Selected Physiological, Psychological and Performance Characteristics of National-Caliber United States Women Weightlifters

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ABSTRACT

Stoessel, L., Stone, M.H., Keith, R., Marple, D. and R. Johnson. Selected physiological, psychological and performance characteristics of national caliber United States women weightlifters. J. Appl. Sport Sci. Res. 5(2):87-95.1991.—The purpose of this study was to describe physical, performance, physiological and psychological characteristics of national-level female weightlifters (TWL) and to compare these variables to untrained (UT) controls of similar age and weight. The subjects were 14 national-level weightlifters (age = 27 ± 5; weight = 61.3 ± 11.5 kg) comprising the TWL and 13 UT (age = 26 ± 7; weight = 61.3 ± 9.9 kg) comprising the UT group. Body composition was assessed using skinfolds and girths. Performance was assessed by a vertical jump (VJ) and static vertical jump (SVJ) and conversion of these two measures to power. Hormones were measured by RIA. Blood lipids and glucose were measured by standard procedures (Sigma Kits). A questionnaire was used to assess menstrual cycle differences. Personality differences were assessed using the Personality Attributes Questionnaire (PAQ). The degree of satisfaction with body parts and functions was determined with the body catathexis scale. The TWL were leaner (p ≤ 0.05) than the UT as assessed by sum of skinfolds (TWL = 117.7 ± 24.0; UT = 181.6 ± 31.2). The TWL had a greater (p ≤ 0.0001) VJ (50 ± 8 cm) compared to the UT (32.4 ± 7.3 cm) and a greater (p ≥ 0.05) SVJ than the UT (TWL = 45.8 ± 6.4 cm; UT = 27.2 ± 6.5). Serum concentrations of hormones (testosterone, estradiol, growth hormone, cortisol), lipids (cholesterol, HDL-C and triglycerides), glucose, menstrual cycle phase and body catathexis values were not significantly different between groups. The PAQ indicated that the TWL had more masculine traits than the UT. These data suggest that the TWL are leaner, more powerful and have more masculine personalities than the UT, but are similar to the UT in terms of resting serum hormones, lipid, and glucose concentrations.

INTRODUCTION

In recent years women’s athletics have become increasingly popular. Because of this increased popularity and acceptance, many women are beginning to participate in sports that were once thought to be masculine endeavors. For example, women’s weightlifting is now part of the U.S. Olympic Festival and four World Championships have been held. Furthermore, it appears that women’s weightlifting may become part of the Olympic program as early as 1996 (47).

To date there has been little research concerning any aspect of women’s weightlifting. Attempts to generalize from studies of male weightlifters (10, 17, 34, 35) or studies from endurance activities (28, 29) is difficult at best.

Descriptive studies of the physical characteristics of female bodybuilders (14) and longitudinal studies of the effects of resistance training on physical and performance parameters of untrained women (44, 45) suggest that
women can gain considerable strength and favorably alter body composition. However, the applicability of these studies to weightlifting is limited by marked differences in the types of weight training employed (for example, emphasizing small versus large muscle mass exercises or differences in the number of repetitions per set used), the time span of training, nutritional differences, and most likely, psychological differences (13, 16, 36).

A descriptive study of national-level female weightlifters is needed. This study will promote additional understanding of the possible effects of specific long-term strength training on women.

The purpose of this study was to describe the physical, physiological (hormonal), psychological and performance characteristics (vertical jump and vertical jump power) of national- and world-level U.S. female weightlifters.

METHODS

Subjects

Twenty seven female subjects ages 17 to 41 (14 trained and 13 untrained) volunteered for the study. Trained subjects were recruited from a local women's weightlifting team and from the 1987 Women's Weightlifting World Championship team. Trained subjects met the following criteria: all had been involved in weight training, specifically for competitive weightlifting, for at least 1.3 years before the study; and all were national-caliber weightlifters, i.e., they had met the qualifying standards for participation in the National Weightlifting Championships set by the United States Weightlifting Federation. This standard consists of a qualifying total for each weight class. The total is the best snatch lift combined with the best clean and jerk lift. The qualifying total must be set at a USWF sanctioned meet.

The USWF has set classification standards for each weight class. These standards identify the caliber of the athlete and range from Third Class (lower end of range) to International Elite (highest end of range). The participants in this study fell into the classification standards as follows: one First Class, four Master, four Elite and five International Elite.

