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Analysis of Some Variations in Method of Performing the Push-Up among College Women

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ANALYSIS OF SOME VARIATIONS IN METHOD OF PERFORMING THE PUSH-UP AMONG COLLEGE WOMEN

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by

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This study utilized 90 college women from Central Washington University to determine if there are significant differences in strength scores between Rowney Knees-on Push-up Method and three body position variations and cadences. The main outcome of this research reflected two significant differences between Rowney's method and body position and cadences. No significant differences were found between experimental body position variations and cadences. The results of this study confirm the hypothesis that changes in push-up technique may produce significant differences in strength scores.

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CHAPTER I

INTRODUCTION

Prior to the decade of the 80s little attention was given to the development of muscular strength among girls and women. Virtually no method of rapid evaluation of strength changes applied to women are to be found in the literature of physical education. This is undergoing change at present, perhaps traceable to the social liberation of women who are now found in increasing numbers in exercise salons, weight-training facilities in schools and in privately-owned gyms. Provision of federal law prohibits sex discrimination which has encouraged women to participate in activities which were traditionally male-dominated. With the increasing interest shown in personal physical fitness by both sexes, physical education is presently somewhat unprepared to judge both objectively and quickly the status of muscular strength for women.

Over the years several testing procedures have been developed for assessing muscular strength in men and boys. These tests often required diverse and expensive instruments which, in turn, contributed to a greater demand on the time of the instructor and the class. The Rogers Physical Fitness Index (PFI) (1931) battery requires seven tests (in its complete form), three of which require rather expensive instruments. The test is acknowledged, however, to be one of the best of its kind in the field of physical education. In all, the test requires a dynamometer for the measurement of back and leg strength, a manuometer for the measurement of grip strength, a spirometer for the measurement of vital capacity, chinning bar for men, stall bar for women's push-ups, parallel bars for men's bar dips, and adjustable bar for women's pull-ups.

The PFI test requires considerable time for its administration even when adequate numbers of trained testers are available. Very few schools have the necessary equipment and trained instructors to administer the test. Some other method of objective assessment would be beneficial to meet the requirements of validity, reliability, objectivity of testing, and which is relatively inexpensive and rapidly accomplished.

A method of objectively assessing total dynamic strength (TDS) can be found through the research of Berger (1965) applied to men and Rowney (1985) for women. Berger related chinning and dipping strength among men in order to predict TDS. Dynamic strength was measured for most of the large muscle groups by utilizing six different exercises commonly used in weight training (curls, military press, bench press, deep knee bend, sit-up, and bent-over rowing). A composite score from these lifts was used as a criterion for the TDS score. This score was then correlated with

1-RM chin-up and dip strength. The method for obtaining the chin-up and dip score was formulated by having the subjects perform the chin-ups and dips at their body weight plus additional weights which were continually added until the subject would perform only 1-RM. Comparative correlations between 1-RM chin-up strength and TDS was .846; for 1-RM dip strength and TDS the correlation was .83.

Rowney also utilized several common lifts (leg extension, seated military press, bench press, bar curl, and bent-over row) as a criterion for the TDS score. His study design was patterned after the same methods as Berger's study. The slight difference was the type of lifts used to establish a TDS score since unlike Berger, Rowney's test referred to women only thus requiring modified pull-ups and push-ups.

The Baumgartner (1978) modified pull-up test was used in Rowney's study. Baumgartner demonstrated reliability for a method of executing the pull-up for women. With the modified pull-up technique satisfied, Rowney developed a method of evaluating the push-up. The writer referred to this test as the "Rowney Knees-on Push-up Method." Through experimentation, Rowney produced a method of executing the push-up which is best described in his thesis:

> The subject placed both knees on the bench, four inches from the front edge. The subject then lowered her arms to the floor such that her knees were still in the same position on the bench, and her back was straight, with a 90 degree angle between upper arms and torso. Hands were placed directly

> underneath the shoulders with fingers pointing forward.
>
> Without bending at the waist, the subject was asked to perform as many push-ups as possible at a steady pace. Repetition where the subject failed to achieve a 90 degree angle at the elbow were not counted. Subjects were not allowed to rest between repetitions. (p. 58)

The outcome of Rowney's study in correlating the modified lifts to TDS reflected a high positive relationship. Both Rowney and Berger's tests are reliable assets in determining one's TDS. In addition, both tests are easy to administer rapidly and can be easily calculated.

