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A study to develop a Montana State University motor fitness test battery and test norms

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A STUDY TO DEVELOP A MONTANA STATE UNIVERSITY MOTOR FITNESS TEST BATTERY AND TEST NORMS

by

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Dedicated to

JBA

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CHAPTER I

THE PROBLEM

Statement of the Problem

The purpose of this study was to develop a test to evaluate the motor fitness of male students at Montana State University. A sub-purpose of this study was to establish norms for the motor fitness test developed herein.

Significance of the Study

Motor fitness is recognized as a primary concern of college physical education programs. In order to meet the individual needs in this area, it is first necessary to know the existing individual motor fitness levels. With this problem in mind, this study was undertaken.

There are many existing motor fitness tests, but they are difficult to use because they either do not meet accepted standards of validity, or are not adaptable to the facilities or the time available at Montana State University. An example of this is the Indiana Motor Fitness Test, which would be adaptable to Montana State University facilities, but has a validity correlation coefficient of only .859, which is not considered very high for this type of test. These factors illustrate the desirability of developing a motor fitness test which will meet the needs at this institution.

The motor fitness test developed herein may be of value to the Men's Physical Education Department in: (1) the evaluation of male Freshmen entering Montana State University in order to place them into developmental physical education service courses designed to improve

the fitness of students with low fitness levels; (2) the evaluation of individual motor fitness progress of students enrolled in men's physical conditioning classes; and (3) the evaluation of students enrolled in other activity courses in relation to motor fitness.

Basic Assumptions

The following assumptions were basic to this study:

1. Muscular strength, muscular endurance, circulatory endurance, muscular power, and muscular speed are the essential components of motor fitness.
2. These factors can be adequately measured by selected physical performance tests.

Definitions

Physical Fitness. As referred to in this study, physical fitness is an expression of the total or quantitative fitness of an individual.[1]

Motor Fitness. As referred to in this study, motor fitness is a limited phase of general motor ability with emphasis on the individuals' ability to perform acts of vigorous physical activity which do not include any of the primary elements of skill and coordination.[2]

Muscular Strength. Muscular strength is the maximum strength which can be applied in one muscular contraction.[3]

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[1]Donald K. Mathews, Measurement in Physical Education (second edition; Philadelphia and London: W. B. Saunders Company, 1963), pp. 3-4.

[2]H. Harrison Clarke, Application of Measurement to Health and Physical Education (third edition; Englewocd Cliffs, N.J.: Prentice Hall, Inc., 1959), p. 222.

[3]Ibid.

Muscular Endurance. Muscular endurance is the ability to continue sub-maximal muscular contractions for a long period of time.[4]

Circulatory Endurance. The ability of the circulatory-respiratory system to adjust to activities which involve moderate contractions of the large muscle groups for relatively long periods is referred to as circulatory endurance.[5]

Muscular Power. Muscular power is the ability to release a maximum muscular force in the shortest period of time.[6]

Muscular Speed. Muscular speed is the speed at which successive movements of a similar nature can be performed.[7]

Limitations

The following limitations apply to this study:

1. The motor fitness test developed was limited to tests of muscular strength, muscular endurance, circulatory endurance, muscular power, and muscular speed.
2. The test items comprising the preliminary test battery were empirically selected from previously validated test items. It is recognized that many of these test items were originally validated, at least in part, on the basis of empirical reasoning.

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[4] Ibid.

[5] Ibid.

[6] Ibid.

[7] Ibid.

3. The norms which were developed are applicable only to male students at Montana State University.
4. The Motor Fitness test battery developed herein is not a complete test of motor fitness in itself, but provides an adequate predictor of an individual's performance on a complete motor fitness test, which in this case is the complete battery of selected items.

CHAPTER II

SURVEY OF RELATED LITERATURE

Various forms of motor ability testing date back to the turn of the century, but it was not until World War II that the term motor fitness came into common usage. As previously stated, motor fitness is a phase of general motor ability and reflects the individuals' ability to perform fundamental physical acts which do not require a high refinement of skill or coordination. In an effort to find valid motor fitness test items for inclusion in the test developed herein, the following motor fitness tests were reviewed as well as several studies in which factor analysis of motor fitness test items were presented.

Physical Fitness Tests

AAHPER Youth Fitness Test.[1] The purpose of this test was to determine the general fitness of boys and girls from grades five through twelve. Pull-ups, sit-ups, the shuttle run, the fifty yard dash, the six hundred yard run-walk, the standing broad jump, and the softball throw were empirically selected for inclusion in the test by a committee of members of the Research Council of the American Association for Health, Physical Education and Recreation. The validity and reliability of the test items were not computed for the items as part of this study, but the items which make up the test were validated in previous studies and were thought to lend their validity and reliability to this test.

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[1] AAHPER Fitness Department, AAHPER Youth Fitness Test Manual, 1201 Sixteenth Street, N.W., Washington 6, D. C., 1958.

