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A Study to Determine the Correlation Between Various Arm Strength Tests

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A STUDY TO DETERMINE THE CORRELATION
BETWEEN VARIOUS ARM STRENGTH TESTS

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CHAPTER I

INTRODUCTION

I. PURPOSE OF THE STUDY

Studies have been made to determine arm strength of male subjects using a number of components. A few of these studies have become accepted traditional tests of arm strength. Usually arm strength has been only a part of the study to determine athletic ability, or physical fitness. It has been determined that arm strength has a highly significant relationship with the overall condition of the body.

Three of the more widely accepted traditional tests of arm strength have been selected criteria in this study.

1. Rogers' Arm Strength:[1]

   A.S. = Chins + Dips (Weight/10 + Height - 60.)

2. McCloy Arm Strength (dips).[2]

   A.S. = 1.77 x Weight + 3.42 (dips) - 46.

3. McCloy Arm Strength (chins).[3]

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[1]Fredrick Rand Rogers, Physical Capacity Tests in the Administration of Physical Education, (New York: Bureau of Publications, Teachers College, Columbia University, 1926), p. 43.

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

[3]Ibid.

A.S. = 1.77 x Weight + 3.42 (chins) - 46.

The other arm strength test used in this study being the Irish Arm Strength formula.[4]

1. Irish Arm Strength:

A.S. = 1.54 x Weight + 16.19.

Actual arm strength will be established by measuring flexor and extensor strength of both arms with a cable tensiometer.[5]

The formula having the highest correlation with the actual arm strength, as measured by the cable tensiometer,[6] was determined by the Pearson Product-moment Method of Correlation.[7]

Thus, one purpose of this study was to determine by experimental means the validity of the selected criteria.

After determination of these correlations a second purpose was to study the components of the various tests to determine which arm strength measures are quickest and/or least costly to administer. Any arm strength measure being highly significant and at the same time having the above mentioned characteristics would be a desirable measure.

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[4]Everett A. Irish, "Optimum Conditions for Endurance Measurement of Elbow Flexion Ergography of Various Strength, Anthropometric, and Fatigue Measures to Selected Arm Strength Criteria," (Unpublished Report, University of Oregon, Eugene Oregon, 1958), p. 79.

[5]H. Harrison Clarke, Cable-Tension Strength Tests, (Chicopee, Mass: Brown-Murphy Co., 1953) p. 16.

[6]Ibid.

[7]Henry E. Garrett, Statistics in Psychology and Education, (New York: Langmans, Green and Co., 1947).

II. REVIEW OF LITERATURE

Strength Tests

Dudley A. Sargent, in 1880 developed a battery of tests in which the individual elements were measured by calibrated mechanical instruments. This test became known as the Intercollegiate Strength Test[8] consisting of the following items: (1) the strength of the expiratory muscles, (2) the gripping strength of the hands, (3) the strength of the back, (4) the strength of the legs, and (5) the strength of the arms. The strength of the expiratory muscles was represented by the record made by the subject in blowing against a monometer which registered the maximum pressure by the lungs. Gripping strength, and the strength of the back and legs was measured by dynamometers. The strength of the arms was represented by one-tenth of the subject's weight multiplied by the sum of the push-ups (dips), on parallel-bars, and the pull-ups (chins) that a subject could execute.

Rogers' Arm Strength

In 1925 Fredrick Rand Rogers[9] revised and refined the Intercollegiate Strength Tests developed by Sargent. In standardizing

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[8] Dudley A. Sargent, "Intercollegiate Strength Tests" *American Physical Education Review*, 2:216-218, December, 1897.

[9] Fredrick Rand Rogers, *Physical Capacity Tests in the Administration of Physical Education*, (New York: Bureau of Publications, Teachers College, Columbia University, 1926).

this test procedure, Rogers, among other things, modified the arm strength formula. He contended that the original formula (pull-ups plus push-ups multiplied by one-tenth the weight) unduly penalized the individual who could pull-up (chin) or push-up (dip) only a few times and favored the individual who could perform these activities many times.

