PERFORMANCE CHARACTERISTICS OF A DIVISION IA
NATIONALLY RANKED INTERCOLLEGIATE CHEERLEADING
SQUAD

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Part I

Performance Characteristics of a Division IA Nationally Ranked Intercollegiate Cheerleading Squad

Introduction

Collegiate cheerleading has evolved from leading cheers on the sidelines to being a competitive sport (Gottlieb 1994, Hage 1981, Hutchinson 1997, Lockey 1991). The advent of national cheerleading competitions for both high school and collegiate teams has increased the physical demands of cheerleading (Gottlieb 1994, Hage 1981, Lockey 1991, Thomas et al. 2004). Competitive collegiate cheerleading (CCC) squads perform complex and demanding dance, stunt, and gymnastic routines that consist of carefully choreographed: pyramids, partner stunts, tumbling, throws, catches, lifts, twists, jumps, and dance steps (Bucaro 1995, DeBenedette 1987, Hage 1981, Hutchinson 1997, Thomas et al. 2004). In order to perform their routines properly and safely, the athletes are required to possess a combination of: strength, power, muscular endurance, balance, agility, and flexibility.

Several authors have raised concerns regarding the lack of scientific data related to the training and physical conditioning of cheerleaders (DeBenedette 1987, Gottlieb 1994, Hage 1981, Hutchinson 1997, Lockey 1991, Thomas et al. 2004), as well as the paucity of data on cheerleading injuries (DeBenedette 1987, Hage 1981, Hutchinson 1997). Although lower injury rates have been reported for cheerleading than other sports, the injuries tend to be more severe (Axe et al. 1991, Hutchinson 1997). Improper conditioning has been cited as a possible contributor to the problem (Hutchinson 1997).
Recently, Thomas et al. (2004) investigated the fitness status of a CCC squad by measuring various physical fitness components such as: muscular strength and endurance, flexibility, body composition, and aerobic fitness. The cheerleaders in this study were found to have a high level of physical fitness and displayed similar body composition, muscular strength and muscular endurance when compared to other collegiate athletes. However, general fitness tests may not provide sufficient information for coaches and athletes in regards to sport specific physical requirements necessary for safe and successful competitive cheerleading. This was the only study found that reported performance characteristics of a CCC squad.

Consequently, a need exists to obtain sport specific data on CCC athletes and to collect gender specific strength data due to the different gender role requirements of the sport. For example, a male cheerleader must be able to toss or throw a female cheerleader above eye level and be able to press them over-head; this type of stunt is performed many times in succession during a performance. The movement is facilitated by the female cheerleaders utilizing an explosive jump and a technique known as "flicking, which involves pushing off the male cheerleader’s wrists similar to performing dips on parallel bars.

Thus, the demands of competitive cheerleading require that an athlete be physically fit, and requires sport specific movements that have yet to be addressed in the scientific literature. These specific demands of cheerleading dictate that cheerleaders develop requisite amounts of strength to perform the required stunts optimally and safely. Therefore, the purpose of the present study was to examine and describe selected performance and anthropometric characteristics of a Division IA Nationally ranked
cheerleading squad. This CCC had placed in the top ten teams in the nation three out of the last five years (third, fifth, and eight) at the Universal Cheerleading Association (UCA) Nationals. They won the western division seven out of the last nine years, placing second in 1997 and 2003.

Methods

Subjects

Subjects were recruited from a CCC squad with a history of being nationally ranked at cheerleading competitions. Fourteen Division IA college cheerleaders volunteered for the study, eight females (age = 20.9 ± 1.4, ht = 150.2 ± 4.0 cm, wt = 47.0 ± 3.4 kg, BMI = 20.9 ± 1.3) and 6 males (age = 21.7 ± 2.9, ht = 174.7 ± 5.2 cm, wt = 89.0 ± 21.9 kg, BMI = 29.0 ± 5.7). The squad’s workout schedule included: practice three days a week for three hours; weight training using both free weights and machines, and plyometrics sessions on non-practice days. This was in addition to cheering at varsity athletic events and being active members of the community. The University Institutional Review Board for the Study of Human Subjects approved the study and written informed consent was obtained from each subject prior to testing.

Protocol

Data were collected near the end of the school year immediately after completion of the basketball season. Two batteries of tests were developed to investigate sport and gender specific performance characteristics required for success in CCC competitions. One battery of tests investigated body composition, anthropometry, and flexibility. A second battery consisted of tests of muscular strength, muscular endurance, and power.
The tests chosen for the present study were selected after an evaluation of the specific demands of the sport by the authors of the present study, and so that direct comparisons could be made with data from a cheerleading study by Thomas et al. (2004).

**Anthropometry and Body Composition.**

*Anthropometry.* Height was measured to the nearest tenth of a centimeter using a stedometer (Seca, Country Technology Inc, Gays Mills, WI, Model # 67032), and weight was measured to the nearest tenth of a pound using a beam balance scale and later converted to kilograms (Cardinal Detecto Certifier Scale, model # 442, Webb City, MO). Humeral and femoral breadths were measured with a Holtain (UK) caliper. Humeral breadth was determined by having the subject flex their right shoulder and elbow to ninety degrees. The distance between the humeral epicondyles was measured to the nearest tenth of a centimeter. The breadth of the femur was measured by having the subjects rest their right foot on a chair with the knee flexed to ninety degrees. The distance between the femoral epicondyles was then measured to the nearest 0.1 cm.

*Circumferences.* Circumference measures of the upper arm and the calf were taken using a Gullick anthropometric tape measure. Measurements of the upper arm were taken with the subjects’ right arm supinated and flexed at the shoulder to ninety degrees in the frontal plane. Subjects then flexed the biceps brachii, and the widest point was recorded to the nearest 0.1 cm. The circumference of the calf was measured with the subjects in a standing position. The greatest circumference of the calf was recorded to the nearest 0.1 cm. These data were used to calculate somatotypes using the Heath Carter anthropometric somatotype technique (Carter 1980).
Bioelectrical Impedance (BIA). Bioelectrical impedance (BIA) (Quantum II, RJL Systems, Clinton Twp., MI) was used to estimate body composition. Subjects were instructed to lie supine on a treatment table. Four surface electrodes were placed according to manufacture’s specifications on the dorsal surface of the right hand and foot. One electrode was placed at the distal metacarpals and another at the distal prominence of the radius and ulnar. Two more surface electrodes were placed on the dorsal surface of the right foot at the distal metatarsals and between the medial and lateral malleoli at the ankle. Resistance and reactance were recorded for each individual. Results were analyzed using Cyprus 206 Body Composition Analysis software (RJL Systems) to estimate percent body fat based on total body water concentration. Female subjects also had their percent body fat calculated from an equation by Fornetti et al. (1999).

Skinfold Tests. Percent body fat was also estimated using a Lange skinfold caliper and ten skinfold sites measured to the nearest 0.5 millimeter. The ten sites were the subscapular, triceps, chest, biceps, midaxilla, abdominal, suprailiac, supraspinale, thigh and calf. Percent body fat was calculated from seven site equations by Jackson and Pollock (Jackson and Pollock 1985). The other sites were used to calculate somatotypes.

Flexibility

Sit-and-Reach. Subjects were allowed to walk or jog on a treadmill and stretch for a period of five to ten minutes prior to flexibility measurements. A standardized sit-and-reach test (ACSM 2000) was then performed using an Acuflex I sit-and-reach box (Novel Products Inc., Rockton IL). Subjects were asked to remove their shoes and place
both feet on the Acuflex box. Keeping their knees straight, they slid the maximum reach indicator as far as they could reach. The maximum distance attained was recorded to the nearest 0.1 cm.

**Splits.** Subjects were instructed to perform a front-to-rear split test. Starting from a standing position subjects performed a front-to-rear split by extending their legs apart in front and behind lowering the crotch as near to the floor as possible (Johnson and Nelson 1986). Hand placement to the sides was permitted for support and stability of the body. The lowest static point attained without bouncing was determined visually from the floor to the nearest 0.1 cm. Measurements were then taken on the contralateral side using the same method. Subjects then performed a side-splits test, this is similar to the front-to-rear splits test, but the legs extend to the side lowering the crotch as near to the floor as possible (Johnson and Nelson 1986). Hand placement in front of the body was permitted for support. The lowest static point attained was determined as described above.

**Shoulder Flexibility.** Passive flexibility of shoulder flexion and extension was measured using a clear plastic goniometer (Baseline Goniometer, model # 12-1000, Nexgen Ergonomics, Montreal, Quebec). Subjects were placed supine on an examination table with the limb being measured not in contact with the table.
Subjects were instructed to raise their arm overhead until maximum flexion was attained. The axis of the goniometer was placed at the acromial process. The stationary arm was aligned parallel to the mid axillary line, and the moving arm was aligned with the midline of the humerus along the lateral epicondyle (Heyward 2002). Subjects then lowered the arm past the bodyline to achieve maximum extension. Measurements were repeated for the contralateral limb.

Hip Flexibility. Passive flexion and extension of the hip was measured using the same goniometer. Subjects were instructed to lie supine and maximally flex the leg at the hip joint while keeping the gluteals in contact with the table. The axis of the goniometer was placed at the lateral aspect of the hip. The stationary arm was aligned with the midline of pelvis. The moving arm was aligned with the lateral epicondyle of the femur (Heyward 2002). This process was repeated for the contralateral leg. Subjects were then instructed to lie prone on the table and achieve maximum extension of the leg at the hip joint while keeping the anterior superior iliac spine in contact with the table. The process was repeated for the contralateral leg.

Strength and Power

**Vertical Jump.** Vertical jump was used to assess instantaneous power. A Vertec Jump Stand (Sports Imports Inc, Columbus OH) was used to measure maximum vertical displacement. Subjects performed trials until they no longer improved jump height; at which point additional three additional trials were attempted. Subjects performed a one step counter-movement prior to jumping. The highest value for vertical displacement was recorded. Power was calculated by the formula from the *Guidelines for athlete assessment in New Zealand sport* (Bishop and Hume 2000).
Wingate Anaerobic Test. A modified-20-second Wingate Anaerobic Power Test on a Monark 834 E cycle ergometer (Varberg, Sweden) was used to determine peak anaerobic power output. Data were collected and analyzed using SMI extended version 2.01 software (SMI Inc, St Cloud, MN). A five-minute warm-up on a cycle ergometer was administered prior to the test. Subjects were then required to peddle at maximum speed for 20 seconds at a resistance determined by their body weight (males = 0.098 kp/kg, females = 0.085 kp/kg). Upon completion of the test, subjects cooled down by walking on a treadmill at three miles per hour for ten minutes.

Strength Tests: Strength tests were divided into three categories: general strength, sport specific strength, and muscular endurance. The sport specific tests were then subdivided by gender.

General Strength Test. Male and female subjects performed a one repetition maximum (1-RM) bench press as a test of general upper body strength. A 1-RM was defined as the maximum amount of weight moved in a single attempt with proper form. Each of the 1-RM tests consisted of two warm-up sets of eight repetitions and started with a weight the subject estimated to correspond to their 1-RM. If the attempt was successful, the weight was increased and the subject was given two minutes to recover before the next attempt. Testing continued until a weight was not successfully lifted. Three attempts were allowed for this weight with two minutes between attempts (ASCM 2000).

