

AN ANALYSIS OF THE PERFORMANCE OF JUNIOR
HIGH SCHOOL GIRLS IN 14 PHYSICAL FITNESS TESTS

by

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TABLE OF CONTENTS

	<u>Page</u>
CHAPTER I INTRODUCTION	1
Statement of the Problem	1
Purpose of the Study	2
Sampling for the Study	2
Procedure for the Study	3
Statistical Methods	6
Limitations of the Study	7
Description of the Experimental Test Items	8
CHAPTER II RELATED STUDIES	15
Flexibility Tests	15
Tests of Arm and Shoulder Girdle Strength and Endurance	19
Tests of Abdominal Strength and Endurance	25
Tests of Power	29
Tests of Running Speed, Endurance and Agility	34
CHAPTER III THE RESULTS	38
Objectivity of the Tests	38
Selection of Tests for Further Analysis	38
Validation and Intercorrelation of the Test Items.	42
Summary	43
CHAPTER IV CONCLUSIONS AND RECOMMENDATIONS	45
The Selection of the Test Battery	45
The Final Test Battery	47
Recommendations for Further Research	48
BIBLIOGRAPHY	50
APPENDIX	54

LIST OF TABLES

<u>Table</u>		<u>Page</u>
I	The Objectivity Coefficients of the 14 Physical Fitness Tests	39
II	The Intercorrelations of the Test Scores With Each Other and With the Criterion Score .	44
III	The Increase in the Multiple Correlation Coefficient With Additional Variables	46
IV	The Work-sheets for the Wherry-Doolittle Test.	55
V	The T-Scales for the Tests in the Final Battery	58
VI	Complete T-Scores and Criterion Scores for All Subjects	60

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CHAPTER I

INTRODUCTION

Mounting interest has been shown in the physical fitness of children and youth, particularly since World War II. Physical educators have concerned themselves with the problems of fitness for many years, but they have shown even greater concern recently.

Physical fitness is one of the commonly accepted objectives for school physical education programs. A highly mechanized age makes it even more important that a high level of fitness be maintained, partially because of the decreasing physical demands made on persons by occupations.

The testing program should serve to motivate and to evaluate the fitness phase of the overall program. Physical fitness tests or programs are not planned to replace a program of a wide range of activities and sports.

Statement of the Problem

For the past 10 years the Oregon State Department of Education has advocated the use of the Oregon Motor Fitness Test to measure qualities of physical fitness of the school age child. The Oregon Department of Education is now

revising the Oregon Motor Fitness Test and is seeking a shorter battery of tests to replace it.

This study is one of several which are being conducted throughout the state. The studies are being carried on in the areas of high school girls, high school boys, junior high school girls, junior high school boys, and upper elementary school boys and girls. The results of these studies will be compiled by the Oregon Department of Education in developing a new physical fitness test battery.

Purpose of the Study

This study analyzes the results of the testing of 99 junior high school girls on 14 physical fitness test items. This study will report its findings to the Oregon State Department of Education.

Through statistical methods the test battery has been cut to a minimum number of test items which still maintain the validity of the test battery. The final battery should be valid, objective, short and economical for teachers to use in a physical fitness testing program.

Sampling for the Study

The subjects used in this study were girls who were members of physical education classes at Leslie Junior High School, Salem, Oregon. Ninety-nine girls from three

classes were used in the study. The seventh grade class of girls contained 29 subjects. The eighth grade class had 37 subjects. The ninth grade class totaled 33 subjects. Ages of these girls ranged from 12 to 15 years.

Procedure for the Study

Experimental test items were set up by the state committee for the revision of the Oregon Motor Fitness Test. The tests specified for junior high school girls included six factors of physical fitness. These factors and the test items included in those areas were:

Arm and shoulder girdle strength and endurance

1. Hanging in arm-flexed position
2. Modified pull-ups (with stick)
3. Knee push-ups
4. Bench push-ups
5. Bleacher push-ups

Abdominal strength and endurance

6. Crossed-arm curl-ups
7. Sitting V (hands on thigh)
8. Sitting V (reach position)

Power

9. Standing broad jump
10. Jump and reach

Running, speed, agility and endurance

11. 80-yard potato race

Agility

12. Treadmill

Flexibility

13. Floor touch
14. Trunk flexion

One instructor was in charge of the testing and was assisted in each class by four squad leaders. These squad leaders met after school each day to receive information and practice the administration of the tests that were to be given the following day.

The tests were given the 99 subjects in a period of one week. A re-test was given to all students the following week.

For objectivity purposes, the second testing was administered by a different instructor. The squad leaders remained the same, but they administered a different test the second time.

In planning the order in which the tests were administered, two items had to be considered. First, no one of the six factors of physical fitness could be tested twice in one day. For example, two arm and shoulder girdle tests could not be given in the same class period. Second, the time allowed for testing in one 40-minute physical education class had to be watched. It was estimated that four tests could be administered in one period.

Considering the above items, plus the number of trials permitted on the various tests and that some tests required no warm-up, a testing plan was made. This plan follows:

<u>Testing day</u>	<u>Tests</u>
I	<ol style="list-style-type: none"> 1. Floor touch 2. Sitting trunk flexion 3. Hanging in arm-flexed position (first trial) 4. Sitting V (hands on thigh)
II	<ol style="list-style-type: none"> 1. Standing broad jump 2. Cross-arm curl-ups 3. 80-yard potato race 4. Modified pull-ups (stick)
III	<ol style="list-style-type: none"> 1. Sitting V (reach position) 2. Jump and reach 3. Treadmill 4. Knee push-ups
IV	<ol style="list-style-type: none"> 1. Bleacher push-ups 2. Hanging in arm-flexed position (second trial)
V	<ol style="list-style-type: none"> 1. Bench push-ups

Each class was divided into four groups for convenience of administration. Since most days had four tests, each group would report to a testing station. All instructions for the tests to be conducted in one day were explained to the class by the instructor and demonstrated by the squad leaders before any tests were administered.

In order to maintain the desired number of subjects, make-up tests were allowed and were given on the last two days of each testing week. Another consideration in make-up testing is the fact that in any teaching situation where a test battery is given there will always be some students who will be absent and will need to make up the work later.

Statistical Methods

All raw scores were changed to T-scores by the percentage method (37, pp.317-322). The T-scores were used to correlate the first tests with the re-tests. The Pearson Product-Moment method was used to find the objectivity coefficients. The two pass or fail tests, floor touch and sitting trunk flexion, however, could not be correlated by this method. The tetrachoric method of correlation was used to obtain those objectivity coefficients (18, pp.376-379).

The tests with objectivity coefficients above .60 were then used in the validation stage. Intercorrelations of the first scores from the objective tests were figured. The scores from the tests were also correlated with the criterion in order to obtain validity coefficients. The criterion for validation in this study was the average of the T-scores on the numerically scored tests that had an objectivity coefficient above .60. Once again the pass or fail tests could not be correlated in the same manner. The bi-serial correlation was used in correlating the two pass or fail tests with each of the numerically scored tests and tetrachoric correlation was used in correlating floor touch with sitting trunk flexion.

These correlation coefficients were then used in the Wherry-Doolittle method of multiple correlation. This

method was used to select the minimum number of tests that could be included in the battery and also obtain the highest validity coefficient for any group of tests selected from this battery (13, p.404).

Limitations of the Study

In order to draw conclusions from a study of this type one must take into consideration the following:

1. The results obtained from the small number of subjects used may not be indicative of junior high school girls throughout the state.
2. The limited time in administering the test gave the subjects little rest between trials.
3. The limitation of time prevented students from taking each day's tests in the same order.
4. Muscle fatigue from continual testing may have affected results of tests administered later in the week.
5. Make-up tests were allowed in order to maintain the desired number of subjects. This may or may not have affected the results of the testing.
6. The validating criterion of the test was the average of the T-scores on the numerically scored tests. The reader must consider first that flexibility was not included in the criterion. If flexibility is a part of physical fitness it has not been determined in this study.

Secondly, more test items were included in some areas than others, thus giving a larger percentage of the criterion score to that area. It may be, however, that strength and endurance do play a larger part in the physical fitness of the child than do other components.

Description of the Experimental Test Items

1. Floor touch

- a. Starting position: The pupil stands erect, feet together and hands at sides. The tester places his hands on the pupil's knees to determine whether they remain straight.
- b. Action: The pupil bends down and touches the floor with his finger tips without bending the knees. This position is held for three seconds.
- c. Rules: No warm-up is permitted. The pupil is not allowed to bob or bounce. The knees must be kept straight.
- d. Scoring: Touching the floor with the finger tips without bending the knees and holding this position for three seconds constitutes passing the test. Even the slightest bend in the knees constitutes failure.

2. Trunk flexion

- a. Starting position: The pupil sits on the floor with legs extended and together. A partner sets his fists on the subject's knees, holding the knees down.
- b. Action: The pupil bends forward, keeping the knees straight. Reaching forward with the arms, the pupil bends down continuously and touches his forehead to his partner's fists.
- c. Rules: No warm-up is permitted. The pupil is

not allowed to bob or bounce. The knees must not be bent in performing the test.

