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THE DEVELOPMENT OF AN INSTRUMENT FOR MEASURING STRENGTH OF ELBOW FLEXION IN ELEMENTARY SCHOOL CHILDREN

by

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APPROVAL SHEET

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This study was carried out in an attempt to develop and evaluate an instrument which would satisfactorily measure the strength of elbow flexion of boys and girls in grades three, four, five and six. Elbow flexion was chosen as an important element of total strength and as a factor in many of the activities in which children participate.

The bar-scale apparatus used in this study consisted of either a Chatillon spring scale or a regular bathroom scale and a portable chinning bar set in a doorway. The test using this apparatus was administered to 112 children and evaluated for reliability, validity and objectivity. Since strength varies widely in children of different ages and between the sexes, the evaluation was done separately by grade and sex. A cable-tension test of elbow flexion strength was used as the criterion for the validity coefficients.

The reliability coefficients for the bar-scale test using the spring scale varied considerably, but for five of the eight groups evaluated the reliabilities were found to be satisfactory. For the bathroom scale, the reliability coefficients were slightly higher than for the spring scale and were acceptable for six out of the eight groups.

The validity coefficients for the spring scale ranged from .08 to .79. Five of these coefficients were .58 or better and were considered acceptable. For the bathroom scale, the validity coefficients had a similar range and mean, and as on the spring scale, five of the groups had acceptable validity

coefficients.

The objectivity coefficients for both scales were, with one exception, consistently .94 or better, and indicated that the bar-scale apparatus could be given by different administrators with a high degree of uniformity.

Because the number of subjects in each group was quite small, the coefficients, especially the validity coefficients, were subject to considerable variation due to extreme scores and were consequently somewhat lower than might have been the case with larger samples.

There were several factors, in addition to the formal statistical analysis, which appeared to support the possible use of the bar-scale apparatus as a measurement device in the elementary school. It was found, for instance, that three trials on the bar-scale apparatus could be easily administered to a group of approximately fifteen children in a forty minute class period.

The equipment needed for this apparatus was relatively inexpensive and could be used in other aspects of the physical education program. The apparatus required no permanent setting and was easily set up and dismantled. The test required only one administrator and students participated in the administration as recorders and scorers.

Finally, the test appeared to be intrinsically interesting to the students; they appeared to be able to understand the principle underlying the test and were motivated to perform their best--and to improve their scores--throughout the testing sessions.

1. The bathroom scale generally produced what appeared to be higher coefficients than did the spring scale and is recommended for use in the bar-scale test.
2. Although using the highest score produced only slightly better results than using the total score, this method is recommended for use since it makes computation of the score somewhat easier.
3. The bar-scale test proved to be a reliable measure for all groups except the fourth grade girls.
4. The bar-scale test proved to be a valid measure for the fourth, fifth and sixth grade girls and to have low but acceptable validities for the third and fifth grade boys.
5. The bar-scale test proved to be an objective measure for all groups.

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CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

The elementary school child, in order to be able to successfully carry out his daily tasks, must possess adequate muscular strength. This strength enables the child to participate in those activities which serve as the basis for the physical education program--running, throwing, climbing and jumping.

If the elementary school child does not possess, or acquire, sufficient strength to carry on these fundamental activities, he is further handicapped in attempting to learn and perform the skills which are the basis of the sports and games program of the junior and senior high schools. What was a seemingly mild shortcoming in the young child compounds itself and becomes increasingly serious as the youngster becomes older and encounters more strenuous demands in both his daily tasks and the physical education program.

Since physical education is the principal source of muscular activity in the school program, it is also the chief source of evaluation of strength sufficiency. This evaluation has been done for the most part indirectly, as an assessment of whether or not the child is capable of performing adequately. Attempts at more objective measurement of strength have been almost exclusively limited to tests of grip strength.

The particular limitations imposed by the situation in elementary school physical education make it difficult to develop adequate tests of strength.

Equipment is often negligible and little money is available to supplement what already exists; space is often inadequate; and many schools lack a full-time physical education instructor. In addition, whatever test is used must be straight-forward enough to be easily interpreted by the physical education or classroom teacher and to be understood by the students.

One of the important aspects of the total strength which the elementary school child requires is that of arm and shoulder girdle strength. For instance, strength of elbow flexion plays an essential part in the climbing, hanging and pulling activities in which young children so often participate.

STATEMENT OF PURPOSE

The purpose of this study was to develop a simple, inexpensive instrument for the measurement of the strength of elbow flexion of elementary school children in grades three, four, five and six. This instrument was evaluated to determine reliability, validity and objectivity.

CHAPTER II

REVIEW OF LITERATURE

The Physical Development of Children

The establishment of certain general growth patterns for children has been attempted through longitudinal and cross-sectional studies by several investigators. (25, 26, 63, 78, 83, 84) In general, they agree that although individual differences are often quite pronounced and are of importance in the single case, there is a definite pattern of growth as measured either by height-weight indices or anthropometric measures.

Hurlock (12) states that growth is not regular--that is, it does not operate as a linear function of age, but that it is rhythmic, operating in definite cycles according to age. She defines the following periods of growth:

1. Birth to two years--very rapid growth.
2. Two years to puberty (8-11 years)--continuous growth at a much slower rate
3. Puberty to sixteen--another period of rapid growth, the adolescent growth spurt
4. Later adolescence--a sharp tapering off of growth until maturity is reached

Hurlock also states that height and weight converge at about age six, run parallel until ten, and then diverge, as height is gained at a decreasing rate and weight at an increasing rate.

This same growth pattern is reiterated by McCandless, who states:

> The growth curve for height and weight gain shows a rapid increase in infancy, a much slower gain in childhood, another rapid increase a year or two before pubescence, and, in later adolescence, a slow year-by-year gain. (16:286)

Scammon (71), using semiannual measurements on a single individual, as well as a curve established for the general French population, described the same two periods of rapid growth in infancy and prepuberty, and the periods of slower growth covering the ages from three to thirteen and from post-puberty to maturation. He found, however, that: "The prepuberal increase in height of the individual is a little more abrupt than that of the group . . . ." (71:335)

The growth curves as established by researchers show definite differences in the development of boys and girls. Shuttleworth (83), using data collected on 1553 cases by the Harvard Growth Study, found that boys were taller at age nine, girls passed the boys at approximately eleven and reached their greatest advantage over the boys at twelve and a half. By the age of fourteen, the boys had again regained their superiority and they increased it throughout the remainder of the growth cycle.