Sport Specific Strength Test. Male subjects performed two sport specific muscular strength tests: Test 1 consisted of a 1-RM hanging power snatch and Test 2 consisted of a 1-RM seated military press. These tests were selected to simulate the toss
and press motions used in cheerleading. Using an Olympic power station, barbell, free weights and the guidelines for 1-RM testing, subjects attempted to snatch the barbell from a hanging position just above the knee to an overhead position with the arms fully extended. The heaviest weight lifted was recorded. Test 2 consisted of the seated military press was tested on an Olympic power station with free weights and a barbell using 1-RM guidelines. The test began with subjects holding the bar in front of them at shoulder height. Subjects were instructed to then press the bar overhead while keeping contact with the bench. The heaviest weight lifted was recorded.

Muscular Endurance Tests. The males and females were tested for muscular endurance. The Males performed three muscular endurance tests. Test 1 consisted of a max HPS test used the same motion as the 1-RM hanging power-snatch. The resistance used was nearly equal the mean mass of the female squad members (45 kg). Subjects attempted to perform as many consecutive repetitions as possible. Test 2 consisted of the male subjects performing as many push-ups as possible according to ACSM guidelines (2000). Test 3 consisted of the male subjects performing as many abdominal crunches as possible as described by ACSM guidelines (2000).

The female subjects performed three muscular endurance tests. Test 1 consisted of the maximum number of parallel bar dips they could perform at 75% their body weight using a Kell Pro Elite assisted dip machine. Subjects were allowed two warm-up trials of five repetitions and then given a two-minute break prior to being instructed to perform as many dips as possible with proper form. The greatest number completed was recorded. Females also performed the push-up and abdominal crunch tests using the same protocol as the males.
Statistical Analysis

Data were analyzed using the SAS software package (version 8e). Descriptive statistics were generated for each variable. A one-way ANOVA was used to compare methods of body composition analysis. The alpha level was set at 0.05.

Results

Anthropometry and Body Composition.

Anthropometry and Body Composition. Body composition and anthropometric results for males and females from the present study are summarized in Table 1. Data from the Thomas et al. (2004) study were included for the purpose of comparison.

Somatotypes. Female subjects had a mean endomorph value of 3.3 ± 0.9, mesomorph rating 4.4 ± 0.5, and ectomorph rating of 1.9 ± 0.8. Male subjects had a mean endomorph rating of 4.1 ± 2.3, mesomorph rating 7.8 ± 1.6, and ectomorph rating of 0.9 ± 0.9.

Bioelectrical Impedance (BIA). The mean percent body fat for female subjects estimated via BIA using Cyprus Software was 28.2 ± 2.5 % while the mean percent body fat for females calculated from the equation of Fornetti et al. (1999) was 25.4 ± 1.4%. The mean percent body fat for male subjects calculated via Cyprus Software was 21.6 ± 5.4 %.
Skinfolds. The mean percent body fat for female and male subjects estimated from the seven-site skinfold test was $17.1 \pm 3.1\%$ and $26.7 \pm 8.4\%$, respectively. Results of the ANOVA revealed significant differences between BIA using the Cyprus software and skinfold values for percent body fat ($p=0.0357$). The Fornetti et al. (1999) equation also resulted in significantly different estimates of body composition when compared to skinfolds ($p=0.0002$).
Table 1. Body Composition and Anthropometric information compared to the data of Thomas et al. (2004) (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Males Present study</th>
<th>Males Thomas et al. 2004</th>
<th>Females Present study</th>
<th>Females Thomas et al. 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.7 ± 2.9</td>
<td>20.1 ± 1.6</td>
<td>20.9 ± 1.4</td>
<td>19.4 ± 1.1</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.7 ± 5.2</td>
<td>177.3 ± 5.7</td>
<td>150.2 ± 4.0</td>
<td>157.4 ± 2.8</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>89.0 ± 21.9</td>
<td>89.7 ± 12.4</td>
<td>47.0 ± 3.4</td>
<td>53.5 ± 4.4</td>
</tr>
<tr>
<td>Humeral breath (cm)</td>
<td>7.5 ± 0.6</td>
<td>NA</td>
<td>5.7 ± 0.2</td>
<td>NA</td>
</tr>
<tr>
<td>Femur breath (cm)</td>
<td>10.7 ± 1.2</td>
<td>NA</td>
<td>8.5 ± 0.3</td>
<td>NA</td>
</tr>
<tr>
<td>Upper Arm Circumference (cm)</td>
<td>39.0 ± 3.4</td>
<td>NA</td>
<td>25.2 ± 1.2</td>
<td>NA</td>
</tr>
<tr>
<td>Calf Circumference (cm)</td>
<td>40.8 ± 3.9</td>
<td>NA</td>
<td>32.6 ± 1.5</td>
<td>NA</td>
</tr>
<tr>
<td>Percent body fat (skinfold)</td>
<td>16.0 ± 9.7* t</td>
<td>16.4 ± 5.2**</td>
<td>17.1 ± 3.1* t</td>
<td>15.5 ± 6.9**</td>
</tr>
<tr>
<td>Percent body fat (Cyprus)</td>
<td>21.6 ± 5.4 t</td>
<td>NA</td>
<td>28.2 ± 2.5 t</td>
<td>NA</td>
</tr>
<tr>
<td>Percent body fat (Fornetti et al.)</td>
<td>NA</td>
<td>NA</td>
<td>25.4 ± 1.4 t</td>
<td>NA</td>
</tr>
<tr>
<td>BMI</td>
<td>29.0 ± 5.7</td>
<td>NA</td>
<td>20.9 ± 1.3</td>
<td>NA</td>
</tr>
<tr>
<td>Sit-and-Reach (cm)</td>
<td>34.7 ± 2.9</td>
<td>35.1 ± 12.7</td>
<td>43.6 ± 4.1</td>
<td>44.9 ± 7.0</td>
</tr>
</tbody>
</table>

Percent body fat calculated via *skinfolds
Percent body fat calculated via ** hydrostatic weighing
* = significantly different between methods (p<0.05)
Flexibility

*Flexibility.* Flexibility data are presented in table 2.

**Table 2.** Flexibility test results (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Split (cm)</td>
<td>19.0 ± 9.9</td>
<td>4.3 ± 6.6</td>
</tr>
<tr>
<td>Left Split (cm)</td>
<td>20.0 ± 7.8</td>
<td>4.9 ± 7.5</td>
</tr>
<tr>
<td>Middle Split (cm)</td>
<td>29.1 ± 10.7</td>
<td>11.4 ± 10.0</td>
</tr>
<tr>
<td>Right shoulder flexion</td>
<td>179.5 ± 14.9°</td>
<td>166.6 ± 14.1°</td>
</tr>
<tr>
<td>Left shoulder flexion</td>
<td>180.3 ± 15.8°</td>
<td>163.5 ± 16.9°</td>
</tr>
<tr>
<td>Right shoulder extension</td>
<td>65.0 ± 4.7°</td>
<td>67.1 ± 5.4°</td>
</tr>
<tr>
<td>Left shoulder extension</td>
<td>64.1 ± 9.6°</td>
<td>69.6 ± 3.5°</td>
</tr>
<tr>
<td>Right hip flexion</td>
<td>89.5 ± 8.7°</td>
<td>106.8 ± 19.6°</td>
</tr>
<tr>
<td>Left hip flexion</td>
<td>90.3 ± 5.7°</td>
<td>110.9 ± 19.8°</td>
</tr>
<tr>
<td>Right hip extension</td>
<td>20.3 ± 4.0°</td>
<td>32.1 ± 20.5°</td>
</tr>
<tr>
<td>Left hip extension</td>
<td>24.7 ± 7.1°</td>
<td>32.0 ± 19.2°</td>
</tr>
</tbody>
</table>

Strength and Power

*Strength.* Strength and power scores for males and females are summarized in Table 3. Included for the purpose of comparison are the mean results from Thomas *et al.* (2004).
Table 3. Strength and power test results (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Males Present study</th>
<th>Males Thomas et al. 2004</th>
<th>Females Present study</th>
<th>Females Thomas et al. 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-RM bench (kg)</td>
<td>106.2 ± 10.2</td>
<td>102.7 ± 19.2</td>
<td>33.7 ± 3.3</td>
<td>37.0 ± 7.7</td>
</tr>
<tr>
<td>1-RM military press (kg)</td>
<td>76.0 ± 8.1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>1-RM hanging power snatch (kg)</td>
<td>68.3 ± 20.3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Maximum hanging power snatches (@ 45 kg)</td>
<td>16.8 ± 9.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Crunches</td>
<td>69.2 ± 14.3</td>
<td>55.8 ± 24.0</td>
<td>69.3 ± 16.3</td>
<td>64.7 ± 18.7</td>
</tr>
<tr>
<td>Push-ups</td>
<td>43.8 ± 16.8</td>
<td>40.3 ± 11.9</td>
<td>25.6 ± 10.0</td>
<td>24.3 ± 7.6</td>
</tr>
<tr>
<td>Dips (@ 75% body weight)</td>
<td>NA</td>
<td>NA</td>
<td>21.5 ± 9.0</td>
<td>NA</td>
</tr>
<tr>
<td>Vertical Jump (cm)</td>
<td>70.5 ± 8.3</td>
<td>NA</td>
<td>45.5 ± 5.2</td>
<td>NA</td>
</tr>
<tr>
<td>Power (W)</td>
<td>1626.7 ± 471.7</td>
<td>NA</td>
<td>686.79 ± 61.6</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Vertical Jump.* The mean vertical jump score for female subjects was 45.5 ± 5.2 cm. Mean power calculated from the vertical jump score was 686.79 ± 61.6 Watts. The mean score of male subjects on the vertical jump test was 70.5 ± 8.3 cm, which calculated to 1626.7 ± 471.7 Watts.

*Wingate Anaerobic Test.* Wingate results are summarized in Table 4. The mean maximum power output was 10.5 ± 1.3 W/kg for the females. Their percent fatigue was 30.2 ± 10.3%. The male subjects mean maximum power output was 14.7 ± 1.6 W/kg. The percent fatigue of male subjects was 17.4 ± 2.2%.
Table 4. Modified Wingate Anaerobic Power Test results (mean ± SD).

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wingate Minimum W/kg</td>
<td>12.1 ± 1.1</td>
<td>7.3 ± 1.2</td>
</tr>
<tr>
<td>Wingate Maximum W/kg</td>
<td>14.7 ± 1.6</td>
<td>10.5 ± 1.3</td>
</tr>
<tr>
<td>Wingate Mean W/kg</td>
<td>13.6 ± 1.5</td>
<td>9.2 ± 1.1</td>
</tr>
<tr>
<td>Wingate percent fatigue</td>
<td>17.4 ± 2.2%</td>
<td>30.2 ± 10.3%</td>
</tr>
</tbody>
</table>

Discussion

The purpose of this study was to examine and describe anthropometric and performance characteristics of the members of a Division IA nationally ranked cheerleading squad; and, where appropriate, compare the results to recently published data by Thomas et al. (2004). The present study also examined sports specific strength and performance variables. Fourteen members of a CCC squad volunteered to participate in the investigation of body composition, flexibility, anaerobic power, muscular strength and endurance.