- d. Scoring: Completing this movement correctly constitutes passing the test. Anything less is failure. A second trial is allowed if the pupil fails the first time.

3. Hanging in arm-flexed position

- a. Starting position: The pupil stands on a stool or table placing the hands shoulder width apart, palms forward, on a horizontal bar or ladder with elbows flexed to permit chin to be at bar level.
- b. Action: The support is removed. The pupil holds his chin at the level of the bar as long as possible.
- c. Rules: The legs should remain extended throughout.
- d. Scoring: The number of seconds the pupil is able to maintain some flexion in the elbow, preventing the upper arm from reaching 180° angle of flexion (arms straight). Two trials were given and the highest score recorded.

4. Sitting V (hands on thigh)

- a. Starting position: The pupil lies on back (on a mat) with feet together and arms extended with hands resting on upper thighs to prevent upper arms from pushing against the floor.
- b. Action: The legs are extended and feet held about six inches from the floor. Simultaneously, the upper spine is raised to about the same position.
- c. Rules: The knees must not be bent. The arms in no way should aid in the movement. It is permissible to bend the head forward.
- d. Scoring: The timer counts seconds aloud. When either the back or the feet are lowered, the time in seconds is recorded. Two trials were given; the highest score is taken.

5. Standing broad jump

- a. Starting position: A take-off line is drawn on the floor. At a distance that all can jump, additional lines are drawn parallel to the take-off line and two inches apart to a point exceeding the farthest jump anticipated. The first line is an even number of feet from the take-off line. The pupil toes the take-off line with both feet, but with feet slightly apart, prior to each jump.
- b. Action: Taking off from both feet, the pupil jumps as far as he can. In jumping he crouches slightly and swings the arms to aid the jump.
- c. Rules: The pupil must take off from both feet and land on both feet. The start must be from a stationary position.
- d. Scoring: The distance to the nearest inch from the take-off line to the closest heel position. If the pupil falls back, he should re-take the test. Record the best of three trials.

6. Crossed-arm Curl-ups

- a. Starting position: The pupil assumes a lying position on the back with knees bent a short distance from the buttocks, soles of the feet flat on the floor, the arms folded and held against the chest. The feet of the pupil tested should be held down firmly by a partner.
- b. Action: The pupil arises to an erect sitting position and returns to a back-lying position as many times as possible without stopping.
- c. Rules: The feet must remain on the floor throughout the test. The elbows must be kept down; and the arms are not used to help the body sit up. Bouncing from the floor is not permissible. Resting during any phase of the performance is not allowed.
- d. Scoring: The number of times the pupil raises himself correctly to a sitting position.

7. 80-yard potato race

Equipment: Two three-inch blocks 2" x 4" (blackboard erasers) are used as "potatoes". Two circles, each one foot in diameter are drawn on the floor. Circle one is behind and tangent to the starting line. The center of circle two is 30 feet from the starting line. Both blocks are placed in circle two.

- a. Starting position: The pupil assumes a position for a standing start with one foot against the starting line.
- b. Action: On the command "go": (a) The pupil runs to circle two, picks up the potato, and carries it to circle one where he places it in the circle. (b) He then repeats the run to obtain and place the second block in circle one. (c) He immediately picks up the first block again, carries it across and deposits it in circle two. (d) He then returns and does likewise with the second block. (e) Finally, he races back across the starting line.
- c. Rules: The blocks must be placed, not thrown or dropped, in the proper circle each time.
- d. Scoring: The time in seconds to complete the race.

8. Modified pull-ups (with stick)

- a. Starting position: A stout stick (broomstick) is placed across the backs of two chairs and held by assistants. The pupil sits on the floor and assumes a position with knees bent, soles of the feet on the floor and shoulders directly under the bar. Reaching up, the pupil grasps the bar with both hands, palms toward the face, and raises the hips from the floor, extending the arms fully with the knees bent at right angles and the body parallel to the floor.
- b. Action: The pupil pulls with the arms until the upper part of the chest touches the stick, lowers to the starting position, and repeats as many times as possible.

- c. Rules: The upper part of the chest must touch the bar with each pull-up. The arms must be fully extended with each lowering of the body. The body must be held straight at all times. The feet are not allowed to shift on the floor.
- d. Scoring: The number of times the body is pulled up so that the chest touches the stick. Score only those pull-ups done correctly.

9. Sitting V (reach position)

Same as test number 4, except arms are extended forward in reach position.

10. Jump and Reach

- a. Starting position: The pupil stands with the right side (or left, if left-handed) next to a smooth surface wall (or jumping board). Keeping the feet flat on the floor, the pupil reaches up with the right (or left) arm and places a mark on the wall with chalk as high as it is possible to reach.
- b. Action: The pupil bends the knees and ankles, assuming a semi-crouch position with the arms swung backward. Then, swinging the arms forward and upward and extending the legs and ankles, he jumps as high in the air as possible and places a second chalk mark on the wall.
- c. Rules: In placing the first chalk mark on the wall, the pupil must stretch as high as possible while keeping both feet flat on the floor. The same length of chalk gripped at the same position should be used for the two marks. Bounding or double jumps are not permitted.
- d. Scoring: The distance in inches between the first mark and the highest mark made from three trials is recorded. Measure to the nearest one fourth of an inch.

11. Treadmill

- a. Starting position: The pupil assumes a modified front-leaning rest position with one knee flexed under the chest and the other leg fully extended behind. While the student is in this position, a chalk line is drawn about a foot long under the ball of the front foot and another line in front of the toe of the back foot.
- b. Action: On the signal "go", the pupil exchanges the position of the feet as rapidly as possible, touching both the front and back lines with his feet.
- c. Rules: Both the front and back lines must be touched on each exchange of the feet.
- d. Scoring: A partner watches and counts only those times in which both feet touch the front and back lines within 30 seconds.

12. Knee push-ups

- a. Starting position: The pupil takes a modified front-leaning rest position on a mat with the weight supported on the hands and knees. The back is straight. The arms are straight and at right angles with the floor; the wrists directly below the shoulders.
- b. Action: The pupil bends the elbows touching the chest to the floor, pushing back to the starting position. Repeat as many times as possible.
- c. Rules: The chest (no other part of the body) must touch the floor with each dip. The arms must be completely extended with each push-up. The body must be held straight with no bend in the hips through the exercise.
- d. Scoring: Count only the times the body is correctly pushed up.

13. Bleacher push-ups

- a. Starting position: The gymnasium bleachers are used in this test. The pupil grasps the

near edge of the lowest bleacher (16" to 18" high) and performs the exercise from this position.

- b. Action: The pupil lowers the body so that the upper chest touches or nearly touches the near end of the bleacher, then raises to a straight arm position as many times as possible.
- c. Rules: The chest must touch or nearly touch the edge of the bleacher. The arms must be completely extended with each push-up. The body must be held straight throughout the exercise.
- d. Scoring: The number of times the body is correctly pushed up. If the body sags, if the hips rise, if the body is pushed far forward on the toes, or if the pupil does not push completely up or go completely down, no credit is given.

14. Bench push-ups

- a. Starting position: A stall bar bench, or stool, 13 inches high by 20 inches long by 14 inches wide, is used. The pupil grasps the outer edges of the bench at the nearest corners and assumes the front-leaning rest position, with the balls of the feet on the mat and with the arms forming a right angle. If a mat is not available, a partner braces the pupil's toes with her foot.
- b. Action: The pupil lowers the body so that the upper chest touches or nearly touches the near edge of the bench, then raises to a straight arm position as many times as possible.
- c. Rules: The chest must touch or nearly touch the edge of the bench. The arms must be completely extended with each push-up. The body must be held straight throughout the exercise.
- d. Scoring: The number of times the body is correctly pushed up. If the body sags, if the hips rise, if the body is pushed far forward on the toes, or if the pupil does not push completely up or go completely down, no credit is given.

CHAPTER II

RELATED STUDIES

This chapter reports those studies reported in the literature which include some phase of testing the factors found in physical fitness and which are pertinent to the test items used in this study. The report is not intended to be an inclusive review of all literature in the area of physical fitness. All reliabilities and validities reported are plus coefficients of correlation unless designated otherwise.

Flexibility Tests

Flexibility is the capacity of the body or any of its parts to move easily through the full range of movement allowed by the structure of the joint or joints involved in the movement (28, p.17).

Floor Touch

This is one of the items included in the Kraus-Weber Test used in determining minimum muscular fitness of school children (17, p.178). A similar pass-fail test is described by Cureton as a part of the Illinois Motor Fitness Test (11, p.35). In the Illinois test the student stands with the feet 12 inches apart and knees straight. To pass he must bend forward and touch the floor with the fingers.

Brace also includes the floor touch item in his Motor Ability Tests (7, p.4).

The Standing, Bobbing Test has the subject standing on a platform in front of which there is a scale marked in half-inch intervals; this scale extends above and below the platform. The subject bends forward and then bobs down forcefully, reaching with both hands. The knees must remain straight and the score is the lowest point reached in the series of bobbings. This numerically scored test is described in Scott and French (37, p.181).