Untrained subjects were recruited from the department of Nutrition and Foods at Auburn University. The selection of the control (untrained) subjects was based on the following criteria: age, weight, oral contraceptive use and physical activity. The purpose of screening the control subjects was to match trained and control subjects according to these criteria so that the two groups would differ primarily in level of participation in physical activity. The controls could not have participated in any regular physical training for the previous six months.

Data were collected at two intervals. The first group consisted of four trained subjects and eight control subjects, all of whom were tested at Auburn University in February 1987. The second group consisted of 10 trained subjects and five control subjects; the control subjects of the second group were tested at Auburn University, and the trained subjects were tested at Daytona Beach during a training camp for the 1987 Women's Weightlifting World Championships (these subjects comprised the U.S. team). Both the control subjects and the trained subjects of the second group were tested in September 1987, one week apart.

Physical Characteristics and Anthropometric Measures

Body composition was determined using skinfold measures. Skinfold thicknesses were measured at nine sites (biceps, triceps, pectoral, axilla, subscapular, abdominal, suprailiac, thigh and gastrocnemius) by two experienced testers. All skinfolds were taken on the right side of the body using Lange skinfold calipers. Three measurements were taken at each site; these values were averaged to yield the value for the particular skinfold site.

All skinfold measurements replicated the procedures outlined by Pollock, Wilmore and Fox (27) with the following exceptions: suprailiac measurement was a vertical fold, and abdominal was measured 4 cm from the center of the umbilicus. For additional measures of fatness, skinfold measures at biceps and gastrocnemius

Table 1: Physical Characteristics of the Subjects

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Body Mass (kg)</th>
<th>Estimated ** Body Fat (%)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWL</td>
<td>26.6±4.5</td>
<td>61.3±11.5</td>
<td>20.4±3.9</td>
<td>161.6±8.6</td>
</tr>
<tr>
<td>n=14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UT</td>
<td>25.9±6.7</td>
<td>61.3±9.9</td>
<td>26.9±7.4</td>
<td>164.2±8.5</td>
</tr>
</tbody>
</table>

TWL: Trained Weightlifters
UT: Untrained Controls
Χ±SD
** p<0.01

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were included in the sum of skinfolds. Biceps was measured as a vertical fold on the anterior midline of the upper arm halfway between the acromion process and the center of the elbow joint with the arm extended and relaxed. The gastrocnemius was measured as a vertical fold on the posterior midline of the lower leg halfway between the center of the patella and the talus with the foot flat against the floor and body weight placed on the left leg. Percentage of body fat was estimated using a normogram developed by Baun et al. (1). Sum of triceps, suprailiac, thigh skinfolds and age were used to calculate an estimate of body fat. Percentage of fat in this nomogram is calculated by the formula of Siri (30).

Further description of the subjects' physical characteristics was provided by circumference (girth) measure. All girth measures of the extremities were taken on the right side of the body by experienced testers. Eleven sites were measured; three measures (cm) were taken at each site and an average of the three was used as the value for that particular site. Circumferences were measured at the following sites: neck, shoulder, chest, bust, abdomen, waist, gluteal, arm, forearm, thigh and calf. All circumference measures duplicated the procedures outlined by Pollock et al. (27) with the following exceptions: chest-high corresponded with chest girth; chest-middle corresponded with bust girth; and additional neck girth was taken in the horizontal plane at the maximum circumference of the neck.

Vertical Jump and Static Vertical Jump

The vertical jump was performed according to the standards described by Stone and O'Bryant (36). In the static vertical jump, subjects were instructed to lower their hips until the upper thighs were parallel with the floor. Subjects held this position for a three-second count by the tester. On a signal from the tester the subject jumped straight up as high as possible and touched an adjacent marked wall at the apex of the jump. Subjects were verbally encouraged to jump as high as possible in each trial of both jumps. Subjects performed a total of three jumps each for the vertical and static vertical jump; the highest jump of the three was recorded.

Questionnaires

Subjects were required to complete three questionnaires. Two were psychological questionnaires and one was designed to inquire about variables that may affect hormone concentrations, i.e., oral contraceptive use, smoking, previous physical activity, phase of menstrual cycle, ergogenic aids and typical training regimen. Questions concerning the menstrual cycle included the following areas: date of the first day of last menstruation, menstrual frequency, menstrual flow and duration and age at first menstruation. The third questionnaire also asked about the best individual lifts and total, as this information would be used as indicators of success in weightlifting for correlations with other data.