Two sets of percentile tables were established on the basis of a survey of 8,500 boys and girls in the fifth through the twelfth grade. One of the percentile tables was based upon age and the other upon the Neilson-Cozens Classification Index.[2]

The committee which devised this test looked upon it as a pilot study and not the complete answer to phsycial fitness testing; however, the test is probably as good as any other available for this age group. Norms have also been developed for college men and were based upon administration of the test to 2,200 students.

Indiana Motor Fitness Test.[3] This test was originally designed for use as a test of motor fitness for secondary school boys and college men. Since the test's original adoption, it has been revised for use on the elementary school level. The Indiana Motor Fitness Test appears to be very good since it meets the criterion of ease of administration and has a fair validity.

Four Motor Fitness Indices were developed and validated against a twelve item criteria consisting of two or more measures of strength, velocity, motor ability, and endurance. The zero order correlations of these indices with the criteria were: (1) MFI I (Chins + Push-ups x chins) .859; (2) MFI II (Chins + push-ups x standing broad jump) .818; (3) MFI III (straddle chins + push-ups x vertical jump) .841; (4) MFI IV (straddle chins + push-ups x standing broad jump).812.

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[2]Donald K. Mathews, Measurement in Physical Education (second edition; Philadelphia and London: W. B. Saunders Company, 1936), p. 94.

[3]Karl W. Bookwalter, "Test Manual for Indiana Motor Fitness Indices for High School and College Men," Research Quarterly, 14:356-365; December, 1943.

On the basis of these validations, Index I was selected as the final test.

Youth Physical Fitness Test.[4] The Youth Physical Fitness was developed for testing boys and girls from age ten to age seventeen. The test was designed to measure strength, flexibility and agility. The scoring of the individual test items was done on a pass or fail basis. This scoring technique as well as the minimum standards that were established for passing the test might be questioned, since, for example, one pull-up was considered to be passing for boys from ten to thirteen years old. A performance of this level would not appear to be discriminating enough to be considered a valid evaluation of motor fitness.

The test consists of pull-ups, sit-ups, and squat thrusts. The test items were selected empirically on the basis of formerly established validity. The overall validity and reliability of this test was not shown in this report.

Jump Chin Run Test.[5] The JCR Test consists of the vertical jump, chinning with the natural grip, and a 100 yard shuttle run in which the subject covers a ten yard course ten times with the aid of bank boards to assist him in making 180 degree turns. This test was developed to measure the ability of individuals to perform basic fundamental motor skills which are related to strength, power, speed, agility, and endurance.

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[4]Mathews, op. cit., pp. 105-108.

[5]B. E. Phillips, "The JCR Test," Research Quarterly, 18:12-29; March, 1947.

The validity of the JCR Test was evaluated in several ways. A multiple correlation of .81 was obtained when the test was correlated with Larson's 25 item criterion measure of motor ability. A correlation of .90 was obtained between it and a 19 item criterion of physical fitness used to test 168 West Point Cadets. A third correlation of .78 was obtained when the JCR Test was correlated with the Army Air Force Physical Fitness Test. Furthermore, a correlation of .66 was obtained with a 670 yard 17 unit obstacle course. Although the zero order correlation of .90 is quite high, the other correlations were not high enough to justify the use of this test.

Norms are available and have been established on the basis of 3,788 sample scores. The rating categories were set as follows: (1) excellent, 197 and up; (2) good, 174 to 195; (3) average, 129 to 171; (4) poor, 105 to 126; (5) very poor, 103 and below.

The reliability of the test items was established through the test re-test method. The vertical jump was found to have a reliability coefficient of .89 while the chinning test had a reliability of .95.

Army Air Force Fitness Test.[6] This test was developed by Larson during World War II for the purpose of measuring the fitness of an individual in relation to aviation skill and wartime needs.

The test included the following items: (1) chinning, (2) sit-ups, and (3) 300 yard shuttle run. For administration indoors, the 250 yard

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[6]Leonard A. Larson, "Some Findings Resulting from the Army Air Force Physical Training Program," Research Quarterly, 17:144-164; May, 1946.

shuttle run, run in laps of twenty-five yards each, may be substituted for the 300 yard shuttle run as these two items had an intercorrelation of .86.

These items were selected from fourteen preliminary test items which had been empirically grouped into seven components of physical fitness. The seven components selected by Larson were: (1) muscular endurance of a nature that required sub-maximal contractions for a long period, (2) muscular endurance of a nature that required successive exertions when a load is placed on the muscle groups being tested, (3) explosive power, (4) agility, (5) speed, (6) body coordination, and (7) speed and endurance.

The validity of the test was computed by correlating the final test battery with the sum of all scores of the preliminary test battery. The validity correlation of the test was found to be .86.

Clarke[7] did not feel that the above physical fitness ratings would be applicable for civilian use and does not consider the test appropriate for civilian use because of the exhaustive nature of the shuttle run test items.