Evaluation of the Floor Touch. Seven different testers were used by Phillips in her study of the Kraus-Weber Test. A reliability coefficient of .954 was reported from her study (30, p.316). Kirchner and Glines found girls to be superior to boys in the floor touch. Only 14 per cent of the girls failed to pass while 33.98 per cent of the boys failed (15, p.24). In testing 451 school children Brace reports a constancy of failure between the first and second trial of 62.5 per cent for the floor touch (7, p.30). Schrodtt found that 95.83 per cent of the high school girls tested performed the same on the second trial as they did on the first trial (36, p.50).

No material is available on the validity of the floor touch test. The floor touch is, however, intercorrelated and validated against the total scores of the tests in this study.

Sitting Trunk Flexion

Another measure of forward trunk flexibility is the sitting trunk flexion test. This test has been used and scored in numerous ways. The Oregon Motor Fitness Test includes trunk flexion. In order to pass the test, the student must sit on the floor with legs extended and together, reach down, grasp the ankles and touch his forehead to his knees. The legs must remain straight and bobbing is not permitted (28, p.27). The revision of trunk flexion as used in this study employs the help of a partner, whose fists are placed on the knees of the subject. To pass the test, the subject touches the forehead to the fists of the partner under the previously mentioned conditions. The Illinois Motor Fitness Test contains a similar pass-fail test for flexibility. The variation in the Illinois test is the placement of legs 18 inches apart, and to pass the item the subject must bring his head within eight inches of the floor (11, p.21).

Numerically scored tests also have been used in the trunk flexion area. Cureton suggests the variation in the Illinois test mentioned above. The subject clasps his hands behind his head and the score is the distance in inches of the head from the floor (10, p.389). The Sitting, Bobbing Test has the subject assume the same sitting position, with feet together but arms outstretched. A scale is marked on the floor extending above and below the heels.

The score is the distance the finger tips reach when the subject bends forward (37, p.183).

Evaluation of Sitting Trunk Flexion. The Oregon Motor Fitness variation of the trunk flexion test was found to have a consistency of 94.7 per cent between two performances (6, p.67). Schrodt found in a study of 96 high school girls a 79.16 per cent consistency for two performances on the sitting trunk flexion as it is described in this study (36, p.50). In measuring the distance of the head from the floor, Cureton obtained a reliability coefficient of .958 (10, p.389). Wells and Dillon found the reliability coefficient to be .98 on college women on the distance reached on a scale between the legs (40, p.118).

Reported validity coefficients vary considerably. For pass or fail tests, the forehead to knee tested by Bowman reported .70 (6, p.79). Trunk flexion using the method of forehead to partner's fists as studied by Schrodt received .4039 (36, p.55). O'Connor and Cureton found the validity of their test to be .415 (27, p.303). The criterion in each case was a composite score of the motor fitness test battery given the subjects. Wells and Dillon reported a correlation coefficient of .90 between sitting trunk flexion and the Standing, Bobbing Test (40, p.118).

Tests of Arm and Shoulder Girdle Strength and Endurance

Pull-ups and push-ups presumably measure muscular strength and endurance of the arm and shoulder girdle relative to the weight of the body. The Oregon State Department of Education defined strength as the slow contractile ability of a muscle or group of muscles. Relative strength and muscular endurance tested by pull-ups and push-ups are a measure of an individual's capacity to do heavy work relative to body weight in a short interval of time (28, pp. 14-15).

Pull-ups

The pull-up was used as a test of arm strength in the first intercollegiate strength test in 1880 and since that time it has been used in a variety of ways. Sargent, in 1902, described a variation of pull-ups which is included in both the Oregon Motor Fitness Test and this study. His description is as follows:

Support a wooden stick, or wand, about 36 inches long, and one inch in diameter, from the back of two chairs placed about 24 inches apart, so that the wand is about 30 inches from the floor, or just high enough to allow the body to clear the floor when supported at arms length..... Grasp the bar with palms toward the face, arms fully stretched, body held horizontally on a line with the thighs, and legs bent at an angle so that the feet are directly under the knee..... While maintaining this position, pull with the arms until the chest touches the bar..... (35, p.12).

The National Section on Women's Athletics of the American Association for Health, Physical Education and Recreation* recommends Sargent's type pull-up with the exception of two modifications. First, the bar height is raised to three feet six inches and second, the palms are held away from the face (26, p.356). The United States Office of Education proposes the same modified pull-up with the bar placed three feet from the floor (39, p.90).

Rogers proposes a different type pull-up as a component of his Strength Index test. The subject grasps a pair of rings suspended from a horizontal bar at a height that the bottom of the rings are four feet from the floor. The heels are placed on a mat and the body is held rigid so that the trunk and extended arms form a right angle. The arms are flexed and extended as many times as possible (32, p.113).

A variation of Rogers' test is described by Clarke (9, p.164). The horizontal bar is placed at the height of the apex of the sternum. The use of the Gay apparatus is also described. This apparatus consists of a platform with movable heel rests which may be raised or lowered in relation to the height of the subject; thus the need for adjustment of the horizontal bar is eliminated.

*Now known as The National Section for Girls' and Women's Sports of the American Association for Health, Physical Education and Recreation.

Evaluation of the Pull-up. Bowman reported a reliability coefficient of .846 for the type pull-ups used in the Oregon Motor Fitness tests (6, p.64). Schrodtt obtained a coefficient of .6484 for the same test (36, p.48).

In validating the pull-ups as a measure of physical fitness, Bowman, in her study of 158 senior high school girls, used the composite scores of the motor fitness test as the criterion and obtained a correlation coefficient of .475 (6, p.76). Schrodtt used the same method of validation with 96 senior high school girls and obtained a correlation coefficient of .7124 (36, p.56).

Using the Rogers' type pull-up for girls, Wilson obtained a coefficient of correlation of .797 with the short Rogers' Strength Index test (41, p.260). Rogers found that for boys the pull-ups correlated .59 with the Athletic Index (33, p.35).

Push-ups

Many types of push-ups are reported in the literature. This type test is commonly used to measure arm and shoulder girdle strength.

One of the widely used types of push-ups for men is called floor push-ups. The performer starts in a prone position, with hands on the floor and under the shoulders, and with body straight from shoulders to toes. He raises his body and then lowers it until his chest touches the

floor, keeping his body straight throughout the movement. The score is the number of correctly executed push-ups (21, p.170).

A similar test is given by Rogers in the Physical Fitness Index for girls. Instead of placing the hands on the floor, the subject grasps the near corners of a stall bar bench placed on a mat six inches from a wall. The student then performs the same type of push-up by touching the upper chest to the front edge of the stall bar bench (18, p.95).

A variation to the push-up test just described is used in this study. Instead of a stall bar bench the lower level of the gymnasium bleacher is used. This accommodates more students at one time since many schools do not have a supply of stall bar benches. The action for performing the test is the same except that the student grasps the front edge of the bleachers.

Another popular type of push-up used is known as the "knee push-up" or "knee dips." In performing this test the student lies down in a prone position, with knees bent at right angles, and both hands are under his shoulders. Keeping his body straight from head to knees, he extends his arms and then lowers his body until his chest touches the floor. This is repeated and his score is the number of correctly executed push-ups (26, p.356).

Sargent proposed a similar test in 1902. Instead of resting the hands on the floor, the hands were rested on blocks of wood or books about four inches thick. The subject then pushed up to an extended arm position and lowered the body again until the chin was at the same level as the top surface of the blocks or books (35, p.13).

The Women's Army Corps Physical Fitness Test includes the knee push-up, but it is called knee dips. The list of the test items included in the battery is reported in the book by Larson and Yocum (18, p.179).

Evaluation of the Push-up. Many results have been reported on push-ups. Bowman and O'Connor and Cureton used knee push-ups in their studies with high school girls. Bowman reports a reliability coefficient of .83 (6, p.64). O'Connor and Cureton report a reliability coefficient of .94 (27, p.303). In testing 140 college women, Mohr found the reliability coefficient of the knee push-ups to be .925 (25, p.342). Schrodt, in testing high school girls, used three types of push-ups: knee, bench and bleacher. Her report shows reliability coefficients of .8258, .8635 and .8949, respectively (36, p.48).

Variations on validity coefficients have been reported, possibly because different criterion have been used. Bowman correlated knee push-ups with the total scores of the battery and found a coefficient of .348 (6, p.76). Using

high school girls, Schrodtt reports a correlation coefficient of .7017 between knee push-ups and the score on the test battery (36, p.56). O'Connor and Cureton report a coefficient of .583 for the same type of study (26, p.305). Wilson's study deals with knee and bench push-ups for college women. These tests were correlated with the short form of the Rogers' Strength Index and were reported as .717 for knee push-ups and .632 for bench push-ups (41, p.260).