Flory found that girls were ahead of boys in rate of growth at all times.

> Girls at any age and for any physical trait have attained a larger percentage of their maximum development than have boys of the same age. There is growth potential related to sex which determines to some extent the rate at which growth and development take place. (45:205)

He found that by school age the girls were one year advanced over the boys. By the age of nine, they were one and a half years ahead, and by puberty, they

were two years ahead of the boys. (45:211)

Bayley, using skeletal maturity as the measure, found that there was " . . . about 2 years difference between the sexes in the age at reaching bone maturity (complete closure of the ephiphyses of hand and knee)." (27:83) She found, however, that if the differences in skeletal maturity are adjusted " . . . then the growth curves for per cent of mature height are closely similar for the two sexes." (27:88)

Individual growth patterns differ from person to person and between the sexes. They also differ within a sex depending on the age at maturation and rate of physiological development. Bayley, in a study of growth curves scaled according to age at physical maturity, found that:

> . . . the greatest annual increment of weight is above average for the early-maturing girls, and below average for the slow-maturing girls. However, for boys this is not true. The physically accelerated boys appear to have consistently large average weight gains, with no exceptional spurts. The retarded boys, on the other hand, remain slender, with small gains in weight, until the sharp increase with puberty . . . . (26:191)

She found that there may be as much as three years difference in the rate of maturation, either as acceleration or retardation. (26:190)

The Development of Strength

The development of strength in children is closely related to general physiological development and the onset of maturity. Garrison (10) cited a number of studies showing a positive relationship between sexual maturity and strength. Hurlock (12) stated that steady strength increases followed the pattern of general development, but felt that the relationship was not marked until

puberty, when there was a rapid increase in strength.

In a longitudinal study of one hundred girls done at the Institute of Child Welfare at the University of California, Pryor and Smith found that:

> Strength increased with age from 10 to 15 1/2 years, after which the curve flattened. A period of rapid increase was seen from age 10 to age 12 1/2 years with a more gradual increase after that until the plateau was reached at age 15 1/2 years. (65:615)

They found that strength was directly affected by age, height and weight. Weight was the most important influencing factor and age the second, with height having little influence.

Breckenridge and Vincent also found strength to be more closely related to weight than to height " . . . which has its spurt of growth about one and one-half years prior to that of strength . . . ." (2:235)

Cullumbine (40), in a study of seven thousand Ceylonese ranging in age from ten to seventy-nine years, found that the mean strength of males increased from age ten until approximately age thirty. He stated that this increase was " . . . fairly rapid until the age of 18 years, the mean strength of each age differing significantly from the previous age." (40:500) In the girls, he found that the increase was more gradual than in the boys, and that strength became fairly constant in the girls from sixteen to thirty, after which it declined. He stated, in comparison, that males were superior in strength at all ages, and that the superiority became greater as age increased. (40:501)

Jokl and Cluver (51) found that both boys and girls, when measured on strength, skill and endurance, improved at a steady rate from childhood until

approximately the age of puberty. At puberty, the girls underwent an interruption of development, holding constant their pre-puberty levels of development. In boys, puberty slowed down the development but did not actually interrupt it. After puberty, the girls' development differentiated for the three types of performance.

> Skill remains stationary. There is a gain in strength, explained by the increase in body weight and muscular development. Endurance, however, declines. (51:2387)

Once again, they emphasized the relationship between weight and strength.

Breckenridge and Vincent stated that:

> While boys are somewhat stronger than girls, both make similar progress until about thirteen years, after which boys increase their rate of growth in strength while girls decrease their rate. Thus the sex difference becomes pronounced . . . . (3:235)

They also noted that, in addition to being somewhat less strong than boys of similar ages, girls, as in other phases of development, are more advanced toward their terminal strength than are boys of the same ages.

Hettinger (11) stated that after the age of ten, the strength of girls was approximately two-thirds of that for boys, but felt that this was due to the greater muscle mass of the boys, since " . . . the strength of the muscle in relation to the cross section per cm^2 is practically the same. In other words, it is the actual size of the muscle which determines its strength." (11:12)

Strength, then, has a fairly definite developmental pattern, as does general growth as measured by height and weight, and is related to this general pattern, although it does not parallel it. Strength development is marked by

wide individual differences among individuals and between the sexes and by a rapid period of growth during the puberal period.

The Nature of Strength

Strength has been defined in many ways. According to Willgoose it is " . . . the ability of a muscle or muscle group to exert maximum strength in a single contraction." (22:105) Cureton stated that "Strength is the capacity of the body to exert force on some external resistance." (7:356)

As a result of an extensive review of factor analysis studies, Fleishman (9) described three broad strength factors, designated as explosive strength, dynamic strength and static strength. There was some correlation between these factors, but it was not high. The first of these, explosive strength, was characterized by the exertion of maximum energy in a single act.

> The common feature of tests of Explosive Strength is that one is required to jump, or to project oneself, or to project some object, as far or as high as possible. The factor appeared distinguished from other strength factors in requiring one short burst of effort, rather than continuous stress or repeated exertion. (9:29)

Tests which indicate this factor include the standing broad jump, vertical jump and medicine ball put.

The second factor, dynamic strength, involved the exertion of strength in moving or supporting the body over a period of time, such as in chins, dips and rope climbing. "Individual differences in this ability are largely a function of how many repetitions can be made." (9:30)

Static strength, the final factor, was characterized by continuous exertion of force until a maximum was reached, lasting only a short time.

"Typically, the force was exerted against a fairly immovable object, such as a dynamometer." (9:30)

The Importance of Strength

The importance of adequate muscular strength has been repeatedly emphasized. In a report by the National Conference on Physical Education for Children of Elementary School Age, there is an emphasis on the acquisition and maintenance of adequate strength.

> Every child needs sufficient muscular strength to maintain good posture at rest and in motion and to do with ease the tasks of each day . . . . Strength coupled with a flexible body gives him ability to move quickly and effectively. He needs the stamina and endurance that depend on well-developed heart and lungs to persist in work and play without undue fatigue. (18:9-10)

Kraus and Hirschland (54, 55), in evaluating the results of the Kraus-Weber Tests for Muscular Fitness, felt that the lack of a minimum level of muscular strength and flexibility made children ineffective in meeting the demands of daily living, an ineffectiveness that became more pronounced as they became older.