Motive for This Study

Using Rowney's method for performing and scoring the push-up for women has proven to be valuable for evaluating the general strength of women, but has, at the same time, provoked some questions concerning specifics in performance technique.

Rowney's description specified:

1. Bench height;

2. Position of the knees 4 inches back from the front edge of the bench;

3. Back straight and parallel to the floor;

4. Angle of 90 degrees between the torso and arms when extended;

5. Hands directly under the shoulders, with fingers pointed forward;

6. Performance to maximum at a steady pace;

7. At the flexed position the elbow bend must reach a 90 degree angle;

8. Perform without hesitation or rest once the task commences.

Of the specifications above, the following present no problem: #1, #3, #4, #7, and #8. In #2, the knees on the bench act as a fulcrum--the further back they are placed, the greater is the advantage to the performer since the resultant load is lessened. No performer has been observed in #5 with hands closer together than shoulder width. To the contrary, many women placed the hands further apart than shoulder width which, from the standpoint of body mechanics, makes the resultant task easier since the load is placed closer to the floor at the outset and needs to be moved a lesser distance with each successive push-up. In #6 no problems were seen with the pace being steady--the problem is in the possible influence of the speed of performance.

While the method has overall merit, enough questions exist about the variations in technique and cadence to justify a systematic study.

Statement of the Problem

The problem was to analyze the effect of systematically applied variations in performance technique upon the number of push-ups which can be performed by a sample of Central Washington University women in physical education activity classes.

Purpose of the Study

The following were the two purposes of this study:

1. To test the significance of alterations in body position and speed of performance on scores made in the Rowney Knees-on Push-up Method; and

2. To systematically test these various alterations for significance of difference between means.

Hypotheses

1. There will be no significant difference in push-up strength among groups of performers matched initially in push-up strength despite the systematic introduction of alterations of body position and cadence.

2. There will be no significant difference between push-up strength in test stage 1 and test stage 2 levels.

Definition of Terms

The following are terms as defined by Rowney (1985):

Total dynamic strength (TDS) - The composite score of the individual 1-RM strengths of the muscle groups measured (in pounds) by the leg extension, seated military press, bench press, bar curl, and bet-over row, weight lifts.

1 repetition maximum (1-RM) - The maximum load which allowed a subject to perform only one repetition.

Limitations

1. The test utilized 90 female students from Central Washington University, ages 18-30, who were registered in physical education activity courses.

2. The motivational outlook of each subject could not be controlled.

3. Rest periods varied due to subjects' schedules which sometimes conflicted with those of the writer.

4. An additional monitor was utilized as a tester in this experiment.

CHAPTER II

REVIEW OF LITERATURE

The present study is concerned with testing the effect of variations in body position and cadence upon push-up performance scores of college women. In question form the writer asked, "To what extent will changes in performance technique alter the scores of college women in the push-up test?"

Relatively little information exists in the literature pertaining to this study. It was decided to report instances from the field of measurement and evaluation in which alterations of instrumentation or technique had been performed in an effort to reduce administration time, reduce cost, simplify some existing procedures, or in some other way produce a more readily usable measurement product. At the same time integrity of both validity and reliability was to be minimally disturbed in the process.

During the 1960s, Berger, following the lead of McCloy in the 1930s, successfully challenged the notion that a given number of pull-ups or push-ups performed by men could be accepted as identical effort when body weights among the performers varied. As a consequence of this, Berger developed a method of scoring pull-ups and parallel bar dips at a performer's body weight which makes an evaluation of his total dynamic strength (TDS) valid, reliable, and rapidly calculated (Berger, 1963, 1965, 1967).

In 1963, Berger showed that the relationship between 1-repetition maximum (1-RM) military press strength and a criterion of seven common weight training lifts was .87. He referred to this strength criterion as TDS, and noted that while the 1-RM military press was valuable as a single item predictor of the strength criterion, it was quite time consuming as a test for large numbers of men. As a consequence of this, in 1966, he investigated the relationship between 1-RM chinning strength and six common weight training lifts. The result was a correlation of .85 between the two. While publication of the 1966 study was pending, Berger investigated the relationship between 1-RM dipping strength and TDS as well as the relationship between TDS and a combination of both 1-RM chinning and dipping strength. He found that the 1-RM dip strength correlated .83 with TDS strength and that the combination of 1-RM chin strength and dip strength correlated .90 with TDS. Predicted 1-RM chin strength varied on average from actual 1-RM chin strength by 5.13 lbs and predicted and actual 1-RM dip strength varied by an average of 6.9 lbs (Berger, 1965).

