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Strength comparisons in untrained men and trained women athletes

JAMES R. MORROW, JR. and W.W. HOSLER

Dept. of H.P.E.,
Univ. of Houston,
Houston, TX 77004 and
Human Factors Engineering
Bell Technical Operations,
Sierra Vista, AZ 85635

ABSTRACT

MORROW, JAMES R., JR. and W.W. HOSLER. Strength comparisons in untrained men and trained women athletes. *Med. Sci. Sports Exercise*, Vol. 13, No. 3, pp. 194-198, 1981. The purpose was to compare untrained college men with trained collegiate women basketball and volleyball players in terms of absolute and relative upper and lower body strength. Absolute and relative strength comparisons were also made between the two groups of women athletes. Eighty subjects were included in each group. Relative strength was expressed per unit of weight, height, biacromium, and biiliac widths. It was hypothesized that while men are significantly stronger than trained women athletes, such differences may be removed once body size characteristics are controlled. MANOVA and MANCOVA were utilized to test hypotheses. Results indicate that untrained men have greater upper and lower body strength than trained women athletes in terms of both absolute and relative strength. Women basketball players have greater absolute and relative lower body strength than women volleyball players. The two groups of women athletes are alike in terms of upper body absolute and relative strength.

ISOKINETICS, SEX COMPARISON, STRENGTH, WOMEN ATHLETES

Men and women have been compared on a variety of physiological parameters (23). Various comparative techniques have been utilized by researchers reporting strength characteristics of men and women (2,5,8,11,16,17,19,-20,22,25,26). In some cases, comparisons have been made in terms of absolute strength only. Results indicate that while absolute strength differences exist between the sexes, there is a great deal of variability in the amount of difference. Results depend upon the study reported and the strength measurements obtained. In other studies, various means have been utilized to express strength in relative terms. The methods utilized to express strength in relative terms have included the development of strength-to-weight ratios (strength/weight), strength-to-lean body weight ratios (strength/lbw), expressing weight changes in terms of percent change, expressing weight per unit of muscle cross-sectional area, and covariance techniques. Perhaps the most widely utilized technique is to express strength in one of the ratio forms.

Strength differences would appear to have an effect upon successful performance in activities such as basketball and volleyball. Morrow, Jackson, Hosler, and Kachurik (21) have reported that strength is one of the dimensions that differentiates successful and less successful women's intercollegiate volleyball teams. It has been suggested that trained women athletes may be as strong as untrained men; it has also been suggested that strength differences in men and women are primarily attributable to differences in body size characteristics. Thus, it was the purpose of this paper to compare trained intercollegiate women basketball players and volleyball players with untrained college-age men in terms of absolute and relative strength for the upper and lower body. Second, absolute and relative strength comparisons were made between the two groups of women athletes.

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METHODS

Subjects for the study included trained intercollegiate women athletes (basketball and volleyball players) and untrained college-age men. The women subjects from the volleyball and basketball teams were selected from more than two dozen universities and colleges throughout the Southwest. Data were gathered during regional tournaments for the respective sports and informed consent was obtained from each participant as well as from each coach. Eighty basketball players and 80 volleyball players were randomly selected from larger samples of subjects. Eighty men were randomly selected from a larger sample of subjects. All men were enrolled in required or elective physical education classes; none of the men were physical education majors and none of them were on an intercollegiate athletic team of any type. Informed consent was obtained from each man.

All data were collected by trained individuals. The same persons collected data on all subjects. The following measurements were obtained on each subject: height, weight, biacromium width, biiliac width, isokinetic bench (BP), and leg press (LP) scores. Anthropometric measurements were taken according to the procedures outlined by Behnke and Wilmore (1).

Isokinetic bench and leg press scores were obtained using bench and leg press apparatus Models 7153 and

7154, respectively (Lumex Inc., Bayshore, N.Y.). Each subject was given three submaximal practice trials on each instrument at 20°/s and then instructed to perform four maximal exertions; all were permitted to rest after each trial. The average of the four trials was used as the criterion score for each subject. Strip chart readings were obtained for each subject and the output is interpreted as the maximal force exerted in the range of movement.

Investigators (3,4,18,22,24) have reported on the intercorrelations between strength and various anthropometric characteristics for both men and women. Lamphiear and Montoye (16) investigated muscular strength and body size, and found that most of the explained variation in strength variables could be accounted for by five body-size variables: height, weight, biacromial diameter, arm girth, and triceps skinfold thickness.

Based upon the reported intercorrelations between various anthropometric and strength characteristics, it was decided to express relative strength for this study in terms of the subject's weight, height, biacromium and biiliac widths. Thus, these four anthropometric characteristics were utilized as covariates when developing a relative strength score for each subject.