Barrow and McGee (1) felt that strength was a prerequisite to agility, power, speed and endurance. They considered muscular strength necessary " . . . if the student is to perform his normal daily activities in an efficient manner. Strength in excess of this amount will enable him to perform them more easily and effectively." (1:115)

Rogers (69) considered strength to be the basis of all physical activity, and thought that a strength deficiency impaired all other life functions.

McCloy, in his article "How About Some Muscle," likened adequate strength to life insurance, and stated that "The individual whose muscular experience is constantly at a subnormal level has a heart that is as flabby as his arms and legs." (59:303)

In another article, McCloy stated that in comparing individuals of approximately equal size and proportion, the one with the greater muscular development would in general function better, be less fatigued by daily tasks and would have a better developed heart.

> Every individual is required to carry or support his body weight from morning to night. He must do this with the musculature he has. It is known that a muscle that is too weak for its task works at a lower efficiency than does one that is adequately developed . . . . (61:62-63)

Clarke, in explaining the role physical education could play in the development of physical fitness, stated that the greatest concern was the improvement of " . . . three fundamental fitness components: Muscular strength, muscular endurance, and circulatory endurance. These are the plus qualities which constitute physical education's primary contribution to physical fitness." (6:2)

The Development and Uses of Strength Tests

The use of strength tests has been proposed variously as a method of classification and as a diagnostic tool. Latchaw and Brown (15) emphasized the need for adequate strength reserves, and the use of strength tests to measure these reserves.

> Strength tests may be used to provide experiences in which the individual studies his own strength problems and needs. He makes a plan for developing a strength reserve, for developing the strength needed to participate in new movement areas or to develop necessary strength to withstand fatigue in the performance of daily tasks. When he has developed his strength reserve, he may re-test from time to time to determine if he is maintaining this reserve. (15:56-57)

They also felt that strength tests might be used to locate reasons for difficulties in the performance of certain activities, either by locating a strength deficiency or by eliminating the possibility that such a deficiency existed. (15:57)

After studying the growth and development of 183 elementary school children, Jones stated that strength testing as a part of the physical education program could serve as a means of:

> . . . improving the general standards of physical performance, helping children with physical deficiences to approach these standards, and helping them to make secure and realistic adjustments to deficiencies which cannot be overcome. (53:175)

Clarke (4, 6) felt that strength tests could be used to discover the need for remedial or developmental work, to indicate progress and to motivate students, as well as serving as a basis of classification for physical education activities. He emphasized, however, that tests should be chosen for a specific purpose, and once given, should be used.

In his book, Physical Capacity Tests in the Administration of Physical Education, Rogers (20) presented the Strength Index and the Physical Fitness Index as means of determining general athletic ability and classifying pupils in physical education programs respectively. He found that the Strength Index was nearly twice as efficient a predictor of athletic ability as weight or age

classifications, and 1.71 times as efficient as the best possible combination of height, weight and age. The Physical Fitness Index, computed by dividing an achieved Strength Index by a normal Strength Index for age and weight, was used to determine a student's physical fitness level as a method of enabling the physical education program to meet individual needs.

The systematic measurement of strength began in the United States during the 1880's with a shift from the previously overwhelming interest in anthropometric measurements. (2) Sargent (70), in his Intercollegiate Strength Test, measured back and leg strength, right and left grip strength, all using dynamometers, lung capacity using a wet spirometer, and upper arm strength using chins and dips.

The next significant development in strength testing came with the introduction of "resistance tests" or tests of "breaking-strength" by Martin in 1915. The initial testing using this technique was done while investigating the after effects of a polio epidemic. Martin defined breaking-strength as " . . . the tension shown on a spring-balance at the instant the resistance of the contracted muscle is overcome by a pull in the opposite direction, exerted through the balance." (62:68) Martin's work was also important in that it showed that the measurement of strength in selected muscle groups could serve as a good indication of the strength of the body as a whole. In testing 240 children between four and eighteen years of age, he found that " . . . calculating based only on the muscles of the forearm and wrist agree reasonably with the results of the complete tests." (62:72)

In 1925 Rogers published his Physical Capacity Test (20), which included the same items as Sargent's Intercollegiate Strength Test, with certain differences in scoring, and adjustments in the directions for chins and pull-ups for girls. His Physical Fitness Index, based on a Strength Index, has been widely used in schools and colleges. His published norms were for ages eleven years six months to nineteen years three months.

In 1948, Clarke (34) proposed the use of an adapted aircraft control cable tensiometer as an instrument for measuring strength in service men with orthopedic disabilities. This instrument was used to measure both strength loss due to disability and increases resulting from therapeutic techniques. In the same article, he reported objectivity coefficients ranging from .91 to .97 on twenty-eight tensiometer tests on non-disabled college men.

In later studies, Clarke (33, 37) investigated the effects of various joint angles in testing, various strap positions for the tensiometer and the effects of gravity, and made appropriate revisions in his tests. He also developed a special table for the administration of the tests.

A comparison made by Clarke of the cable tensiometer, Wakim-Porter Strain Gauge, spring scale and Newman Myometer as instruments for testing strength resulted in the following conclusion:

> As reflected by objectivity coefficients, the cable tensiometer had the greatest precision for strength testing. It was the most stable and generally useful of the instruments; and was free of the faults of the other devices. (32:410)

He found the strain gauge to be very sensitive to slight tensions, including environmental changes such as temperature. The spring scale used measured

only to 100 pounds and was subject to movement when tension was applied. The Newman Myometer was limited to measurements up to 60 pounds.

Rarick, Gross and Mohns (66) compared the results of breaking strength and active strength methods of measurement, using forty-three children from seven to ten years of age. They found that in all cases the breaking strength scores were higher than the corresponding active strength scores. They felt, however, that:

> Although breaking strength tests yield higher average scores, the difficulties encountered in standardizing the technique of measuring breaking strength place some restrictions upon its general use. Furthermore, the activities in which children routinely engage involve most frequently an active type of strength which in itself would recommend the use of active strength measures. (66:79)

Heintz (48), using a bathroom scale as part of a static test of back strength given to 152 college women, found a reliability of .90 using a test-retest method and a validity of .75 using a Narragansett dynamometer as criterion.

Two studies, done in 1938 and 1941, listed requirements for satisfactory strength tests. Carpenter (30) indicated the following criteria:

1. The tests must not be too long nor take too much time to administer.
2. The tests must be valid, reliable and objective.
3. The tests should be such that the administrator and teacher can use them to forward the aims and objectives of education.
4. The strength test or battery of tests must be an adequate and satisfactory measure of the total strength of the body.
5. In selecting tests to be used as representative of the total strength of the body, those tests should be chosen which show a high correlation with total strength but a relatively low intercorrelation with the other tests included.
6. In view of the importance of arm strength in physical educational activities, there should be included in the battery satisfactory measures of arm strength.