Navy Physical Fitness Test.[8] The purpose of this test was to measure the fitness status of Navy personnel. The test included the following items: (1) squat thrust, (2) sit-ups, (3) push-ups, (4) squat

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[7]H. Harrison Clarke, Application of Measurement to Health and Physical Education (third edition; Englewood Cliffs, N. J.: Prentice Hall, Inc., 1961), p. 223.

[8]Mathews, op. cit., p. 119.

jumps, and (5) pull-ups. The validity of the test was not given, but the test items in themselves are generally considered to be valid tests of motor fitness.

Scoring of the test was done by adding the T scores of the individual test items to form a composite score.

The test is considered applicable to high school and college students, but if it is used at these levels, separate tables should be constructed similar to those used for scoring the Indiana Motor Fitness Test, Army Air Force Test, or JCR Test.[9]

Army Physical Efficiency Test.[10] The purpose of this test was to measure strength, endurance, agility and coordination. The test consisted of five items: (1) pull-ups, (2) squat jumps, (3) sit-ups, (4) push-ups, (5) 300 yard shuttle run. When the test is administered indoors, either the 250 yard shuttle run or the sixty second squat thrust may be substituted for the 300 yard shuttle run. Scoring tables are available but are not applicable for civilian use.

Validity of the test was computed. When correlated with the Navy Test, a correlation of .88 was obtained, while it was found to have a correlation of .86 with the Army Air Force Test.

This particular test has been revised and is not generally used by the Army today. The current test, which has been specifically designed for use by the Army, consists of the following items:

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[9] Ibid., p. 119.

[10] Mathews, op. cit., p. 120.

(1) 40 yard low crawl, (2) horizontal ladder test, (3) dodge run and jump, (4) grenade throw, and (5) one mile run.[11] This test is not extensively reviewed here since the inclusion of items such as the grenade throw make it inapplicable for civilian use.

Purdue Motor Fitness Test.[12] The Purdue Motor Fitness Test was designed to test what the authors considered as the basic elements of motor fitness, namely: (1) strength, (2) agility, (3) speed, (4) accuracy, (5) flexibility, (6) power and velocity, (7) cardio-vascular capacity, and (8) eye-hand-foot coordination. The four batteries comprising the test and their multiple correlations with the criteria were: (1) softball throw, standing broad jump and chins, .932; (2) softball throw and chins, .912; (3) softball throw and standing broad jump, .861; (4) standing broad jump and chins, .858.

Validation of the four test batteries was computed by: (1) correlating the scores on the Purdue Motor Fitness Test for each battery and the composite score on the twelve selected test items which were used as a criteria; (2) correlating the Purdue Motor Fitness Test for each battery with the scores on the Indiana Motor Fitness Test, the Cowell Athletic Aptitude Test, McCloy's Athletic Quotient, and the Strength Index. Reliability of the test was found to be .817.

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[11] Physical Conditioning, (TM 21-2000 Department of the Army Technical Manual, Headquarters, Department of the Army). December, 1957.

[12] A. H. Ismail and C. C. Cowell, "Purdue Motor Fitness Test Batteries and a Development Profile for Pre-Adolescent Boys," Research Quarterly, 33:553-559; December, 1962.

Oregon Motor Fitness Test for Boys.[13] The Oregon Motor Fitness Test was designed to test the following selected elements of motor fitness: (1) arm and shoulder girdle strength and endurance, (2) abdominal strength and endurance, (3) muscular power, (4) running speed and endurance, (5) agility, and (6) trunk flexibility.

The preliminary test items were empirically selected on the basis of their potential as tests of the previously mentioned motor fitness elements. The final test items, selected on the basis of high objectivity coefficients were: (1) pull-ups, (2) jump reach, and (3) 160 yard potato race. The validity for the three item battery, when correlated with each individual test, ranged from .91 to .94

Tables of norms for the junior and senior high school boys were computed. The raw scores were converted into T-scale scores.

Factor Analysis Studies

In a factor analysis of twelve athletic events, McCloy[14] identified four factors: (1) circulo-respiratory endurance, (2) velocity, (3) muscular endurance, and (4) a factor which was tentatively identified as mesomorphic body build. Most significant finding of this study was the very high factor weighting given to the 300 yard run divided by the six second run. This factor, when correlated with a circulo-respiratory combination of the 300 yard run, 440 yard run, 60 second squat thrust, and a run with a man astride the back yielded a correlation of .8835.

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[13]Clarke, op. cit., p. 231.

[14]C. H. McCloy, "A Factor Analysis of Tests of Endurance," Research Quarterly, 27:213-216; May, 1956.

In a factor analysis of 26 wartime fitness test items, Cousins[15] isolated four factors. The factors were identified in terms of the correlations obtained between the individual test items and the factors. Isolated factors identified were: (1) arm and shoulder girdle strength, (2) strength or power of the leg extensors, (3) velocity, and (4) power of the thigh flexors.