Since college women may now be found in considerable numbers in weight training facilities, Kindig et al. in 1984 reported standard score norms for college women by body weight classes for five commonly performed weight training lifts. While very valuable in its own right, the study did nothing to shorten the testing time required for class or individual evaluation of performance since the actual time consuming lifts themselves had to be used.

In 1985, Rowney devised a method of evaluating strength for college women based in principle upon Berger's work but requiring modified tasks for the pull-up and bar dip.

In 1978, Baumgartner had developed a method of evaluating arm flexor strength for girls and women using a low, four-wheeled scooter board upon which the subject laid in a prone position. She pulled herself up a sturdy 10-foot plank inclined at 30 degrees from the horizontal to an attached pipe frame pull-up bar. Since the sine of 30 degrees is .5, each subject actually raises 50% of her body weight using this device. The reliability of the test was reported as .91 and was subsequently adopted by Rowney as described, as one-half of the arm strength measurement to accompany Rowney's "knees-on" method of assessing push-up strength for women and girls.

In the 1940s, A. E. Gay of Lockport, New York devised an apparatus which both simplified the administration and increased the reliability of the pull-up test for girls and women which was given as a portion of the Rogers Physical Fitness Index (PFI) test. Its principal limitation was its cost which added further to the considerable expense of the basic necessary test instruments. In an effort to counteract the expense without sacrificing test reliability, Lacey (1969) substituted for the Gay apparatus with two 10-foot two-by-fours into which holes had been drilled 2 inches deep and 2 inches apart. The two-by-fours were placed 30 inches apart, parallel to each other, and spanned by a short piece of water pipe laid across the nails that were placed in the holes of the two-by-fours. Lacey found that an angle of 53 degrees from the horizontal revealed no significant difference existed between use of the Gay apparatus and the device used by Lacey, thus validating this low-cost alternative.

Prior to 1938 the leg lift, one of the test used in the Rogers PFI battery, was performed with a short bar attached to a chain which was in turn attached to the dynamometer. The performer lifted as much as he could while gripping the bar as securely as possible. It was found that any performer could invariably lift a great deal more with his/her legs than could be gripped with the hands. For this reason, Everts and Hathaway perfected the so-called "belt technique" which increased the efficacy of the lift and necessitated alteration of the entire scoring procedure and subsequent norms (Everts & Hathaway, 1938).

As noted earlier, the Rogers PFI test requires some rather expensive equipment, one of its principal limitations to wider acceptance. During World War II, H. Harrison Clarke, assigned to injury rehabilitation work, adapted the aircraft cable tensiometer to the measurement of isolated muscle groups in order to ascertain the extent of injury as well as to determine the nature of progress as a result of treatment. Subsequently, he utilized the instrument to develop muscle tests of 38 different muscle groups around the body among the healthy (Clarke et al., 1952). In 1956, Kennedy, working under the direction of Clarke, adapted the cable tensiometer for use in testing strength of the back and leg muscles thus substituting a less costly instrument for the more expensive original back and leg dynamometer without sacrificing validity and reliability of the test.

In 1957, Clarke and Geser tested three different hand grip manuometers among a group of college students. Means and standard deviations varied enough to be significantly different which suggested the necessity for careful calibration of any instrument prior to its use.

Carter (in Clarke & Carter, 1959), working under the direction of Clarke, studied by means of regression equations, ways by which the full seven-item PFI test could be modified for use with elementary school age boys and girls as well as those from junior high school and high school. Correlations between the full test and modified versions at each school level for both sexes were extremely high indicating virtual identity between original and modified versions of the test battery.

In the early 1960s the Australians Gray, Start, and Glencross had challenged the use of so-called "power" tests which consisted of such tests as the vertical jump, standing broad jump and squat jump as valid measures of power as defined in the realm of physics. They subsequently perfected a test of leg power (equivalent to work done divided by time taken) with a validity coefficient of .985. It presented problems, however, which made it unattractive for use in a practical, school-oriented way. In response to this, they modified their original test to a much easier form having a validity of .989 and a reliability of .977 (Gray, Start, & Glencross, 1962a, 1962b).