7. The activities involved in performing the tests should be related as closely as possible to natural types of activities so that the strength measured is truly indicative of the strength applicable to those activities.
8. The tests should use the muscle groups involved at relatively favorable angles in order that the scores may indicate the best work possible for those muscles.
9. The equipment for giving the tests should, if possible, be sufficiently inexpensive to enable the average school to purchase it.
10. The test should be simple to score in order that the score can be computed quickly and comprehended easily by the average student.
11. The tests should be interesting to the participant in order to stimulate him to do his utmost, and to make the experience of being tested of educational value to him. (30:8)

Metheney (64) indicated that in either research or service testing, the following points should be considered:

1. The instrument must be suited to the size of the child's hand . . . .
2. The child must be given sufficient experience with the test so that he understands what is expected of him, and care must be taken to motivate him to exert all the force of which he is capable.
3. . . . Comparison of scores should probably be made only within the group being tested . . . .
4. The relationship of grip strength to gross bodily size is so close that the size of the individual must be taken into account in evaluating any grip strength record.
5. The existence of a sex difference in grip strength during the elementary school years has been sufficiently well established to make it evident that scores for boys and girls may not be combined either for research or clinical evaluation.
6. Since a significant number of children will exhibit greater strength with the left than with the right hand, both hands should be tested and the score of the stronger hand used . . . . (64:128)

Strength Testing in the Elementary School

Strength testing for elementary school children has been largely confined to dynamometer tests, especially of grip strength. Metheney (64), in a review of elementary school strength testing, stressed that this aspect of

physical education had been largely neglected by research workers. She also indicated that with young children the most difficult aspect of strength testing was the problem of developing enough motivation so that a maximum effort was insured.

Griffitts (46) discussed the use of grip strength norms for elementary school children and found that the results obtained from different dynamometers were not comparable, and that differences varied from subject to subject.

Torpey (73), using Clarke's cable tension test for leg extension on 450 children, first through sixth grade, found it possible to test an average class of approximately twenty-eight in a one hour class period.

CHAPTER III

PROCEDURE

The plan of this study was to administer bar-scale tests of elbow flexion strength to third, fourth, fifth and sixth grade students, and to evaluate these testing instruments for validity, reliability and objectivity.

Selection of Subjects

The subjects used in this study were third, fourth, fifth and sixth grade students at Curry School, the laboratory school for the University of North Carolina at Greensboro. A total of 112 subjects was tested. Of this number, 108 completed all of the tests. Of these, there were twenty-six third graders, twelve girls and fourteen boys; twenty-six fourth graders, fourteen girls and twelve boys; twenty-eight fifth graders, evenly divided; and twenty-eight sixth graders, thirteen girls and fifteen boys.

Description of Tests

Bar-Scale

The equipment used for this test consisted of either the Chatillon scale or the bathroom scale and a portable chinning bar manufactured by Whitely, Inc. (See Figures 1 and 2.)

The subject stood on whichever scale was being used with his feet comfortably apart and his weight was recorded. The chinning bar was moved in the

FIGURE 1

BAR-SCALE APPARATUS USING THE SPRING SCALE

FIGURE 1

BAR-SCALE APPARATUS USING THE SPRING SCALE

FIGURE 2

BAR-SCALE APPARATUS USING THE BATHROOM SCALE

FIGURE 2

BAR-SCALE APPARATUS USING THE BATHROOM SCALE

doorway so that when the subject grasped it with his hands in a supinated position the angle of his elbow, as measured with a goniometer, was 115 degrees. The hands were approximately shoulder-width apart and the thumbs were placed around the bar.

The subject stood erect, with the head up and eyes looking directly ahead. The elbows were at the subject's side, even with the back but not braced on the hips. To insure this position, the administrator stood beside the subject and placed one hand on the subject's upper back and one hand at his waist and maintained the position throughout the trial.

The subject attempted to lift the bar with a steady, continuous motion. The administrator urged the subject to lift as hard as he could, in an attempt to secure a maximal effort. Since the bar was stationary and could not be lifted, the exertion resulted in a depression of the scale, giving a higher weight reading. The score was the difference between the subject's weight and the maximum depression weight as recorded to the nearest pound.

The trial was discounted if the administrator felt the subject leaning forward or backward, or if the subject rose up on his toes.

Cable-Tensiometer

The cable tensiometer test of elbow flexion strength was administered according to the directions given by Clarke (5) in his book Cable-Tension Strength Tests (see Appendix for complete description). In this test the subject pulls against a strap which is attached to his forearm and the other end of which is attached to a wall hook in such a way that the elbow is at a 115 degree angle.

The pull exerts tension on a flexible cable attached to the strap. The tension is measured in calibrated units by an aircraft type tensiometer, and the units converted to the nearest pound using a conversion table.

Administration of Tests

The subjects were tested during their regular physical education class period. A total of five tests was administered--four using the bar-scale apparatus and one using the cable tensiometer. Each test consisted of three trials and the score for each trial was recorded.

During the first session, all of the tests were explained to the subjects and any questions were answered. During subsequent sessions, either the boys or girls of a particular grade were tested, so that in the course of two weeks--with four testing periods each week--all grades had completed one test. Each group, as a result, missed only one instructional class every two weeks.

The testing area was a large supply room adjacent to the office of the girls' physical education instructor. A doorway was used for the bar-scale apparatus and one corner of the room was set aside for the cable tensiometer table and storage of the scales being used. Since the walls were cinder block, special arrangements had to be made for the hooks used in the tensiometer test. This was done by securing corner brackets to a 2 x 4 board six feet long and fastening the brackets with C-clamps to the shelves which ran along one wall. The hooks were screwed into the board at three inch intervals. To facilitate the bar-scale tests, and to insure that the chinning bar was in a

horizontal position, lines were painted one inch apart on both sides of the door-jamb using washable tempera paint. These marks were later used to measure the height of the subjects.

The scales used in the two bar-scale tests were a Chatillon Spring Scale and a regular Sears bathroom scale, both with a maximum reading of 300 pounds. The scales were not calibrated, but were checked to see that they were giving consistent repeated measurements.

