from astride right arm.

D. Rings (Still and Swinging)

1. Inverted hand into nest hand (Still and swinging).
2. Tap on swing and swing in inverted flex hang.
3. Front double cut off (still).
4. Front double cut off at the end of back swing.
5. Back double cut off (still).
6. Back double cut off on end of forward swing.
7. Muscle Up - Fall into flexed inverted hand (still).
8. Dislocate (Still).



9. Dislocate at end of back swing.
10. Dislocate at end of front swing.
11. Uprise at end of back swing.
12. Kip (False grip - Still).
13. Kip at end of back swing.

Optional Stunts

1. Uprise at end of front swing.
2. Drop uprise at end of back swing.

Routines: Each student is asked to learn one routine on each piece of apparatus. Since routines are expected on both the still and the flying rings, the student will be asked to perform five routines.

Control Objectives:

1. Skill in executing the movements involved in performing the stunts and routines listed above.
2. Knowledge of the nomenclature commonly used in connection with apparatus stunts.
3. Knowledge of the principles involved in performance of apparatus and tumbling stunts.
4. Disposition to participate in a sportsmanlike manner.
5. Disposition to participate in a healthmanlike manner.
6. Condition to perform apparatus and tumbling stunts for one half hour without undue fatigue.

2. Examination and Grading Scale

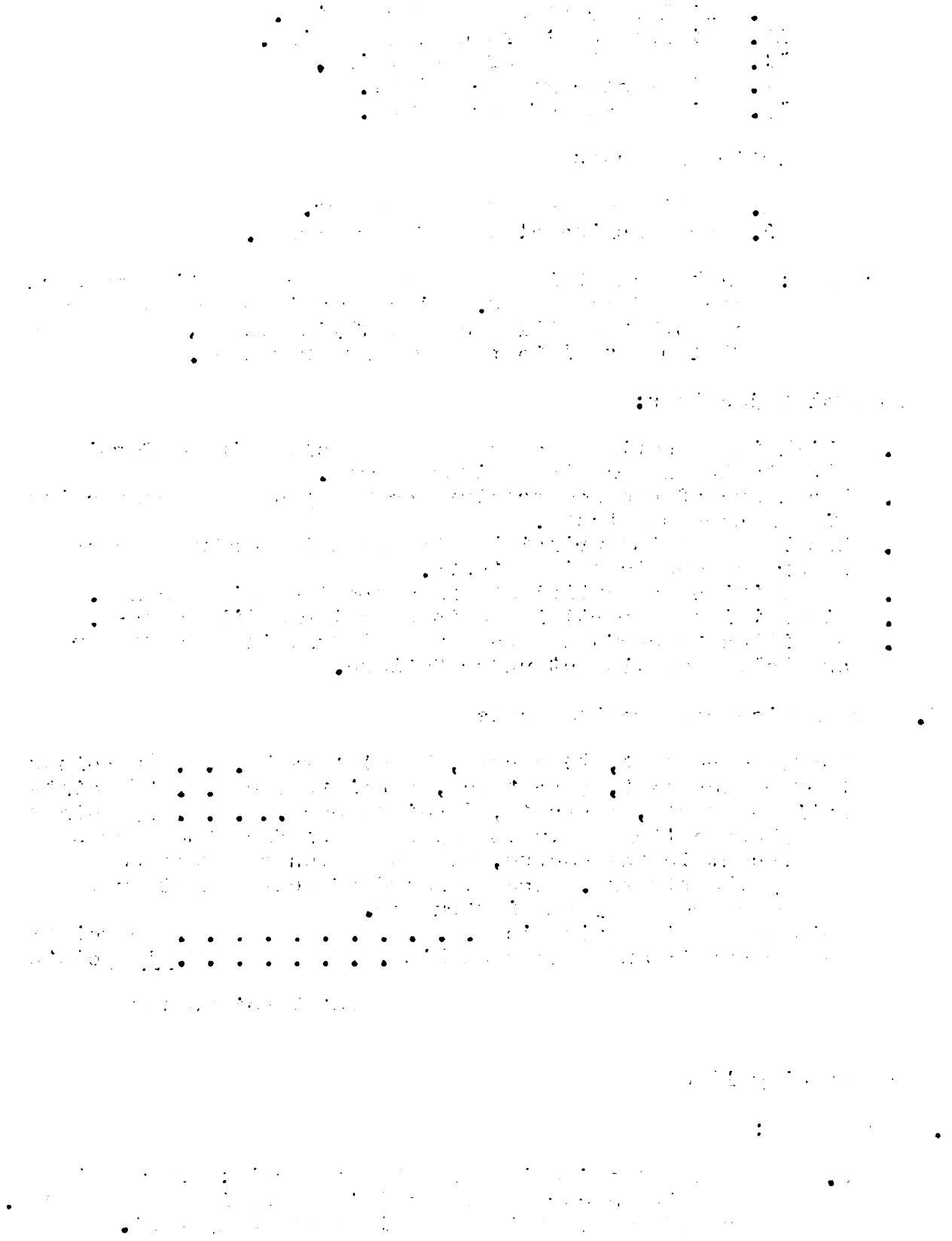
Performance test, 40 stunts, 1 point each . . . 40 points
Performance test, 5 routines, 5 points each . . 25 points
Optional tests, 5 stunts, 3 points each. . . . . 15 points
These optional stunts may be taken from the stunts taught in the course, or other stunts developed by the student. The standard of achievement must be approved by the instructor.
Written Final Examination . . . . . 10 points
Healthmanship and Sportsmanship . . . . . 10 points