Hanging in Arm-flexed Position

This test requires the subject to stand on a stool, face a horizontal bar or ladder, with palms toward his face, place his hands on the bar with the width of the shoulders between the hands. The stool is removed and the subject hangs from the bar, with arms flexed and body straight. He maintains this position as long as possible. The score is the number of seconds from the time the stool is removed until the arms are fully extended. This item is proposed as a test of arm and shoulder girdle strength by the United States Office of Education (39, p.90). The same arm-flexion test is incorporated in this study, except that the palms are placed in a forward position on the bar.

Evaluation of Hanging in Arm-flexed Position. Wilson obtained a correlation coefficient of .471 between the results obtained by the United States Department of Education

test and the scores made on the "push-pull" and hand dynamometers by 52 college women. McHone, et al scored high school boys with the same test item except that he gave credit only for the time the arms were fully bent. He reported a reliability coefficient of .246 when the results were correlated against a composite score of 19 physical efficiency tests (24, p.91). Schrodt reported results with the palms facing forward on the bar during the test and she obtained an objectivity coefficient of .7978. She reported a validity coefficient of .7995 when the results were correlated with a composite score of the test battery (36, pp.48 and 56).

Tests of Abdominal Strength and Endurance

It has been commonly accepted that tests of abdominal strength and endurance such as the sit-ups are measures of what has been called "muscular" or "local" endurance. The Oregon State Department of Education states that local fatigue develops in the particular muscle groups being tested without noticeable fatigue in other parts of the body. No great stress is put on the cardiovascular-respiratory function (28, p.15).

Sit-ups or Curl-ups

The sit-ups have many variations. Basically, the test requires the subject to pull himself from a supine position

to a sitting position with the use of the abdominal muscles, while the feet are anchored.

McCloy and Young describe the knee-touch sit-ups in which the student, hands behind his head, sits up, touches the right elbow to the left knee and returns to a back-lying position. This is repeated, except on the next rise the student touches the left elbow to the right knee. This is repeated as many times as possible. The feet are about 18 inches apart and anchored by a partner. The knees are slightly flexed (21, p.171). The Women's Navy Reserve Physical Fitness Test as described by Larson and Yocum includes the sit-ups as described above, except that the knees and legs were kept flat on the floor (18, p.181).

The Women's Army Corps Physical Fitness Test includes a type sit-ups with knees bent and arms at the side (18, p.179). The Oregon Motor Fitness Test uses a test called the "curl-ups." This is fundamentally the same as the sit-ups described previously, except that the student curls the arms around his knees as he rises to the sitting position. The arms, however, are not to be used in aiding the subject to a sitting position (28, p.24).

Mohr reports on the easiest sit-ups to perform and to standardize as follows:

The subject's starting position is lying down on his back on a mat, legs straight and together, hands on shoulders with elbows close to the body. A partner sits on

the subject's feet, holding down his ankles, and counts the number of sit-ups completed. The subject must keep moving constantly, his trunk becoming alternately vertical and horizontal. Speed is not stressed, but no pauses are allowed. The score is the number of sit-ups possible (23, p.342).

A combination of the above test and the curl-ups was used by Schrodt. The crossed-arm curl-ups is performed with the arms folded across the chest and elbows close to the body. The knees are bent and held by a partner. The subject comes to a sitting position as many times as possible.

Evaluation of the Sit-ups or Curl-ups. Mohr reports a reliability coefficient of .936 on the straight leg sit-up (25, p.342). O'Connor and Cureton reported a reliability coefficient of .96 (27, p.303).

Bowman, who tested high school girls with the curl-ups, found a reliability coefficient of .807 (6, p.64). In testing the same age group, but using the crossed-arm curl-ups, Schrodt reported a reliability coefficient of .7114 (36, p.48). McCloy ran a study on the knee touch type sit-ups on 345 elementary school boys. The resulting reliability coefficient was .643 (20, p.57).

Phillips correlated sit-ups with the Scott Motor Ability Test (29, p.62 and 37, p.193). The resulting validity coefficient was .243. Scott and Wilson reported a correlation coefficient of .522 between sit-ups and the work

output on the bicycle ergometer while testing college women (38, p.64).

Other studies have been done in validating the sit-ups by the use of a composite score of the tests as the criterion. Among these are: O'Connor and Cureton with high school girls, .577 (27, p.305); Bowman with high school girls, .378 (6, p.76); and Schrodtt with high school girls, .6750 (36, p.56).

Sitting V

In this test, the subject lies on his back with arms extended and resting on the thighs. He then sits in a "V" position with the feet and upper spine raised about six inches from the floor; the head may be bent forward. The score is the number of seconds that this position can be held. This test has been included in the United States Office of Education and the Women's Army Corps physical fitness batteries and is described in Schrodtt (36, p.19).

This study proposes the use of the sitting V thigh as well as a modification in which the arms are extended forward in a reach position, rather than on the thighs.

Evaluation of the Sitting V. Phillips tested 200 college women in the manner described by the United States Office of Education. She found this test to correlate .15 with the Scott Motor Ability Test (29, p.62).

Schrodt found reliability coefficients of .7556 and .8486 on sitting V thigh and sitting V reach position, respectively. Since the reliability was found to be higher on the sitting V reach position, Schrodt then correlated it against the composite scores of the battery to receive a validity coefficient of .4391 (36, p.56).

Tests of Power

The jump-reach and the standing broad jump are proposed as tests for indicating the degree of explosive effort that can be developed by the legs. They are essentially a measure of relative power in an instantaneous force-time relationship. The score indicates the ability of the performer to increase the velocity relative to the weight of the body (28, p.16).

Standing Broad Jump

Clarke describes the standardized form of the standing broad jump. The subject toes a line and jumps as far as possible, with a double-foot take-off and landing. The jumps are made to a mat held firmly on the floor two feet from the take-off line. Three trials are allowed, with the best jump being recorded. The distance from the take-off line to the closest heel position is measured to the nearest inch (9, p.277). The National Section on Women's

Athletics* also uses this test, but only two trials are permitted (26, p.355).

Cureton includes the standing broad jump in the Illinois Motor Fitness Test for men. Instead of recording the length of the jump, it is recorded on a pass-fail basis with everything less than seven feet a failure (11, p.26).

Evaluation of the Standing Broad Jump. Using high school girls as subjects, Schrodts found the reliability coefficient of the standing broad jump to be .8461 (36, p. 48), while O'Connor and Cureton reported a coefficient of .98 (27, p.303).

McCloy found the reliability coefficient to be .669 after testing 345 elementary school boys (20, p.57). McGraw and Tobbert found in their study of 128 seventh grade boys that if the best of three trials was taken the reliability coefficient was .916. If only one jump was allowed, however, the correlation coefficient fell to .797 (23, p. 79).

Validity coefficients established by using composite scores of motor fitness tests as the criterion include the studies by O'Connor and Cureton who reported a coefficient of .396 (27, p.305); Powell and Howe, .766 (31, p.83); and Schrodts, .7720 (36, p.56).

*Now known as The National Section for Girls' and Women's Sports of the American Association for Health, Physical Education and Recreation.

Other methods of validating the standing broad jump have been used. Phillips found that with college women the standing broad jump correlated .7178 with the Scott Motor Ability Test (29, p.62). Anderson and McCloy reported that this test correlated .576 with a subjective rating of sport skills of high school girls (4, p.6). Harris stated that the standing broad jump correlated .3566 with the Strength Index and .4069 with the Physical Fitness Index (14, p.117).

Vertical Jump or Jump-Reach

The vertical jump has been used in many forms to measure power of the legs. The earliest form of this jump was used by Sargent and became known as the Sargent Jump. Sargent's description of the test follows:

The individual stands in the center of an eighteen-inch circle. He is instructed to swing his arms downward and backward, inclining the body slightly forward and bending the knees to about ninety degrees. He is instructed to pause in this position, the purpose of the pause being to eliminate the possibility of a double jump. He is then told to jump upward as high as possible, swinging his arms violently forward and upward to the vertical. He is instructed to swing his arms forward and downward just before the highest point of the jump is reached, the end of this downward motion being timed to coincide exactly with the end of the upward jump. The whole body at this moment is straight and the crown of the head is extended upward as high as possible. The score was the number of inches that the top of the head could be projected upward (34, p.190).

Several methods of measuring the vertical jump have been proposed. Schrodts describes a method devised by Martin in which graduated markers or slats are suspended from a horizontal beam. The slats are four inches apart and each one is one inch higher than the previous slat. The subject touches the highest slat that he can reach from a standing position, and then jumps at progressively higher markers until he fails to reach the one for which he is trying (36, p.23).

The "Leap-Meter" was devised by Bovard and Cozens. It consists of an upright stand with an operating arm from which a cap or harness is suspended to fit the subject's head. As the subject jumps, a guide-held pencil is moved on graph paper, recording the height of the jump in reduced size (5, p.141).

A modification of the Sargent jump is described by Clarke (9, p.192). The "chalk jump" or jump and reach uses a blackboard or smooth surface wall. The subject holds a piece of chalk and places a mark on the blackboard at his highest standing reach. He then jumps up and marks the board at his highest jumping reach. Three trials are allowed and the best of the three is recorded. Scores are measured in inches from the standing mark to the jumping mark.