The equipment used for the cable-tension test was a standard tensiometer, model number T5-6007-117-00, purchased from the Pacific Scientific Company. The cable was 7 x 7 ply flexible aircraft control cable, 1/16th inch in diameter. The tensiometer was calibrated by hanging metric weights from the cable and recording the reading from the tensiometer. A regression equation was used to convert the metric readings to pounds.

The testing period for the third and fourth grades was forty minutes long, for the fifth and sixth grades, fifty minutes long. After the first testing period, three trials were easily completed within the allotted time.

The tests were given in the following order: test and retest on the bar-scale using the Chatillon scale, cable tensiometer test, and test and retest on the bar-scale using the bathroom scale. This involved a total of five testing periods for each group. Because of vacations and school activities which interfered with testing, the entire testing program took twelve weeks. Absentees were made up as a group during two periods, one half-way through the testing program and the other at the end of testing. Anyone missing more than

one test was dropped from the number of subjects used for evaluation, but continued to take the tests with his group.

The author and one other graduate student served as administrators throughout the testing program after practicing both tests before the program began. It was found that students in the test groups could effectively serve as recorders and this was used as both a motivating device and as a means of maintaining discipline. When the boys were being tested, the administrators were assisted by a senior high student assigned as class helper by the boys physical education instructor.

The age of each subject was secured by the author from their cumulative records before the testing program began. Weight was measured during each administration of the bar-scale test. Height was measured at the completion of the last day of testing for each subject.

Treatment of Data

The validity of the bar-scale tests was determined by computing a Pearson Product Moment Correlation Coefficient between the initial test for each scale and the results of the cable-tension test, which served as the criterion.

The reliability was determined by computing the Pearson Product Moment Correlation Coefficient between the initial test and retest for the bar-scale test using each scale.

The objectivity was determined by computing the Pearson Product Moment Correlation Coefficient between the scores on the initial tests as

recorded independently by the two administrators. The calculations were based upon the score for the highest recorded trial of the first reader and the score of the corresponding trial of the second reader.

Many of the studies cited previously, such as Pryor and Smith (65), Jokl and Cluver (51), and Hettinger (11), stressed the differences in strength which exist between the sexes and at different ages for both boys and girls. In order to make allowances for these developmental differences, all of the coefficients were computed separately for each grade and for the boys and girls separately within a grade.

CHAPTER IV

ANALYSIS OF DATA

The bar-scale apparatus for measuring the strength of elbow flexion in elementary school boys and girls was evaluated to determine reliability, validity and objectivity in two situations, one using a Chatillon spring scale and the other using a regular bathroom scale.

RELIABILITY

Spring Scale

Using the highest of the three trials as the score, the reliability coefficients for the spring scale ranged from .49 for the fifth grade boys to .95 for the fifth grade girls. The mean reliability for the girls was .77 and for the boys was .66.

Using the total of the three trials as the score, the reliability coefficients ranged from .47 for the fifth grade boys to .87 for the fourth grade boys. Again, the mean coefficient for the girls, .78, was somewhat higher than that for the boys, .71.

The total score produced more uniformly high reliability coefficients than did the highest score. Using the total score, then, five of the eight coefficients were .82 or higher and acceptable for the group. The reliability coefficients for the third grade boys and girls and the fifth grade boys were

unacceptable.

The evaluation of these reliability coefficients, and the validity and objectivity coefficients which follow, was done on the basis of suggested standards cited by Barrow and McGee. (1:42)

Bathroom Scale

The reliability coefficients for the bathroom scale, using the highest score, ranged from .59 for the fourth grade girls to .93 for both fifth grade groups and the sixth grade girls. The mean reliability for all groups was .84.

Using the total of the three trials, the coefficients ranged from .63 for the fourth grade girls to .93 for the fifth grade girls. The mean reliability was .83.

The bathroom scale produced considerably higher coefficients than did the spring scale for most grade groups. These data are presented in Table I.

For the bathroom scale, the highest score produced more higher reliability coefficients than did the total score. That for the fourth grade boys, .76, was questionable, and that for the fourth grade girls was unsatisfactory. The other reliabilities ranged from .83 to .93 and were acceptable.

VALIDITY

Spring Scale

The validity coefficients for the spring scale, using the highest trial as the score, ranged from .08 for the sixth grade boys to .79 for the third grade

TABLE I

RELIABILITY COEFFICIENTS

Grade	Sex	N	Spring Scale		Bathroom Scale	
			Highest of Three Trials	Total of Three Trials	Highest of Three Trials	Total of Three Trials
3	girls	12	.58	.59	.86	.80
3	boys	14	.66	.66	.89	.83
4	girls	14	.73	.82	.59	.63
4	boys	12	.72	.87	.76	.80
5	girls	14	.95	.86	.93	.93
5	boys	14	.49	.47	.93	.92
6	girls	13	.81	.86	.93	.90
6	boys	15	.77	.84	.83	.87

boys. The mean coefficient for the girls was .59 and for the boys was .47.

When the total score was used, the validity coefficients ranged from .13 for the sixth grade boys to .77 for the sixth grade girls. The mean coefficients were .60 for the girls and .39 for the boys.

The validity coefficients for the spring scale were somewhat better when the highest scores were used rather than the total scores. The third grade girls, the fourth grade boys, and the sixth grade boys all had validity coefficients which were unacceptable. The coefficient of .58 for the fourth grade girls was low but acceptable. The other validity coefficients, however, were all higher than .70 and were considered satisfactory.

Bathroom Scale

Using the highest trial, the validity coefficients for the bathroom scale ranged from .19 for the fourth grade boys to .80 for the sixth grade girls. Again, the mean coefficient for the girls, .67, was considerably higher than that for the boys, .44.

When the total score was used, the validity coefficients were similar to those for the highest score, ranging from .21 for the fourth grade boys to .80 for the fifth grade girls. Similarly, the mean coefficient for the girls was considerably higher than that for the boys, .65 and .42 respectively.

For the bathroom scale, the validity coefficients for the highest trial again were slightly higher than those for the total score. Using those scores, the fourth and sixth grade boys and the third grade girls had validity coefficients

which were unacceptable. The fifth and sixth grade girls had validity coefficients which were quite good, and the others were acceptable.

The validity coefficients for the bathroom scale were somewhat better than those for the spring scale. These data are in Table II.

OBJECTIVITY

The objectivity coefficients, with one exception, were consistently .94 or better. See Table III. The lowest coefficient was .86, for the third grade girls on the spring scale. Also on the spring scale, however, five of the eight coefficients were .97 or higher.

For the bathroom scale, the lowest coefficient was .94 for the third grade boys. The mean objectivity coefficient for the bathroom scale was .97.