The female subjects in this study were shorter and lighter than those of the Thomas et al. (2004) study while the male subjects were similar in mass, but were shorter in stature than those of Thomas et al. (2004). The female subjects were also shorter and lighter compared to normative data (Frisancho 1990). The male subjects were heavier, but comparable in stature when compared to normative data (Frisancho 1990). The performance requirements of the sport are reflected in these values, as the male cheerleaders are required to lift and toss the female cheerleaders when performing routines.

The physique of the cheerleaders was determined using the Heath Carter anthropometric procedure. Both female (3.3, 4.4, 1.9) and male (4.1, 7.8, 0.9) (endomorphic, mesomorphic and ectomorphic ratings) subjects displayed predominantly
mesomorphic characteristics. The female somatotypes in the present study were similar
to female Olympic gymnasts (2.7, 4.2, 2.8) (Carter 1984), but rated higher in the
endomorphic and lower in the ectomorphic components. Male somatotypes were similar
to that of Olympic male gymnasts (1.4, 5.9, 2.4) (Carter 1984) but rated higher in the
endomorphic component.

In the present study, body composition was estimated both by skinfolds and BIA
procedures. Body composition is an important attribute for cheerleaders for both
aesthetic and performance reasons. Neither skinfold analysis nor BIA are considered
Gold Standard measurements of body composition; however, both are readily accessible
and used to determine body composition in the field. Although there exists data to
suggest that both methods are of questionable accuracy and should be viewed with
caution (Clasey et al. 1999), coaches will continue to use these procedures to evaluate
their athletes until more accurate field methods become available. Results of the present
study suggest that the two methods are not interchangeable for this population of
subjects.

The mean percent body fat for female subjects calculated via Cyprus software
from BIA was 28.2 ± 2.5 %, while the calculated percent body fat from the equation of
Fornetti et al. (1999) was 25.4 ± 1.4%. The equation of Fornetti et al. (1999) was
developed on college female athletes and was shown to have good agreement with
DEXA values. The mean percent body fat for male subjects calculated via Cyprus
software from BIA was 21.6 ± 5.4 %. The use of skinfold analysis resulted in lower
percentages of body fat for both male and female subjects. The mean percent body fat
scores for the female subjects was 17.1 ± 3.1%. A score that placed female subjects in
the 80th percentile according to ACSM norms (2000) and can be considered very lean (Baechle and Earle 2002). The body composition scores from the study by Thomas et al. (2004) were assessed by hydrostatic weighing, which has long been considered to be a Gold Standard. Direct comparisons of body composition between the two studies should be made with caution, as differences in body composition maybe due to the methods employed rather than actual differences in body composition. Differences between the two studies may also be due to the relatively small sample sizes. However, the female cheerleaders of this study were not as lean as those in the Thomas et al. (2004) study even though they were shorter and lighter (Table 1). The mean body fat scores for female subjects were similar to other data reported on female college gymnasts, distance runners, and heptathlon athletes (DeBenedette 1987, Baechle and Earle 2002, Sinning 1978). The mean percent body fat obtained from skinfold analysis for male subjects was 16.0 ± 9.7%, which placed them in the average category (15.9%) according to ACSM norms (2000) and was similar to the of the male subjects of Thomas et al. (2004) (16.4 ± 5.2%).

Flexibility is an important attribute for both male and female cheerleaders because of the gymnastic elements involved and other unique gender specific cheerleading skills. Specifically, females need flexibility of the hamstring and hip joint to perform cheerleading specific elements such as ‘stretches’, ‘arabesques’ and ‘bow-and-arrows’ while males need to balance upper body muscle mass with shoulder flexibility. Male subjects had a mean sit-and-reach score of 34.7 ± 2.9 cm; which placed them near the 80th percentile (35 cm) for normative data for their age group (ACSM 2000) and was similar to the data reported by Thomas et al. (2004) (35.1 ± 12.7). Female subjects
placed above the 90th percentile with a score of 40.6 ± 4.1 cm, which was also similar to the subjects in the study by Thomas et al. (2004), who also placed beyond the 90th percentile (44.9 ± 7.0) (Thomas et al. 2004).

The performance of splits is often included in competitive routines; therefore, an evaluation of split performance was included in the present study. Splits require flexibility of the hamstring, hip flexors, and hip joint. Male subjects scored 19.0 ± 9.9 cm on the front-to-rear splits, which placed them in the intermediate performance level (16.5 – 31.1 cm). Females scored (4.3 ± 6.6 cm) in the advanced intermediate performance level (4.4 - 11.4 cm) for front-to-rear splits (Johnson and Nelson 1986). Males scored (29.1 ± 10.7 cm) within the intermediate performance level (21 – 44.4 cm) for middles splits. While Females scored (11.4 ± 10.0 cm) at the advanced intermediate performance level (7.6 – 19 cm) (Johnson and Nelson 1986). Surprisingly, three of the eight subjects female subjects could not perform full front-to-rear splits.

Female subjects were more flexible than male subjects in all flexibility tests except for shoulder flexion. Mean shoulder flexion for females (165.5°) was within the average range of motion (ROM) (150-180°); while mean shoulder extension (68.35°) was greater than the average ROM (50-60°) (Heyward 2002). Mean male shoulder flexion (179.9°) was at the upper end of the average (ROM) values for healthy adults (150-180°). Mean male shoulder extension (64.55°) was greater than the average values (50-60°) (Heyward 2002).

The mean hip flexion value of the females (108.9°) was within the average ROM (100-120°) for healthy adults. Mean hip extension (32.1°) was greater than the average ROM (30°) though (Heyward 2002). It was unexpected that mean hip flexion of the
female subjects was not greater than the average ROM values. Several cheerleading skills require females to stand on one leg while raising the other as high as they can. Such movements require both strength and flexibility of the hip flexors. Average adults don’t raise their leg up to their ear; cheerleaders do this on a routine basis. Mean hip flexion (89.9°) and extension (22.5°) of male subjects was below the average ROMs (100-120°; 30°) (Heyward 2002).

Strength and power are also important attributes used in performing competitive cheerleading routines. Leg power is the driving force behind the cheerleading toss for both males and females and is an important component of tumbling as well. The faster and higher a female cheerleader jumps the easier she is to toss. Female subjects vertical jump scores (45.6 ± 5.2 cm) were most similar to college female basketball players (45.7 cm) and other competitive female college athletes (41-47 cm) (Baechle and Earle 2002). Male cheerleaders also use predominantly leg power when performing a toss of their partner. Vertical jump scores for male subjects (70.5 ± 8.3 cm) were most similar to college male basketball (71.1 cm) and football players (71.1 cm) (Baechle and Earle 2002).

Anaerobic power is another important attribute for successful competitive cheerleading. Anaerobic power is important to CCC because competitive routines are two and a half minutes of tosses, tumbling, and explosive movements. Anaerobic leg power was assessed using the Wingate Anaerobic Test. The maximum Wingate score was a measure of highest power output during the test. Male subjects had a mean maximum Wingate score of 14.7 ± 1.6 W/kg which placed them above the 95th percentile for their age group (11.08 W/kg) (Maud and Schultz 1989). Female subjects
also had a maximum Wingate scores (10.5 ± 1.3 W/kg) above the 95th percentile for their age group (7.61 W/kg) (Maud and Schultz 1989). Thus both male and female subjects displayed excellent leg power scores. It should be noted that the normative data from the Maud and Schultz study were based on a resistance of 0.075 Kp per Kg body weight. The higher resistance used in the present study would be expected to result in higher maximal anaerobic power scores.

Similar to other sports, cheerleading has its own specific strength requirements for success. Male subjects scored well in the sport specific 1-RM tests if the mean scores lifted are compared to the mean mass of the female subjects. Male subjects placed above the 70th percentile for 1-RM bench press (106.2 ± 10.2 kg) (ACSM 2000) with a score that was similar to college baseball players (106 kg) (Baechle and Earle 2002). Male subjects in this study were slightly stronger compared to the male subjects (102.7 ± 19.2 kg) in the Thomas et al. (2004) study. Bench press scores for female subjects (33.7 ± 3.3 kg) were similar to the females of Thomas et al. (2004), (37.0 ± 7.7 kg) both groups of female subjects placed near the 60th percentile according to ACSM norms (2000).

Cheerleading movements are unique to the sport; therefore there is a lack of comparative data for 1-RM military press and 1-RM Hanging Power Snatch. The ability to perform multiple tosses in succession were tested by having male subjects execute as many hanging power snatches as possible without stopping at a resistance nearly equal to the mean mass of the female subjects. The mean score for the hanging power snatch repetition test was 16.8 ± 9.0 snatches. Male subjects placed above the 90th percentile (41.0) for the muscular endurance push up test (43.8 ± 16.8) according to the ACSM (2000). The male subjects push up score was similar to that of Thomas et al.'s (2004)
male subjects (40.3 ± 11.9). The female subjects (25.6 ± 10.0) placed at the 80th percentile (26.0) (ACSM 2000) similar to the female subjects of Thomas et al. (2004). Female subjects scored a mean of 21.5 ± 9.0 dips, indicating their ability to adequately perform multiple flick movements during a competitive routine.

In summary, there exists a need to develop normative data sets on performance characteristics of various populations of athletes. These types of data exist for other sports such as football, rugby, soccer, tennis, baseball, basketball, rock climbing, judo, etc., but not for others (Ackland et al. 1997, Buchanan and Vardaxis 2003, Davis et al. 2004, Gabbet 2002, Little 1991, Newsham et al. 1998, Roetert et al. 1995, Secora et al. 2004, Watts et al. 2003, Wisloff and Hoff 1998). Although the data presented in this paper are not normative in nature, they do provide an indication of the performance characteristics of a team from a successful Division IA CCC squad. Normalized data should be developed for both CCC and non-competition squads in order to help better condition cheerleaders and aid in the prevention of injuries. Cheerleading may or may not be recognized as a sport, but based on the results of the present study and the study by Thomas et al. (2004) there is little doubt that cheerleaders are athletes.

**Practical Applications**

The results of this study were similar to the findings of Thomas et al. (2004) revealing that cheerleaders are of comparable fitness levels to other collegiate athletes. This study included sport specific performance characteristics of both male and female
cheerleaders. These data may be useful for coaches and athletes to help develop training programs that result in requisite strength and power values needed for success in CCC, which may aid in preventing injuries. Because each gender has unique role requirements in this sport, their conditioning programs should reflect these differences.
Part II
Review of Literature

Very little scientific literature has been written concerning cheerleaders. The majority of the published literature on cheerleading are articles and editorials that have addressed issues involving cheerleading as a sport and cheerleaders as athletes (DeBenedette 1987, Ebersole 2001, Gottlieb 1994, Hage 1981, Hutchinson 1997, Lockey 1991). A few authors have investigated cheerleading injuries and preventative strategies (DeBenedette 1987, Hage 1981, Hutchinson 1997), and recently a study by Thomas et al. (2004) was published which investigated the fitness status of collegiate cheerleaders. However, there still remains a significant gap in the scientific literature in regards to cheerleading. Cheerleading incorporates (skills) from other sports such as gymnastics and dance. Cheerleading, like gymnastics and dance, has an aesthetic quality that cannot be ignored. Several studies have investigated the physical and anthropometric characteristics of both dancers and gymnasts. The following review of literature address studies and articles that are pertinent to the study of cheerleading as a sport.