Total points 100

Tap Dancing 102e

1. Objectives:

a. The conduct objective of this course is: Performing tap dancing according to social and hygienic standards. The standard of achievement is reasonably well.



b. The control or immediate course objectives are learning the steps of the following dances:

1. The Broadway Special
   (a) Sevens crossing front
   (b) Sevens crossing rear
   (c) Peg leg left
   (d) Peg leg right
   (e) Chorus hop
   (f) Full circle
2. The Panama Fling
   (a) Strike hop
   (b) The Buffalo
   (c) The Rock Away
   (d) The Broken rhythm
   (e) Fidgety Feet

2. Examination and Grading Plan

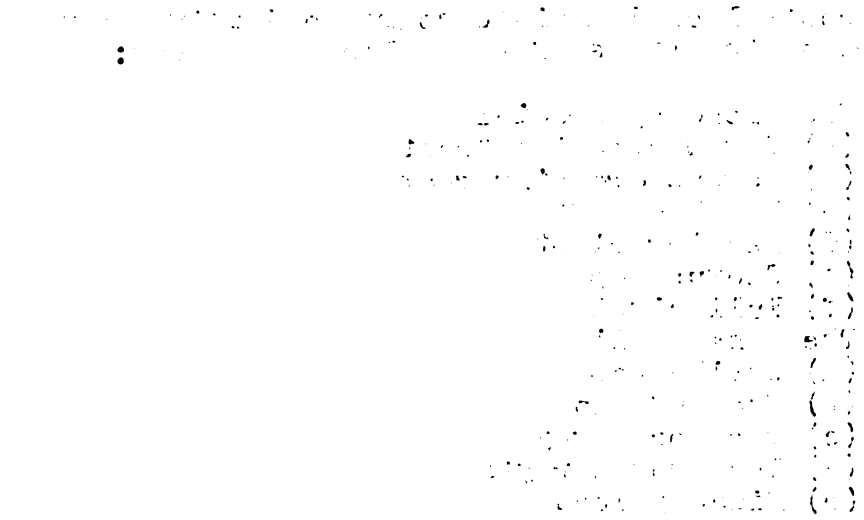
A.	Preliminary Examination in two dances, 13 points each	26 points
B.	Final Examination in two dances, 27 points each	54 points
C.	Written Examination on knowledge of routines and assigned reading	10 points
D.	Healthmanship, Sportsmanship	10 points
	Total Points	100

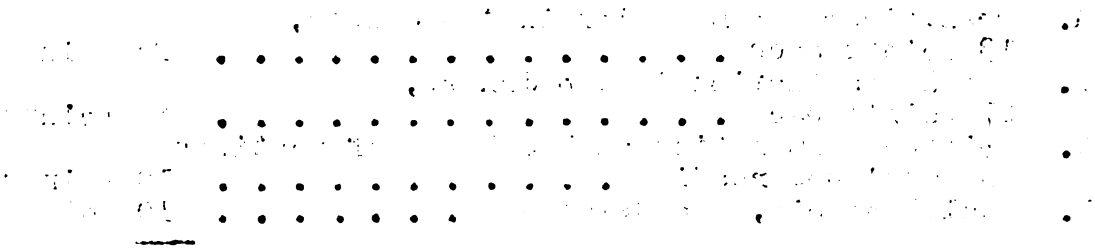
Ice Skating PE 1021

1. Objectives: The primary objectives of this course are: 1. To learn the fundamental skills of ice skating; 2. to appreciate and enjoy ice skating as a social and healthful activity; 3. to provide practice time under supervision.
The specific activities taught in this course are given below. The standard of achievement for each of the techniques, unless otherwise specified is: reasonable well.

1. Beginning Skating

   a. Gain confidence in balance
   b. Bend the knees while skating
   c. Bring knees together for balance as you shift from one leg to the other.
   d. Learning to stop
      (1) Flex the knees, lean forward, toes in
      (2) Horizontal stop
   e. Changing direction
      (1) Swinging turn
      (2) Horizontal stop and change of direction
   f. Skating backward (length of rink)
   g. Couple skating





2. Speed Skating
   a. Skill in executing movements involved in speed skating.
   b. Knowledge of the principles involved in speed skating.
   c. Knowledge of the terms and phrases commonly used in connection with speed skating
   d. Sportsman like etiquette
3. Figure Skating
   a. Knowledge of the principles involved in figure skating.
   b. Knowledge of common figure skating terminology.