All of the objectivity coefficients were sufficiently high to indicate that the bar-scale test, using either the spring scale or the bathroom scale, could be read by different administrators with a high degree of uniformity.

TABLE II

VALIDITY COEFFICIENTS

Grade	Sex	N	Spring Scale		Bathroom Scale	
			Highest of Three Trials	Total of Three Trials	Highest of Three Trials	Total of Three Trials
3	girls	12	.31	.35	.43	.40
3	boys	14	.79	.68	.58	.46
4	girls	14	.58	.55	.64	.61
4	boys	12	.25	.18	.19	.21
5	girls	14	.73	.74	.79	.80
5	boys	14	.76	.57	.57	.59
6	girls	13	.74	.77	.80	.79
6	boys	15	.08	.13	.43	.42

TABLE III

OBJECTIVITY COEFFICIENTS

Grade	Sex	N	Spring Scale	Bathroom Scale
3	girls	12	.86	.96
3	boys	14	.91	.94
4	girls	13	.97	.99
4	boys	12	.98	.95
5	girls	14	.99	.99
5	boys	14	.98	.96
6	girls	13	.99	.98
6	boys	15	.94	.99

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was carried out in an attempt to develop and evaluate an instrument which would satisfactorily measure the strength of elbow flexion of boys and girls in grades three, four, five and six. Elbow flexion was chosen as an important element of total strength and as a factor in many of the activities in which children participate.

The bar-scale apparatus used in this study consisted of either a Chatillon spring scale or a regular bathroom scale and a portable chinning bar set in a doorway. The test using this apparatus was administered to 112 children and evaluated for reliability, validity and objectivity. Since strength varies widely in children of different ages and between the sexes, the evaluation was done separately by grade and sex. A cable-tension test of elbow flexion strength was used as the criterion for the validity coefficients.

The reliability coefficients for the bar-scale test using the spring scale varied considerably, but for five of the eight groups evaluated the reliabilities were found to be satisfactory. For the bathroom scale, the reliability coefficients were slightly higher than for the spring scale and were acceptable for six out of the eight groups.

The validity coefficients for the spring scale ranged from .08 to .79. Five of these coefficients were .58 or better and were considered acceptable.

For the bathroom scale, the validity coefficients had a similar range and mean, and as on the spring scale, five of the groups had acceptable validity coefficients.

The objectivity coefficients for both scales were, with one exception, consistently .94 or better, and indicated that the bar-scale apparatus could be given by different administrators with a high degree of uniformity.

Because the number of subjects in each group was quite small, the coefficients, especially the validity coefficients, were subject to considerable variation due to extreme scores and were consequently somewhat lower than might have been the case with larger samples.

There were several factors, in addition to the formal statistical analysis, which appeared to support the possible use of the bar-scale apparatus as a measurement device in the elementary school. It was found, for instance, that three trials on the bar-scale apparatus could be easily administered to a group of approximately fifteen children in a forty minute class period.

The equipment needed for this apparatus was relatively inexpensive and could be used in other aspects of the physical education program. The apparatus required no permanent setting and was easily set up and dismantled. The test required only one administrator and students participated in the administration as recorders and scorers.

Finally, the test appeared to be intrinsically interesting to the students; they appeared to be able to understand the principle underlying the test and were motivated to perform their best--and to improve their scores--

throughout the testing sessions.

CONCLUSIONS

1. The bathroom scale generally produced what appeared to be higher coefficients than did the spring scale and is recommended for use in the bar-scale test.
2. Although using the highest score produced only slightly better results than using the total score, this method is recommended for use since it makes computation of the score somewhat easier.
3. The bar-scale test proved to be a reliable measure for all groups except the fourth grade girls.
4. The bar-scale test proved to be a valid measure for the fourth, fifth and sixth grade girls and to have low but acceptable validities for the third and fifth grade boys.
5. The bar-scale test proved to be an objective measure for all groups.

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APPENDIX

CABLE-TENSION STRENGTH TEST OF ELBOW FLEXION (5:16)

Starting Position

(a) Subject in supine lying position, hips and knees flexed, feet resting on table; free hand resting on chest.

(b) Upper arm on side tested adducted and extended at shoulder to 180 degrees; elbow in 115 degrees flexion; forearm in mid-prone supine position.

Attachments

(a) Regulation strap around forearm midway between wrist and elbow joints

(b) Pulling assembly hooked to wall at subject's feet

Precautions

(a) Prevent raising elbow and abducting upper arm by bracing at elbow

Objectivity Coefficient: 0.95

RAW SCORES

Subject		Age	Ht.	Wt.	Spring Scale Test 1	Test 2	Test 3	Retest 1	Retest 2	Retest 3	Second Reader Spring Scale
Third	1	8-10	50	57	38	39	53	38	34	45	45
Grade	2	8-5	49	63	45	36	43	38	34	36	43
Girls	3	8-7	52	70	51	47	53	40	45	53	50
	4	8-3	51	56	34	38	38	37	37	37	40
	5	8-7	51	56	52	48	60	39	42	54	61
	6	9-2	54	67	57	38	55	49	44	46	59
	7	9-3	54	66	42	31	38	40	39	45	43
	8	8-11	54	61	52	46	45	47	49	41	49
	9	8-6	52	82	32	44	45	51	44	52	43
	10	8-7	50	64	37	34	50	33	27	34	39
	11	8-9	54	63	49	53	41	50	43	53	52
	12	8-5	56	86	41	46	43	42	42	47	44
Third	13	9-3	54	78	30	29	45	49	48	47	44
Grade	14	8-10	49	56	43	37	37	42	46	40	41
Boys	15	10-1	55	76	60	45	57	58	69	70	64
	16	8-8	52	69	39	36	35	46	48	43	41
	17	9-1	53	69	35	35	37	42	45	47	36
	18	9-0	54	70	55	42	50	43	41	51	50
	19	8-6	52	66	44	27	50	35	50	51	46
	20	8-6	51	53	35	40	41	38	44	43	41
	21	9-2	55	79	31	43	53	46	47	54	46
	22	9-3	52	68	36	36	43	40	49	56	42
	23	9-1	49	53	39	33	32	40	47	52	37
	24	9-1	54	73	36	33	40	40	44	41	42
	25	9-0	55	75	35	39	45	40	40	42	40
	26	8-9	56	87	28	33	39	49	36	51	38
Fourth	27	9-8	56	79	42	45	46	37	41	48	46
Grade	28	9-0	53	76	28	27	41	24	40	48	39
Girls	29	9-11	55	82	56	64	70	49	60	54	78
	30	9-9	54	64	48	46	40	35	43	41	46
	31	10-7	55	70	35	42	30	35	30	42	40
	32	9-4	51	49	43	46	47	37	47	45	48
	33	9-4	53	62	33	48	42	31	36	42	48
	34	8-11	54	84	40	56	58	42	54	56	56