McCloy[16] completed a correlational study to devise a new method of scoring chinning and dipping. He proposed two formulas which can be readily computed from the tables provided by the author.

$$TS = 1.77\ W + 3.42\ C - 46$$

$$TS = 1.27\ C^{\cdot 133\ W}$$

The formula used in this study required less calculation and had a slightly higher correlation with what McCloy called "total strength."

Summary

The tests reviewed in this chapter illustrate the variety of test items used in existing motor fitness and physical fitness tests. (See Table I, page 14.) The pull-ups or chins type test item was included in all of the tests surveyed, while five of the tests surveyed included the sit-up test and some variation of the shuttle run. A variety of other test items were used to complete the various test batteries.

In the factor analysis studies, the motor fitness test items studied were related to the following factors of muscular strength, muscular

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[15]George F. Cousins, "A Factor Analysis of Selected Wartime Fitness Tests," Research Quarterly, 26:277-288; October, 1955.

[16]C. H. McCloy, "A New Method of Scoring Chinning and Dipping," Research Quarterly, 2:132-143; December, 1931.

TABLE I

MOTOR FITNESS TESTS AND TEST ITEMS

Test Item	AAHPER	Indiana MFT	Youth PFT	JCR Test	Navy PFT	Army FT	Air FT	Purdue MFT	Oregon MFT	Totals
Pull-ups	x	x	x	x	x	x	x	x	x	9
Sit-ups	x		x		x	x	x			5
Shuttle Run	x									1
300-yard Shuttle Run						x	x			2
Potato Race									x	1
50-yard Dash	x									1
600-yard Run and Walk	x									1
Standing Broad Jump	x							x		2
Softball Throw	x							x		2
Straddle Chins			x							1
Squat Thrusts			x		x	x				3
Vertical Jump		x		x					x	3
Squat Jumps					x	x				2
Push-ups		x			x	x				3
100-yard Shuttle Run				x						1

endurance, muscular velocity, and muscular power. A significant finding of the studies was the high factor weighting given to the 300 yard run divided by the six second run.

CHAPTER III

PROCEDURE

Selection of Criteria

Criteria for the selection of test items were set up after consideration of the local situation and a review of recommended criteria for tests of this type.[1,2,3] The final criteria used for the selection of test items for the preliminary battery of this test were as follows:

1. The items selected must be valid tests of motor fitness factors and also be acceptably reliable and objective.
2. The test items should be easy to administer and require a minimum of personnel for their administration.
3. The test should not demand any unusual skill or coordination on the part of the test subject.
4. Each test should measure one performer and his performance, and should be independent of any other person, either student or test assistant.
5. Test items must be applicable to the age level of the subjects.

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[1] AAHPER, Research Methods Applied to: Health, Physical Education and Recreation (revised edition; National Educational Association, Washington, D. C., 1952), pp. 393-401.

[2] George F. Cousins, "A Factor Analysis of Selected Wartime Fitness Tests," Research Quarterly, 26:277-288, October, 1955.

[3] C. Frank Consolazio, Robert E. Johnson and Louis J. Pecora, Physiological Measurement of Metabolic Functions in Man (New York, Toronto, London: McGraw-Hill Company, Inc., 1963), p. 341.

6. The test items must either test one, or a combination of the components of motor fitness.
7. The test items must be of a nature which would allow their administration to a large number of men while using the facilities of Montana State University.

Subjects

Two hundred and seventy-four male Freshmen students enrolled in the Montana State University physical education service courses during the Spring quarter served as subjects for this study. Students enrolled in bowling classes were excused from participation in the testing program. An additional seventeen students were not tested because of medical exemptions or excessive absence from class.

Test Battery

Review of Test Items

On the basis of the studies reviewed in Chapter II, thirty-four tests of motor fitness were examined on the basis of their validity, reliability and objectivity as indicated by the study from which they were chosen. The thirty-four items were:

1. 300 yard run divided by six second run
2. Six second pick-a-back run equated with six second run
3. 300 yard run
4. Shot put
5. Three standing broad jumps
6. Six second run
7. Squat thrust
8. Chinning
9. Push-ups
10. Sit-ups (straight legs)
11. Sit-ups (flexed knee)
12. Standing broad jump
13. Baseball throw
14. Softball throw

15. Fifty yard dash
16. Basketball goals
17. Vertical jump
18. Straddle chins
19. Sixty yard dash
20. 360 yard dash
21. Dips
22. 300 yard shuttle run
23. 220 yard dash
24. 200 yard shuttle run
25. Medicine ball throw
26. Two minute sit-up (flexed knee)
27. 100 yard shuttle run
28. Running broad jump
29. 360 yard shuttle run
30. Twenty yard shuttle run over twenty second period
31. 250 yard shuttle run
32. Standing-hop-step and jump
33. 100 yard pick-a-back run
34. McCloy's Strength formulae

The thirty-four test items were then evaluated against the criteria adopted for this study. Evaluation of the original thirty-four test items was done by subjectively rating each test on a maximum three point basis with each of the seven criteria. Evaluation by this method resulted in the selection of ten test items to be used as the preliminary test battery.