2. Examination and Grading Plan

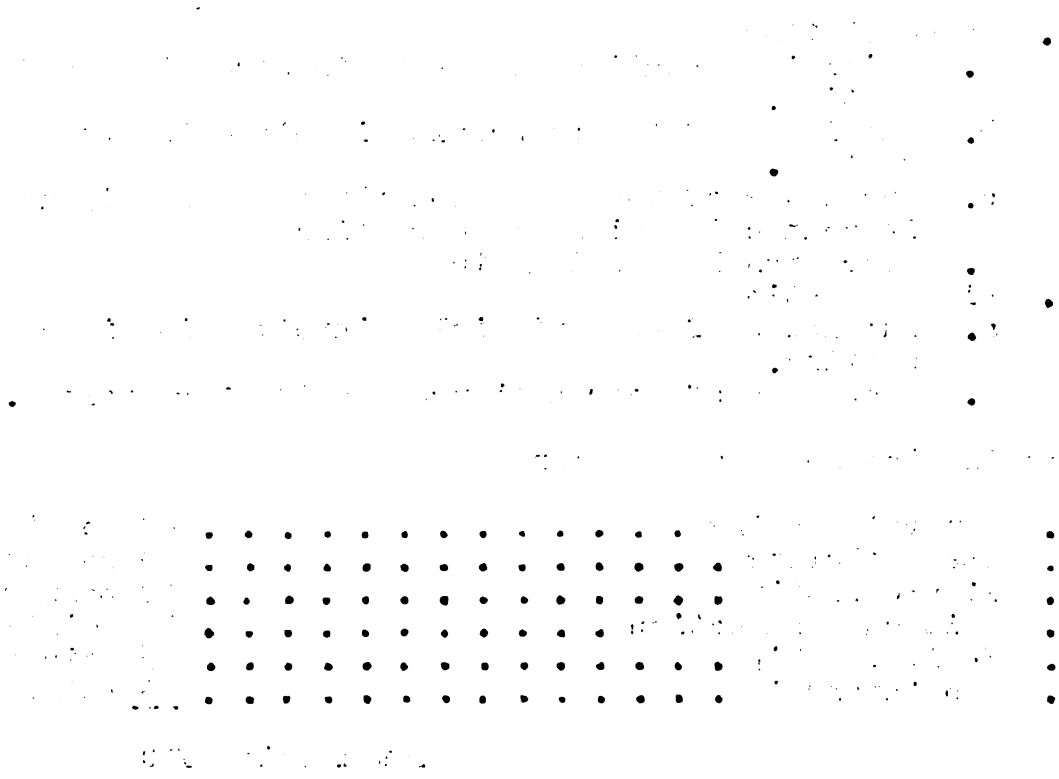
a.	General skating	40 points
b.	Speed skating	20 points
c.	Figure skating.	20 points
d.	Written Examination	10 points
e.	Healthmanship	5 points
f.	Sportsmanship	5 points
	Total Points	100

Individual Athletics PE 102k

1. Objectives:

   a. Participating in individual athletic events according to social and hygienic standards.
   b. The control or immediate course objectives are: Performing the events listed below reasonable well.

Activities	Standard of Achievements
220 (one lap).	30 seconds
880 (1/2 mile).	2:45.0
75 dash	9.5 seconds
Running Broad Jump	17 feet
Running High Jump.	Height of performer's nipples
Wall climb.	9 sec. (10 yds. and return)
Standing Hop, Step, and Jump. . .	4 times performer's height
Standing Broad Jump	2 feet plus performer's height
Rope climb.	9 seconds
Chins.	12 times (regular grasp)
Pushups	25 times
Situps	40 times



2. Examination and Grading Plan

a. Performance test (12 events allowed 4 offical trials at each event) Activities No. 1, 2, 3, 6, 9, 10 evaluated at 8 points each . . . . . 48 points
Activities No. 4,5,7,8,11,12, evaluated at 7 points each. . . . . 42 points
b. Healthmanship and Sportsmanship. . . . . 10 points