As a result of these observations, Rogers' proposed the following formula:

$$A.S. = C. + D\,(W./10 + H. - 60)$$

Wherein:

A.S. = Arm Strength

C. = Pull-ups (chins)

D. = Push-ups (dips)

W. = Body Weight

H. = Height in Inches

In effect Rogers was attempting to add the distance traveled as a factor in arm strength.

Other changes in the Intercollegiate Strength Tests made by Rogers concern lung capacity and the testing apparatus for girls. Neither of these components have a bearing on this study. Therefore, their discussion was omitted.

McCloys Revisions

Charles H. McCloy, State University of Iowa, proposed three changes in Rogers PFI battery: one, his Strength Index

Revision;[10] a second, the Athletic Index;[11] and the third, Pure Strength Index.

<u>Strength Index Revision</u>. Two changes in the PFI battery are suggested: a different formula for computing arm strength, and the elimation of lung capacity. Otherwise, the test items remain the same.

In discussing arm strength determined from push-ups and pull-ups, McCloy states that "the formula used by Rogers unduly penalizes the individual who is small and unduly rewards the person whose dipping and chinning are above the average".[12] He experimentally developed the following formula for the computation of chinning and dipping strength.

A.S. = 1.77 x W. + 3.42 (C. or D.) - 46.

Wherein:

A.S. = Arm Strength

W. = Body Weight

C. = Chins (Pull-ups)

D. = Dips (Push-ups)

McCloy advocates the elimation of lung capacity from the PFI battery on the grounds that lung capacity is not a test of strength.

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[10] C. H. McCloy, <u>Tests and Measurements in Health and Physical Education</u>, (New York: F.S. Croft and Co., 1939), pp. 21-24.

[11] <u>Ibid</u>.

[12] <u>Ibid</u>.

Athletic Strength Index. In constructing an Athletic Strength Index.[13] McCloy weighted the test items in his revision of the Strength Index so as to give the total amount of strength usable in athletic events. Two formulae are given, as follows:

Long Form: Right grip plus left grip plus .1 times back lift plus .1 times leg left plus 2 times chinning strength plus dipping strength minus 3 times weight.

Short Form: Same, except omitting back and leg lifts.

Of the two formulae presented above it was found that the short form which is a measure of arm strength alone, was as accurate a predictor of athletic ability as was the longer form which uses back and leg strength, the correlation of the long form being .914 with a valid criterion of general athletic ability, while that of the short form was .911.

Pure Strength Index. Through factor analysis, McCloy[14] found that two elements emerge from strength tests: one of these is pure strength, or force; the other is dependent on body size. To predict pure strength, he gave the following weighting: .5 times right plus left grips plus .1 times leg left plus chinning strength plus dipping strength. The test items were administered and scored in accordance with his revision of the Strength Index. No norms have been published.

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[13] McCloy, Op. Cit., p. 25-26.

[14] Ibid., p. 26.

Coefficients of correlation of about (.95) have been obtained between arm strength for boys as measured by a dynamometer and the McCloy pull-up plus push-up strength scores.[15] The formula for boys is quite accurate within limits of "normality".[16] For boys of exceptional endurance, however, it is somewhat inaccurate at the upper extreme. Also it slightly rewards the small boys and slightly penalizes the large ones.

Cable-Tension Strength Tests

H. Harrison Clarke,[17] over a period of ten years, developed tests for measuring strength of thirty-eight muscle groups using a tensiometer. These tests were constructed originally with the idea in mind for use with orthopedic disabilities in hospitals and Veterans Administration centers. However, application of these tests has been made in numerous research studies, particularly at Springfield College.