Test Items Selected

The following ten items were selected, on the basis of their ability to meet the established criteria, to comprise the preliminary test battery.

Push-ups. Cousins[4] and McCloy[5] included the push-up in separate factor analysis studies. Cousins found the push-up to have a correlation

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[4] George F. Cousins, "A Factor Analysis of Selected Wartime Fitness Tests," Research Quarterly, 26:277-288; October, 1955.

[5] C. H. McCloy, "A Factor Analysis of Tests of Endurance," Research Quarterly, 27:213-216; May, 1956.

of .6621 with a factor identified as shoulder girdle strength. McCloy found a correlation of .5746 between the push-up and what he identified as a muscular endurance factor. The correlations obtained are quite high for studies of this type, and on the basis of this it was felt that the push-up merited inclusion in the preliminary test battery.

Chins. In validating the Jump Chin Run Test, Phillips[6] found the chin to have correlations of .72 with the nineteen item criteria and .70 with a twenty-five item criterion. Ismail and Cowell[7] also obtained a high correlation (.694) between chins and the twelve item criteria used in developing the Purdue Motor Fitness Test Battery. The reliability of the chins was also computed by Phillips through use of the test re-test method and found to be .95.[8]

Dips. Cousins[9] identified this as a test of arm and shoulder girdle strength and found the correlation with this specific factor to be .5631. Larson[10] found a correlation of .6323 with what he classified as a fitness constituent of muscular endurance.

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[6]B. E. Phillips, "The JCR Test," Research Quarterly, 18:12-29; March, 1947.

[7]A. H. Ismail, and C. C. Cowell, "Purdue Motor Fitness Test and a Development Profile for Pre-Adolescent Boys," Research Quarterly, 33: 553-559; December, 1962.

[8]Phillips, loc. cit.

[9]Cousins, loc. cit.

[10]Leonard A. Larson, "Some Findings Resulting from the Army Air Forces Physical Training Program," Research Quarterly, 17:144-164; May, 1946.

Two minute flexed knee sit-up. The sit-up was identified by Larson[11] and McCloy[12] as a test of muscular endurance. Larson found a correlation of .5422 with a muscular endurance combination comprised of chinning, dipping, sit-ups, leg lifts and floor push-ups. McCloy correlated the sit-up with a muscular endurance combination of chinning, push-ups, sit-ups, and squat jumps, and obtained a correlation of .5821. The flexed knee sit-up was used in this study since it has been established as a truer test of abdominal strength than the straight leg sit-up.[13]

Three standing broad jumps. Larson[14] found the standing broad jump to have a correlation of .6740 with the muscular power of the leg extensors. This test item was also identified by McCloy[15] as a test of muscular speed, having a correlation of .5993 with speed.

Vertical jump. This test has been identified as a test of muscular power. A correlation of .6035 was obtained when correlated with Larson's three item criteria (vertical jump, three standing broad jumps, and shuttle race) for muscular explosiveness or power.[16] Ismail and Cowell[17]

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[11] Ibid.

[12] McCloy, loc. cit.

[13] Donald K. Mathews, Measurement in Physical Education (Philadelphia and London: W. B. Saunders Company, 1963), p. 90.

[14] Larson, loc. cit.

[15] McCloy, loc. cit.

[16] Larson, loc. cit.

[17] Ismail and Cowell, loc. cit.

found this item to have a correlation of .718 with their criteria of twelve preliminary test items of motor fitness. In the validation of the Jump Chin Run Test, the vertical jump had a correlation of .61 with twenty-five items of motor ability.[18] Phillips also computed the reliability of the vertical jump by means of the test re-test method and obtained a correlation of .89.[19]

Sixty yard dash. As indicated by Larson,[20] this is primarily a test of speed. It was found to have a correlation of .6775 with his twelve item criteria of motor fitness tests.

300 yard run. This test item was found to have a correlation of .7948 with a four item factor composed of circulo-respiratory endurance events.[21]

300 yard fall-off index. The time for the 300 yard run was equated with the time projected for the sixty yard dash to determine fall off. The following formula was used:

$$\text{Fall-off Index} = \frac{\text{Time 60 yard dash x 5}}{\text{Time 300 yard run}} \text{ X } 100$$

McCloy[22] used a similar technique when he equated the 300 yard run and a six second run which gave him a correlation of .8835 with a circulo-respiratory factor composed of 300 yard run, 440 yard run, 60 second squat thrust, and the run with the man astride the back.

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[18] Phillips, loc. cit.

[19] Ibid.

[20] Larson, loc. cit.

[21] McCloy, loc. cit.

[22] Ibid.