In 1967, Eckert and Day devised a study that would employ the use of an electric metronome in dictating the pace of push-up performance. The experiment utilized 15 well-conditioned female subjects, who had been trained to perform the correct push-up technique. The rate of 41 push-ups per minute was subjectively discovered to be a relatively comfortable pace by most of the subjects. The basic methodology of enforcing the pace was replicated by the writer. Eckert and Day (1967) reflected the following procedures:

> During the course of the testing, the electric metronome, used as the pacemaker, was set at 82 beats per minute so that the subject was in the high position for one beat and in the low position for the following beat. All subjects began in the high position, which was determined by their own arm lengths, and touched the thin pole set at 8 in., in the low position. The number of complete push-ups the subject was able to perform within the prescribed high-low position at the rate of 41 push-ups per minute until the subject could no longer maintain the pace due to exhaustion was recorded and dated. (p. 381)

Although Eckert and Day employed the use of the electric metronome, they did not study the effect of different cadences.

An attempt has been made in this chapter to show that testing of modifications in technique, instrumentation, and general and specific test administration are frequently undertaken with results which often simplify or hasten calculations and test time with minimal damage to test validity and reliability.

CHAPTER III

PROCEDURES

Sample Procedures

The study utilized 90 Central Washington University female students between the ages of 18 and 30, who were enrolled in physical education activity classes during winter quarter 1986. Classes from which the subjects were obtained were aerobic conditioning, weight training, conditioning exercises, and aerobic dance conditioning.

Testing Schedule and Location

The experiment was conducted during winter quarter 1986 in Nicholson Pavilion at Central Washington University, Ellensburg, Washington. The test period started on 24 February and was completed on 4 March 1986.

Monitors

Two monitors gathered and recorded data during the testing stages. Stephen M. Matson, a Central Washington University student, and the writer collaborated to assess the 90 female subjects within the stipulated time period. Prior to the test periods, Mr. Matson was thoroughly trained by the writer in data collection procedures.

Equipment

The following equipment was used in this study:

1. Electric metronome,

2. Stopwatch,

3. Cassette tape recorder,

4. Yardstick,

5. Detecto-Medic beam type weight scale,

6. Two benches - Both wooden benches were constructed with minimal cost to the writer. The dimensions of each bench was 13 inches high, 14 inches wide, and 20 inches long. In addition, a thin piece of carpet was used to cover the top of each bench.

Test Stages

Test Stage 1: An initial test of the Rowney Knees-on Push-up was performed by each subject in accordance to Rowney's specifications. This initial test established a cadence score plus an initial push-up total for each girl.

Test Stage 2: All subjects performed the posttest in which one of three body position deviations from the Rowney Knees-on Push-up Method plus a fast, medium, or slow cadence was imposed on each individual.

Description of Each Test Stage

Test Stage 1

1. Body Weight: The body weight of each subject was measured on the Detecto-Medic beam type weight scale prior to performing Rowney's Push-up test.

2. Rowney Knees-on Push-up Test: Prior to performing the push-up, the subjects were thoroughly briefed on the prescribed technique. After the briefing, each participant performed the test while specifically adhering to those directions set by Rowney, plus the imposed specification that the legs be extended at the knee joint during performance. The latter specification, through prior experimentation by the writer, determined that the extended knee joint most closely complied with Rowney's description that each subject would be lifting approximately 50% of her body weight.

3. Cadence: In order to determine performance cadence, a stopwatch was used to time the first 10 push-ups performed by each subject. The recorded times established fast, medium, and slow cadences for the second stage test. The cadence rates were obtained by utilizing the mean of the 30 fastest push-up times which indicated the fast rate, second 30 fastest times the medium cadence, and the slowest 30 push-up times the slow cadence.

Test Stage 2

1. Body Weight: The subjects' body weight were remeasured; and to ensure that measurements were consistent in both stages, the writer required the subjects to wear the same clothing for the second stage.

2. Cell Assignment: A 3 x 3 factorial design was used in this study. There was a total of nine cells into which all 90 subjects were allocated, thus reflecting a total of

10 subjects per cell. The variables were the fast, medium, and slow cadences as determined in Stage 1, plus three body position variables chosen empirically by the writer which reflect common departures from strict test specifications: (a) knees 4 inches from front edge of the bench with hand placement extended greater than 3 inches beyond shoulder width; (b) knees 1 inch from front edge of the bench with hand placement equal to shoulder width; (c) knees 1 inch from front edge of the bench with hand placement extended greater than 3 inches beyond shoulder width. A yardstick was used to measure the increased distance in hand placement by 3 inches in relation to shoulder width. The measurement was made to the middle finger tip of each hand.