Subject	Bathroom Scale						Cable-Tension Test				Second Reader
	Test			Retest							Bathroom
	1	2	3	1	2	3	1	2	3	Con.	Scale
1	43	46	40	45	45	47	23	20	21	35	48
2	39	44	46	45	45	47	19	21	22	34	46
3	57	60	50	51	54	56	24	26	27	41	53
4	43	43	45	35	36	45	15	20	26	40	45
5	42	50	46	48	55	49	22	20	26	40	50
6	42	36	43	42	53	47	23	26	33	50	44
7	34	31	33	40	43	43	22	22	23	35	35
8	55	52	55	46	52	52	18	25	24	38	57
9	51	56	48	48	55	46	25	33	31	50	56
10	38	41	42	38	40	46	23	23	21	35	42
11	48	50	59	55	38	57	24	28	25	43	60
12	57	54	54	54	56	51	23	22	29	44	55
13	49	51	54	49	53	38	27	19	19	41	64
14	40	39	38	43	46	41	17	21	22	34	39
15	67	75	72	65	69	73	33	30	28	50	75
16	40	44	43	39	45	43	16	12	13	25	42
17	53	53	54	46	55	36	18	15	16	28	53
18	44	48	54	54	58	57	25	27	23	41	54
19	39	34	43	37	46	41	20	18	17	31	42
20	40	41	43	43	49	46	18	13	21	32	43
21	47	31	55	57	55	49	33	25	28	50	48
22	51	57	53	47	57	48	27	22	26	41	57
23	43	42	44	41	54	57	14	21	17	32	46
24	38	40	41	31	48	45	16	20	24	37	40
25	37	47	35	38	48	47	23	18	25	38	47
26	48	44	56	52	48	51	15	17	12	26	56
27	36	47	44	48	52	53	15	14	19	29	44
28	47	43	45	47	46	46	19	15	14	29	47
29	55	52	59	60	62	57	23	24	23	37	59
30	44	43	48	44	42	45	24	23	22	37	48
31	38	37	37	47	46	46	17	17	16	26	38
32	36	34	36	43	48	50	17	17	13	26	37
33	45	50	47	43	51	45	18	18	18	28	--
34	54	54	48	44	46	47	22	20	18	34	53

RAW SCORES (Continued)

Subject		Age	Ht.	Wt.	Spring Scale Test 1	Test 2	Test 3	Retest 1	Retest 2	Retest 3	Second Reader Spring Scale
	35	9-7	57	60	30	40	42	30	42	48	42
	36	9-7	58	95	36	53	52	51	54	52	54
	37	9-9	55	58	40	46	48	38	38	48	47
	38	10-1	51	57	39	51	53	38	43	53	53
	39	9-0	53	100	41	43	39	36	45	44	43
	40	9-11	53	65	46	51	70	42	50	46	60
Fourth	41	9-4	54	67	34	49	37	36	31	36	49
Grade	42	10-1	57	74	46	57	59	39	45	60	58
Boys	43	10-1	58	72	46	50	62	49	46	62	58
	44	9-4	55	68	50	50	53	45	46	54	57
	45	9-7	58	108	38	58	66	28	53	53	64
	46	9-5	58	96	51	52	57	46	43	49	56
	47	9-10	54	85	55	58	54	50	50	59	55
	48	9-6	55	74	34	40	42	49	36	46	42
	49	9-4	51	59	41	56	53	46	40	50	56
	50	9-7	59	84	68	73	89	68	61	65	90
	51	9-4	53	58	52	40	45	47	47	47	51
	52	9-7	57	85	62	60	62	49	48	52	60
Fifth	53	10-6	56	82	42	47	49	41	39	40	50
Grade	54	11-0	60	67	42	46	52	44	46	52	52
Girls	55	10-9	57	66	38	32	43	45	41	47	43
	56	10-2	64	88	61	59	56	60	59	62	62
	57	10-9	57	73	51	49	35	36	44	50	47
	58	10-5	56	71	39	35	38	35	31	39	39
	59	10-10	58	66	44	49	42	47	45	51	48
	60	11-1	58	66	48	39	57	40	55	55	58
	61	10-8	55	61	42	43	49	49	49	50	48
	62	11-2	57	70	34	41	43	33	36	41	40
	63	11-0	54	67	38	41	42	41	33	27	42
	64	10-4	56	75	49	28	47	44	40	37	49
	65	11-1	60	102	36	47	68	53	68	63	68
	66	10-9	56	62	29	23	34	31	31	29	34

Subject	Bathroom Scale						Cable-Tension Test				Second Reader
	Test			Retest							Bathroom
	1	2	3	1	2	3	1	2	3	Con.	Scale
35	40	32	40	43	49	41	23	22	20	35	41
36	52	54	54	52	59	58	23	27	23	41	54
37	39	38	38	34	39	42	15	18	15	28	41
38	47	43	41	42	52	43	22	19	18	34	45
39	51	50	45	43	50	46	19	22	20	34	51
40	45	48	42	41	44	49	21	25	27	41	48
41	34	35	39	36	37	39	20	20	22	34	38
42	49	51	55	53	52	53	24	19	20	37	54
43	54	56	62	56	56	56	22	25	25	38	62
44	43	45	49	50	52	55	21	22	20	34	48
45	46	44	45	49	45	52	22	29	25	44	43
46	44	44	46	52	54	44	20	19	19	31	45
47	57	56	60	50	55	53	23	23	23	35	58
48	41	51	48	40	43	42	16	22	21	34	52
49	42	37	32	33	39	42	23	21	21	35	43
50	41	53	60	58	61	70	21	20	22	34	52
51	35	36	40	39	42	43	14	14	22	34	39
52	55	52	36	54	52	50	20	26	22	40	55
53	61	60	60	51	52	56	21	24	20	37	60
54	51	55	54	54	54	54	24	22	24	37	53
55	42	54	55	44	47	56	23	26	24	40	54
56	65	70	70	70	76	78	32	27	26	49	69
57	51	52	52	53	51	52	19	17	20	31	51
58	40	48	50	44	52	49	21	23	19	35	49
59	57	60	61	56	56	54	23	19	19	35	61
60	47	58	52	52	59	58	17	23	18	35	57
61	51	52	52	46	57	49	24	22	30	46	52
62	51	53	60	48	53	63	23	20	22	35	60
63	55	56	55	48	52	51	18	20	23	35	57
64	51	56	53	48	50	48	22	25	20	38	55
65	70	71	74	71	65	74	29	32	30	49	74
66	29	23	35	31	29	33	14	12	13	22	36