McCloy's total strength formula.[23] The formula devised by McCloy for scoring chins was also used as a variable in this study since it gives a relatively pure strength measure which is not affected by the endurance of the shoulder girdle muscles. The technique of calculating the total strength is shown below.

$$TS = 1.77\ W + 3.42\ C - 46$$

Statistical Procedure

Raw data from the individual test scores were converted into T scores. The T scores for each subject's tests were then added and the sum was used as a criterion for later multiple correlations. The Pearson Product Moment Method was used to find intercorrelations between the raw scores of each of the ten test items, and between each of the ten items and the criterion. These correlation coefficients were calculated from ungrouped data using a formula described by Edwards.[24] Finally, through application of the Wherry-Doolittle[25] test selection method, the combination of test items which provided the best predictor of the entire test battery was selected as the final test battery. Norms were then developed utilizing the regression equation derived from the Wherry-Doolittle analysis.

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[23]C. H. McCloy, "A New Method of Scoring Chinning and Dipping," Research Quarterly, 2:132-143, December, 1931.

[24]Allen L. Edwards, Statistical Analysis (New York: Rhinehardt and Company, Inc., 1955), p. 91.

[25]Henry E. Garrett, Statistics in Psychology and Education (fifth edition; New York, London, Toronto: Longmans, Green and Co., 1960), pp. 426-437.

Testing Procedure

The preliminary motor fitness test battery was administered during two testing periods as follows:

Period I: (1) sit-ups; (2) push-ups; (3) sixty yard dash; (4) 300 yard run.

Period II: (1) dips; (2) vertical jump; (3) pull-ups; (4) standing broad jump.

Administration of the preliminary test battery was done during the student's regularly scheduled physical education period. Six class periods were used in an effort to include all eligible students in the testing program. Specific test instructions and individual test score cards are shown in Appendix A, pages 35 to 38, and B, page 39.

Montana State University physical education majors served as testers for this study. Prior to the actual testing, testers were provided with test instructions and an explanation of the testing procedure was given by the author. All testing was done under the supervision of the author, or qualified graduate students.

CHAPTER IV

ANALYSIS OF DATA

Intercorrelations of Selected Tests

Before the final test battery could be selected, it was necessary to intercorrelate the raw scores of each of the ten preliminary test items and the criterion. The derived correlations are shown in Table II, page 25.

Selection of Final Test Battery

The final step in construction of the test battery was to determine the coefficient of multiple correlation between each of the ten preliminary test items and the criterion. Through application of the Wherry-Doolittle[1] test selection method each test was added one at a time, starting with the test which produced the highest correlation with the internal criterion, to produce a multiple correlation coefficient. The test items that were selected were those tests which contributed the most to the multiple correlation.

The first test selected for inclusion in the final test battery (See Table III, page 26) was the sixty yard dash since it had the highest correlation (-.716) with the internal criteria. When the push-up and total strength tests were added, the multiple correlation increased from .716 to .9110. The addition of the vertical jump test raised the correlation

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[1] Henry E. Garrett, Statistics in Psychology and Education, (fifth edition; New York, London, Toronto: Longmans, Green and Co., 1960), pp. 426-437.

TABLE II

INTERCORRELATIONS FOR 10 ITEMS INCLUDING THE CRITERION

		60-yd. Dash	300-yd. Run	Push-ups	Sit-ups	Dips	Vertical Jump	Standing Broad Jump	Chins	300-yd. Fall-Off	Total Strength	Criterion
		1	2	3	4	5	6	7	8	9	10	11
60-yard dash	1		.747	-.399	-.418	-.449	-.522	-.496	-.369	-.237	-.099	-.716
300-yard dash	2			-.496	-.514	-.291	-.396	-.490	-.453	-.663	-.169	-.657
Push-ups	3				.574	.649	.292	.265	.815	.190	.087	.712
Sit-ups	4					.413	.234	.236	.487	.260	.186	.648
Dips	5						.262	.350	.642	.085	.027	.696
Vertical Jump	6							.670	.259	.038	.098	.624
Standing Broad Jump	7								.054	.285	.283	.537
Chins	8									.241	-.051	.689
300-yard fall-off	9										.747	.447
Total strength	10											.413
Mean		7.89	43.67	28.04	50.01	11.52	20.63	82.52	8.73	90.70	265.91	499.79
Standard Deviation		.406	3.65	10.45	12.14	5.06	2.68	7.30	5.67	5.18	30.11	100.00

coefficient to .9395. An additional increase to .9655 was obtained by adding the chins test, and the final test included was the dips test which raised the multiple correlation coefficient to .9795. The addition of the sit-ups test increased the correlation coefficient to .9885, an increase of only .0090. Since an increase of this level is not considered statistically significant, the sit-ups test was not included in the final test battery. According to the Wherry-Doolittle test selection method, when an insignificant increase in the multiple correlation coefficient is obtained, the process of adding test variables is discontinued. The tests which were retained in the final test battery were the sixty-yard dash, the push-ups, the McCloy total strength formula, the vertical jump, the chins, and the dips.