Evaluation of the Vertical Jump or Jump-Reach. Reliabilities for many of the variations to the Sargent jump have been reported. With the "Leap-Meter", Bovard and Cozens found a reliability coefficient of .61 (5, p.104). Alden used a method of marking a blackboard with a wet finger. The reliability coefficient of this method with college women was reported to be .87 (2, p.101).

Testing high school girls with the jump and reach method and using a piece of chalk, Bowman found a reliability coefficient of .877 (6, p.64). Schrodtt in the same type of study reports a coefficient of .8515 (36, p.48).

McGraw used 128 seventh grade boys in a study of the effects of various methods of testing on reliabilities. He found that when one trial was given the reliability coefficient was .758, but when the best of three trials was recorded the coefficient went up to .889 (23, p.79).

In validating the test with a composite score of motor fitness tests, Bowman reports a coefficient of .677 (6, p.76). Schrodtt found a coefficient of .6573 (36, p.56). Adams found the Sargent jump to correlate .6039 with total points in athletic events for junior high school girls (1, p.99). Powell and Howe correlated the results of vertical jump made high school girls and their results in 18 motor ability tests and found a correlation of .634 (31, p.83).

Carpenter used 100 college women as subjects and found the Sargent jump to correlate with track and field achievement at .5267 (8, p.24). Carpenter also reported .2086 with the Physical Fitness Index (8, p.24). McCloy, using high school girls, reported validity correlation coefficients of .582 with track and field events and .661 when compared with motor ability tests (19, p.238). The Sargent jump correlated .540 with track and field athletics according to Anderson who tested 300 high school girls (3, p.70).

Tests of Running Speed, Endurance and Agility

Cardiovascular-respiratory endurance is the capacity of the individual to sustain effort over a relatively long period of time, or the ability for long continued muscular contraction where a large number of muscles are exercised for a duration of time and at an intensity to put demand on the functions of circulation and respiration (28, pp.15-16).

Speed is generally recognized as one of the main factors affecting performance in physical activity. Speed is the capacity of an individual to make rapid successive movements.

Potato Race

The potato race, a type of shuttle run, involves a combination of running, changing direction and handling

small objects. It is named such because the early use of the test employed boxes and potatoes.

The test is described by The National Section on Women's Athletics.* Two circles are placed on the floor 30 feet apart, with two blocks or "potatoes" in circle 2. The subject starts running from circle 1, and is scored on the number of seconds taken to perform the race. He runs to circle 2, picks up one block and places it in circle 1. He repeats the run to place the second block in circle 1. He immediately picks up the first block and returns it to circle 2, then repeats this with the second block. To finish, he races back across the starting circle (26, p. 356). The United States Office of Education advocates a potato race with a starting line (39, p.81).

Other forms of this race have been employed, with variations in the position of circles or lines. The Reilly potato race as described by McCloy has three lines drawn on the floor at specified distances. One line is used as a starting line and a block is placed on each of the other two. The same sequence is followed as was described above (20, p.43).

Evaluation of the Potato Race. In testing high school boys, Knapp reported a reliability coefficient of .91 (16, p.30). For high school girls, Schrodts obtained a

*Now known as The National Section for Girls' and Women's Sports of the American Association for Health, Physical Education and Recreation.

of .1806 (36, p.48). McCue reports .827 for college women (22, p.91).

McCloy obtained a validity coefficient of .754 with a validating criterion of total points on 18 tests of athletic power for high school boys (20, p.43). McCue obtained a coefficient of .644 in relating the potato race to composite scores made on 19 physical efficiency tests (22, p.91).

Treadmill

The treadmill, performed at full speed for 30 seconds, is a measure of speed and cardiovascular-respiratory endurance. It was listed and described by Stafford in his book, Football Conditioning Exercises (28, p.9). The treadmill was standardized and used in the Oregon Motor Fitness tests (28, p.25).

To perform the test, the subject assumes a modified front-leaning rest position with one knee flexed under the chest and the other extended directly behind the body, with body weight being supported on the hands and balls of the feet. During the test, the subject exchanges the position of the feet as rapidly as possible and is scored for each exchange of position. Legs must be extended completely behind and touching chest in front (28, p.25).

A modification to the treadmill has been used by Schrodt and in this study. A chalk line is drawn on the

floor by the ball of the front foot and a similar line is drawn in front of the toe of the back foot. The exchanges of feet position then must change from line to line in order to count.

Evaluation of the Treadmill. Bowman tested high school girls with a line drawn only in front of the rear foot. She obtained a reliability coefficient of .738 (6, p.64). She reported a validity coefficient of .551 with the criterion being the composite scores of six motor fitness tests (6, p.76).

Schrodt also administered the test to high school girls but used the lines on both front and back feet. Her results for reliability were .5799 (36, p.48). The validating criterion was the composite score on eight physical fitness test items for which she received a validity coefficient of .6256 (36, p.56).

CHAPTER III

THE RESULTS

Objectivity of the Tests

The first statistical procedure used in analyzing the data was correlation of the test and re-test for an objectivity coefficient. The objectivity of a test is the degree of uniformity with which a number of testers can score the same test. If a test is objective it is assumed to be reliable (9, p.37).

The objectivity coefficient for the numerically scored tests were obtained by use of the Pearson Product-Moment method of correlation. These figures obtained appear in Table I.

The objectivity coefficients for the pass or fail tests were correlated by the tetrachoric method of correlation. These results are also listed in Table I.

Selection of Tests for Further Analysis

To analyze the data, it was necessary to select those tests with the highest degree of objectivity. Since a test with an objectivity coefficient below .60 is not considered desirable, the tests with low coefficients were eliminated from further analysis. A study of Table I reveals that three tests do not meet this requirement. Two more tests were eliminated for other reasons.

TABLE I
THE OBJECTIVITY COEFFICIENTS
OF THE 14 PHYSICAL FITNESS TESTS

Test	r
Hanging in arm-flexed position	.8534
Sitting V (hands on thigh)	.5883
Standing broad jump	.9182
Crossed-arm curl-ups	.7133
80-yard potato race	.6322
Modified pull-ups (with stick)	.3276
Sitting V (reach position)	.6937
Jump-Reach	.5891
Treadmill	.6223
Bleacher push-ups	.6684
Knee push-ups	.6301
Bench push-ups	.6264
Floor touch*	.7500
Trunk flexion*	.8333

*Tetrachoric method of correlation employed.

1. Sitting V (hands on thigh). This test shows an objectivity of .5883 which is only slightly below the desired .60 level. Since two similar tests were given and the sitting V reach had a much higher coefficient, the sitting V (hands on thigh) was eliminated. The writer observed that students had better balance in the sitting V (reach) because the arms were higher from the body and gave better leverage. It is possible that this factor aids in the administration of the reach type test.

2. Pull-ups. This test had an objectivity coefficient of .3276 which is much too low for consideration in the final test battery. During the administration of the test the student often had a variation of foot position when getting into position under the bar. If the feet were in a comfortable place for the student she did well on the test. During the next time the test is taken, a variance of an inch or two in the position of the feet may cause the student to do worse or better on the test. Since the feet may not be moved during the administration of the test, it may indicate the reason for the low objectivity.

3. Jump-Reach. Even though three trials were allowed on each administration of this test, the objectivity coefficient was still not desirable. The writer observed that students did better on the second trial of the test, apparently because of a learning factor. On the first trial, the student would jump and reach to the wall on what

appeared to be the down swing of the arm. On the second administration some students were getting the "feel" of the jump and getting the chalk mark on the upswing of the arms and thus reaching the highest peak of the jump.

4. Knee push-ups. Even though knee push-ups had a coefficient above .60 it was felt that only one test of this type was necessary in the final battery. Since other push-ups gave higher objectivity coefficients, this item was eliminated.

5. Bench push-ups. This test is in the same category as the knee push-ups as far as objectivity is concerned. It was eliminated because only one push-up test was needed. The bench push-up produced bad distribution of scores. Most students were unable to do more than one push-up of this type. This grouping of scores indicated that the test is too difficult for the sample of students evaluated.

After eliminating the above tests from consideration for the final battery, the following test items were retained in the study for further analysis: (1) hanging in arm-flexed position, (2) standing broad jump, (3) crossed-arm curl-ups, (4) 80-yard potato race, (5) sitting V (reach position), (6) treadmill, (7) bleacher push-ups, (8) floor touch and (9) sitting trunk flexion.

Validation and Intercorrelation of the Test Items

The next step in the treatment of the data was the determination of the criterion score, against which the tests could be validated. The criterion score for this study was the average of the T-scores on the numerically scored test items remaining in the study. T-scores were necessary in that all scores had to be of comparable value. This was accomplished by adding the T-scores of each subject on the seven numerically scored tests and dividing by seven to obtain the arithmetic mean T-score for each student.

To obtain the validity coefficients of the test items, the tests were intercorrelated. The T-scores of each numerically scored test were intercorrelated with each of the other tests and with the criterion score. This was accomplished through the calculation of the zero order correlations by the Pearson Product-Moment method. These correlation coefficients are found in Table II.