The tensiometer used by Clarke in these tests is an instrument originally designed to measure the tension of aircraft control cables. Cable-tension is determined by measuring the force needed to create off set (on riser) in the cable between two set points

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[15] C. H. McCloy, Norma D. Young, Tests and Measurements in Health and Physical Education, (New York: Appleton-Century Crofts, Inc., 1954), p. 133.

[16] Ibid.

[17] H. Harrison Clarke, A Manual: Cable-Tension Strength Tests, (Chicopee, Mass., Brown-Murphy Co., 1953).

(the sectors). This tension may be converted directly into pounds on a calibration chart.

The tensiometer used in strength testing has been improved by the manufacturers for this purpose by: special calibration for an up-pull on a cable, rather than placement on a taut cable; and by addition of the maximum pointer to facilitate reading the subject's score.

Clarke uses two tensiometers: one, for small muscle groups, which will record a force of 5 to 100 pounds; the other, from 30 to 400 pounds.

Irish Arm Strength

In 1958 Everett A. Irish completed his study, "Optimum Endurance Measurement of Elbow Flexor Muscles and the Relations of Strength, Anthropometric and Fatigue Factors to Arm Strength Criteria".[18] The tests involved muscle groups used in the following movements: shoulder extension, shoulder flexion, shoulder inward rotation, shoulder adduction and elbow flexion. The only test of endurance being the elbow flexion ergograph in which the subjects exercised to exhaustion. The Kelso-Hellebrandt Ergograph was used in the conducting of this endurance test.

Cable-tension[19] methods were one method used in testing for

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[18]Everett A. Irish, "Optimum Conditions for Endurance Measurement of Elbow Flexion Ergography of Various Strength, Anthropometric, and Fatigue Measures to Selected Arm Strength Criteria," (Unpublished Report, University of Oregon, Eugene Oregon, 1958).

[19]Clarke, Op. Cit.

strength in all of the above mentioned movements.

Irish also used, as variables in his study Rogers' arm strength formula and McCloy's arm strength formulae reported earlier in this chapter. Correlations of (.84) were obtained between McCloy's arm strength formula (using pull-ups) and the strength measures of grip strength, shoulder adduction, and push-ups.

Body weight correlated very highly (.95) with McCloy's arm strength formula (pull-ups). Combined strength and anthropometric variables obtained using McCloy's arm strength (pull-ups) as the criterion resulted in an R of (.95) and the predictive index of (.69) when using body weight and shoulder adduction strength.

Shoulder adduction strength[20] added only .0001 to the R resulting in no change in the predictive index. It is therefore assumed that body weight may be highly significant in determining arm strength.

Irish[21] computed three formulae to determine arm strength. These are:

1.54 x W. + 16.19

1.54 x W. = 2.93 x L.U.A. - 82.20

8.27 x T.F.U.A.G. + 19.65 x M.W. - 185.98.

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[20] Irish, Op. Cit., p. 64.

[21] Ibid., p. 62.

Wherein:

W. = Body Weight

L.U.A. = Length of Upper Arm

T.F.U.A.G. = Tensed Flexed Upper Arm Girth

The first mentioned formula was selected for use in this study for the following reasons:

1. It is easier to administer because only one measurement, body weight, need be taken.

2. Body weight has frequently appeared as a significant variable in other researches. In McCloy's study, "The Importance of Arm Strength in Athletics"[22] in his formulation of an arm-strength formula, in Rogers' Arm-strength Score,[23] and in the recent Springfield work formulae, body weight has been a basic factor. In Irish's doctoral dissertation[24] body weight correlated highly with both strength and anthropometric variables. It appeared statistically significant with five strength variables. These were left grip strength (.69), shoulder inward rotation (.54), shoulder flexion (.49), shoulder extension (.48), and shoulder adduction (.45).

Three significant correlations between weight and other

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[22] C.H. McCloy, "The Apparent Importance of Arm Strength in Athletics," Research Quarterly, 5:3, March, 1934.