TABLE III

SELECTED TEST ITEMS AND MULTIPLE CORRELATIONS

Test Items		R.
Sixty-yard Dash	R. 1	.7160
Push-ups	R. 1,3	.8531
McCloy Total Strength Formula	R. 1,3,10	.9110
Vertical Jump	R. 1,3,10,6	.9395
Chins	R. 1,3,10,6,8	.9655
Dips	R. 1,3,10,6,8,5	.9795
Sit-ups	R. 1,3,10,6,8,5,4	.9885

With the selection of the final test battery completed, regression equations derived from the Wherry-Doolittle process were established for three possible test batteries. (See Table IV, page 27.)

TABLE IV

MONTANA MOTOR FITNESS TEST BATTERIES

AND REGRESSION EQUATIONS

MMFT	I	Score = 9.311 (60-yard dash) + .702 (push-ups) + 1.202 (total strength) + 10.235 (vertical jump) + 5.96 (chins) + 4.58 (dips) - 215.021. (Standard error of estimate = 20.119)
MMFT	II	Score = 9.311 (60-yard dash) + .702 (push-ups) + 1.202 (total strength) + 10.235 (vertical jump) + 5.96 (chins) - 175.073. (Standard error of estimate = 26.269)
MMFT	III	Score = 9.311 (60-yard dash) + .702 (push-ups) + 1.202 (total strength) + 10.235 (vertical jump) - 125.423. (Standard error of estimate = 34.23)

The analysis of the six test items selected to comprise the final test battery indicate that the final test battery measured speed, muscular endurance, strength, and muscular power. The sixty-yard dash was included in the preliminary test battery as a test of speed and was the first test selected by the multiple correlation process. The push-up test, chins test, and dips test (second, fifth and sixth selected tests) were included in the original test battery as tests of muscular endurance and strength. McCloy's total strength formula (third selected test) is a measure of strength and the vertical jump (fourth selected test) was included as a test of muscular power.

As shown in Chapter II, the tests included in the final battery revealed high correlations with the factors which they purport to measure. The final test battery, therefore, appeared to meet the original purpose of this study.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

Purpose of the study. The purpose of this study was to develop a test to evaluate the motor fitness of male students at Montana State University. A sub-purpose of this study was to develop norms for the motor fitness test developed herein.

Selection of test items. On the basis of existing tests and factor analysis studies of motor fitness tests, thirty-four test items were examined from which ten items were selected to comprise the preliminary test battery. The preliminary test battery consisted of: (1) 60-yard dash, (2) 300-yard run, (3) push-ups, (4) two minute flexed knee sit-ups, (5) dips, (6) vertical jump, (7) standing broad jump, (8) chins, (9) 300-yard fall-off, and (10) McCloy total strength formula.

Collection of data. Data for this study were collected from two hundred seventy-four male Freshmen students enrolled in Montana State University physical education service courses during the Spring quarter of the 1962-1963 school year.

Analysis of data. The final test battery was selected by the following process:

1. Raw data from the individual test scores were converted into T-scores and combined to form the criterion measure.

2. The intercorrelations between each of the ten variables and the criterion were computed.

3. The Wherry-Doolittle test selection method was used to compute

the multiple correlation coefficient between the ten preliminary test items and the internal criteria to determine what test items should be included in the final test battery.

4. Norms were established utilizing the regression equation derived from the Wherry-Doolittle analysis.

Results. Through application of the Wherry-Doolittle test selection method a multiple correlation coefficient of .9795 was obtained between the criterion measure and the independent variables which were the sixty-yard dash, the push-ups, the McCloy total strength formula, the vertical jump, the chins, and the dips.

Conclusions

On the basis of the findings of this study, the following conclusions were made:

1. The six test items selected to comprise the final test battery are the best predictor of the entire test battery.

2. The six test items selected to comprise the final test battery measure speed, muscular endurance, strength, and muscular power.

3. The insignificant correlation (-.057) between the chins test and the McCloy total strength formula emphasize the importance of the weight factor in computing this item.

4. The sixty-yard dash would appear to measure more than speed as it had the highest correlation with the internal criteria.

5. The motor fitness test developed herein meets the criteria established for this study.

Recommendations

1. On the basis of the multiple correlation coefficient (.9795) obtained, it is recommended that the Montana Motor Fitness Battery I be used. The regression equation for this battery was listed as: MMFT I Score = 9.311 (60-yard dash) + .702 (push-ups) + 1.202 (total strength) + 10.235 (vertical jump) + 5.96 (chins) + 4.58 (dips) - 215.021. (Standard error = 20.119)

2. It is recommended that in the future, physiological experiments should be conducted to determine the true relationship of the factors of speed, muscular endurance, strength, and muscular power to the individual test items.

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APPENDIX

APPENDIX A

PRELIMINARY MOTOR FITNESS TEST INSTRUCTIONS

The preliminary motor fitness test battery will be administered during two testing periods as follows:

Period I: (1) push-ups, (2) sit-ups, (3) 60-yard dash, (4) 300-yard run.