Cheerleading

Hage observed in 1981 that high school and college cheerleading programs were changing to incorporate more complex routines and requiring greater skill, better training, and increased athleticism. Cheerleading routines have evolved from simple choreographed arm motions and jumps to the performance of complex pyramids, partner stunts, catches, flips, twists, and lifts as well as tumbling passes similar to those performed by gymnasts on the floor exercise.
Hage (1981) noted the lack of knowledge about the dangers of cheerleading routines and injury prevention. The most common injuries suffered by cheerleaders were sprains and strains to the ankle, wrist, finger, knee, and lower trunk. It was suggested that stretching, wrapping, taping, proper spotting and appropriate shoe selection could help prevent these injuries. Unfortunately, few to no guidelines regarding cheerleading existed in 1981. Hage also noted that cheerleading was not taken seriously at the collegiate level after examining the budgets for various athletic groups.

DeBenedette (1987) addressed the question of how best to define cheerleading, either as an activity or as a sport. DeBenedette viewed cheerleading as a complex cross between gymnastics and dance. While difficult to classify, cheerleading has been described as being an explosive anaerobic activity that requires power and flexibility (DeBenedette 1987). DeBenedette cited Chris Kirby (doctoral candidate and cheerleading coach) who stated that cheerleading already meets the classic definition of a sport, which is an activity with rules and competitions carried out by numerous people.

DeBenedette noted similar problems in regards to cheerleading injuries. The most common injuries were sprains and strains to the ankle, wrist, knee, and lower trunk. DeBenedette also noted a lack of a national system of regulations including the National Collegiate Athletic Association (NCAA), which set no limits on cheerleading. Safety standards were regulated by four large primary cheerleading organizations the US Cheerleaders Association (USCA), National Cheerleading Association (NCA), International Cheerleading Federation (ICF), and Universal Cheerleaders Association (UCA). Because these four organizations each hold its own national competition, there is no single national championship.
Axe et al. (1991) conducted a study on sports injuries of adolescent athletes. The purpose of this research was to better document epidemiological information on types of injuries, severity of injuries and other vital information. The subjects of this study were athletes of the state of Delaware between 14 to 18 years old. An injury survey was completed for athletes who suffered a reported injury from June 1989 through June 1990. The survey included the sport involved, date of visit, athlete’s school, diagnosis, treatment, X-ray results, further studies, date permitted to return to participation, physical therapy, and date of next appointment. A total of 619 athletes in 23 sports reported 870 injuries. Cheerleading was among six other sports that had less than one percent of the overall injuries. However, cheerleading had the largest number of days lost per injury (28.8 days).

An editorial by Lockey (1991) described the changes of the cheerleading programs in the secondary schools in the state of Mississippi. These programs had shifted to become a major competitive sport. As the programs changed, they became more aggressive and more physically demanding. These changes were associated with an altering of the injury pattern away from minor sprains and strains to more serious injuries. As of 1991, Lockey states that there were “no requirements outlining the training and physical requirements necessary for participation” in cheerleading.

Gottlieb (1994) stated that cheerleaders must be recognized as athletes in order to identify sport specific risks and in order to develop methods that would prevent such injuries. Gottlieb observed that many cheerleading squads do not just lead cheers from the sidelines, but also perform in competitions against other cheerleading squads. As these cheerleading squads became more competitive, the stunts and tumbling involved in
the routines became more intense, and the skill required to perform such routines also 
increased. As of 1994, Gottlieb found that there was little information regarding 
cheerleading injuries or methods of identifying individuals at risk. Of the little 
information available on cheerleading injuries, it was known that cheerleading accounted 
for the greatest number of days of practice time lost (28.8 days) by adolescent athletes 
participating in a variety of sports.

Bucaro (1995) described combining cheerleading with gymnastics as 
“cheernastics”. She defined cheernastics as the spirit of athleticism with the art form of 
gymnastics. Cheernastics is supposed to improve performances by including gymnastic 
skills in choreographed routines with partner stunts, pyramids, jumps and dance. 
Cheernastics has three important physiological requirements. An ample amount of 
muscular strength is needed in order to perform partner stunts and pyramids. Flexibility 
is important for tumbling, jumps, and dance movements, and finally cardiovascular 
endurance which is critical for leading a crowd throughout an athletic event while 
performing innumerable cheerleading skills.

Hutchinson (1997) researched cheerleading injury patterns and prevention 
strategies. He found that cheerleading has become an increasingly competitive activity 
that includes nearly one million participants and has a year-round season with 
competitions held at regional and national levels. Hutchinson described cheerleading 
routines as a combination of gymnastic movements, tumbling passes, partner stunts, 
pyramids, and dance sequences. Hutchinson discovered that there were little literature 
available comparing cheerleading injuries with injuries from other activities, although it 
had been found that more days were lost per injury in cheerleading than in any other
sport. The most commonly injured joints were the ankles and knees. The most common cheerleading injuries are ligament sprains and muscle strains related to overuse and most occur during either gymnastic skills or partner stunts. As of 1997, cheerleading safety guidelines existed, but varied depending on several factors including the state, the school, and the particular cheerleading organization involved.

Mueller (2001) conducted research in order to describe the incidence of catastrophic head injuries in a variety of high school and college sports. The data was collected by the National Center for Catastrophic Sport Injury Research with the assistance from a variety of sources including: coaches, athletic trainers, athletic directors, executive officers of state and national athletic organizations, national newspaper clipping service, professional associates of the researchers, and national sport organizations. Mueller found that cheerleading accounted for over 50% of the catastrophic injuries to high school and college female athletes from 1984-2001.

An editorial by Ebersole (2001) discussed cheerleading injuries and methods to prevent such injuries. Ebersole found that the average cheerleading injury results in a loss of 28-35 practice days per injury, yet cheerleaders receive little respect as athletes. The most common cheerleading related injuries were ankle sprains. It was believed that these injuries could be prevented with proper conditioning, stretching, and warm-up exercises. Adding to the incidence of cheerleading injuries was the fact that cheerleading practice facilities are often not suitable practice areas. Ebersole also reported that while catastrophic injuries were rare, they were more common among female cheerleaders than in any other sport. According to the National Center for Catastrophic Sport Injury Research, between 1982 and 1999, college cheerleading accounted for 76.2% of
catastrophic injuries and high school cheerleading accounted for 46.3%. Ebersole cited Hutchinson and Mueller, who stated that future cheerleading injuries could possibly be prevented if cheerleaders were respected as athletes.

Tecco (2002) described cheerleading as an athletic activity that demands superior athleticism. According to the article, cheerleaders are at much lower risk of injury than other athletes, but cheerleading related injuries require more lost practice time than any other sport. Tecco points out that most cheerleading related injuries are related to overuse injuries that result in sprains or strains of the ankle, wrist, knee, back and shoulders while head and neck injuries were less common, but more severe. Tecco stated that sports medicine specialists prescribe rest for such chronic overuse injuries, which is difficult considering that cheerleading is a year-round activity. The American Association of Cheerleading Coaches and Advisors developed safety guidelines for cheerleading in 1987, but adherence to such guidelines is left up to individual school districts and states.

Boden et al. (2003) researched catastrophic cheerleading injuries. The purpose of the study was to identify risk factors that may predispose cheerleaders to catastrophic cheerleading injuries and based on this information recommend preventative measures that could help to reduce these risks. The study was a retrospective cohort study in which 29 of 39 cheerleading injuries were reported to the National Center for Catastrophic Sport Injury Research (NCCSIR) from 1982-2002 were reviewed. According to the authors, there were an estimated 450,000 high school and college cheerleaders in 2002 as reported
by the American Association of Cheerleading Coaches and Advisors. Making cheerleading one of the four most popular organized sports activities for women in high school.

There have been few epidemiological studies of cheerleading injuries. Boden et al. (2003) report that the NCAA injury surveillance survey does not include cheerleading even though, high school and college cheerleading accounted for more than half of all catastrophic injuries to female athletes according to the NCCSIR. There were 29 cases of catastrophic cheerleading injuries reported to the NCCSIR between 1982 and 2002. The questionnaire examined individual characteristics such as: sex, height, weight, and age, as well as level of sport (high school or college) and the experience level of the cheerleader and coach. Information was collected on the circumstances of the injury (during a sanctioned practice or not, indoors versus outdoors, supervised or unsupervised). Data were collected in order to determine the mechanism of injury: what stunt was being performed, the practice surface, and whether or not spotters were involved.

Fifteen of the injuries were classified as nonfatal, 12 as serious, and two as fatal. The accidents included 17 severe head injuries, eight cervical fractures or major cervical ligament injury, a spinal cord contusion in three cases, and one cervical fracture and severe head injury. Twenty-seven injuries occurred in female cheerleaders while the other two were male cheerleaders. Fourteen injuries occurred at the high school level, 11 at the college level and four occurred in junior high school. All but one of the injuries occurred during the winter months (November-March). All the injuries occurred during school participation with the exception of two cheerleaders injured during practice with a private team or at home. Seventeen of the injuries occurred during practice, nine
occurred at a game, and three occurred during warm-up prior to a game. In 23 of the injuries cheerleaders were under direct supervision, during three of the injuries there was no supervision, and supervision was unknown during three of the injuries.

In all cases injury was a result of direct trauma. Twenty-four of the injuries occurred indoors on a hard gym surface. Outdoor surfaces included grass, Astroturf, cement, and asphalt. A spotter was present during 13 of the injuries, not present in 14, and unknown during two injuries. Nine of the cheerleaders were injured while performing a pyramid. Eight cheerleaders were injured during a basket toss. Four injuries occurred while performing an advanced gymnastic maneuver. Four occurred in conjunction with a wet surface. Two occurred while performing partner stunts. One occurred while using a mini trampoline, and one injury occurred when a basketball player ran out of bounds and pushed a girl into a cement wall. The two primary areas of concern for catastrophic injuries found in this study were pyramids and basket tosses. To reduce the risk of injuries incurred by these skills the authors recommend: improved training of spotters, mandatory use of floor mats, limiting pyramids and basket tosses to experienced cheerleaders, and encouraging certification of cheerleading coaches.

Recently Thomas et al. (2004) published a study on the physiologic profile and fitness status of collegiate cheerleaders. The purpose of the study was to assess the physical fitness status of college cheerleaders and compare their fitness status with that of other college level athletes. The study consisted of eighteen college cheerleaders who underwent a battery of fitness tests investigating cardiovascular fitness, body composition, muscular endurance, muscular strength, and flexibility. Cardiovascular fitness was assessed via the Bruce protocol VO₂ max test. Body composition was
estimated using hydrostatic weighing. Muscular endurance was measured by a maximum sit-up and push-up tests. A 1 RM bench press and an isokinetic leg extension test were used to measure muscular strength. A standard sit-and-reach test measured hamstring flexibility.

Compared to the norms from the ACSM's Guidelines for Exercise Testing and Prescription both men and women had body fat percentages within zones associated with good health. VO\textsubscript{2} max scores placed the men and women at the 80\textsuperscript{th} percentile. The authors found that when compared to the norms from the American College of Sports Medicine's (ACSM) Guidelines for Exercise Testing and Prescription, the flexibility scores of the men and women placed them in the 70\textsuperscript{th} and beyond the 90\textsuperscript{th} percentile respectively based on age and gender. The bench press scores placed both men and women in the 60\textsuperscript{th} percentile. Both men and women scored above the 80\textsuperscript{th} percentile for abdominal endurance. The women scored in the 75\textsuperscript{th} percentile for the push-up test, and the men scored at the 90\textsuperscript{th} percentile. Leg strength scores also placed both men and women in the high fit range. The results of this study show that these college cheerleaders have equivalent aerobic fitness and body composition levels; and were just as muscular and athletic as other college level athletes.