[23] Fredrick Rand Rogers, Physical Capacity Tests in the Administration of Physical Education, (New York: Bureau of Publications, Teachers College, Columbia University, 1926).

[24] Irish, Op. Cit., p. 51-53.

anthropometric variables were tensed flexed upper arm girth (.83), relaxed upper arm girth (.66), and girth increase (.52). This would indicate that it is a measure which may have future significance and should be investigated further.

CHAPTER II

EXPERIMENTAL SETTING

I. TESTING PROCEDURE

Every effort was made to adopt arm strength procedures which would result in objective results. These procedures were patterned after the techniques for testing of arm strength described by Rogers,[1] McCloy,[2] and Clarke.[3] The techniques were as follows:

1. Before testing each subject was orientated to the purpose of these tests and the general techniques were described and demonstrated.

2. Each subject was given a score card upon which he entered his name and age. This score card accompanied the subject throughout the various phases of the tests for the purpose of recording the necessary data and scores.

3. Push-ups (dips): Push-ups, Figure I, were administered on the parallel bars. The subject grasped the bars, one in each hand, while standing in front of the parallel bars. He jumped to the

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[1]Fredrick Rand Rogers, Physical Capacity Tests in the Administration of Physical Education, (New York: Bureau of Publications, Teachers College, Columbia University, 1926), p. 43.

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

[3]H. Harrison Clarke, Cable Tension Strength Tests,(Chicopee, Mass. Brown-Murphy Co.) p. 16.

cross rest with arms straight (this counts one). He then lowered his body until the angle of the upper arm and forearm reached 90 degrees. He was aided in this by a spotter who held his fist at the desired position for the 90 degrees. The subject then pushed up to the straight arm position. In executing this movement the body and the legs of the subject were approximately in a straight line, and under no circumstances was a jerk or kick permitted. He was allowed to do the exercise as rapidly as he wished. If he did not go all the way down, or all the way up to a straight arm position, half credit was given. Four half-counts were allowed.

Height. The subject stood on a platform stadiometer with his back to the measuring rod. The height was recorded in inches to the nearest one-half inch.

Body Weight. Body weight was determined by placing the subject on the scales and reading the dial to the nearest one-half pound.

Pull-ups (Chins). Pull-ups were administered by placing the subject on a horizontal bar of sufficient height that his feet would not touch the floor when the arms were extended. The palms were turned away from the body. One pull-up was counted for each time the subject raised his chin to the bar. Care was taken to see that the subject fully extended his arms when lowering his body. Four half-counts were allowed.

This concluded the first phase of the testing. Because of the length of class periods, during which the testing of each group

FIGURE 1

PUSH-UPS, PARALLEL BARS
(FROM DONALD K. MATHEWS, MEASUREMENT IN PHYSICAL EDUCATION, PHILADELPHIA: W. B. SAUNDERS CO., 1958, p. 68.)

had to be completed, there was insufficient time to complete the tensiometer tests on the same day.

Cable-Tension Tests[4]

A specially adapted and calibrated aircraft tensiometer, Figure II, was utilized to record the amount of tension the subject can apply to cable appropriately placed for specified movements of the joints. The pulling apparatus, Figure III, necessary to obtain a tension reading is a twelve-inch piece of one-sixteenth inch extra flexible cable with a means for attachment to the wall on one end, and a parachute webbing strap at the other end to attach to the limb being tested. The pulling apparatus was anchored to the wall so the direction of pull was perpendicular to the limb being tested. The subject was tested while lying on a regulation training room plinth which was equipped with the necessary hooks for anchorage of the pulling apparatus. A detailed description of the above mentioned instruments and apparatus has been completely described by Clarke.[5]

Elbow Flexion. Figure IV shows the subject placed in a supine lying position, hips and knees flexed, feet resting on a table and free hand resting on the chest. Upper arm on the side being tested abducted and extended at the shoulder to 180 degrees;