3. Assignment of Subjects: Each participant was placed into a specified cell for Stage 2 based upon the results of the strength score in Stage 1. The strength score was computed by using Rowney's total dynamic strength formula for push-ups. After the strength scores were determined, each score was placed in rank-order from the highest to the lowest score and systematicly placed into each cell as illustrated in Figure 1, Chapter IV.

4. Strength Score Computation: As stated above, the strength scores were obtained by the use of Rowney's strength formula for push-ups. The formulas which are based on body weight (BW) are listed below:

a. BW = 110 lbs. Push-up strength = .997 x number of push-ups + 57.3.

b. BW = 120 lbs. Push-up strength = .882 x number of push-ups + 72.7.

c. BW = 140 lbs. Push-up strength = .816 x number of push-ups + 87.3

d. BW = 160 lbs. Push-up strength = 1.07 x number of push-ups + 94.1.

5. Statistical Analysis: A one-way analysis of variance was used to determine the success of strength matching from the strength scores obtained from Stage 1. In Stage 2, the two-way analysis of variance analyzed the effects of interactions of cadence and body position variations on push-up strength. And finally, the *t*-test examined the relationship between Rowney's Knees-on Push-up Method (Stage 1) and individual performance scores (Stage 2), for each of the nine cells. All analyses were based on the 5% level of confidence.

CHAPTER IV

RESULTS OF THE STUDY

The first purpose of the study was to test the significance of difference made by alterations in body position and speed of performance upon strength scores made in Rowney's Knees-on Push-up Method. In order to do this, each girl was tested using Rowney's original test specifications with the additional stipulation that legs were to be extended at the knee joints throughout the test. These results were then scored by utilizing Rowney's strength formulas which in turn are based upon body weight. Each of the scores were rank-ordered into a single series. The foregoing was designated as the Stage 1 test. The rank-ordered series of strength scores can be found in the Appendix.

Following the ranking of each subject's strength score, the scores were assigned to the cells of a 3 x 3 matrix in which the columns were variations in body position and the rows variations in cadence. The assignments were made in the manner shown in Figure 1.

The numbers represent test subjects within the rank-ordered series. Variations in body position were combinations empirically chosen from those commonly observed to occur among subjects perviously tested. In addition to

	*A	B	C
*F (1)	*1, 18, 19, 36, 37, 54, 55, 72, 73, 90,	6, 13, 24, 31, 42, 49, 60, 67, 78, 85	7, 12, 25, 30, 43, 48, 61, 66, 79, 84
M (2)	2, 17, 20, 35, 38, 53, 56, 71, 74, 89	5, 14, 23, 32, 41, 50, 59, 68, 77, 86	8, 11, 26, 29, 44, 47, 62, 65, 80, 83
S (3)	3, 16, 21, 34, 39, 52, 57, 70, 75, 88	4, 15, 22, 33, 40, 51, 58, 69, 76, 87	9, 10, 27, 28, 45, 46, 63, 64, 81, 82

*A = Knees 4 inches from front edge of the bench with hand placement extended greater than 3 inches beyond shoulder width.

B = Knees 1 inch from front edge of the bench with hand placement equal to shoulder width.

C = Knees 1 inch from front edge of the bench with hand placement greater than 3 inches beyond shoulder width.

*F = Fast cadence (57 beats per minute)

M = Medium cadence (48 b/p/m)

S = Slow cadence (38 b/p/m)

*1 = Starting point to the pattern used to assign the subjects to the 3 X 3 design . . . at cell C3 the pattern is reversed.

Figure 1. Assignment of Subjects into the 3 X 3 Factorial Design

the push-up strength score for the Stage 1 test, the cadence for Stage 2 was determined by obtaining the mean of the time for the first 10 push-ups in which each subject performed at her own pace. The mean of the 30 fastest 10 push-up times became the fast cadence, the mean of the next 30 fastest times established the middle cadence, and the mean of those performing slowest was the slow cadence. A one-way analysis of variance testing for significance of difference between the cadence scores produced an *F*-ratio of 143.6 indicating highly significantly different cadence groups. Table 1 indicates the cadence groups.