**Gymnastics**

Sinning (1978) examined anthropometric estimations of body density, fat, and lean body weight in female gymnasts. It has been reported in the literature that college female gymnasts are shorter, lower in weight, higher in body density and lower in fat content when compared to other college age females. Therefore, the purpose of this
research was to evaluate the accuracy of previously derived equations for measuring body composition of female gymnasts and to develop new equations specific for female gymnasts. Forty-four female college gymnasts participated in the study.

All subjects had their body composition measured by densitometry using underwater weighing. Skinfolds were taken using either a Lange or a Harpenden caliper at the chin, triceps, subscapular, midaxillary, supra-iliac, umbilicus, supra-pubic, thigh, and calf. Skeletal diameters were measured using Gncepal anthropometric calipers and circumference measures were taken using linen tapes. These measurements were then used to study the accuracy of various equations used in estimating body composition on female gymnasts.

The results of this study are similar to previously reported data that female college gymnasts tend have a specific body type that is shorter, lower in weight, yet more dense than other college females. The authors also found that previously derived regression equations could be used to estimate body density and lean body weight if minor adjustments are made to account for a constant source of error. New equations were also developed to estimate body density, fat, and lean body weight in female gymnasts, but these equations still need to be validated.

Nelson et al. (1983) investigated the physical characteristics of female gymnasts including hip flexibility and arm strength. The purpose of this study was to compare the flexibility and strength response patterns to varying intensities of gymnastics training. Two hundred thirty-seven female gymnasts (7-13 yrs of age) participated in the study divided. Subjects were divided into three groups based on the number of hours they practiced in the six months prior to testing. Group I, physical education group, spent
approximately 20 hrs practicing. Group II, recreational gymnastic group, spent
approximately 75 hrs practicing, and Group III, competitive gymnastic group, practice up
to 175 hrs. Hip flexion was measured on front-to-rear splits with a flexometer. Arm
strength was tested by performing an Overhead Pull Test using a Spring Scale Rig.
Ponderal index was also calculated in order to estimate somatotype. There were
significant differences between all groups with the competitive group having the highest
degree of flexibility and relative strength followed by the recreational group and finally
the physical education group. Significant differences were also found between
comparisons of body weight with the competitive group being the lightest followed by
the recreational group and the physical education group being the heaviest. The results of
this study show that the competitive gymnasts differ from the other two groups by being
more flexible, stronger and weighing less.

Carter (1984) reviewed and combined data on somatotypes rated by the same
method on Olympic athletes between 1948 and 1976. The method of somatotyping used
in these studies was the Heath-Carter method. The subjects were from the 1948 London
Olympics and were from a mixture of medalists, finalists and less successful competitors.
Carter (1984) found that compared to nonathletes of similar age both male and female
Olympic athletes were more mesomorphic and less endomorphic. Olympic female
gymnasts in the 1968 were more endomorphic than those in the 1976. The differences
were attributed to ethnicity. Somatotypes of female divers were found to be similar to
that of gymnasts. Mean somatotypes for the 1968 and 1976 Olympic female swimmers
were nearly identical. There were no significant differences between the means and
standard deviations of the 1968 Mexico City Olympics and the 1976 Montreal Olympics. Male gymnasts from the 1968 and 1976 studies had the highest mesomorphy and lowest endomorphy of all the athletes sampled and were the most ecto-mesomorphic athletes. The average somatotype for Olympic male and female athletes was 2-5-2.5 and 3-4-3 (endomorphic, mesomorphic, ectomorphic) respectively.

Moffatt et al. (1984) compared the body composition and physiological characteristics of female high school gymnasts to that of non-athletic high school females. The subjects were 13 high school gymnasts and 13 control subjects. Hydrostatic weighing was used to determine total body volume. Skinfolds were taken at six sites (triceps, subscapular, supra-iliac, abdomen, thigh and calf) using a Lange caliper. Girth measurements included neck, shoulders, chest, waist, abdomen, hips, biceps, forearm, wrist, thigh, knee, calf, and ankle. The subjects performed a continuous maximal stress test on a Quinton treadmill at five mph. The test started at a 0% grade and was increased 2% every two minutes until exhaustion. Anaerobic power output and capacity were determined for each subject by using a mechanically braked bicycle ergometer. The authors made group comparisons for age, height, body fat, lean body weight, body density, \( V_\text{O}_2 \text{ max} \), and anaerobic capacity using independent t-tests. The results of this study showed that the gymnasts had significantly less percent body fat and lower in body fat weight. The gymnasts had significantly greater lean body weight and higher body density. The finding that the gymnasts were leaner than the controls was to be expected. The authors found it surprising that the gymnasts had smaller
circumferences than the controls. The gymnasts were also found to have significantly
greater VO₂ max, greater anaerobic capacity and greater anaerobic power output than the
control group.

Faria and Faria (1989) investigated the relationship of the anthropometric and
physical characteristics of male junior gymnasts on performance. They argue that
successful competitors in various sports have unique attributes (physiques, strength,
power, and flexibility) that are distinct and differ between individuals. It is these
characteristics, the authors’ claim, that influence the level of performance of a given
athlete. The purposes of their study were to identify anthropometric and physical
characteristics related to superior gymnastic success, and to determine if there was a
significant difference in these qualities between the top 10 all round gymnasts and those
individuals placing 11th to 34th in all round scoring. Sixty-five class I and class II
gymnasts participated in the study. To determine body density the generalized equation
of Pollock et al. (1980) was used and the Siri equation was used to estimate percent body
fat. Skinfold testing was conducted using a Harpenden caliper on seven sites. Height
and weight were also measured along with upper and lower limb lengths. Muscle
strength of the fingers, wrist, and forearm were measured using a Stoelting grip
dynamometer. Strength to body weight ratio was measured using a weighted pull up with
a resistance equal to 20% of the individual’s body weight and a maximum bench press.
Flexibility of the back, shoulders, and hips were measured. A standing Vertical jump
was used to determine the power of the extensor muscles of the lower extremity while
rebound explosive power was measured using a plyometric jump.
For the purpose of comparison only gymnasts were grouped into four categories; class I, class II, top class I, top class II. The gymnasts in this study were short in stature and muscular. The class I gymnasts were significantly heavier than the other groups. While percent body fat was similar between groups, the top class II gymnasts were significantly leaner than the class I and class II gymnasts. The class I gymnasts had significantly higher lean body weight than the class II gymnasts who had the lowest. Both the top class I and class I gymnasts were significantly stronger than the class II gymnasts. The top class I gymnasts were significantly stronger for the chin up than both class II and top class II gymnasts. The class II gymnasts had a significantly higher vertical jump and plyometric jump. No significant differences were found between groups for shoulder extension, or right and left split performance.

The data generated by this study would suggest that male gymnasts regardless of competitive level are similar in lean muscle mass. These data also support the observation that body composition, strength, power, flexibility, and physical characteristics can distinguish between highly proficient gymnasts in the classes involved in this study.

Alexander (1989) examined the physiological characteristics of elite rhythmic gymnasts because the ability to execute the difficult skills involved in rhythmic gymnastics requires high levels of strength, flexibility, aerobic and anaerobic fitness. The purpose of the study was to determine the mean and range of physiological requirements for a group of elite rhythmic gymnasts. The subjects in this study were nine elite gymnasts who were all tested according to standardized testing procedures on the following: maximum oxygen uptake, anaerobic treadmill test, flexibility, strength, body
composition, and blood lactate. Maximum oxygen uptake was measured using a graded treadmill test to exhaustion. For the anaerobic treadmill test subjects were to maintain a workload for a time period less than one minute. The subjects ran to exhaustion on a treadmill set to a 20% grade and 7 mph. The time on the treadmill is recorded at the time of exhaustion. The strength tests were conducted on a Kin/Com isokinetic dynamometer and consisted of hip flexion/extension, knee flexion/extension, and shoulder flexion/extension. Body composition was estimated using underwater weighing and the sum of five skinfolds. Blood lactate levels were taken following the performance of both the hoop and rope routines. There was no consistent relationship between body composition and ranking in this study. The subjects’ mean percent body fat was 13%, which is a very low value for female athletes. The main finding of this study was that elite female gymnasts who train together with a similar number of practice hours in similar activities have few significant differences in the physiological characteristics.

Benardot and Czerwinski (1991) conducted a study on the body composition and growth measures of junior elite gymnasts. The purpose of their research was to evaluate body composition and anthropometric variables in young female gymnasts. The study involved 146 female gymnasts. Data collected included height, weight, five site skinfold (triceps, subscapular, suprailiac, abdomen, and mid-thigh) using a Harpenden caliper, mid-arm circumference, and thigh circumference. The authors used these data to calculate body-fat percentage, arm muscle area, muscle circumference, and body mass index (BMI). The gymnasts were divided into two groups for purposes of comparison only, a younger group and an older group. The mean age of the two groups was 9.07 and 11.35 for the younger and older groups, respectively. There was a significant difference
in height, weight, and BMI between the groups. There was no significant difference found between age and body fat percentage. However, there was a significant difference between the younger and older groups in lean mass. Lean mass increased significantly from age 9 to 10. There were no significant differences found between the groups for the skinfold test. Overall, the authors found that subjects were small in stature and light in weight but highly muscled relative to their size. The authors believe that these characteristics are strongly associated with having a successful gymnastic performance.

Eckerson et al. (1997) studied the validity of bioelectrical impedance equations for estimating fat-free weight in high school female gymnasts. Bioelectrical impedance (BIA) is a rapid, portable, noninvasive technique used to estimate body composition. Few equations used to estimate body composition from BIA data have been validated on athletes of similar age and body composition. The purpose of this study was to compare the validity of selected BIA prediction equations for estimating fat-free weight (FFW) in high school female gymnasts using underwater weighing as a gold standard. Ninety-seven female gymnasts participated in this study. Each of these subjects had their body composition estimated via underwater weighing and BIA. BIA was measured using a RJL systems BIA –106 Spectrum analyzer and standardized procedures. Three skinfolds (triceps, subscapular and calf) were taken using a Lange caliper and arm circumference was measured with a Lufkin metal tape. Seventeen BIA equations were used to estimate FFW. Fat-free mass as determined by underwater weighing was similar to data reported by other studies on high school and college-aged female gymnasts. The authors
recommend that the equations of Houtkooper et al. (1992), the IBIA equation of Van Loan et al. and Lohman would be best to use with high school gymnasts if underwater weighing is unavailable.

Claessens et al. (1999) examined the contribution of anthropometric characteristics to performance scores in elite female gymnasts. According to the authors, success in many athletic events depends on physical characteristics including anthropometric dimensions, somatotype and body composition. The authors also feel that morphological characteristics are quite evident in artistic sports (ie gymnastics, figure skating, diving) in which the judges’ perception maybe influenced the participants’ physical appearance. It has been demonstrated that top-level female gymnasts characteristically are short in stature, light body mass, have narrow hips with broad shoulders, an ecto-mesomorphic somatotype, and a low percentage body fat with a high fat free mass. The purposes of this study were to identify anthropometric variables correlated with gymnastic performance scores and to predict scores obtained during a competition from the anthropometric and derived variables.