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[4]Clarke, *Op. Cit.*

[5]*Ibid.*

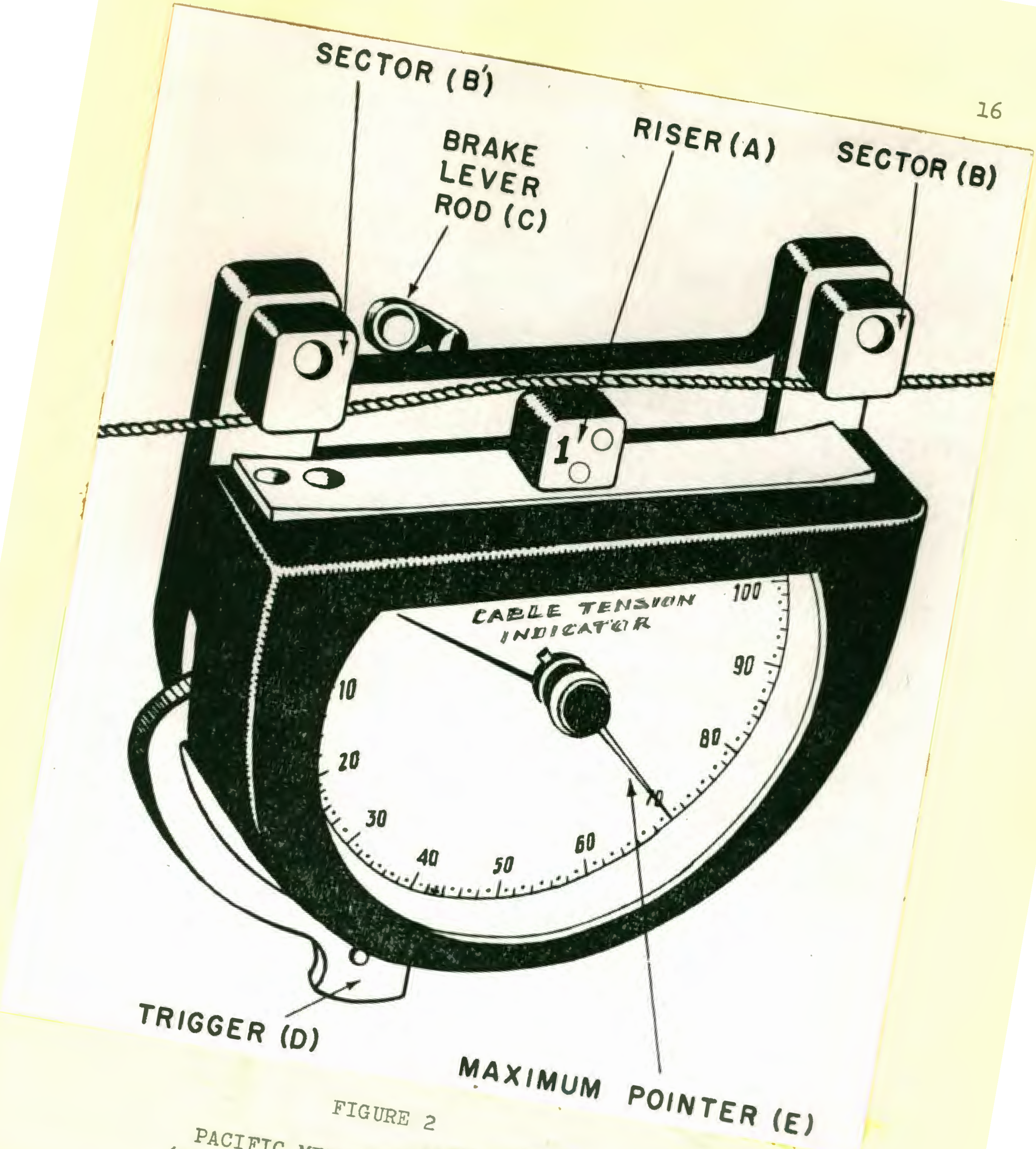

FIGURE 2

PACIFIC MEDICAL TENSIOMETER
(FROM MATHEWS, OP. CIT. p. 57)