Total points 100

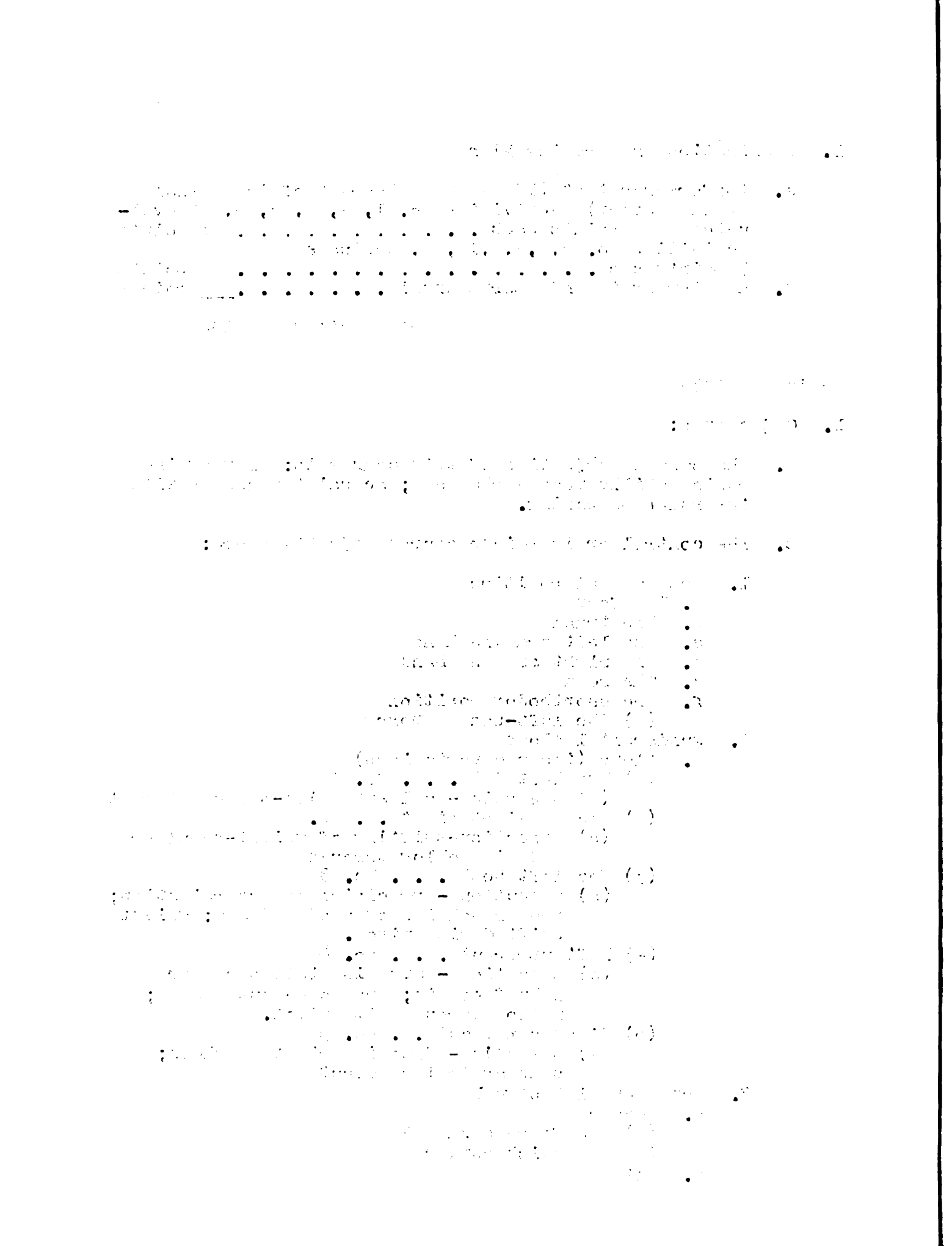
Boxing PE 103a

1. Objectives:

a. The conduct objective of this course is: Performing boxing skills reasonable well; acquaint students with the rules of boxing.

b. The control or immediate course objectives are:

1. Fundamental position
   a. The feet
   b. The trunk
   c. The left arm and hand
   d. The right arm and hand
   e. The head
   f. The unorthodox position
      (1) The left-handed boxer
2. Fundamental blows
   a. Blows (include variations)
      (1) The left jab . . . No. 1
         (a) Execution-full extension-through target
      (2) The straight right . . No. 2
         (a) Execution-shifting of weight-shoulder and hip follow through
      (3) The left hook . . . No. 3
         (a) Execution - precision and coordination; proper holding of hand and arm; weight shifted with pivot.
      (4) Left uppercut . . . No. 4
         (a) Execution - dropping left shoulder palm faced in; arm moves out and up; follow through with pivot.
      (5) Right upper cut . . No. 5
         (a) Execution- dropping right shoulder; same as left uppercut
3. Fundamental Footwork
   a. Advance
      (1) The forward shuffle
      (2) The quick advance
   b. Retreat



(1) The backward shuffle
(2) The forced retreat

c. Circling
(1) Circling to the left
(2) Circling to the right

4. Elements of Defense
a. Blocking
(1) The catch - open glove
(2) Forearm block
(3) Parrying
(a) Outside parry
(b) Inside parry
(c) Cross parry

b. Slipping - Movement of head to left or right
c. Ducking - Head and body forward
d. Weaving - Movement of upper body down, to left and right
e. Rolling - sway of body or head with blow
f. Sidestepping - to left step with left, to right step with right
g. Clinching - Grasp arms: Keep body close and arms locked
h. The rockaway - shifting weight to rear foot

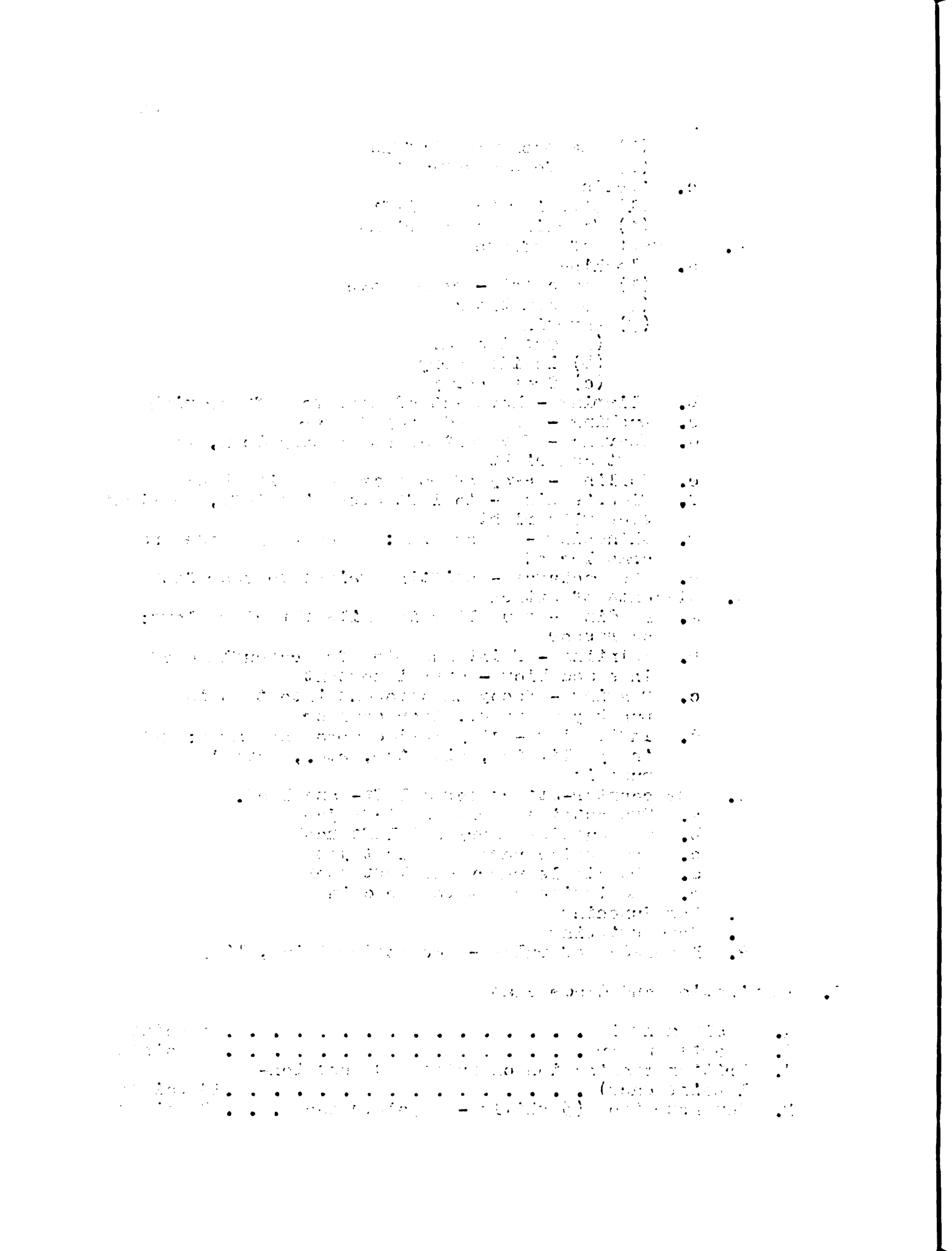
5. Elements of Attack
a. Leading - shuffling in while throwing blows; aggressor
b. Feinting - Feint and blow for camouflage of intended blow - eyes important
c. Drawing - Decoy an opponent into throwing punch you expect, then counter
d. Infighting - stay inside opponents arms; get in by slipping, sidestep, etc., move in punching