Period II: (1) dips, (2) vertical jump, (3) chins, (4) standing broad jump.

Subjects are required to wear gym shoes, stockings, supporter, shorts, and T-shirt.

Period I

Push-ups: The subject lies on the floor, face down, body straight, arms bent, with hands on the floor in front of the armpits. From this position he straightens his arms until he is in a front-leaning rest. The support is on the toes and hands with a straight line from feet to head. He then lowers his body until the elbows have a ninety degree bend; this should place the chest from one to three inches from the floor. The exercise is repeated as many times as possible.

Rules: (1) The body should remain rigid and straight, with head, trunk, and legs in line throughout the movements. (2) Avoid a "sway-back" or raised hip position. (3) Keep the head up and look straight ahead.

Scoring: Record the number of completed push-ups to the nearest whole number.

Flexed knee sit-ups. The starting position for the flexed knee sit-ups is flat on back with hands clasped behind the head. The knees are bent so that the soles of the shoes are flat on the floor. The exercise partner holds the toes to keep the sole of the foot flat on the floor throughout the exercise. From the starting position sit up to a position in which the body is in a right angle position to the floor.

Rules: (1) Hands must remain clasped behind the head throughout the exercise. (2) The back should be rounded and the head and elbows brought forward when sitting up as in a "curl" up. (3) When returning to the starting position, elbows must be flat on the mat before sitting again.

Scoring: Record the number of complete sit-ups done within the two minute testing period.

Sixty-yard dash. Five subjects will be tested per running. Prior to the running, each will present his score card to the timers at the finish line. In starting the race, subjects will assume a sprinter's position and will begin the dash at the sound of the starter's whistle. The starter will give the following commands: on your mark, get set, and then blow his whistle to begin the race.

Rules: Subjects should be instructed to run in their own lane and not to cut in front of other runners.

Scoring: The subjects' time for the run will be recorded to the nearest tenth of a second.

Equipment needed: One sixteen foot two by four for use as a permament starting block; five stop watches and one starter's whistle.

300-yard run. Five subjects will be tested per running. Prior to

the running, each subject will present his scorecard to the timers at the finish line. In starting the race, the subjects will assume a standing start position. The starter will give the following commands: on your mark, get set, and then blow his whistle to start the run.

Rules: Subjects should be instructed not to cut in front of another runner unless they are at least one full stride ahead of the person whom they are passing.

Scoring: The subjects' time for the run will be recorded to the nearest tenth of a second.

Equipment needed: Same as for the sixty-yard dash.

Period II

Dips. The subject jumps to an arm rest position at the end of the parallel bars with the arms fully extended. From this position the subject lowers himself to the point where the elbows form a right angle. The tester notes this place with his fist, which the subject touches each time he lowers himself. The exercise is repeated as many times as possible.

Rules: The subject is not allowed to kick or swing while raising himself to the starting position.

Scoring: The count is one for the jump into the first position and one for each succeeding dip. Up to four half counts are allowed for incomplete push-ups, kicking or swinging.

Equipment needed: Parallel bars.

Vertical jump. The jumper toes the line, one foot in front of the board. The index fingers of both hands are chalked with magnesium.

The subject reaches as high as possible with feet kept flat on the floor and makes a mark with his chalked fingers. He next executes three jumps from a crouched position, making a mark each time on the board. The distance from the top of the reach mark to the top of the highest jump mark is recorded as his score.

Scoring: The best of three jumps is recorded to the nearest quarter inch.

Equipment needed: Blackened boards on which to record the jumps, Magnesium, and yard sticks to measure the jumps.

Chins. Using the underhand grip, the subject assumes a hanging position from which he raises his body by his arms until his chin can be placed over the bar and then lowers his body to a straight arm hang as in the starting position. The exercise is repeated as many times as possible.

Rules: (1) Allow one trial unless it is obvious that the pupil has not had a fair trial. (2) The body must not swing during the execution of the movement. If the pupil starts swinging, check this by holding your arm across the front of the thighs.

Scoring: Record the number of completed chins.

Standing broad jump: The student toes a line four feet from the first six inch mark on the mat, and springs forward from both feet. The nearest point touched by any part of the body, at right angles to the take-off line, is his jump. Three jumps are made consecutively and the best jump of the three is recorded.

Scoring: The subject's best jump of three is recorded to the nearest inch.

APPENDIX B

SAMPLE OF INDIVIDUAL SUBJECT'S SCORE CARD

Name _____ Age _____ Weight _____ Sect. No._____

Test Event	Raw Score	T Score
60-yard dash	_____	_____
300-yard dash	_____	_____
Push-ups	_____	_____
Sit-ups	_____	_____
Dips	_____	_____
Vertical jump	_____	_____
Broad jump	_____	_____
Chins	_____	_____
300-yard fall-off	_____	_____
McCloy Total Strength Formula	_____	_____
Criteria	_____	_____