FIGURE 3

PULLING ATTACHMENTS FOR TENSIOMETER ARM STRENGTH
(IBID. p. 75.)

elbow in 115 degrees flexion, forearm in mid-prone supine position. Regulation strap was placed around the forearm midway between the wrist and elbow joint. The pulling assembly was attached to a hook below the subject's feet. Care was taken to prevent the subject from raising his elbow and abducting the upper arm by bracing at the elbow.

Elbow Extension. Subject was in the same position except the elbow was in 120 degrees flexion. The regulation strap was placed around the forearm midway between the wrist and elbow joints. The pulling assembly was hooked to the wall above the subject's head. Caution was taken to keep the subject's head straight so as to reduce any tendency to flex the spine laterally.

This procedure was followed with both arms of each subject. Dial readings of the tensiometer were converted into pounds by use of a calibration chart, with the tensiometer, for each effort. The four scores were then totaled to give the arm strength in pounds of each subject.

Objectivity of Testers

Objectivity of the testers were determined by running each of the tests twice using the same subjects but different testers. Thirty subjects were used in each test. The coefficients of objectivity were as follows:

Rogers Arm Strength	.78
McCloys Arm Strength (Push-ups)	.81
McCloys Arm Strength (Pull-ups)	.88

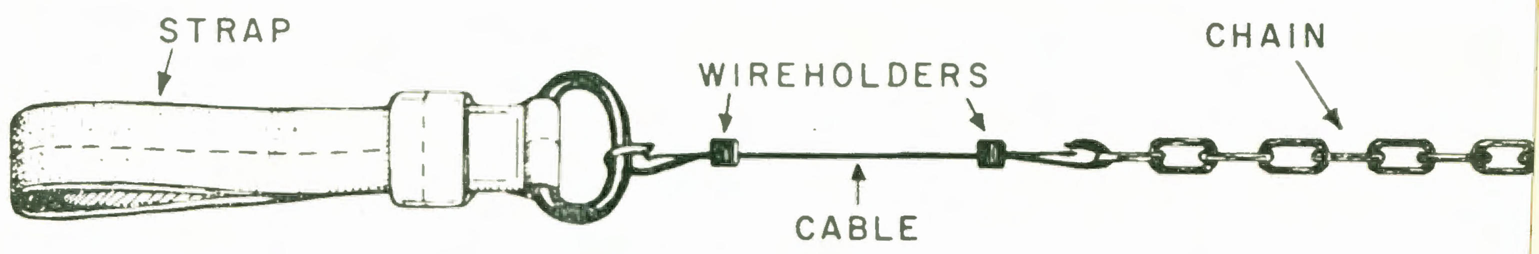

FIGURE 4

CABLE-TENSION TEST OF ELBOW FLEXION
(FROM MATHEWS OP. CIT. p. 77.)

Irish Arm Strength	.98
Cable Tensiometer Strength	.95

These objectivity coefficients compare well with those reported for the various tests, so the competence of the testers was considered adequate for collection of the necessary research data.

Subjects

For this study, dealing with arm strength relationship, 153 Central Washington College of Education males enrolled in the various physical education activity classes were utilized as subjects. All men having physical defects were excluded from the tests. Their ages ranged from 18 to 25 years.

Statistical Treatment

All experimental variables, cable-tension strength and arm strength tests were inter-correlated with each other. With Rogers arm strength, McCloy pull-up, McCloy push-up, Irish arm strength and the cable tensiometer tests making ten zero-order correlations. The standard error of the obtained scores were taken to determine how closely one could predict the true score of a subject.

The highest correlation with the criterion (cable-tension strength test) was found in order to determine the best test for arm strength. Ease of administration was also a factor in the selection of a usable test for arm strength.