The study consisted of 168 gymnasts who participated in all events and had competition scores for each of the four apparatus (uneven bars, beam, vault, and floor). The test battery consisted of: body mass; stature; sitting height; forearm length; biacromial, bibicristal, biepicondylar, and bicondylar breadths; upper arm, forearm, thigh, and calf circumference; skinfolds of the triceps, biceps, subscapular, suprailiac, and medial calf. Skinfolds were taken using a Harpenden caliper. Somatotype was estimated with the Heath-Carter Anthropometric protocol. Skeletal maturity was estimated using the Tanner-Whitehouse II method based on hand-wrist radiographs. Performance scores
were based on the final rankings obtained during the competition on the four apparatus and the final total score. Based on the correlational analysis the authors feel that performance scores are associated primarily with the degree of endomorphy of the athlete. As the degree of endomorphy of the gymnast increases, the performance scores decrease. Body mass and some of the length and girth measurements also contributed significantly and negatively to predicting performance scores.

The best predictor of score in this study was endomorphy. The authors discuss three trends presented by the data. The first trend was the homogeneity and selective nature of the data, which led to relatively high correlations. The second trend was the associations between age, anthropometry, and somatotype and performance scores are insufficient to predict individual performance scores. The third trend was that the data suggest an interaction of age and fatness on performance scores.

Jackson and Pollock (1985) reviewed the scientific basis for generalized body composition prediction equations for evaluating body composition in order to present applicable and practical field methods to use with adults of varying age and body fatness. Jackson and Pollock (1985) found three trends in the research: skinfold fat is distributed differently in men and women, there is a nonlinear relationship between body density and skinfold fat, and age is independently related to body composition. These authors found that generalized equations can replace several different population specific equations and were valid for adults 18-61 years of age with varying degrees of body fatness. While the authors admit that skinfold testing is not as accurate as hydrostatic weighing, the skinfold measures described by the authors is valid and sufficient for bulk testing.
Fornetti et al. (1999) investigated body composition measures on female athletes. The purpose of their research was to determine the reliability and validity of bioelectric impedance analysis (BIA) and near-infrared interactance (NIR) for estimating body composition in female athletes. The authors found that the standard error of estimate (SEE), total error (TE), and the validity coefficient (r) were similar between groups. The authors also developed a BIA and NIR prediction equation for fat-free mass (FFM). This equation was found to predict values very close to the values measured from college age female athletes via dual-energy X-ray absorptiometry (DEXA).

Koutedakis and Jamurtas (2004) reviewed published literature examining professional dancers as performing athletes. The authors focused on the physiological elements of dance to assess physical fitness as well as overtraining, biochemistry and haematology. The authors found that in general professional dancers had lower maximal oxygen uptake values when compared to other athletes. Professional dancers also had lower anaerobic values than other athletes. Body composition of dancers is commonly assessed with the use of skinfold calipers or measuring total body electrical conductivity. Body fat values for ballerinas were between 16-18%. It was reported that professional ballerinas consume below 80% of the recommended daily allowance of energy intake to keep bodyweight low. The authors state that dance injuries have been linked to poor levels of physical fitness. Presently, for most dancers, the only form of training is dance. Unfortunately the research shows that dance does little to improve muscular strength, bone-joint integrity, and aerobic power. Therefore, the authors suggest other
supplemental exercise training to improve physical fitness levels, but warn that these exercises must be approached carefully to ensure the aesthetic content of dance is not affected.

Koutedakis et al. (1999) studied the effects of a six-week summer break on selected physiological parameters. Seventeen professional ballerinas volunteered for the study. The authors investigated body composition, flexibility, Wingate anaerobic test, muscular strength, and aerobic capacity. Percent body fat did not change significantly. Hamstring, trunk, and shoulder flexibility all improved significantly. Peak anaerobic power increased significantly as well as VO₂ max. Leg strength also improved significantly. The main finding of this study was that significant increases in selected physiological variables resulted from a six-week break.

Maud and Shultz (1989) developed percentile norms for the Wingate test for mean power and fatigue index, compared the results with the Katch test, and developed equations for predicting one protocol. One hundred and twelve males and 74 females between the ages of 18-28 volunteered for the study. Subjects completed a 30 second (s) Wingate test at a resistance determined by their body weight (0.0075 kp * kgBW⁻¹) and a Katch test. The Katch test is similar to the Wingate test except the resistance is 6 kilopounds (kp) for men and 5 kp for women and the duration of the test is 40 s. Normative data was presented in tabular form. The mean power for the Katch 30 s test was significantly higher than the Wingate 30 s for the men. The men’s Wingate correlated r = 0.79 with the Katch 30 s protocol and r = 0.81 with the 40 s protocol. The women’s Wingate correlated r = 0.65 with the 30 s Katch and r = 0.66 with the 40 s Katch protocol.
Micheli et al. (1984) examined the physiologic characteristics of nine professional female ballerinas, and flexibility of 25 young ballet dancers. Several physiologic parameters were measured including: cardiovascular fitness, muscular strength, anthropometry, and body composition. An injury profile of each subject was also conducted. The subjects’ mean VO₂ max was 41.8 ml O₂ per kg per minute, which was greater than female gymnasts and average women of similar age, but lower than that of endurance athletes. This is in opposition to the findings of Koutedakis and Jamurtas (2004). Muscular strength was measured using a Cybex II isokinetic dynamometer. The authors found that the subjects had strong lower extremities and relatively weak upper extremities. The subjects estimated percent body fat was 15.3% and compared favorably to other ballerinas. The young ballet dancers were found to have significantly greater external rotation and abduction at the hips when compared to age matched controls, but other flexibility measurements were not significantly different. The most common dance injuries were to the knee, foot/ankle, and back. The authors intend this profile to be useful in determining risk factors that may increase the possibility of injury, and to enhance performance and safety of ballet.
Summary

There is limited scientific data on cheerleading. Much of what has been written are editorials attempting to describe and define cheerleading. The scientific literature that is available has concentrated on cheerleading injuries except for a single paper, which detailed physical performance characteristics of cheerleaders. There is significantly more scientific literature on the physical characteristics of gymnasts and dance. Most of these studies have described both male and female gymnasts as being short in stature, low in percent body fat, and high in lean body mass.
MEMORANDUM

December 29, 2003

TO: Justin B. Davis
   Principal Investigator
   Kinesiology and Leisure Science

FROM: William H. Dendle
      Executive Secretary

SUBJECT: CHS # 12394, "Performance Characteristics of a Nationally Ranked UCA Division IA Intercollegiate Cheerleading Squad"

This acknowledges receipt of your response dated December 18, 2003, including the revised protocol and consent form, to the recommendations made by the Committee on Human Studies during its review of this project at its meeting of November 18, 2003. This information satisfactorily addresses the CHS concerns.

On behalf of the Committee, your project as revised, is granted approval for one year effective November 18, 2003.

If, during the course of your project, you intend to make changes which may significantly affect the human subjects involved, you should obtain CHS approval prior to implementing these changes. Any unanticipated problems related to your use of human subjects must be promptly reported to the CHS. The CHS may be contacted through its office. This is required so that the CHS can update or revise protective measures for human subjects as may be necessary. In addition, under the University’s Assurance with the U.S. Department of Health and Human Services, the University must report certain situations to the federal government. Examples of these reportable situations included deaths, injuries, adverse reactions or unforeseen risks to human subjects. These reports must be made regardless of the source of funding for your project.

In accordance with the University policy, you are expected to maintain as an essential part of your project records, any records pertaining to the use of humans as subjects in your research. This includes any information or materials conveyed to, and received from, the subjects, as well as any executed forms, data and analysis results. These records must be maintained for at least three years after project completion or termination. If this is a funded project, you should be aware that these records are subject to inspection and review by authorized representatives of the University, State of Hawai‘i, and the federal government.

Please note that the CHS approval cannot exceed one year. If you expect your project to continue beyond this approval period, you must submit continuation applications to the CHS for renewal of CHS approval. CHS approval must be obtained and maintained for the entire term of your project or award.
Please notify this office when your project is completed. We may ask that you provide information regarding your experiences with human subjects and with the CHS review process. Upon notification, we will close our files pertaining to your project. Any subsequent reactivation of the project will require a new CHS application.

Please do not hesitate to contact this office if you have any questions or require assistance. We will be happy to assist you in any way we can.

Thank you for your cooperation and efforts throughout this review process. We wish you success in this endeavor.

Enclosure
## Protection of Human Subjects
### Assurance Identification/IRB Certification/Declaration of Exemption
(Common Rule)

**Policy:** Research activities involving human subjects may not be conducted or supported by the Departments and Agencies adopting the Common Rule (50FR28003, June 18, 1991) unless the activities are exempt from or approved in accordance with the Common Rule. See section 101(b) of the Common Rule for exemptions. Institutions must have an assurance of compliance that applies to the research to be conducted and should submit certification of IRB review and approval with each application or proposal unless otherwise advised by the Department or Agency.

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<td>[ ] OTHER.</td>
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<tbody>
<tr>
<td>“Performance Characteristics of a Nationally Ranked UCA Division IA Intercollegiate Cheezeaing Squad”</td>
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<table>
<thead>
<tr>
<th>5. Name of Principal Investigator, Program Director, Fellow, or Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justin B. Davis</td>
</tr>
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<th>6. Assurance Status of this Project (Respond to one of the following)</th>
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<td>[X] This Assurance, on file with Department of Health and Human Services, covers this activity: Assurance Identification No. F-3526, the expiration date October 15, 2005 IRB Registration No. IORG0000169</td>
</tr>
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<td>[ ] This Assurance, on file with (agency/dept)<strong><strong><strong><strong><strong><strong><strong><strong><strong><strong><strong><strong><strong>, the expiration date</strong></strong></strong></strong></strong></strong></strong></strong></strong></strong></strong></strong></strong>, IRB Registration/Identification No. ________________________(if applicable)</td>
</tr>
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<td>[ ] No assurance has been filed for this institution. This institution declares that it will provide an Assurance and Certification of IRB review and approval upon request.</td>
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<tr>
<td>[ ] Exemption Status: Human subjects are involved, but this activity qualifies for exemption under Section 101(b), paragraph________.</td>
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<th>7. Certification of IRB Review (Respond to one of the following IF you have an Assurance on file)</th>
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</thead>
<tbody>
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<td>[X] This activity has been reviewed and approved by the IRB in accordance with the Common Rule and any other governing regulations. by: [X] Full IRB Review on (date of IRB meeting) November 18, 2003 or [ ] Expedited Review on (date)</td>
</tr>
<tr>
<td>[ ] If less than one year approval, provide expiration date</td>
</tr>
<tr>
<td>[ ] This activity contains multiple projects, some of which have not been reviewed. The IRB has granted approval on condition that all projects covered by the Common Rule will be reviewed and approved before they are initiated and that appropriate further certification will be submitted.</td>
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<th>9. The official signing below certifies that the information provided above is correct and that, as required, future reviews will be performed until study closure and certification will be provided.</th>
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<table>
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<th>10. Name and Address of Institution</th>
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</thead>
<tbody>
<tr>
<td>University of Hawaii at Manoa</td>
</tr>
<tr>
<td>Office of the Chancellor</td>
</tr>
<tr>
<td>2444 Dole Street, Bachman Hall</td>
</tr>
<tr>
<td>Honolulu, HI 96822</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>11. Phone No. (with area code)</th>
<th>(808) 956-5007</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Fax No. (with area code)</td>
<td>(808) 539-3954</td>
</tr>
<tr>
<td>13. Email:</td>
<td><a href="mailto:dendle@hawaii.edu">dendle@hawaii.edu</a></td>
</tr>
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</table>

<table>
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<tr>
<th>14. Name of Official</th>
</tr>
</thead>
<tbody>
<tr>
<td>William H. Dendle</td>
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<table>
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Public reporting burden for this collection of information is estimated to average less than an hour per response. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: OS Reports Clearance Officer, Room 503 200 Independence Avenue, SW, Washington, DC 20201. Do not return the completed form to this address.
Human Subjects Approval

Application for New Approval of a Study Involving Human Subjects
University of Hawai`i, Committee on Human Studies (CHS)
Spalding Hall 252B, 2540 Maile Way, Honolulu, Hawai`i 96822
Telephone: (808) 956-5007

Date: November 4, 2003
PI (name & title): Justin B Davis Email: Stuntrock2525@hotmail.com
Phone: 808-957-1432 Department: KLS
[ ] Faculty or Staff [ ] Student - name of supervising professor: Ronald Hetzler, PhD, AssociateProf.; KLS Department

Training in Human Subject Protection: When, where, & what?