Psychological Questionnaires

The Personality Attributes Questionnaire (PAQ) determined each respondent to be either androgynous, sex-typed or undifferentiated (31). The directions asked the respondent to indicate the extent to which each item was typical of herself.

The Body Cathexis Scale evaluated the degree of satisfaction or dissatisfaction a respondent felt about various body parts and functions (37). By means of a five-point scale, respondents were asked to describe themselves as they saw themselves. Respondents were asked to circle the letter that best represented their feelings concerning the body parts and functions listed according to the scale provided.

Blood Collection

All blood samples were drawn with the subject in a postabsorptive state (after a 12-hour fast) between 7 a.m. and 8:30 a.m. Blood was drawn by experienced personnel. Venous blood samples were taken from a single venipuncture in an antecubital vein. Approximately 20 ml of blood were collected per subject. From each blood sample, two microhematocrit tubes were filled for hematocrit analysis directly from the syringe after removing the needle. The remaining blood was transferred

<table>
<thead>
<tr>
<th>Table 2: Skinfolds and Girths of the Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Sum of Skinfolds (mm) ***</td>
</tr>
<tr>
<td>TWL</td>
</tr>
<tr>
<td>N=14</td>
</tr>
<tr>
<td>UT</td>
</tr>
<tr>
<td>N=13</td>
</tr>
</tbody>
</table>

TWL: Trained Weightlifters
UT: Untrained Controls
Table 3: Resting Hormone Concentrations for the Subjects

<table>
<thead>
<tr>
<th></th>
<th>CORT (nmol/L^-1)</th>
<th>T (nmol/L^-1)</th>
<th>E2 (pmol/L^-1)</th>
<th>hGH (μg/L^-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWL n=13</td>
<td>670.437 ± 314.53</td>
<td>1.3868 ± 1.7335</td>
<td>433.178 ± 422.165</td>
<td>1.7 ± 1.9</td>
</tr>
<tr>
<td>UT n=13</td>
<td>612.498 ± 231.76</td>
<td>1.7335 ± 1.3868</td>
<td>403.81 ± 315.706</td>
<td>1.2 ± 1.1</td>
</tr>
</tbody>
</table>

CORT: Cortisol  hGH: Human Growth Hormone
T: Testosterone  E2: Estradiol
TWL: Trained Weightlifters  UT: Untrained Controls

into two centrifuge tubes. 10 ml of the blood were added to a centrifuge tube containing heparin. The remaining ten ml of blood were centrifuged without heparin for lipid analysis. Each of the tubes was covered with Parafilm and then mixed by gentle inversion. The tubes were centrifuged in a cooled HN-centrifuge (International Equipment Co., Needham Heights, Massachusetts) for 20 minutes at 3500 x g. The plasma was allocated into four separate storage tubes and sealed with caps. Samples from Daytona Beach were placed in ice for transport (one day) to Auburn University. Samples were frozen and kept at -70° C until analysis.

Hematocrit

Hematocrit values were determined immediately after each blood collection. Capillary tubes were filled to three-fourths total capacity and sealed with Crito seal. Capillary tubes were spun in an IEC.MB microhematocrit centrifuge and hematocrit determined using a micro-hematocrit reader.

Hormone Assay

Within-assay and between-assay coefficients of variance were 4 percent and 6 percent, respectively, for each RIA.

Plasma testosterone (nmol/L^-1) concentrations were determined using a Coat-A-Count No Extraction Testosterone Radioimmunoassay (RIA) Kit (Diagnostic Products Corp., Los Angeles, California). Assay procedure was followed as outlined by the kit manual. Samples for the testosterone assay and all other RIAs were counted for one minute per tube in a Micromedic 4/600 automatic gamma counter (Micromedic Systems Inc., Hor sham, Pennsylvania). Conversion of counts of radioactivity per minute to concentrations was performed by using the logit-log transformation described by the manufacturer’s instructions for all RIAs except growth hormone. Samples for all RIAs were assayed in duplicate in a single assay. For the testosterone assay, the percentage of label bound when no standard was present was 32 percent.

Growth hormone (μg/L^-1) was assayed using the Diagnostic Products Corporation RIA Kit. Assay procedure was followed as outlined by the kit manual. Conversion of counts of radioactivity per minute to ng/ml was calculated following kit instructions and plotting on log-log graph paper. The percentage of label bound when no standard was present was 30 percent.