The .01 and .05 levels of confidence were determined for the number of cases involved. For 153 cases an r of (.16) is needed to be significant at the .05 level of confidence, an r of (.21) is needed to be significant at the .01 level.

Facilities

Site. The Men's gymnasium at Central Washington College of Education served as the testing site.

Apparatus. The following apparatus were utilized:

1. A Horizontal bar was used for measuring pull-ups (chins).
2. Regulation gymnasium parallel bars were used for measuring push-ups (dips).
3. A standard scale was used for measuring weight of the subjects.
4. A platform stadiometer was used for measuring height in inches.
5. A regulation training room plinth with attachments was used for cable-tension strength tests.
6. A cable tensiometer with the attachments for arm strength testing.[6]

The above apparatus was arranged in stations with trained testers at each station who gave instructions, administered tests, and entered scores on respective score cards.

Testing stations were set up in such a manner that subjects

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[6]H. Harrison Clarke, Cable-Tension Strength Tests, (Chicopee, Massachusetts: Brown-Murphy Co., 1953), p. 16.

passed from one to another in a continuous line, and so that lines would not merge or cross when passing from station to station. The stations were as follows:

Station 1: Distribute score cards, record name and age.

Station 2: Push-up (dips); parallel bars.

Station 3: Height and weight: stadiometer, scales.

Station 4: Pull-ups (chins); horizontal bar.

Station 5: Actual Arm Strength: tensiometer, plinth.

Station 6: Check station: collect score cards.

The score cards were given to each participant at the start of the test and carried by him to each station.

CHAPTER III

ARM STRENGTH RELATIONSHIP RESULTS

A statistical analysis of the arm strength data was made. This analysis included computation of zero-order correlations by the Pearson product-moment method.

INTERRELATIONSHIPS AMONG EXPERIMENTAL VARIABLES

The product-moment intercorrelations between the five experimental variables appear in Table I. Appropriate interpretations of these results are given below.

Arm Strength Variables

1. A number of high correlations among the variables were obtained. The formulae that correlated highly were Irish's and McCloy's. The highest of these was (.93), between the Irish formula and McCloy's formulae using pull-ups. The Irish formula is significant well beyond the .01 level of confidence with all variables except Rogers' arm strength.

2. McCloy's two formulae, arm strength (pull-ups) and arm strength (push-ups), correlated (.91) with each other. This may be considered an expected result because the two formulae are much the same. The difference being the components of pull-ups and push-ups are interchanged. Both of these formulae are significant beyond the .01 level of confidence as above.

3. A high correlation of (.83) was also obtained between Irish's Arm Strength and McCloy's Arm Strength (using push-ups). The latter being the formula that correlated most highly with the tensiometer test conducted in this study (.73).

4. The tensiometer arm strength tests correlated well with McCloy's Arm Strength (push-ups) and Irish's Arm Strength, these correlations being (.73) and (.46) respectively. Other correlations with the tensiometer tests were: McCloy's Arm Strength (pull-ups) (.37) and Rogers' Arm Strength (.03), the latter being of no significance.

5. Very low correlations were obtained when Rogers' test was one of the variables. These correlations were: (.033), (.034), (.039) and (.067). None of these correlations reached the .05 level of confidence.

Standard Error

A standard error of an obtained score for each of the variables was determined. These were as follows:

Rogers arm strength	± 97.29
McCloy arm strength (push-ups)	± 15.84
McCloy arm strength (pull-ups)	± 11.97
Irish arm strength	± 4.44
Cable tensiometer	± 1.23

This means that the subjects true score is the one he obtained plus or minus the score listed opposite the type of test.

It is obvious that some tests give a more true measure than others. With the exception of Rogers' arm strength all of the tests are within reasonable limits.