Initially, trained women athletes were compared with untrained men in terms of absolute and then relative strength. The basketball and volleyball women were then compared in terms of absolute and relative strength. Relative strength measures were expressed by extracting the covariation in strength that was related to the four anthropometric characteristics. The controlled variables were weight, height, biacromium and biiliac widths. Thus, relative strength is defined as a residualized variable resulting from control of mean group differences in body size characteristics. The methodology utilized is an extension of that suggested by Dubois (6), Katch (12,13), and Katch and Katch (14) and similar to that used by Hoffman, Stauffer, and Jackson (11). Analysis consisted of two multivariate analysis of variance Helmert (7) contrasts (C1: men contrasted with women; C2: basketball contrasted with volleyball) to investigate differences in absolute strength. Multivariate analysis of covariance was utilized with similar Helmert contrasts in order to determine the differences between contrasted groups in terms of relative strength. Post hoc univariate analyses and discriminant analysis were utilized to further investigate absolute and relative strength differences once a significant multivariate result was obtained.

RESULTS

Anthropometric means and standard deviations for the groups are presented in Table 1. Results of C1 (men vs women) indicated that the untrained men differed significantly from the trained women athletes in terms of absolute strength ($F[2,236] = 209.81$; $p<0.01$). Univariate F results were: LP ($F[1,237] = 158.61$; $p<0.01$) and BP ($F[1,237] = 407.00$; $p<0.01$). Men and women differed significantly on both of the absolute strength measures. The discriminant analysis results indicate the ability of the dependent variable to contribute to group differences when the other dependent variable is controlled. Only the bench press had a significant ($p<0.01$) discriminant coefficient indicating that the bench press significantly differentiates between the groups when leg press is controlled. However, when differences between upper body strength (bench press) are controlled, lower body strength does not contribute significantly toward group differentiation. Relative strength differences were then determined based upon multivariate analysis of covariance. Results indicate when body composition characteristics are controlled, untrained men and trained women differ in terms of relative strength ($F[2,23] = 93.91$; $p<0.01$). Univariate and discriminant analysis results are similar to those in absolute strength. Differences exist in both upper and lower body relative strength ($p<0.01$). However, when correction is made for upper body relative strength differences, the groups are similar in lower body relative strength. Adjusted kg means for the strength tests were: men LP = 219.38, BP = 79.28; basketball women LP = 181.84, BP = 45.03; and volleyball women LP = 147.03, BP = 43.13, with the four body-size characteristics controlled. The relative strength values for the groups are in the same order as those of absolute strength. However, the magnitude of the differences is not as large as those found in absolute strength. In terms of absolute isokinetic strength, the women's values are 71% and 50% of those for the men on leg press and bench press, respectively. When strength is expressed in relative terms, these values increase to 75% and 56%, respectively.

The second contrast (C2) compared the basketball women and the volleyball women in terms of absolute

TABLE 1. Anthropometric and strength variables for young men and women athletes.

	Men	Basketball Women	Volleyball Women
N	80	80	80
Age	20.71[a] 2.22	19.61 1.27	19.35 1.48
Weight (kg)	74.50 12.09	65.58 8.13	63.94 6.93
Height (cm)	176.69 7.12	171.69 7.31	169.82 6.04
Biacromium (cm)	40.81 2.05	37.77 1.77	37.77 1.56
Biiliac (cm)	28.44 1.88	29.13 1.80	27.93 1.42
Leg Press (kg)	226.73 48.90	177.74 36.30	143.78 26.10
Bench Press (kg)	83.54 20.91	43.17 11.70	40.73 10.29

[a] First entry is mean; second is standard deviation

strength. Results indicate that the women differed in terms of absolute strength ($F[2,236] = 17.19$; $p<0.01$). Univariate results indicate that the women differed primarily in terms of lower body strength, with basketball players being stronger (LP: $F[1,237] = 31.52$; $p<0.01$, and BP: $F[1,237] = 1.05$; $p>0.05$). Discriminant analysis results indicate that the women differed primarily in terms of lower body strength.

MANCOVA was again utilized to compare the women in terms of relative strength. The multivariate test was significant ($F[2,231] = 17.94$; $p<0.01$), indicating that the contrasted groups differed in terms of relative strength (i.e., strength per unit of weight, height, biacromium, and biiliac). Univariate results indicate that differences were primarily in lower body strength. Discriminant analysis results again indicated that when either of the dependent variables was controlled, LP was best able to contribute significantly toward group differentiation.