Table 1

Times for 10 Push-ups and Cadences for Fast, Medium, and Slow Cadence Groups

Fast	Medium	Slow
n = 30	*n* = 30	*n* = 30
M = 10.5 sec.	*M* = 12.5 sec.	*M* = 15.6 sec.
Cadence rate = 57	Cadence rate = 48	Cadence rate = 38

To test for significance of difference between groups as assigned to cells in the 3 x 3 matrix, a one-way analysis of variance was calculated between the scores in the nine cells (A1 through C3) simultaneously. The results are summarized in Table 2.

Table 2

One-way Analysis of Variance to Test for Differences Between Assigned Subjects in Cells A1 through C3

Source	*df*	*SS*	*MS*
Between groups	8	20.76	2.59
Within groups	81	16634.58	205.36
Total	89	16655.34	

F-ratio = .012

As one can see, the *F*-ratio is extremely small indicating virtually no difference in strength among the groups.

The testing during Stage 1 produced an initial push-up strength score for each subject. Following systematic assignment to a body position-cadence cell, the test was repeated under the new test specifications. This permitted a comparison between means of Stage 1 versus Stage 2 for each of the nine groups. Thus, the *t*-ratio test for significance of difference between correlated means of Stage 1 versus Stage 2 can be seen in Table 3.

Two of the nine *t*-ratio comparisons indicated that differences between strength score means of both testing stages were significant. The mean of Stage 2 was significantly better than that of Stage 1 in cell A2 where the knees were 4 inches from the front of the bench, hands

Table 3

Significance of Difference Between the Rowney Stage 1 Strength Scores and Strength Scores from Subsequent Body Position-Cadence Variations in Stage 2

Cell	*M* Stage 1	*M* Stage 2	Difference between *M*s	*SE M*	*t*
*A1	110.4	115.4	5.0	1.03	1.52
A2	110.2	116.1	5.9	1.53	2.46
A3	109.4	106.1	3.3	1.04	0.98
B1	109.1	112.2	3.1	7.26	1.36
B2	109.2	108.6	0.6	6.87	0.28
B3	108.9	101.3	7.6	5.62	4.34
C1	109.4	111.7	2.3	6.72	1.08
C2	109.2	112.9	3.7	1.03	0.87
C3	109.2	117.7	8.5	1.37	1.96

*1, 2, and 3 are fast, medium, and slow cadences (57, 48, 38 beats per minute).

A = Knees 4 inches from front edge of bench; hands greater than 3 inches beyond shoulder width.

B = Knees 1 inch from front edge of bench; hands at shoulder width.

C = Knees 1 inch from front edge of bench; hands greater than 3 inches beyond shoulder width.

(*df* in all comparisons is 9; *t* must equal 2.262 for significance at .05.

3 inches beyond shoulder width, at medium cadence. In contrast to this in cell B3, the Stage 1 mean was significantly better than Stage 2 where the latter was typified by knees 1 inch from the front of the bench, hands at shoulder width, and executed at a slow cadence.

It was felt that since the push-up score depends on body weight, the influence of the latter needed investigation inasmuch as dietary changes and water retention among women are known to exert an influence on body weight. Since the *t*-ratio for body weight means at Stage 1 versus Stage 2 was 1.33, it was apparent that body weight changes were not significant. In view of the foregoing evidence, one must conclude that test performance specifications must be followed stringently to avoid undue influence on subsequent performance in this form of women's push-up.

The second purpose of this study was to systematically test the significance of difference between body positions, cadences, and their interaction. Table 4 shows the two-way analysis of variance for all three areas. The test resulted in *F*-ratios less than the required critical value of 2.53 for the body positions, cadences, and their interaction. Thus, purpose two of this study may be said to have produced only chance differences with respect to the variables employed.

Based on the results of this study, one may conclude that changes in body position and cadence affect strength scores.

Table 4

Significance of Difference in Push-up Performance Between Body Position, Cadence, and Their Interaction

Source	*df*	*SS*	*MS*	*F*-ratio
Between cells		(2186.8)		
Body position (columns)	2	717.5	358.75	1.89
Rows (cadence)	2	518.3	259.15	1.35
Interaction	4	951.0	237.75	1.25
Within cells	81	15355.3	189.56	

CHAPTER V

SUMMARY AND CONCLUSIONS

The main purpose of this study was to determine the extent to which adaptations of Rowney's Knees-on Push-up Method would affect push-up strength scores. The study utilized 90 CWU women subjects from physical education activity classes during winter quarter 1986. Each subject was tested in two stages. In the first stage each girl performed according to Rowney's specifications with the added stipulation that the knees be extended during the push-up trial. Time for the first 10 push-ups was scored for each girl as she performed at her own pace. This made it possible to create three significantly different cadence groups for the Step 2 test.