RAW SCORES (Continued)

Subject		Age	Ht.	Wt.	Spring Scale Test 1	Test 2	Test 3	Retest 1	Retest 2	Retest 3	Second Reader Spring Scale
Fifth	67	10-10	57	91	45	48	54	60	64	60	53
Grade	68	10-11	61	77	42	51	48	51	41	46	48
Boys	69	10-6	58	80	40	46	50	54	54	54	49
	70	10-3	58	82	35	48	47	56	46	45	47
	71	10-5	58	89	57	59	57	59	53	59	58
	72	10-5	55	78	36	48	47	38	46	48	47
	73	10-5	53	61	34	40	39	38	39	41	40
	74	10-7	55	76	47	53	51	49	54	55	49
	75	11-0	60	92	79	73	73	55	67	52	78
	76	11-4	57	72	51	57	45	57	53	55	57
	77	10-7	57	75	31	35	48	41	46	41	45
	78	10-11	61	98	36	60	58	74	75	78	57
	79	10-7	52	67	36	38	40	47	47	47	45
	80	10-10	54	71	38	43	41	45	44	48	43
Sixth	81	12-1	61	107	66	70	79	67	74	73	78
Grade	82	11-10	54	67	55	50	70	65	52	66	68
Girls	83	12-4	59	91	46	44	62	38	49	46	62
	84	11-10	64	137	83	98	93	86	92	94	97
	85	11-8	55	62	62	59	56	33	35	35	60
	86	11-9	55	96	49	59	54	38	41	41	56
	87	11-6	60	89	65	50	63	63	63	68	63
	88	11-8	59	83	58	61	65	69	72	71	62
	89	12-2	58	86	74	53	63	51	61	64	74
	90	11-9	61	95	60	50	82	74	69	71	80
	91	11-8	55	67	45	49	48	45	49	43	50
	92	12-0	60	99	73	74	78	70	66	53	80
	93	10-10	63	113	59	70	90	79	82	84	87
Sixth	94	13-1	58	86	68	66	62	60	61	64	66
Grade	95	12-0	60	99	86	85	91	101	103	97	91
Boys	96	12-2	57	88	57	56	62	56	47	54	64
	97	11-3	56	102	57	54	65	69	46	64	63
	98	12-2	56	82	49	61	62	61	60	62	50
	99	12-0	60	84	49	51	56	55	63	52	56
	100	11-11	63	105	61	62	62	55	87	77	62

Subject	Bathroom Scale						Cable-Tension Test				Second Reader Bathroom Scale
	Test			Retest							
	1	2	3	1	2	3	1	2	3	Con.	
67	57	57	64	68	64	67	35	34	28	53	57
68	45	49	63	56	58	63	21	24	29	44	62
69	53	53	60	49	50	64	22	23	23	35	58
70	58	53	48	51	55	58	29	25	29	44	53
71	53	50	53	61	64	59	30	29	30	46	53
72	43	47	48	48	51	54	26	27	23	41	48
73	34	35	34	31	39	37	19	22	23	35	35
74	50	47	51	58	57	60	28	23	27	43	52
75	67	69	64	72	66	68	24	27	27	41	68
76	52	46	53	60	58	59	31	24	29	47	51
77	46	39	42	49	49	48	22	20	22	34	47
78	61	56	64	70	73	73	26	27	30	46	65
79	40	44	47	45	42	47	18	21	20	32	47
80	42	49	47	49	46	52	22	18	23	35	52
81	76	76	76	81	91	79	30	26	37	56	76
82	54	54	51	54	50	55	23	26	23	40	55
83	23	34	41	40	40	44	18	20	20	31	41
84	80	75	81	96	79	101	46	40	43	70	82
85	43	40	40	45	54	58	20	16	23	35	33
86	48	49	55	55	44	53	25	26	23	40	56
87	55	56	59	68	71	76	22	22	21	34	60
88	55	60	60	67	60	62	24	27	32	49	59
89	47	53	48	51	60	70	31	28	24	47	53
90	59	69	67	62	66	69	31	32	31	49	67
91	38	45	39	40	42	44	30	24	23	46	43
92	62	66	68	65	62	58	26	27	23	41	68
93	75	70	79	96	73	86	37	33	32	56	81
94	64	61	62	64	59	54	38	44	35	67	61
95	104	88	84	93	95	85	39	37	43	65	104
96	63	63	56	53	56	63	37	41	32	62	65
97	66	76	78	68	62	67	27	33	31	50	76
98	50	51	69	61	56	66	33	32	33	50	70
99	58	58	60	57	46	50	27	38	25	58	60
100	87	74	92	78	79	82	33	34	44	67	94

RAW SCORES (Continued)

Subject	Age	Ht.	Wt.	Spring Scale Test 1	Test 2	Test 3	Retest 1	Retest 2	Retest 3	Second Reader Spring Scale
101	11-11	62	102	56	64	70	83	84	81	70
102	11-11	61	124	86	77	86	74	73	83	86
103	11-6	57	77	74	66	76	67	67	66	78
104	11-11	57	66	49	53	58	44	55	54	63
105	11-7	62	95	61	53	67	57	68	66	64
106	11-6	63	87	48	57	51	43	56	56	56
107	11-3	62	109	62	57	63	53	53	61	61
108	11-8	57	72	51	59	58	55	52	55	60

Subject	Bathroom Scale						Cable-Tension Test				Second Reader
	Test			Retest							Bathroom
	1	2	3	1	2	3	1	2	3	Con.	Scale
101	82	83	82	79	79	85	31	30	34	52	85
102	73	73	67	69	60	48	31	30	28	47	79
103	72	73	64	61	55	61	28	23	30	46	74
104	53	61	63	63	70	66	23	27	35	53	63
105	66	67	71	80	73	69	27	30	31	47	72
106	53	45	63	50	44	53	27	34	34	52	59
107	65	52	54	50	51	55	25	25	31	47	62
108	51	48	47	60	51	59	21	28	23	43	51

Typed by

Marie E. Teague