To calculate the validity and intercorrelation coefficients of the pass or fail tests, floor touch and sitting trunk flexion, each of the pass or fail tests was correlated with each of the numerically scored tests and the criterion score by use of the bi-serial method of correlation. In order to obtain a correlation coefficient between the two pass or fail items, tetrachoric correlation

was used. These results also appear in Table II.

Summary

In this chapter the writer has presented the data as they were collected in the testing. The results presented in the chapter are the presentation of the material as it was analyzed through statistical processes. The selection of the test battery is discussed in the next chapter.

TABLE II

THE INTERCORRELATIONS OF THE TEST SCORES WITH EACH OTHER
AND WITH THE CRITERION SCORE

	1*	2	3	4	5	6	7	8	9
C	.8241	.8264	.6559	.7158	.6394	.5703	.6552	.3463**	.2304**
1		.6402	.5168	.4841	.5168	.3700	.4858	.1837	.2072
2			.4654	.6500	.4762	.3644	.4354	.2957	.1805
3				.3871	.3549	.2038	.2833	.2773	.2800
4					.2665	.2876	.4276	.2407	.1889
5						.2294	.2791	.2788	-.0275
6							.3452	.1219	.0092
7								.2489	.1286
8									.6429***

*Key to variables in Table II.

- | | | | |
|----|-----------------------------------|----|----------------------------|
| C | Criterion score (average T-score) | 5. | Sitting V (reach position) |
| 1. | Hanging in arm-flexed position | 6. | Treadmill |
| 2. | Standing broad jump | 7. | Bleacher |
| 3. | Crossed-arm curl-ups | 8. | Floor touch |
| 4. | 80-yard potato race | 9. | Sitting trunk flexion |

**Bi-serial correlation coefficient in this column.

***Tetrachoric correlation coefficient.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

After obtaining the necessary data, it is necessary to arrive at a physical fitness test battery. In order to draw conclusions and arrive at this final battery, another statistical procedure is necessary. This is the computation of a maximum multiple correlation between certain test items and the criterion score. This is done by the use of the Wherry-Doolittle Test Selection Method by which tests are selected analytically and added one at a time until a maximum multiple correlation coefficient is obtained (13, p.404).

The Selection of the Test Battery

From the intercorrelations of the tests, it was determined that the standing broad jump had the highest correlation with the criterion. The correlation coefficient was .8264. The standing broad jump then would be the first selected test for the battery.

An analysis of Table III shows that the multiple correlation coefficient R is increased .0839 by the addition of a second test. This test, hanging in arm-flexed position, increases the coefficient to .9103.

TABLE III
 THE INCREASE IN THE MULTIPLE CORRELATION COEFFICIENT
 WITH ADDITIONAL VARIABLES

Variables	R
2. Standing broad jump	$R_{C.2} = .8264$
1. Hanging in arm-flexed position	$R_{C.21} = .9103$
7. Bleacher push-ups	$R_{C.217} = .9369$
3. Crossed-arm curl-ups	$R_{C.2173} = .9563$
6. Treadmill	$R_{C.21736} = .9679$

By adding the third variable of bleacher push-ups, the R is increased .0266 to give a multiple correlation coefficient for three tests of .9369.

Crossed-arm curl-ups was the fourth selected test and added .0194 to the coefficient to give a multiple R of .9563. This correlation coefficient is high enough to be valuable as a predictive index of physical fitness.

Adding one further test, the treadmill, the R is raised very little. The treadmill contributes .0116 to the multiple R giving a total for the five tests of .9679. The addition of a sixth variable, sitting V (reach position), increases the multiple R .0074. This is such a small increase that the addition of this test to the battery would not be justified in results or administrative economy.

The Final Test Battery

On the basis of the Wherry-Doolittle method of multiple correlation, the following items are recommended for the physical fitness test battery for junior high school girls:

1. Standing broad jump
2. Hanging in arm-flexed position
3. Bleacher push-ups
4. Crossed-arm curl-ups
5. Treadmill

In the case that a four item battery is preferred, the fifth test (treadmill) may be eliminated and still leave a highly valid test of physical fitness as it is measured in this study.

An analysis of Table III shows that the following elements of motor fitness are represented: arm and shoulder girdle strength and endurance of which there are two tests, power, agility and abdominal strength and endurance. Only two of the elements, flexibility and running speed, agility and endurance, were omitted from the battery.

Recommendations for Further Research

In view of the limitations of this study, the following general recommendations are offered as opportunities for further research:

1. It is recommended that research be conducted to develop a more valid criterion of physical fitness than the one used in this study. It is further recommended that the test items of this study be validated against another criterion.

2. It is recommended that more subjects be used in testing the items in this battery to obtain norms and standards of performance.

3. It is recommended that further study be carried on in an attempt to raise the objectivity level of some of the test items in this study by practice or warm-ups.

4. This study included girls age 12 through 15. It did not, however, make any distinction between ages. Since this is a period of rapid growth and development, it is recommended that studies be carried on at each of the age levels encompassed in this study.

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APPENDIX

TABLE IV
THE WORK-SHEETS FOR THE WHERRY-DOOLITTLE TEST SELECTION

A

	1	2	3	4	5	6	7	8	9
C	.8241	.8264	.6559	.7158	.6394	.5703	.6552	.3463	.2304
1		.6402	.5168	.4841	.5168	.3700	.4858	.1837	.2072
2			.4654	.6500	.4762	.3644	.4354	.2957	.1805
3				.3871	.3549	.2038	.2833	.2773	.2800
4					.2665	.2876	.4276	.2407	.1889
5						.2294	.2791	.2788	-.0275
6							.3452	.1219	.0092
7								.2489	.1286
8									.6429

B

	1	2	3	4	5	6	7	8	9
V ₁	-.8241	-.8264	-.6559	-.7158	-.6394	-.5703	-.6552	-.3463	-.2304
V ₂	-.2950		-.2713	-.1786	-.2459	-.2692	-.2954	-.1019	-.0812
V ₃			-.1619	-.1446	-.1400	-.2008	-.1919	-.1047	-.0354
V ₄			-.1609	-.1129	-.1407	-.1648		-.0635	-.0242
V ₅				-.0392	-.1004	-.1319		-.0270	-.0099

C

	1	2	3	4	5	6	7	8	9
Z ₁	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Z ₂	.5901		.7834	.5775	.7732	.8672	.8104	.9126	.9674
Z ₃			.7022	.5697	.6971	.8355	.7377	.9125	.9532
Z ₄			.7022	.5502	.6971	.8095		.8786	.9507
Z ₅				.4028	.6530	.7802		.8424	.9452

D

m	$\frac{V_m^2}{Z_m}$	K ²	$\frac{N-1}{N-m}$	\bar{K}^2	\bar{R}^2	\bar{R}	Test #
0		1.0000	N= 99				
1	.6829	.3171	1.0000	.3171	.6829	.8264	#2
2	.1474	.1697	1.0103	.1714	.8286	.9103	#1
3	.0499	.1198	1.0208	.1223	.8777	.9369	#7
4	.0369	.0829	1.0316	.0855	.9145	.9563	#3
5	.0223	.0606	1.0426	.0632	.9368	.9679	#6

E

	1	2	3	4	5	6	7	8	9	-C	Check Sum	Test #
a ₁												
b ₁	.6402	1.000	.4654	.6500	.4762	.3644	.4354	.2957	.1805	-.8264	3.6814	#2
c ₁	-.6402	-1.000	-.4654	-.6500	-.4762	-.3644	-.4354	-.2957	-.1805	.8264	-3.6814	
a ₂	1.000	.6402	.5168	.4841	.5168	.3700	.4858	.1837	.2072	-.8241	3.5805	#1
b ₂	.5901		.2189	.0680	.2119	.1367	.2071	-.0056	.0916	-.2950	1.2237	
c ₂	-1.000		-.3709	-.1152	-.3591	-.2317	-.3510	.0095	-.1552	.4999	-2.0737	
a ₃	.4858	.4354	.2833	.4276	.2791	.3452	1.000	.2849	.1286	-.6552	3.0147	#7
b ₃			.0039	.1199	-.0026	.1385	.7377	.1582	.0431	-.1919	1.0041	
c ₃			-.0053	-.1625	.0035	-.1878	-1.000	-.2145	-.0584	.2601	-1.3649	
a ₄	.5168	.4654	1.000	.6500	.4762	.3644	.4354	.2957	.1805	-.6559	3.7285	#3
b ₄			.7022	.3217	.1760	.1434		.1594	.0673	-.1609	1.4041	
c ₄			-1.000	-.4581	-.2506	-.2042		-.2270	-.0887	.2291	-1.9995	