Project Title: Performance Characteristics of a Nationally Ranked UCA Division IA Intercollegiate Cheerleading Squad

Proposed Sponsoring Agency: __________________________ Start Date February 2004
Complete Agency address:
Proposal Submitted to ORS: [ ] No [ ] Yes, when? ______ Proposal #: (if known) ______

1. Summarize your proposed research. Outline objectives and methods.

The purpose of this study is to examine and performance characteristics of a UCA Division IA nationally ranked intercollegiate cheerleading squad. This is a descriptive study in which data collected may be used for future comparisons. There is currently a lack data regarding the anthropometric and physical performance characteristics of collegiate cheerleaders. The proposed study would help alleviate this gap in the literature.

Anthropometry

Height and weight will be measured using a stedometer and a beam balance scale. An experienced skinfold technician will take nine-skinfolds in duplicate. Two bone widths of the elbow and knee and two limb circumference measures of the upper arm and lower leg will be taken to calculate somatotypes of the participants. Skinfolds and bioelectrical impedance will be used to estimate body composition. Individual feedback will be given to the athlete and will not be shared with other squad members or the coach.

Performance tests

All subjects will perform the following tests: a 20 sec Wingate test will be used to determine peak anaerobic power output, and vertical jump scores will be used as a measure instantaneous power. All subjects will be tested on their 1-repetition maximum bench press, the maximum number of push-ups and the maximum number of sit-ups they can perform in order to compare them with Division 1 competitive cheerleaders. All subjects will have their shoulder flexibility, hip flexibility, and trunk flexibility assessed using Leighton Flexiometer. Subjects’ hamstring flexibility will be tested via a sit and reach test and performance of splits. Due to the differences in performance requirements of male and female participants, the following gender specific tests will be performed. Males will be tested on 1-repetition maximum push-press, 1-repetition maximum hanging power snatch, and the maximum number of repetitions of hanging power snatches that can be performed in a single set using a resistance equal to the average weight of the female squad members. Females will have their arm strength tested by using the maximum number of dips that can be performed with 75% of their individual body weight.

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2. Summarize all involvement of humans in this project (who, how many, age, sex, length of involvement, frequency, etc.) and the procedures they will be exposed to. Attach survey instrument, if applicable.

Subjects will be recruited from the 2003-2004 UHM cheerleading squad (approximately 24 individuals, 12 of each gender, age range 18-27). The subjects will be tested individually. Two testing sessions will be required, with each session lasting approximately one hour. During the first session anthropometric measurements will be taken, the Wingate Anaerobic Power Test and vertical jump will be administered. Strength and flexibility measurements will be taken during the second session. The testing protocols will be non-invasive. The subjects will have skinfolds, limb circumferences and bone widths measured. They will have electrodes applied to their hands and feet for determination of body composition via bioelectrical impedance. They will also be asked to perform various tests of strength, power and flexibility as described above.

Check whether any subject of your research will be selected from the following categories:

[ ] Minors  [ ] Pregnant Women  [ ] Mentally Disabled  [ ] Fetuses  [ ] Abortuses  [ ] Physically Disabled  [ ] Prisoners

3. Research involving humans often exposes the subjects to risks: For the purpose of this application, "risk" is defined as exposure of any person to the possibility of injury, including physical, psychological, or social injury, as a consequence of participation as a subject in any research, development, or related activity which departs from the application of those established and accepted methods necessary to meet his needs, or which increases the ordinary risks of daily life, including the recognized risks inherent in a chosen occupation or field or service.

a. Check all the risks to human subjects that apply to your project:

[ x ] Physical trauma or pain  [ ] Deception
[ ] Experimental diagnostic procedures  [ ] Side effects of medications
[ ] Contraction of disease  [ ] Experimental treatment procedures
[ ] Contraction of disease  [ ] Worsening of illness  [ ] Loss of privacy
[ ] Psychological pain  [ ] Loss of legal rights  [ ] Other – explain

b. Check procedures that will be used to protect human participants from risks:

[ x ] M.D. or other appropriately trained individuals in attendance
[ ] Sterile equipment
[ ] Precautions in use of stressor or emotional material (explain below)
[ ] When deception used, subjects fully informed as to nature of research at feasible time (explain below)
[ ] Procedures to minimize changes in self-concept (explain below)
[ x ] Confidentiality of subjects maintained via code numbers and protected files
[ x ] Anonymity - no personally identifiable information collected
[ ] Others-- explain

c. Has provision been made to assure that Human Subjects will be indemnified for expenses incurred as a direct or indirect result of participating in this research?

[ ] Not applicable
[ x ] No - The following language should appear in the written consent form: *I understand that if I am injured in the course of this research procedure, I alone may be responsible for the costs of treating my injuries.*
[ ] YES, explain:
d. Are there non-therapeutic tests that the research subjects may be required to pay for?
   [ ] Not applicable
   [x] No
   [ ] Yes - explain below. The following language should appear in the written consent form:
   *I understand that I may be responsible for the costs of procedures that are solely part of the research project.*

4. Describe mechanism for safety monitoring: How will you detect if greater harm is accruing to your subjects than you anticipated? What will you do if such increased risk is detected?

Participation in this study should not pose undue risk for the participants. Except for the shortened Wingate test, the subjects will have been well trained in the exercises included in this protocol. To assure their safety during the tests of strength and power, the investigators will observe the subjects’ technique and make corrections when necessary. Close visual observation and verbal communication will be used to determine if the subjects are accruing potential harm or undue distress. A modified (shortened) Wingate Anaerobic Power Test was chosen to minimize the chance of distress or nausea associated with the traditional longer version (30 seconds) of this test. If harm or distress is detected, the test will be immediately terminated and appropriate first aid/CPR will be administered. If necessary, there is a first aid kit and an automated external defibrillator (AED) on site, and the Emergency Medical System (EMS) will be summoned without delay. If a female subject feels there is a chance that they may be pregnant, a home pregnancy test will be supplied and administered prior to participation. Female subjects will be excluded from the study if they are found to be pregnant.

5. Briefly describe the benefits that will accrue to each human subject or to mankind in general, as a result of the individual's participation in this project, so that the committee can access the risk benefit/ratio.

This is an important study because of the lack of published research on these athletes. As a result of participation, each subject will learn his or her individual body composition and performance characteristics. The participants would be able to compare their individual data to group means and work on areas of weakness. This information will benefit others in that it will provide data could be used by coaches when selecting team members; and/or by future researchers for purposes of comparison.

6. Participation must be voluntary: the participants cannot waive legal Rights, and must be able to withdraw at any time without prejudice. Indicate how you will obtain informed consent:
   [x] Subject (or Parent/Guardian) reads complete consent form & signs ("written" form)
   [ ] Oral briefings by PI or project personnel, with simple consent form ("oral" form). Explain below the reason(s) why a written consent form is not used
   [ ] Other - explain
7. Are there any other local IRB's reviewing this proposal? [x] No [ ] Yes, Location: _____

I affirm:
(i) that the attached drug sheet(s) submitted to CHS for this project have been checked and confirmed to be accurate and current. If changes in a CHS-approved drug sheet have been made to insure accuracy and currency these changes have been listed on the attached, and

(ii) that the above and any attachments are a true and accurate statement of the proposed research and of any and all risks to human subjects.

Signed: ____________________________ Date: ______________
Principal Investigator

Signed: ____________________________ Date: ______________
Supervising Professor (required if PI is a student)
Date of Human Subject Protection Training: _______________________

Submit the ORIGINAL plus 12 copies of this form with the following attachments:

Three (3) copies of proposal
Thirteen (13) copies of all consent forms
Thirteen (13) copies of any other information to be read or presented to the participants
Thirteen (13) copies of verbal information to be given if short form is used
Thirteen (13) copies of the survey instrument
(Please consult with the CHS staff if providing the survey instrument is a problem.)
Appendix B: Raw Data

<table>
<thead>
<tr>
<th>Guys</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (Kg)</th>
<th>Humerus (cm)</th>
<th>Femur (cm)</th>
<th>Arm Cir. (cm)</th>
<th>Leg Cir. (cm)</th>
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<td>10.5</td>
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<tr>
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<tr>
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<td>176.3</td>
<td>76.2</td>
<td>7.0</td>
<td>10.5</td>
<td>35.0</td>
<td>39.0</td>
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<tr>
<td>Mean</td>
<td>21.7 ± 2.9</td>
<td>174.7 ± 5.2</td>
<td>89.0 ± 21.9</td>
<td>7.5 ± 0.6</td>
<td>10.7 ± 1.2</td>
<td>39.0 ± 3.4</td>
<td>40.8 ± 3.9</td>
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### Appendix B: Raw Data

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<tr>
<th>Guys</th>
<th>Sum Seven Skinfolds</th>
<th>% Fat Skinfolds</th>
<th>% BF Cyprus</th>
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<th>Mesomorphic</th>
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Mean: 128.2 ± 89.3  16.0 ± 9.7  21.6 ± 5.4  4.1 ± 2.3  7.8 ± 1.6  0.9 ± 0.9  29.0 ± 5.7

*%BF=(FM/Kg)*100; FM=Kg-FFM
Heyward and Stolarczyk 1996
## Appendix B: Raw Data

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<th>Win Mean (W/kg)</th>
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Mean 12.1 ± 1.1 14.7 ± 1.6 13.6 ± 1.5 17.4 ± 2.2 % 70.5 ± 8.3 1626.7 ± 471.7

**Power = 21.67 * Body Mass * vertical displacement (m) ^0.5**
### Appendix B: Raw Data

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<th>Middle Split (cm)</th>
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Mean: 19.0 ± 9.9 20.0 ± 7.8 29.1 ± 10.7 179.5 ± 14.9° 180.3 ± 15.8° 65.0 ± 4.7° 64.1 ± 9.6°
### Appendix B: Raw Data