Plasma cortisol (nmol/L^-1) was determined using solid phase Coat-A-Count 125 I RIA kit. RIA procedure was followed per manufacturer’s instructions. The percentage of label bound when no standard was present was 70 percent.

Plasma estradiol (pmol/L^-1) was determined using a no extraction, solid-phase Coat-A-Count 125 I RIA kit. RIA procedure was followed per manufacturers instructions. The percentage of label bound when no standard was present was 43 percent.

Blood Lipids and Glucose

Total and HDL-cholesterol concentrations were determined using the procedures outlined by Sigma Diagnostics (St. Louis, Missouri). Triglycerides were measured using a colorimetric method in a kit from Sigma Diagnostics. LDL-cholesterol was determined from the formula:

LDL-C = TC - HDL - triglycerides/5 (15).

Blood glucose (BG) was measured using an enzymatic method in a kit from Sigma Diagnostics. The Sigma procedure was followed and determination of glucose concentrations were made at 450 nm.

Statistical Analysis

A General Linear Models (SAS) procedure was used to compare all data for statistical analysis. The statical main
effects were treatment (trained and untrained) and experimental effects, which were Time 1 and Time 2. If means were determined to be significantly different, then paired T-tests were used to determine which means differed. The level of significance was \( p \leq 0.05 \).

**RESULTS**

Other than performance and total skinfold measures, no statistical differences were found between groups (TWL versus UT) at T1 or T2. However, the combined means for T1 showed testosterone and estradiol to be significantly higher \( (p \leq 0.02) \) compared to the group measured at T2. These differences may in part be explained by seasonal variations in hormone concentrations \( (43) \). No other differences between T1 and T2 were found. Combined means for trained versus untrained subjects were compared.

**Physical Characteristics**

There were no significant differences in age, body mass (weight) or height between the trained weightlifters (TWL) and the untrained controls (UT) \( (Table 1) \). No differences were found in any aspect of the menstrual cycle between the groups. The sum of skinfolds was significantly smaller in the TWL compared to the UT \( (p \leq 0.001; Table 2) \). Among the girths, only the shoulder and neck measures were significantly larger in the TWL compared to the UT \( (p \leq 0.05) \). No significant differences were found in the sum of 11 girths \( (Table 2) \). The TWL exhibited significantly less estimated body fat than the UT \( (p \leq 0.01; Table 1) \).

**Blood Analyses**

There were no differences between groups in plasma concentrations of testosterone, cortisol, estradiol or human growth hormone \( (Table 3) \). Furthermore, no differences were found between groups in the ratios of testosterone: cortisol, testosterone: estradiol nor were there differences between groups in concentrations of hemoglobin, hematocrit, triglycerides, cholesterol, HDL-cholesterol, LDL-cholesterol or cholesterol: HDL cholesterol ratio \( (Table 4) \).

**Performance Variables**

The TWL displayed markedly superior performances compared to the UT. There was a significant difference between groups on vertical jump and static vertical jump power \( (p \leq 0.001) \). There also was a significant difference \( (p \leq 0.05) \) between groups on static vertical jump \( (Table 5) \).

**Psychological Variables**

There was a significant difference between groups on PAQ scores \( (p \leq 0.05) \). The TWL were categorized as mostly masculine or androgynous and the UT group was categorized as mostly feminine or undifferentiated. There was no significant difference between groups on body cathexis scores \( (Table 6) \).

**DISCUSSION**

This study provides data for the first description of physical, performance, psychological and physiological characteristics of national-level U.S. female weightlifters. Examination of this data can lead to important insights as to how weight training can affect performance and health aspects of women.