6. The counter-attack for a left-hand lead.
a. The outside parry and left jab
b. The outside parry and left hook
c. The inside parry and left jab
d. The single parry and left hook
e. The inside right to the chin

7. Bag Punching
8. Rope skipping
9. Knowledge of rules - See Boxing Guide, 1949

2. Examination and Grade Plan

A. Healthmanship . . . . . 5 points
B. Sportsmanship . . . . . 5 points
C. Written examination on rules (10 question-1 point each) . . . . . .10 points
D. Demonstration (5 skills - 4 points each . . .20 points



E. Bag Punching (20 contacts - 12 seconds). . . 10 points
F. Rope Skipping (120 revolutions - 1 minute) . 10 points
G. Performance (Boxing-3 one minute rounds) . . 40 points
Total Points 100

Wrestling PE 103b

1. Objectives:

a. Conduct objectives
(1) Perform amateur wrestling skills reasonable well.
(2) Increase the physical condition and muscular tone of the body.
(3) Stimulate interest, understanding, and appreciation of amateur wrestling.

b. Control objectives: (Outline of wrestling skills taught)
(1) Wrestling holds from starting position on feet, to mat.
(a) Take downs and go behinds
1. Starting position on feet
2. Slip under arm and behind from the different starting positions.
3. Arm drag
4. Leg drive
5. Leg dive counters; and holds that develop when countering take downs.
(b) Take opponent to the mat from behind.
(2) Hold downs and riding holds. (Pinning procedure is shown from each ride)
(a) Bar arm rides
1. Referee's starting position for offense and defense
2. Bar arm rides
3. Head on arm rides
4. Long waist lock rides - locked variation "Tulsa Ride"
5. Bar arm in reverse crook of elbow (chicken wing).
(b) Leg break downs and rides
1. Push hips down and pull hips down.
(c) Arms and legs riding combinations
1. Scissor rides
2. Blanket rides
(3) Escape and reverse holds
(a) Sit outs
(b) Wings and side rolls
(c) Switch and reverse variations from switch
(d) Pull leg over head (scissor defense)
(4) Pin holds (blocks and counters)

(a) Bar arm and half Nelson
(b) Half Nelson and crotch hold
(c) Hammer lock and half Nelson
(d) Double grapevine and half Nelson
(e) Top scissor and half Nelson
(f) Cradle; jack knife cradle with three quarter Nelson
(g) Reverse half Nelson
(h) Locked, reverse half Nelson with bar under back
(i) Bar arm in reverse crook of elbow and half Nelson (chicken wing)
(j) Locked long waist lock ride with pin (Tulsa ride)
(k) Hook scissor and half Neslon
(l) Cross body stretcher (guillotine)