TABLE V

THE T-SCALES FOR THE TESTS IN THE FINAL BATTERY

Standing broad jump		Hanging in arm-flexed position		Bleacher push-ups		Crossed-arm curl-ups		Treadmill	
Score	T-Score	Score	T-Score	Score	T-Score	Score	T-Score	Score	T-Score
6'9"-6'8"	76	43	76	31-30	76	61-60	76	59-58	76
6'7"-6'6"	72	42	74	29-28	73	59-58	74	57-56	72
6'5"-6'4"	70	41	74	27-26	72	57-56	74	55-54	70
6'3"-6'2"	68	40	74	25-24	72	55-54	74	53-52	68
6'1"-6'0"	64	39	74	23-22	72	53-52	74	51-50	66
5'11"-5'10"	60	38	72	21-20	71	51-50	72	49-48	63
5'9"-5'8"	58	37	71	19-18	69	49-48	71	47-46	62
5'7"-5'6"	56	36	71	17-16	68	47-46	71	45-44	59
5'5"-5'4"	53	35	70	15-14	66	45-44	71	43-42	57
5'3"-5'2"	51	34	69	13-12	64	43-42	71	41-40	57
5'1"-5'0"	48	33	68	11-10	61	41-40	70	39-38	55
4'11"-4'10"	46	32	67	9-8	58	39-38	69	37-36	54
4'9"-4'8"	45	31	67	7-6	56	37-36	68	35-34	53
4'7"-4'6"	44	30	67	5-4	52	35-34	66	33-32	52
4'5"-4'4"	41	29	66	3-2	46	33-32	64	31-30	51
4'3"-4'2"	37	28	65	1-0	37	31-30	62	29-28	49
4'1"-4'0"	34	27	64			29-28	61	27-26	49
3'11"-3'10"	32	26	64			27-26	59	25-24	48
3'9"-3'8"	28	25	63			25-24	57	23-22	47
3'7"-3'6"	27	24	61			23-22	56	21-20	46
3'5"-3'4"	24	23	60			21-20	53	19-18	45

Standing broad jump		Hanging in arm-flexed position		Bleacher push-ups		Crossed-arm curl-ups		Treadmill	
Score	T-Score	Score	T-Score	Score	T-Score	Score	T-Score	Score	T-Score
		22	59			19-18	51	17-16	44
		21	59			17-16	49	15-14	42
		20	59			15-14	47	13-12	40
		19	58			13-12	44	11-10	39
		18	56			11-10	41	9-8	38
		17	55			9-8	38	7-6	36
		16	55			7-6	36	5-4	32
		15	54			5-4	34	3-2	24
		14	53			3-2	31		
		13	52			1-0	24		
		12	51						
		11	51						
		10	49						
		9	48						
		8	46						
		7	45						
		6	42						
		5	40						
		4	38						
		3	36						
		2	35						
		1	30						

TABLE VI
COMPLETE T-SCORES AND CRITERION SCORES
FOR ALL SUBJECTS

Key to Table

S	Subject number
1	Floor touch
2	Sitting trunk flexion
3	Hanging in arm-flexed position
4	Sitting V (hands on thigh)
5	Standing broad jump
6	Crossed-arm curl-ups
7	80-yard potato race
8	Modified pull-ups (with stick)
9	Sitting V (reach position)
10	Jump-Reach
11	Treadmill
12	Bleacher push-ups
13	Knee push-ups
14	Bench push-ups
CS	Criterion score
X	Pass
0	Fail