**Physical Characteristics**

The weightlifters exhibited considerably less subcutaneous body fat than the controls as shown by the

### Table 4: Resting Hct, Hb, and Serum Lipids of the Subjects

<table>
<thead>
<tr>
<th></th>
<th>Hct</th>
<th>Hb (g/dl)</th>
<th>TC (mg%)</th>
<th>HDL-C (mg%)</th>
<th>LDL-C (mg%)</th>
<th>TC/HDL-C</th>
<th>TG (mg%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWL</td>
<td>43±2</td>
<td>14.8±2.3</td>
<td>165±23</td>
<td>62±16</td>
<td>94±25</td>
<td>2.6±0.4</td>
<td>70±25</td>
</tr>
<tr>
<td>n=13</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>UT</td>
<td>41±4</td>
<td>13.4±2.1</td>
<td>170±37</td>
<td>71±14</td>
<td>89±32</td>
<td>2.4±0.4</td>
<td>78±18</td>
</tr>
<tr>
<td>n=13</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Hct: Hematocrit  
Hb: Hemoglobin  
TC: Total Cholesterol  
HDL-C: High Density Lipoprotein Cholesterol  
LDL-C: Low Density Lipoprotein Cholesterol  
TG: Triglycerides  
\( \bar{X} \pm SD \)  
TWL: Trained Weightlifters  
UT: Untrained Control
estimate of body fat (Table 1) and the sum of skinfolds (Table 2). This suggests that weight training can induce reductions in body fat as well as increases in LBM in women. This is in general agreement with descriptive (14) and longitudinal (4, 24, 44) studies concerning the effects of weight training on the body composition of young women.

The degree to which women can produce muscular hypertrophy in response to training is unclear (25). Based on increases in muscle size, the degree of absolute hypertrophy in response to weight training appears to be smaller than that of men but the relative amount (percent of initial) is similar to that of men (6). It was interesting to note that 10 of 11 girths were larger in the weightlifters (with the exception of the waist) than the controls. The differences in girths, the marked differences in skinfolds and the relative differences in estimated body fat suggest that the weightlifters' training has produced marked muscular hypertrophy. Genetic differences may also be responsible for all or part of the body composition differences.

At the same body mass, elite male weightlifters are generally shorter and considerably leaner than untrained subjects, are frequently shorter than many other strength/power athletes such as throwers (10, 38) and are usually shorter than less talented weightlifters (21, 38, 39). The female weightlifters as a group were somewhat shorter than the controls although not significantly. Observations by the authors and other sports scientists involved with weightlifting (Steve Fleck, USOC, personal communication) suggests that weightlifters are usually shorter than untrained men and women at the same body mass. Furthermore, female weightlifters are typically shorter than other national-level female strength/power athletes, such as sprinters and throwers, at the same or similar body mass (38). To an extent, the shorter height at an equal body mass and stocky stature of weightlifters provides a leverage advantage during lifting events (36, 39, 40). Women's weightlifting is a relatively new sport; it is possible that in the future the female weightlifters' physique and stature may resemble that of male weightlifters (i.e. short, stocky stature) to an even greater extent, as this type of physique may provide a performance advantage.

In general the physical characteristics of female weightlifters were similar to those of their male counterparts. Both the men and women tended to be stocky and have relatively low percent fats, total fat and high lean body masses (Table 1).

**Performance**

It was obvious that the female weightlifters were considerably stronger than the controls. The weightlifters' VJ and SVJ were both more than 50 percent higher than the control values. VJP and SVJP were both approximately 25 percent higher than the control values. The performance of the women weightlifters for the vertical jump was similar to that found for other female strength/power athletes (12, 38). The extent to which the weight training employed by the weightlifters was responsible for the differences in the vertical jumps and power outputs is not known. Recent evidence suggests that anaerobic performance of less than 90 seconds is less subject to inherited characteristics than longer term anaerobic exercise (2). Stone, Byrd, Tew and Wood (33) have shown longitudinal increases in vertical jump among men using training similar to that employed by
weightlifters in this study. Thus it is likely that weight training made significant contributions to the observed differences between groups (Table 5).

**Physiological Characteristics**

No significant differences were found among any of the physiological parameters measured (Tables 3 and 4). Values for blood lipids were normal for women of this age group and suggest low risk for cardiovascular and other degenerative diseases.

Cumming et al. (5) have suggested that a mild hyperandrogenism will be produced in chronically weight-trained women. This study provides no evidence of this condition because all resting values for hormones among the weightlifters were similar to the control group. This agrees with observations of no change in resting hormone concentrations of previously untrained women as a result of short-term resistance training compared to untrained control subjects (43).