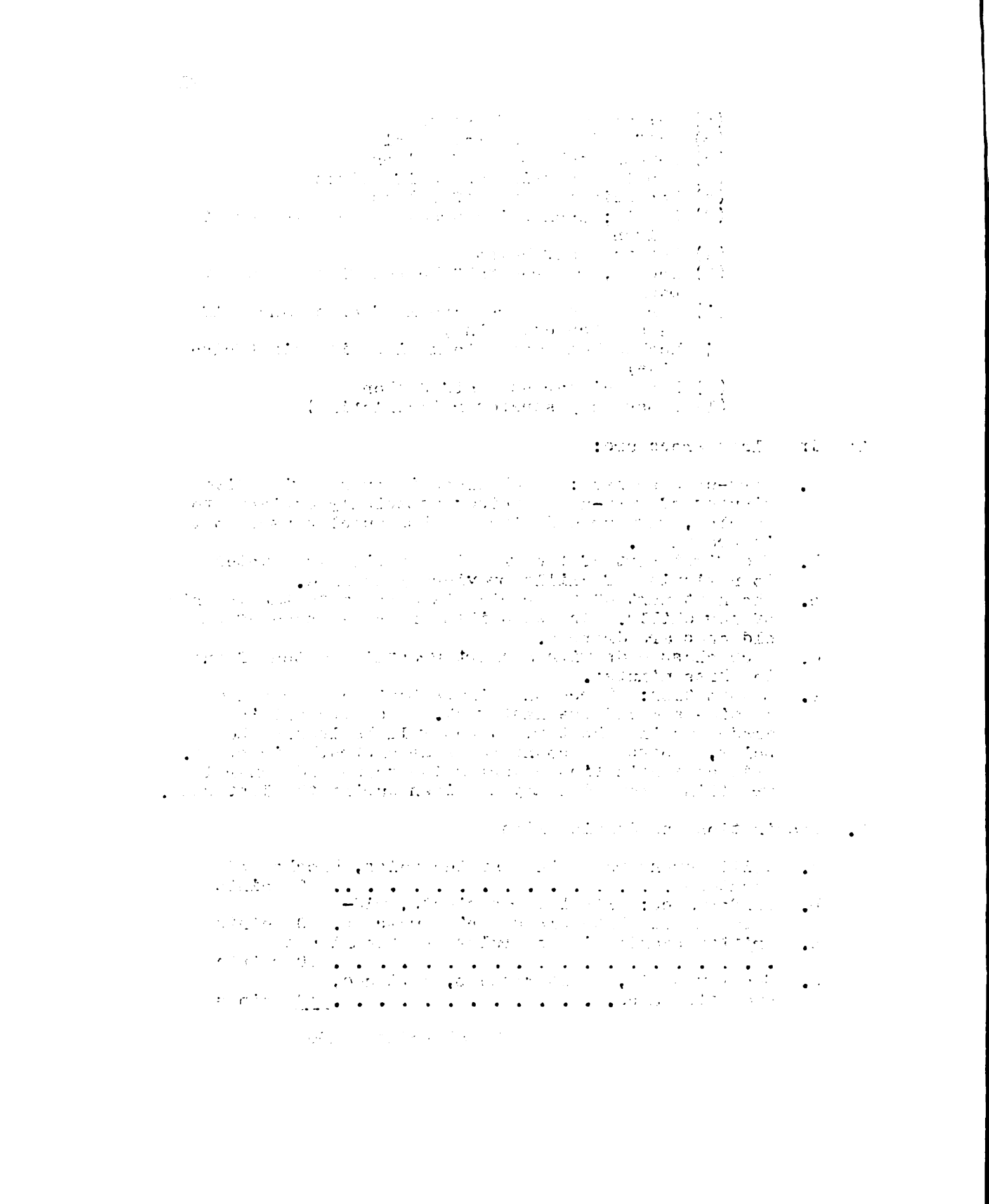
Outline Class Procedure:

a. Warm-up exercises: Each class is opened with five minutes of warm-up exercises especially designed to develop, warm up and strength the muscles used most in wrestling.
b. The first part of the wrestling period is devoted to reviewing of skills previously learned.
c. The next part of the period is devoted to the learning of new skills. As new skills are added some of the old ones are dropped.
d. Each class ends with a short wrestling match of one to three minutes.
e. Examination: Three one minute bouts are wrestled at mid-term and the last week. Each student is graded during the term on how well he learns the holds, blocks and counters as demonstrated in class. Written examination covering the rules and general wrestling knowledge may be given during the last week.

2. Examination and Grading Plan

a. Skill demonstrated in learning holds, blocks and counters . . . . . 40 points
b. Performance: Final three minute, mid-term and regulate class period matches. 40 points
c. Written examination on rules and techniques . . . . . 10 points
d. Healthmanship, sportsmanship, attitude, and attendance. . . . . 10 points

Total points 100



Beginning Foil Fencing 103e

1. Objectives:

   a. The conduct objective of this course is: Fencing foil according to social and hygienic standards. The standard of achievement is: Reasonably well.