Stage 1 push-up strength scores were rank-ordered to form the basis for subject assignement to each of the nine push-up tasks in Stage 2 according to variations in body position and cadence. A one-way analysis of variance indicated strength groups subsequently formed were virtually identical.

To test the hypothesis that no difference would be found between strength means of the girls comprising the nine body position-cadence groups, a two-way analysis of variance was calculated. Results indicated the null hypothesis to be upheld. Thus, differences in strength between girls comprising these groups were random.

To test the hypothesis that no difference would be found between tests conducted according to Rowney's specifications and the strength subsequently calculated for each of the experimental groups, nine *t*-ratios were calculated for significance of difference between means of Stage 1 versus Stage 2 scores. Two *t*-ratios were significant, one at .05 level where the Stage 2 mean was greater and the other at .01 level where Stage 1 mean was greater. Since in these two *t*-ratios both combinations of body position and two of the three cadences are implicated, close adherence to test specifications is necessary.

Implications and Recommendations

The original purpose of this study was to determine the effect in body position and cadence on push-up strength scores of college women. The results of the study developed three implications and recommendations.

First, physical educators may utilize this test with minimal cost to the school, as well as obtain data that are reliable, valid, and easily calculated. The test also complies with time constraints, thus allowing the teacher to evaluate a large female population. In addition, Rowney's strength formula is relatively simple to compute. Immediate results of the student's score may be relayed expeditiously and methods of improving individual performance may be suggested. This type of feedback allows students to recognize weakness and thus work toward improvement of their scores.

Second, the results of the study indicate that variations in body position and cadence do make a significant difference in push-up performance. Instructors must be aware that these changes directly affect the performer's score. Thus, it is recommended that the procedures as stipulated by Rowney and the writer, be stringently followed.

Third, the test developed by Rowney should be considered as a "relative" test, whereas the test developed by Berger can be described as an "absolute" test, as described in the following context. Recently, women have successfully competed for jobs in previously male-dominated fields of employment; fire fighting is a case in point. If successful performance in fire fighting depends upon ability to display a level of strength and muscular endurance denoted by ability to perform 20 push-ups done in "men's style," women must not be allowed to substitute 20 push-ups done in the manner of this study. As just specified, the standard of performance can be specified as "absolute." However, if a standard is desired in which women will be compared with other women, the push-up done in the manner prescribed herein can be considered adequate and can be labelled "relative."

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APPENDIX

RANK ORDER OF STAGE 1 STRENGTH SCORES

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1.	150.8	31.	114.4	61.	102.6
2.	148.6	32.	114.2	62.	101.9
3.	139.7	33.	113.2	63.	101.9
4.	133.6	34.	112.5	64.	101.8
5.	133.6	35.	112.5	65.	101.1
6.	133.6	36.	112.5	66.	100.9
7.	133.6	37.	111.7	67.	100.9
8.	130.0	38.	111.7	68.	100.3
9.	128.9	39.	111.2	69.	100.1
10.	126.2	40.	110.9	70.	99.5
11.	125.1	41.	110.9	71.	99.1
12.	125.1	42.	110.9	72.	98.7
13.	121.9	43.	110.1	73.	95.6
14.	121.9	44.	110.1	74.	95.4
15.	121.5	45.	108.5	75.	95.1
16.	121.5	46.	108.5	76.	94.7
17.	120.8	47.	107.7	77.	93.8
18.	119.9	48.	107.7	78.	92.9
19.	119.1	49.	106.8	79.	92.9
20.	118.3	50.	106.8	80.	92.1
21.	117.6	51.	106.8	81.	92.1
22.	117.6	52.	106.8	82.	92.1
23.	117.1	53.	105.2	83.	92.1
24.	116.6	54.	105.2	84.	91.2
25.	116.6	55.	103.9	85.	90.3
26.	116.5	56.	103.6	86.	90.3
27.	116.5	57.	102.8	87.	88.5
28.	115.9	58.	102.8	88.	87.6
29.	115.8	59.	102.8	89.	87.2
30.	114.4	60.	102.8	90.	87.2