DISCUSSION

Several authors (6,12,13,14) have reported on the problems that arise with the ratio method of "controlling" for body size characteristics. In general, the problem is that the relative strength (ratio) is perceived to be statistically independent of the subject's weight (or lean weight, depending upon the ratio developed). Such a ratio is, in fact, not independent of the "controlled" variable. As a consequence of such studies, it has been suggested that well-trained women athletes may be as strong as untrained men in terms of absolute strength (9,10). It was assumed that the women would necessarily then be as strong or stronger in terms of relative strength. Wilmore (25) reported that women were relatively stronger than men in terms of lower body strength when a strength-to-lean body weight ratio was developed. The women were considerably weaker in terms of relative and absolute upper body strength. Montoye and Lamphiear (19) also reported results based upon this ratio method of adjustment.

The utilization of covariance techniques (6,12,13,14,-15,27) permits one to calculate a residualized variable which is statistically independent of the covariate(s). That is, if one wished to control for weight differences in strength, the subject's weight would be controlled by extracting the covariation in strength that was due to weight. The result would be a strength score for the subject which is statistically independent of the subject's weight. Thus, a better estimate of the subject's "relative strength" is developed. The measure would be interpreted as strength per unit of weight. Such a procedure can be expanded to include more than one covariate. Thus, group differences on the covariates are controlled.

Hoffman, Stauffer, and Jackson (11) have utilized the covariance technique to investigate upper and lower body strength differences in college-age men and women. Their results indicate that relative differences exist between college-age men and women in upper body strength but not in lower body strength. The subjects in their study had "relative strength" expressed per unit of height and lean body weight.

It has been suggested that untrained men would not be as strong as "sport"-trained women athletes. The results of this study do not support this contention. Results indicate that men and women differ in terms of upper and lower body absolute strength. That the present results differ from those reported by others (18,25) may lie in the fact that strength measures for this study were isokinetic, whereas cited research has consisted of isotonic and isometric data. The present results in absolute strength appear to be of the most importance when considering the inclusion of men and women on the same athletic team. Regardless of one's relative strength, any time that force is important in an athletic event, that person with greatest mass will ultimately provide the greatest force for a given acceleration. Thus, men would ultimately have greater potential for force development than would the women. Therefore, it would appear appropriate not to include men and women in the same activity if strength is related to successful performance. This would be particularly true of events where one body contacts another. There are, however, sporting events such as tennis, badminton, and golf wherein skill can offset strength advantages.

The relative strength (controlled for body size characteristics) results indicate that untrained men remain significantly stronger than well-trained women in terms of both upper and lower body strength. Results do indicate that once differences in upper body strength are adjusted for, the contrasted groups do not differ in lower body strength. The general statement, however, is that untrained men remain stronger in upper and lower body relative strength than trained women intercollegiate basketball players and volleyball players.

Results of C2 indicate that women athletes generally differ in absolute strength characteristics. Univariate results indicate that differences are primarily exhibited in lower body strength. Similar results are obtained when utilizing relative strength as defined in this paper. Perhaps the differences that exist in lower body strength for the women are reflective of the differential training modalities utilized by the coaches in such sporting events.

The passage of Title IX legislation has led to the enhancement of interscholastic athletic programs for women in this country. An outgrowth of the legislation is that women are becoming more involved in physical training programs. As a result, it has been suggested that men and women be permitted to participate together on various athletic teams. There have been court cases wherein individuals of one sex have attempted to receive the court's permission to join an athletic team of the opposite sex. Generally, each of these decisions becomes precedent-setting because of the originality of the legislation. Two such cases have involved volleyball and basketball teams at the high school level. The present results, if generalizable to the high school setting, would indicate that it may be inappropriate for members of both sexes to play on the same team. Perhaps it would be better to speak in terms of "separate but equal" athletic programs for men and women, rather than teams comprised of both sexes. The present results are based upon mean group differences. The distributions of absolute strength curves overlap for the men and women. For example, a LP score of 223 kg for women (95th percentile) represents the 45th percentile for the men. Likewise, a BP score of 61 kg for women (95th percentile) represents the 14th percentile for the men. Thus, there are some women who are stronger than some men. This fact should be taken into account when generalizing the present results and when making individual decisions about team membership.

In summary, it appears that untrained men and trained women differ significantly in terms of absolute and relative strength. Both absolute and relative strength differences exist in upper and lower body strength measures. Women basketball players and volleyball players differ significantly in terms of absolute and relative strength. However, differences are primarily found in the lower body.

Further research is needed to identify strength characteristics of various other women athletes. Of particular interest would be comparisons between untrained men and well-trained women from sporting events which are typically depicted as strength oriented. Further investigations should include direct measurement of additional body composition characteristics (e.g., body density, lean weight, and/or fat weight).

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