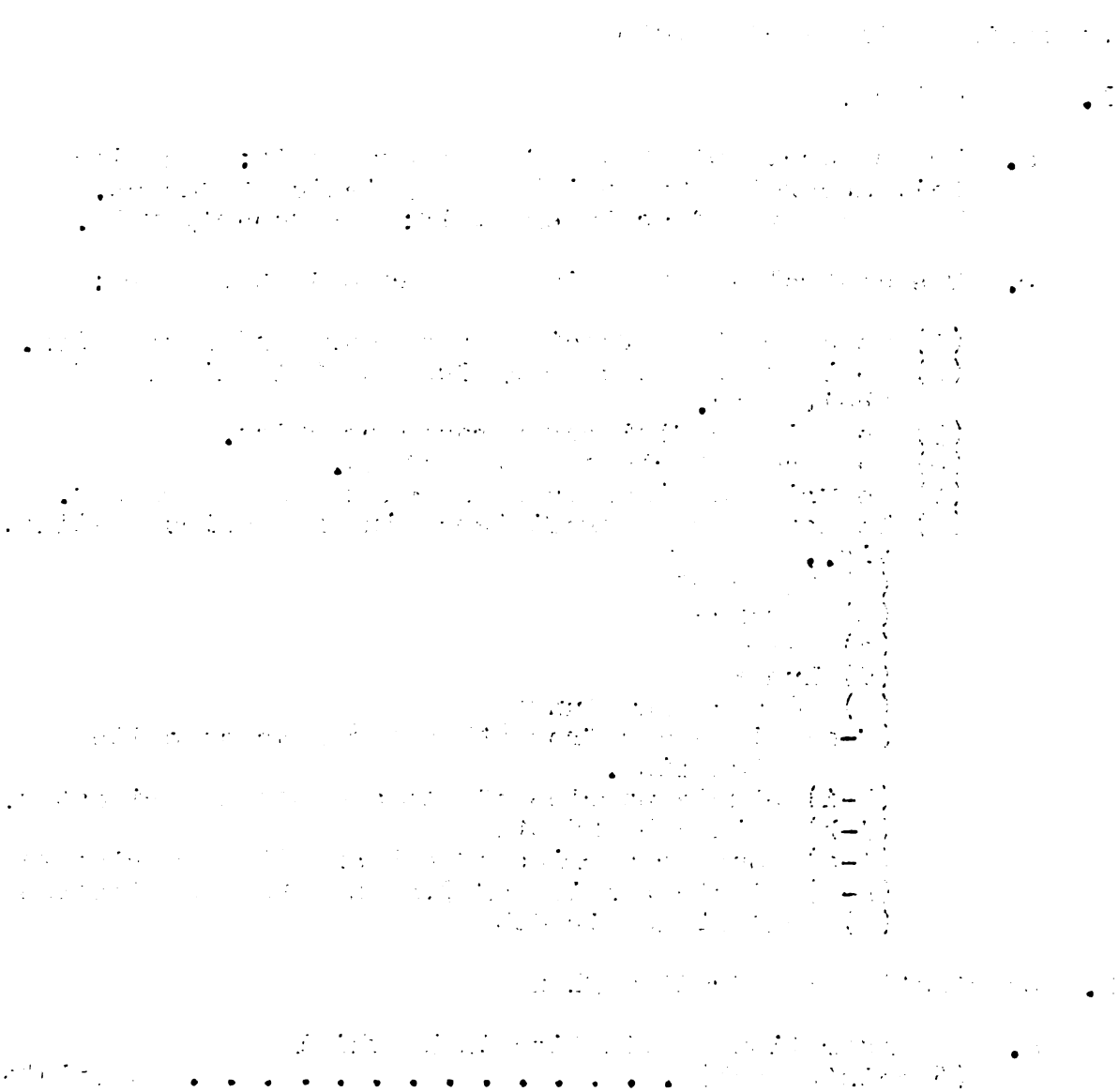
   b. The control and immediate course objectives are:

      (1) To appreciate fencing as a sport and recreation.
      (2) To learn the necessary fundamental skills and their uses.
      (3) To gain proficiency through practice.
      (4) To read materials in the field.
      (5) To write a final quiz on rules and techniques.
      (6) To demonstrate proficiency in the various skills, viz.,
          (a) On guard
          (b) Advance
          (c) Retreat
          (d) Lunge
          (e) Advance and lunge
          (f-g) Disengage from 4th and 6th to opposite high line.
          (h-i) Simple parries of 4th and 6th and ripostes.
          (j-k) 2 in 4th and 6th
          (l-m) Counter parries of 4th and 6th and ripostes
          (n-o) Simple parries of 7th and 8th and ripostes
          (p) Beat attach in 4th

2. Examination and Grading Plan

   a. Demonstration examination in 16 skills (5 points each) . . . . . 80 points
   b. Written final examination . . . . . 10 points
   c. Healthmanship and sportsmanship . . . . . 10 points

   Total points 100



MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION May, 1, 1955

TOPIC Raw Data on Grip Strength

TABULATED BY W. F. TINKLE

	A				B				C				D				F		
	Σx	N	Mx	Σx^2	Σx	N	Mx	Σx^2	Σx	N	Mx	Σx^2	Σx	N	Mx	Σx^2	Σx	N	Mx	Σx^2
100F	4473	18	248.50	1118493	5102	19	268.52	1319172	2367	10	236.70	569509	217	1	217.00	47089				
100F					6229	24	259.54	1646971	4163	18	231.27	1042133								
101A	3549	13	273.00	982409	2942	12	245.16	728772	580	2	290.00	169000								
102A	1803	7	257.57	473115	1820	7	260.00	479128	2721	11	250.08	684063	1777	7	253.85	463233	694	3	231.10	161812
102A	2434	9	272.87	687705	774	3	258.00	206342	1559	6	259.83	428526	957	4	239.25	233231	262	1	262.00	68644
102B	1572	6	262.00	420778	2179	8	272.37	607731	4063	15	270.86	1114727	938	2	219.00	96649				
102B	741	3	247.00	183573	1228	5	246.82	304818	1197	5	239.40	290707	802	3	267.33	214486				
102C	1311	5	262.00	346891	1511	6	253.34	384579	538	2	269.00	145972	226	1	226.00	51076	733	3	244.33	181077
102C	1912	7	273.14	526792	971	4	242.75	239481	1229	5	245.80	307315	941	4	235.25	223995				
102K	1040	4	260.00	274856	5305	20	265.25	1417301	3048	12	254.00	789464	281	1	281.00	78961				
					4697	19	247.15	1180183	3206	13	246.61	753267	1195	5	239.00	293157	266	1	266.00	70756
103A	797	3	265.56	225377	3213	12	267.75	813393	2228	9	247.55	556598								
103A	1943	7	279.51	546519	3645	13	280.38	979623	1774	7	255.20	457428								
103B	1074	4	268.50	292086	1590	6	265.00	426002	2943	12	245.25	732049	745	3	248.33	187929	253	1	253.00	64009
103E	230	1	230.00	52900	2885	11	262.27	768501	1027	4	257.77	267597								
200C	1556	6	259.66	406074	1704	7	243.42	418118	1933	8	241.62	471675	546	2	273.00	151508				
103B	2255	8	281.87	653415	2283	9	253.66	586965	1814	7	259.14	471536	249	1	249.00	62001				
200E	1085	4	271.25	300863	4333	16	270.08	1189161	3700	14	268.28	992106								
200I	1375	5	275.00	385955	3411	13	262.38	912787	1869	8	233.62	440275								
200K	915	3	305.00	282213	2509	10	250.90	641217	3000	12	250.00	763726								
202E	503	2	251.50	126517	1630	6	271.66	444176	2812	11	255.63	729402	923	4	230.75	213501				
202I	4356	17	256.23	1138110	2919	11	265.36	787241	498	2	249.00	122449								
202I	3131	12	260.91	778003	2218	9	246.44	555360	847	3	282.33	243795								
	38055	144	264.27		65098	250	260.39		49116	196	250.59		9297	38	244.65		2208	9	245.33	
			Σx^2 10102644				Σx^2 17037382				Σx^2 12437319				Σx^2 231681				Σx^2 595898	
											D+F	Σx = 11505								
											N =	47								
											Mx =	244.78								
											Σx^2 =	28622709								