It is reasonable to believe that the endocrine system is affected by weight training. However, resting concentrations for hormones appear to be within normal values for these women. It is possible that the endocrine response to training that affects performance, physiology and stature, such as strength, muscle hypertrophy or loss of fat, may be more a function of chronic exposure to exercise rather than measurable changes in resting hormone concentrations (25). A few studies investigating hormone responses have been performed using single bouts of weight-training exercise in untrained and minimally trained women (11, 19, 42). These studies generally provide evidence that absolute changes in androgen concentration in women are less responsive to resistive exercise compared to men, although relative changes in concentration may be similar (42). While short-term training has little effect on androgen concentrations among previously untrained men and women (19), very long-term training or changes in training volume and intensity may effect changes in the testosterone:cortisol ratio (17, 25). However, no studies, short or long term, have been published that used well-trained female strength athletes (25).

Differences in phase of menstrual cycle affect differences in hormone concentrations. Because of the nature of the experiment in dealing with elite female athletes, it was not possible to collect blood when all of the women were in the same menstrual phase. Thus it is important that no group differences in menstrual phase were noted when making hormonal comparisons. No significant differences were found in any parameter associated with the menstrual cycle between the weightlifters and the controls. Furthermore, the lifters did not report any menstrual irregularities such as oligomenorrhea or amenorrhea. This is in contrast to typical findings among female endurance athletes (7) and among women undergoing long-term or severe caloric restriction such as female gymnasts and body builders (9, 18). Exercise-induced amenorrhea has been postulated to be related to nutritional deficiencies, decreased body fat, emotional and physical stress associated with training and competition, increases in beta-endorphin and decreases in estradiol concentrations (8, 23, 41). Although the female weightlifters in this study were exposed to training and competition and did have lower percent fats than untrained subjects, these factors have not resulted in menstrual cycle disturbances. Factors that may reduce the likelihood of developing training-induced amenorrhea among the weightlifters include maintaining normal or higher body masses, normal estradiol concentration and, perhaps, maintaining adequate nutrition (26).

Athletic amenorrhea and decreased estradiol concentrations have been related to degenerative bone changes (18, 22). Based on menstrual cycle histories and serum estradiol concentrations, these female weightlifters do not appear to be at risk for this type of pathological changes in connective tissue. Additionally, it has been suggested that weight training may generally increase

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**Table 6: Psychological Characteristics of the Subjects**

<table>
<thead>
<tr>
<th>Body Cathexis Scale</th>
<th>Personality Attributes (PAQ) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWL n = 14</td>
<td>156 ± 18 0.9 ± 0.8</td>
</tr>
<tr>
<td>UT n = 13</td>
<td>146 ± 15 1.8 ± 1.1</td>
</tr>
</tbody>
</table>

\( \bar{X} \pm SD \)

TWL: Trained Weightlifters
UT: Untrained Controls

* p ≤ 0.05
connective tissue size and strength thus, providing a decreased risk for the development of connective tissue degeneration (32).

**Psychological Factors**

No differences were found between groups concerning body satisfaction (Body Cathexis Questionnaire). This is somewhat surprising considering the striking differences in the physical characteristics, performance and general appearance of the two groups. However, both groups and all individuals were within normal values for this test, suggesting normal adjustment. This may be of particular importance for women participating in weightlifting, which has been traditionally viewed as a male sport.

As a group, the weightlifters were more masculine or androgyous compared to the controls. This contrasts with Ho and Walker (20) who found no differences between various female athletes and non-athletes on measure of femininity. From a practical standpoint, greater masculine characteristics may be of some benefit in weightlifting in which the ability to become aroused, training drive and general aggressiveness are valued assets in high-level performance (3, 46).

**SUMMARY AND RECOMMENDATIONS**

This study suggests that female weightlifters were leaner and possessed more LBM than untrained women of similar body mass and age. These women were stronger and more powerful than untrained women. Resting concentration of hormones associated with reproduction and protein metabolism were normal. As a group, female weightlifters displayed more psychological characteristics associated with masculine traits.

Future studies should focus on hormonal responses to repeated weight-training bouts. These studies should be carried out over a long term (six months to one year) and, if possible, use a group of female athletes training in a similar manner.

**PRACTICAL APPLICATION**

While descriptive and cross-sectional in nature, these data suggest that women can develop muscle hypertrophy and considerable increases in vertical jump parameters (as well as strength) as a result of training for weightlifting competition. This would suggest that the type of training used by these women may be useful in developing strength, power and jumping ability for other sports.

Additionally, this study provides suggestive evidence that weight training even at high levels does not induce alterations in physiology that would place women at risk for degenerative diseases.

**REFERENCES**