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Mean: 89.5 ± 8.7°  90.3 ± 5.7°  20.3 ± 4.0°  24.7 ± 7.1°
Appendix B: Raw Data

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Mean: $34.7 \pm 2.9$  $76.0 \pm 8.1$  $106.2 \pm 10.2$  $68.3 \pm 20.3$  $16.8 \pm 9.0$  $43.8 \pm 16.8$  $69.2 \pm 14.3$
**Appendix B: Raw Data**

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<th>Humerus (cm)</th>
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Mean 20.9 ± 1.4 150.2 ± 4.0 47.0 ± 3.4 5.7 ± 0.2 8.5 ± 0.3 25.2 ± 1.2 32.6 ± 1.5
## Appendix B: Raw Data

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<th>% BF Fornetti et al. 1999</th>
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| Mean   | 81.9 ± 18.3 | 17.1 ± 3.1 | 28.2 ± 2.5 | 25.4 ± 1.4 | 3.3 ± 0.9 | 4.4 ± 0.5 | 1.9 ± 0.8 | 20.9 ± 1.3 |

*Calc BIA=((Kg-FFM 1)/Kg)*100

Fornetti et al. 1999
## Appendix B: Raw Data

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<th>Win Mean W/kg</th>
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Mean: 7.3 ± 1.2 | 10.5 ± 1.3 | 9.2 ± 1.1 | 30.2 ± 10.3% | 43.6 ± 4.1 | 33.7 ± 3.3
Appendix B: Raw Data

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<th>Girls</th>
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Mean: 45.5 ± 5.2  686.79 ± 61.6  21.5 ± 9.0  69.3 ± 16.3  25.6 ± 10.0

*Power = 21.67 * Body Mass * vertical displacement (m) ^0.5
### Appendix B: Raw Data

<table>
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<th>Right split (cm)</th>
<th>Left split (cm)</th>
<th>Middle Split (cm)</th>
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Mean: $4.3 \pm 6.6$ $4.9 \pm 7.5$ $11.4 \pm 10.0$ $166.6 \pm 14.1^\circ$ $163.5 \pm 16.9^\circ$ $67.1 \pm 5.4^\circ$ $69.6 \pm 3.5^\circ$
## Appendix B: Raw Data

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Mean: \(106.8 \pm 19.6^\circ\) \(110.9 \pm 19.8^\circ\) \(32.1 \pm 20.5^\circ\) \(32.0 \pm 19.2^\circ\)
## Mens Statistics

The MEANS Procedure

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Agreement to participate in
Performance characteristics of a UCA Division IA nationally
ranked intercollegiate cheerleading squad

Justin Davis 2555 Dole St #120
Honolulu, Hawaii 96822
808-957-1432

Purpose

I am a graduate student at the University of Hawaii, and this project is part of my
Master’s Degree in Kinesiology and Leisure Science. The purpose of this research
project is to collect data on the performance characteristics of co-ed collegiate
cheerleaders. Your participation will help to establish basic measurements of size and
proportion of the human body, and physical performance characteristics of collegiate
cheerleaders.

Your participation in this research is voluntary, and you will not be paid. Be
assured that all information collected on you will be kept confidential. You and the
researchers will be the only ones to know the individual results of the body composition
analysis (skinfolds and bioelectrical impedance). Individual data will not be shared with
other squad members or your coach. You will be asked to participate in two testing
sessions lasting approximately one hour each.
Procedures

Day One

Prior to reporting for both testing session you will be asked to:

- Refrain from exercise the day of the test
- Report well hydrated (drink at least three 8-oz cups of water two hours prior to reporting)
- Refrain from alcohol for 24 hours prior to the test and caffeine on the morning of the test (no coffee, tea, soda, caffeine-containing beverages, supplements or drugs that contain caffeine).
- Come well rested and dressed in practice clothes.

During the first test session the following measurements will be taken:

- Height and weight.
- An experienced skinfold technician, supervising Professor Ron Hetzler, will take nine skinfolds on the male subjects’ back, arm, side, chest, stomach, and legs while KLS chair Dr. Iris Kimura, will take the same measurements on the female subjects.
- Bone widths will be taken on your elbow and knee, and circumference measurements will be taken on your flexed upper arm and lower leg.
- Bioelectrical impedance is a rapid, noninvasive method for evaluating body composition that will be used to estimate body composition. This requires two electrodes to be placed on the hands and feet. You
will not be able to feel any sensation as low-level electrical current is passed through your body and opposition to flow of current is measured by with a BIA analyzer.

- Individual feedback will be given on body composition by primary investigator and supervising professor.

Upon completion of these measurements you will be asked to perform a vertical jump test to measure instantaneous lower body power. A short warm-up (consisting of a slow jog on a treadmill at approximately five mph for five minutes and followed by five minutes of stretching.) You will be asked to repeat this test at least three times or until you no longer improve jump height. You will then be asked to perform a modified Wingate Anaerobic Power Test to determine your peak anaerobic power in Watts. This test requires that you ride a cycle ergometer, which is similar to an exercise bike, as hard as you can for 20 seconds at a resistance determined by your body weight (males = 0.098 kp/kg, females = 0.085 kp/kg). This test is preceded by a five-minute warm-up on a cycle ergometer, and you will be required to walk on a treadmill at approximately three mph for ten minutes after the test to cool down. This test is considered safe for healthy individuals. This will conclude the first session of tests.

**Day Two**

During the second testing session subjects will have their shoulder flexibility (adduction/abduction and flexion/extension), hip flexibility (adduction/abduction and flexion/extension) and trunk flexibility (flexion/extension) tested using a Leighton Flexiometer. This is a small dial like device that is strapped onto the subject and will be
used to measure the range of motion of a joint. Hamstring flexibility will be tested using a sit and reach test and three splits will be evaluated by measuring the distance from the pubis synthesis to the floor (right, left, and middle splits).

Males

Males will then be asked to perform the following 1-repetition maximum (1-RM) tests: push-press, bench press, and hanging power-snatch. Between each test there will be a five-minute recovery period. A one-repetition maximum is defined as the maximum amount of weight you can move in a single attempt with proper form. Each of the 1-RM tests will consist of two warm-up sets of eight repetitions and will start with a weight that you estimate will correspond to your 1-RM. If the attempt is successful, the weight will be increased and you will be given two minutes to recover before the next attempt. Testing will continue until a weight is not successfully lifted. Three attempts will be allowed for this weight with two minutes between attempts.

Following the 1-RM hanging power-snatch test, you will be given a 5-minute recovery period. You will then be asked to perform the maximum number of hanging power snatches you can perform using a weight equal to the average weight of the female squad members. This test will use the same motion as the 1-RM hanging power-snatch; only the weight will not be increased. The object of this test is to determine how many repetitions you can perform without stopping.
**Females**

During the second day females will be tested on the maximum number of dips they can perform using the *Kell Pro Elite* assisted dip machine using 75% of their body weight. You will be given two warm-up trials of five repetitions. After a 2-minute break, you will be asked to perform as many dips as possible with proper form. There is a slight possibility of strain or injury during the dip test if proper form and protocols are not followed.

After a 5-minute break females will be tested on their 1-RM bench press max. You will be given two warm-up sets consisting of eight repetitions. The 1-RM test will start using a weight that you estimate will correspond to your 1-RM. If the attempt is successful, the weight will be increased and you will be given two minutes between attempts. Testing will continue until a weight is not successfully lifted. Three attempts will be allowed for this weight with two minutes between attempts.

**Males and Females**

The final two tests for both males and females will be the maximum number of push-ups and sit-ups they can perform using proper form. Proper form for push-ups is defined by the American College of Sports Medicine (ACSM) as having hands shoulder width apart, back straight, head up, using toes as the pivotal point. The subject must lower the body until the chin touches the mat. The subject’s back must remain straight throughout the test, and the subject must push up to a straight-arm position (ACSM 2000). For the ACSM sit-up protocol,
subjects will lie supine on a mat with their knees at a ninety-degree angle. Subject’s arms will be at their sides, fingers touching a piece of masking tape. There will be a second piece of masking tape placed twelve centimeters beyond the first. Using a metronome set to 40 beats/minute, subjects will perform slow, controlled sit-ups in time with the metronome. Subjects will perform as many sit-ups as possible without rest up to a maximum of seventy-five (ACSM 2000).

**Compensation**

There is no compensation for being on this project.

**Risks**

During the Wingate anaerobic power test, it is possible that you may experience some or none of the following as a result of the test: nausea, vomiting, fatigue, pain or an unwell feeling. Warm-up and active recovery have been shown to successfully prevent these symptoms in most individuals. Although the risk minimal, this type of test may result in a muscular injury (muscle pull or strain); or, although extremely unlikely, a cardiac event (e.g. heart attack). If you are injured appropriate first aid will be administered, including CPR and/or the use of an automated external defibrillator (AED) and activation of the emergency medical system (EMS). There is a possibility of injury during the 1-RM tests, the maximum repetition hanging power-snatch trials, and the dip test if proper form and protocols are not followed.
Benefits

As a result of participation, you will gain information about your body composition and performance characteristics. You will be able to compare your individual data to group means. These data may help you improve your own performance profile. This information will benefit others in that it will provide data that could be used by coaches when selecting team members; and/or by future researchers for purposes of comparison.
Subject Certification

I certify that I have read and that I understand the foregoing, that I have been given satisfactory answers to my inquiries concerning project procedures and other matters and that I have been advised that I am free to withdraw my consent and to discontinue participation in the project or activity at any time without prejudice.

I herewith give my consent to participate in this project with the understanding that such consent does not waive any of my legal rights, nor does it release the principal Investigator or the institution or any employee or agent thereof from liability for negligence.

If you have any questions related to research, you can call me (Justin Davis) at 957-143 at anytime.

Signature of individual participant ___________________________ Date __________

Witness Signature ___________________________ Date __________

(If you cannot obtain satisfactory answers to your questions or have comments or complaints about your treatment in this study, contact:
Committee on Human Studies, University of Hawaii, 2540 Maile Way, Honolulu, Hawaii 96822. Phone: (808) 956-5007.)
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Sit and Reach: _____ (cm)

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### Male Tests

- 1-RM Push-Press: lbs
- 1-RM Bench Press: lbs
- 1-RM Hanging-power snatch: lbs
- Max number of Hanging-power snatch
- Max number of push-ups
- Max number of sit-ups

### Female Tests

- Max number of dips
- 1-RM Bench press: lbs
- Max number of push-ups
- Max number of sit-ups
Instruction Letter to Subjects:

Dear ________________.

Thank you for taking part in my study. Please meet me in the Kinesiology lab across from the athletic weight room on ________________ at __________. Please come dressed in practice clothes. Keep in mind that clothing will probably need to be moved about during the skinfold testing. Please come well hydrated by drinking at least three 8-oz cups of water two hours prior to reporting. Please refrain from caffeine 4 hours prior to testing, and please no strenuous exercise the day before or the day of the test. If for some reason you will be late or cannot attend your testing session, please contact me at 515-371-3875 or 808-927-1831.

Thank you.

Sincerely,

______________________________

Justin Davis
References


equations for estimating fat-free weight in high school female gymnasts.


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   baseball pitchers' internal/external rotation 180, 300, 450 degrees.s⁻¹. *Medicine 

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   1978.

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