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
1	X	X	63	49	48	53	58	59	55	46	63	66	60	72	58
	X	X	76	60	54	55	55	61	56	47	67	66	64	70	
2	X	X	68	49	56	53	58	64	55	55	59	66	69	76	59
	X	X	70	63	58	76	61	63	64	47	60	72	67	76	
3	X	X	58	40	64	38	58	61	49	53	59	61	53	57	55
	X	X	67	52	67	43	72	63	47	56	58	61	58	65	
4	0	0	30	31	24	36	34	28	28	30	32	37	33	44	32
	0	0	24	30	31	35	38	32	30	44	28	38	34	44	
5	X	X	52	47	48	49	53	51	47	53	36	37	33	44	46
	X	X	52	47	47	35	47	45	40	53	47	38	51	44	
6	X	X	55	56	46	44	53	61	42	48	49	37	41	44	47
	X	X	56	52	45	35	70	45	43	47	46	38	40	44	
7	0	0	51	50	41	41	40	33	53	43	46	52	41	53	46
	0	0	59	55	36	43	41	48	59	49	42	55	44	44	
8	0	0	53	56	58	47	53	55	55	48	53	56	50	44	54
	X	0	62	52	60	41	58	51	60	44	48	55	55	44	
9	0	0	46	40	41	31	48	47	37	35	44	37	41	44	41
	0	0	47	30	36	35	43	32	35	44	42	38	27	44	
10	X	X	42	35	37	53	37	57	45	40	48	37	33	44	43
	X	X	43	47	36	52	39	32	51	35	46	38	34	44	
11	X	X	49	50	41	53	40	64	53	35	47	56	50	53	48
	X	X	51	48	41	45	39	48	47	39	44	51	48	60	
12	0	0	46	47	45	31	44	59	42	46	51	37	47	44	42
	X	0	48	47	43	43	46	41	53	53	52	46	40	44	
13	X	X	53	49	51	53	40	55	45	55	47	61	47	44	50
	X	X	58	52	60	45	76	45	55	64	42	46	51	60	
14	0	0	42	37	41	49	34	47	47	44	48	46	47	44	43
	0	0	51	42	36	52	39	51	49	44	56	55	48	57	
15	X	X	42	47	41	41	44	55	33	43	39	52	44	53	42
	X	X	48	44	39	48	46	41	51	30	45	46	44	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
16	X	X	46	40	44	56	53	51	42	40	55	56	57	57	50
	X	X	46	44	41	52	44	41	49	41	52	55	44	57	
17	X	X	61	52	46	47	48	55	51	48	51	46	53	57	50
	X	X	58	47	47	45	53	48	59	44	55	46	43	60	
18	X	X	48	47	48	49	44	51	45	55	42	52	53	53	47
	X	0	51	42	45	48	50	41	49	35	52	46	55	44	
19	0	0	46	50	32	44	48	47	37	37	59	46	37	53	45
	0	0	40	35	41	35	50	51	43	35	42	46	48	44	
20	0	0	48	52	41	56	30	42	42	51	59	46	44	44	46
	0	0	48	39	41	52	35	45	35	44	45	46	27	53	
21	X	X	38	43	37	51	34	51	42	51	51	37	50	44	41
	X	X	40	35	27	45	44	48	35	56	52	38	34	44	
22	X	0	42	52	37	41	40	51	45	30	42	52	44	53	43
	X	0	46	39	39	45	36	48	43	24	54	38	43	53	
23	X	X	53	43	44	49	44	42	47	40	76	52	53	44	52
	X	X	60	48	47	55	44	45	38	28	76	51	44	44	
24	X	X	53	60	53	47	44	47	62	46	66	52	57	61	54
	X	X	59	55	54	52	47	51	55	44	64	58	53	60	
25	X	X	46	56	44	59	58	55	57	49	55	46	57	53	52
	X	0	55	44	47	59	42	37	47	51	62	46	55	57	
26	X	X	35	60	44	44	44	47	62	60	24	52	44	44	44
	X	0	35	55	43	41	43	41	51	44	38	51	55	44	
27	0	0	30	24	32	31	28	38	28	35	32	46	33	44	32
	0	0	32	24	36	45	24	32	24	39	32	38	34	44	
28	X	0	51	35	41	44	40	42	51	51	38	56	50	53	46
	X	0	48	44	43	48	44	41	45	51	38	55	51	44	
29	X	X	59	38	60	59	72	68	53	54	52	64	47	57	60
	X	X	57	42	65	45	55	59	43	61	56	58	40	53	
30	X	X	42	40	60	62	58	71	33	60	63	58	62	53	54
	X	X	46	49	51	52	58	32	43	39	42	46	56	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
31	X	0	59	52	48	53	48	51	57	43	51	61	41	44	54
	X	X	50	58	49	62	50	59	61	61	53	58	48	53	
32	X	X	61	63	53	59	48	71	59	60	51	71	57	57	57
	X	X	61	72	62	52	61	61	65	67	62	58	53	70	
33	X	X	64	43	53	49	44	55	42	72	45	46	47	44	49
	X	X	55	55	56	45	39	54	43	66	53	46	48	44	
34	X	X	49	56	46	47	48	47	45	60	42	52	53	57	47
	X	X	47	52	45	57	43	51	43	46	48	55	51	44	
35	X	X	55	63	53	62	58	47	55	60	59	46	44	44	55
	X	X	53	65	56	63	58	57	57	53	58	55	64	44	
36	X	X	51	56	48	51	53	59	49	53	53	61	53	61	52
	X	X	51	35	45	45	50	57	40	49	57	61	48	57	
37	X	X	66	58	64	62	64	55	47	57	63	52	69	44	60
	X	X	65	52	58	62	33	51	51	58	48	46	70	53	
38	X	X	72	72	68	72	58	61	76	76	52	71	69	64	67
	X	X	65	76	62	71	61	63	72	67	56	66	48	65	
39	X	0	30	43	32	24	24	42	45	46	49	37	53	44	34
	X	0	32	42	31	30	35	37	30	46	48	38	48	44	
40	X	0	36	40	37	44	44	42	37	40	40	37	57	53	39
	0	X	40	46	43	41	28	41	55	35	54	38	34	44	
41	X	X	52	60	58	49	76	47	42	68	59	58	50	57	56
	X	X	40	46	56	52	67	54	45	53	64	51	40	53	
42	X	X	59	69	48	59	58	42	56	49	59	56	57	44	55
	X	X	54	70	49	52	55	51	59	72	59	51	58	44	
43	X	X	55	54	60	57	64	64	57	64	66	61	62	57	60
	X	X	55	47	62	64	65	63	53	58	62	61	58	60	
44	X	X	56	47	58	62	70	42	33	46	42	56	41	57	52
	X	0	57	39	51	60	53	48	40	35	38	58	48	57	
45	X	X	58	76	53	59	58	47	72	57	48	46	41	44	56
	X	X	61	64	54	57	57	51	76	58	53	46	53	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
46	X	0	38	59	48	36	58	47	51	60	53	46	50	53	47
	X	X	46	48	47	30	61	51	51	61	48	51	40	44	
47	0	0	42	35	41	49	44	47	53	40	57	46	33	44	47
	0	0	43	42	36	43	50	45	40	39	46	38	34	44	
48	0	0	51	35	58	66	64	42	42	68	36	46	33	44	52
	0	0	55	53	51	68	61	59	47	64	48	38	40	44	
49	X	0	55	47	51	53	53	51	51	44	53	46	37	53	52
	X	0	53	44	54	55	50	61	51	37	42	51	34	44	
50	X	0	61	47	48	64	48	55	49	64	32	46	47	44	50
	X	0	66	42	49	63	50	51	45	49	36	51	48	60	
51	X	0	56	55	72	49	58	47	56	60	70	56	59	47	60
	X	X	53	52	72	57	61	63	55	53	60	66	58	57	
52	X	0	51	49	64	41	58	55	42	53	72	61	62	44	56
	X	X	52	57	60	48	58	54	47	53	60	61	64	53	
53	0	0	60	47	45	53	48	51	55	35	40	37	41	44	48
	0	0	56	42	45	49	47	32	49	39	42	61	58	44	
54	X	0	49	54	53	56	40	59	45	55	47	37	50	44	47
	X	0	40	57	49	49	44	41	55	51	40	51	40	44	
55	X	X	76	59	64	76	53	59	60	64	52	76	66	61	65
	X	X	55	53	60	71	55	72	76	76	71	76	76	67	
56	0	0	42	35	37	36	53	42	28	46	42	52	44	44	41
	0	0	40	42	43	38	43	41	45	70	39	38	48	44	
57	X	0	56	56	64	41	64	55	60	57	42	61	47	44	55
	X	X	56	65	58	60	55	63	59	56	71	61	72	60	
58	0	0	46	43	41	44	44	51	42	43	55	46	47	44	45
	0	0	52	48	41	43	46	45	49	53	39	38	51	44	
59	0	0	38	37	41	44	40	28	37	30	42	52	41	44	42
	X	0	35	40	45	24	42	54	49	49	42	38	40	44	
60	X	X	42	45	34	57	53	36	45	40	49	37	60	44	45
	X	X	35	55	36	52	50	76	53	57	34	46	58	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
61	X	0	46	40	53	57	58	51	45	49	57	58	41	44	53
	X	0	51	58	49	57	67	69	63	63	65	61	61	53	
62	X	0	42	28	53	41	48	51	37	48	42	46	41	44	44
	X	0	46	35	49	52	52	45	40	46	34	46	44	44	
63	X	0	52	61	53	49	64	42	69	53	59	46	50	44	56
	X	X	48	66	51	49	65	45	59	41	53	46	48	44	
64	X	X	49	54	58	41	58	76	59	55	36	52	41	44	50
	X	X	48	55	56	48	53	57	51	53	50	51	48	48	
65	X	X	49	49	48	47	34	47	51	60	49	46	57	44	46
	X	X	45	55	47	41	39	51	47	63	50	46	53	44	
66	X	0	58	64	51	64	53	51	62	53	40	56	64	67	55
	X	X	50	61	58	62	47	57	53	39	44	61	64	63	
67	X	X	49	62	56	64	58	38	51	44	48	52	50	61	54
	X	X	52	55	51	57	65	45	53	46	50	51	48	53	
68	X	X	45	66	56	41	40	42	67	44	52	46	50	44	50
	X	X	53	66	62	57	47	54	63	49	60	38	53	44	
69	X	X	46	47	60	44	48	42	37	49	46	52	53	53	48
	X	0	45	42	56	43	50	41	35	49	42	46	55	53	
70	0	X	67	65	60	53	64	64	65	64	66	61	67	61	62
	0	0	68	63	36	48	58	54	66	61	67	66	64	53	
71	0	0	63	56	76	44	64	55	55	51	47	46	50	61	56
	0	0	64	55	76	58	58	51	40	49	42	58	58	53	
72	X	X	49	47	51	47	58	51	37	49	47	46	47	44	48
	X	X	43	35	54	52	58	54	35	47	52	46	40	44	
73	X	X	49	67	51	44	64	47	37	46	46	52	44	61	49
	X	X	43	35	62	49	55	63	51	46	58	51	48	57	
74	X	0	70	69	70	68	48	57	66	57	54	37	65	67	59
	X	X	72	61	67	67	53	69	68	64	60	66	64	60	
75	X	0	42	52	46	53	53	47	62	49	57	46	69	53	51
	X	0	52	55	43	52	52	37	59	51	55	46	67	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
76	X	0	40	52	56	53	53	38	59	51	52	52	57	44	52
	X	X	43	58	51	57	57	54	55	56	48	46	56	44	
77	X	X	54	61	51	53	58	47	62	53	38	56	53	61	53
	X	X	50	60	51	41	55	51	58	61	52	55	51	53	
78	X	0	30	31	28	34	37	28	42	24	32	46	53	57	36
	X	0	24	50	27	38	31	32	55	35	28	51	44	44	
79	X	0	63	52	51	57	53	67	51	60	68	68	62	67	59
	X	0	62	50	54	60	58	63	53	58	60	70	61	70	
80	X	0	56	56	53	56	48	61	51	60	55	56	50	64	54
	X	X	54	58	54	57	65	57	51	58	54	51	58	63	
81	X	X	55	54	64	61	48	47	60	68	54	37	33	44	54
	X	X	48	68	65	48	36	51	62	58	57	38	40	44	
82	X	X	40	56	56	31	48	36	62	40	39	37	47	44	45
	X	X	43	58	51	35	50	45	63	53	34	38	43	44	
83	X	X	60	60	64	70	64	57	55	57	45	52	65	44	59
	X	X	59	48	67	66	61	67	45	57	58	55	58	53	
84	0	X	45	52	44	49	44	47	45	37	46	37	33	44	44
	X	0	45	56	43	48	39	41	40	39	48	46	40	44	
85	X	0	45	64	44	44	53	42	47	46	46	37	41	44	45
	X	0	40	42	54	38	50	37	58	35	52	38	43	44	
86	0	X	38	43	37	38	37	36	42	44	45	37	53	44	39
	X	X	24	44	36	41	31	54	45	51	40	38	58	44	
87	X	0	45	52	51	53	48	42	47	51	57	46	37	44	50
	X	0	37	39	51	55	46	54	38	56	48	46	48	44	
88	X	X	48	59	51	66	48	42	59	53	32	37	44	44	49
	X	X	45	61	54	52	50	51	43	49	36	46	44	44	
89	0	0	30	52	46	53	53	47	51	54	42	46	37	44	46
	X	0	37	30	49	60	46	45	45	46	47	38	40	44	
90	X	0	30	43	48	57	48	53	47	37	62	46	53	44	48
	X	X	35	50	49	59	55	45	35	44	38	38	53	44	

S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	CS
91	X	0	49	42	45	38	48	61	62	44	59	64	57	53	52
	X	0	43	47	45	49	36	45	51	41	50	58	58	44	
92	X	0	66	55	64	49	64	59	69	60	63	64	62	53	63
	X	0	63	60	67	41	58	59	67	53	67	61	64	53	
93	X	0	35	43	34	38	37	33	51	40	38	46	57	44	40
	X	0	32	50	39	38	41	41	59	41	28	55	48	44	
94	X	0	53	47	60	44	53	55	55	51	59	58	53	61	55
	X	0	58	55	60	57	52	57	60	53	60	55	53	60	
95	0	0	58	52	48	49	48	61	55	37	57	46	59	70	52
	0	0	62	50	49	48	47	57	56	47	46	51	53	60	
96	X	0	42	43	60	64	40	36	53	40	54	46	50	44	51
	X	X	45	55	56	66	50	41	59	44	52	38	48	44	
97	X	X	52	35	51	49	37	42	49	55	51	46	57	44	48
	X	X	48	35	54	48	46	51	38	53	53	51	55	44	
98	X	X	40	40	56	56	58	51	42	54	45	56	44	53	50
	X	X	43	39	54	52	55	45	43	51	46	46	61	57	
99	X	0	63	50	56	57	58	64	59	57	51	61	76	64	58
	X	X	60	55	56	57	61	57	59	51	52	61	58	65	