TABLE I

		v^1	v^2	v^3	v^4	v^5
v^1	Irish Arm Strength		.932	.827	.067	.459
v^2	McCloy Arm Strength (Pull-ups)			.912	.033	.371
v^3	McCloy Arm Strength (Push-ups)				.039	.732
v^4	Rogers Arm Strength					.034
v^5	Tensiometer Arm Strength					

Intercorrelation of Arm Strength Measures

CHAPTER IV

SUMMARY

THE PROBLEM

This research dealt with the problem of finding which arm strength test was the most valid and possibly the most useful test as compared with arm strength determined by the use of an instrument. This instrument being a cable tensiometer.

Three types of tests to determine arm strength were used. First, the Irish formula required only the measurement of body weight with no exercise or exertion involved; second, tests in which exercise and its resulting degree of exhaustion were components (the McCloy and Rogers tests); and third, the tensiometer test in which brief exertion, (but no exhaustion) was recorded by an instrument. The experimental test variables were as follows:

1. Irish Arm Strength: The component of body weight used in a formula to determine arm strength.

2. McCloy Arm Strength (pull-ups): Includes the components of body weight and the number of pull-ups (chins) used in a formula to determine arm strength.

3. McCloy Arm Strength (push-ups): Includes the components of body weight and the number of push-ups (dips) used in a formula to determine arm strength.

4. Tensiometer Arm Strength: Consists of the score obtained by totaling elbow flexion and extension strength of both arms determined by reading the amount of exertion brought against the measuring instrument.

PROCEDURE

All data were collected in the men's gymnasium at Central Washington College of Education by graduate personnel trained for the purpose. The subjects were 153 male students from physical education activity classes.

The subjects were tested only once thereby avoiding any learning situation. The results were inter-correlated by the Pearson product-moment method of correlation.

RESULTS

The best test to determine arm strength is McCloy's Arm Strength formula using push-ups (dips). This test correlated highly with three out of four variables. It correlated (.73) with arm strength as determined by the tensiometer.

The more simple test to administer is Irish's Arm Strength formula which had a highest correlation, (.93) with McCloy's (pull-ups) and also correlated high with three of four variables. This test correlated (.46) with the tensiometer test.

Rogers' Arm Strength did not correlate with any of the other variables or the criterion.

The correlations were:

Irish A.S. with McCloy A.S. (pull-ups)	.93
McCloy A.S. (pull-ups) with McCloy A.S. (push-ups)	.91
Irish A.S. with McCloy A.S. (push-ups)	.83
McCloy A.S. (push-ups) with Tensiometer A.S.	.73
Irish A.S. with Tensiometer A.S.	.46
McCloy A.S. (push-ups) with Tensiometer A.S.	.37
Rogers A.S. with Irish A.S.	.07
Rogers A.S. with McCloy A.S. (push-ups)	.04
Rogers A.S. with Tensiometer A.S.	.03
Rogers A.S. with McCloys A.S. (pull-ups)	.03

CONCLUSIONS

In concluding this report a number of observations may be made, as follows:

1. The best test for arm strength, as compared to the criterion, is McCloy's formula using push-ups.

2. Body weight seems to be the most important factor in determining arm strength.

3. The Irish formula could be successfully substituted for other arm strength formula in various batteries of strength tests.

4. Six of the ten correlations were significant. These being the correlations between Irish and McCloy (pull-ups) (.93), McCloy (pull-ups) and McCloy (push-ups) (.91), Irish and McCloy

(push-ups) (.83), McCloy (push-ups) and Cable-tension (.73), Irish and Cable-tension (.46) and McCloy (push-ups) and Cable-tension (.37).

5. Rogers' Arm Strength, the most widely used in physical fitness tests, did not correlate with the other variables in this study or the criterion. It is thereby the thinking of the writer that the arm strength phase of Rogers' PFI should be altered and/or simplified.

6. In three cases the various criteria correlated significantly at the .01 level with the tensiometer tests. These were: McCloy (push-ups), Irish arm strength, and McCloy (pull-ups).

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