O-412

MICHIGAN STATE COLLEGE
DEPARTMENT OF PHYSICAL EDUCATION, HEALTH AND RECREATION FOR MEN

GRADUATE STUDIES AND RESEARCH

TABULATION SHEET

DATE OF TABULATION MAY 1, 1955

TOPIC GRIP STRENGTH RESIDUALS

TABULATED BY W. F. TINKLE

	A				B				C				D				F			
	Σx	N	Mx	Σx²	Σx	N	Mx	Σx²	Σx	N	Mx	Σx²	Σx	N	Mx	Σx²	Σx	N	Mx	Σx²
100F	-101	18	-5.61	6677	-182	19	-9.57	15610	-126	10	-12.6	9502								
100F					-99	24	-2.04	34200	-333	17	-19.5	19809	-59	1	-59	3481				
101A	150	13	11.53	11764	-203	12	-16.91	17105	36	2	18.0	1530								
102A	97	7	6.71	5192	67	7	9.57	3895	15	11	1.36	11037	-1	7	.142	9985	-55	3	-18.33	1433
102A	134	9	14.88	6675	-15	3	-5.00	3275	-39	6	-6.50	2727	-62	4	-22.01	2692	19	1	19.00	361
102B	57	6	9.50	2009	159	8	19.87	11817	199	15	13.26	12109	-46	2	-23.0	1186				
102B	-17	3	-5.66	1570	-43	5	-8.60	1615	-27	5	-5.40	3435	10	3	3.33	98				
102C	-27	5	-5.40	2387	5	6	.833	3219	14	2	7.0	1666	-24	1	-24.0	576	-20.	3	-6.67	2858
102C	201	7	28.71	7773	18	4	-4.50	2277	-48	5	9.60	3130	-140	4	-35.0	7042				
102K	26	4	6.51	2602	147	20	7.35	3575	15	12	1.25	9059	20	1	20.0	400				
102K					-99	19	-4.94	12400	-91	13	-7.0	9951	-48	5	-9.60	3675	16	1	16	256
103A	92	7	13.14	5396	90	13	6.92	16626	-75	7	-10.71	6761								
103A	39	3	13.0	11345	-112	14	-8.00	12136	-12	9	-1.33	3212								
103B	114	8	14.25	16192	-90	9	-10.00	7109	-93	7	-6.14	2059	-24	1	-24.0	576				
103B	17	4	4.25	4793	34	6	5.66	4989	-109	12	-8.66	10584	-36	3	-12.0	3538	1	1	1	1
103E	-50	1	-50.	2500	-33	11	-3.00	10500	13	4	3.25	1527								
200C	13	6	2.16	1385	-137	7	-14.62	7629	117	8	14.62	6198	-7	2	-3.50	569				
200E	28	4	7.00	3322	128	16	-8.00	14410	6	14	.428	12636								
200I	68	5	13.00	6314	-85	13	-6.53	21253	-133	8	-16.62	5670								
200K	89	3	29.66	6201	-75	10	-7.50	8167	-36	12	-3.00	7712								
202E	-24	2	-12.00	416	87	6	14.51	3083	-17	11	-1.54	8888	-89	4	-22.25	2609				
202I	26	17	1.52	12676	153	11	13.90	10459	-72	2	-36.0	2870								
202I	-9	12	-.75	3721	-169	9	-18.77	13053	67	3	22.33	3371								
TOTALS	873	144	6.06	120007	-935	252	-1.72	239248	-674	195	-3.45	155393	-504	38	13.26	31427	-91	9	-9.55	4909
											O+F	Σx -595	N=47		Mx= 11.59		Σx²=	36336		

APPENDIX C

MEAN GRIP STRENGTH BY COURSE

Course	Mean Grip (lb.)	N
Badminton	268.2	34
Boxing	266.6	51
Beginning Swimming	261.9	27
D. Tumbling	260.0	47
Foil Fencing	258.8	16
Ice Skating	258.6	54
Wrestling	258.2	50
Bowling	256.9	25
Tap Dancing	256.8	22
Tumbling	256.1	57
Handball	255.9	26
Individual Athletics	253.8	75
Apparatus Stunts	253.3	37
Group Games	250.0	90
Tennis	249.5	23