

A Comparative Study on Strength between American College Male and Female Students in Caucasian and Asian Populations

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Muscle strength has been considered as a major factor on sport performance, martial arts competitions, self-defense, and other physical activities. The purpose of the study was to investigate potential difference on muscle strength between male and female college students. The results indicated that the muscle strength of female students is significantly lower than male students on strength of arm, upperbody and chest, shoulder, leg, and abdominal. Females have 37-68% of muscle strength of males in general. The difference on muscle strength between females and males is more on upper body, and less on lower body. Females are relatively stronger on their legs than arms and shoulders.

Keywords: muscle strength, sport performance, college students

Introduction

Muscle strength is the most important health-related component of physical fitness (Hoeger, 1996). Muscle strength is also considered as a major factor on sport performance (Chen & Chen, 2008), martial arts competitions, self-defense (Chen, 2004; Chen, 2011), and other physical activities (Heyward, 2006). Based on experience, men should have stronger muscles than women (Field & Roberts, 1999). This common sense usually comes from real life observations and records of sport competitions. For example, in all Olympic track and field events, male athletes run faster, jump higher or farther, and throw discus farther than women (Olympic, 2012). The records of male athletes in Olympic weight

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lifting events are higher than females. In a recent lab study on self-defense ability, male students demonstrated higher rate of escape in many situations that require muscle strength (Chen, 2010).

Potential difference between males and females may have significant impact on student learning and evaluation in physical education classes. In many sports and physical education classes, the potential difference between males and females was ignored, and bias during the evaluation of student performance occurs often. Take badminton as an example, males can easily hit longer clear shots with less effort than females. However, during the skill test, females and males usually are tested with same criteria because of educational equity. It is obviously not fair for female students.

The purpose of the study was to investigate potential difference on muscle strength between male and female college students. The results are expected to provide a base or a basic knowledge on difference of males and female on muscle strength, so that physical education professionals can establish standards for performance expectation and assessment their physical curricula and instruction. It is also expected that this new knowledge will also help physical education teachers and coaches to design proper curricula for their male and female students or athletes.

There are some studies on difference between males and females in terms of muscle strength. People estimated that the average strength of women is about two-thirds that of average men (Rasch, 1990). Lindle et al (1997) compared age-related reduction of muscle strength of men and women, but it was not on the absolute strength of college students. Another study (Frontera et al (1991) found that in the group of 45-78 old subjects, the absolute strength of women ranged from 42.2% to 62.8% that of men. One study in Europe (Miller et al, 1993) found that women were approximately 52% and 66% as strong as the men in the upper and lower body respectively. Janssen (1999) indicated that men have more skeletal muscle than women. One research (Lemmer et al, 2000) indicated no significant difference between young men and women on their increase of strength.

No recent literature has been found on the difference of muscle strength between male and female students in American colleges. This study will serve as a pilot research on this topic.

Research Method

The content analysis technique was used in the study to collect data. The contents are class experiment records of students in college weight training classes. One rep max was used as the indicator of muscle strength on each exercise. Many major muscle groups that students worked on often were examined. Students took enough rest between different exercises to ensure they could do their maximum lift on each exercise. All exercises were measured by pounds except the sit-up exercise that was tested by the numbers of repetitions.

Due to the population limitation in these classes, only Caucasian and Asian students were selected as subjects since other races did not have enough samples. The difference between male and female students was analyzed based on separate comparisons on Caucasian and Asian students, and both groups were combined as one group as the indicator of college students. Because of the lack of Hispanic and African-American participants, it should be very careful on generalizing the results to all college students. The difference between males and females on each muscle group was analyzed by t-test.

Results and Discussion

A. Arm strength

The results in Table 1 showed significant difference between Caucasian female and male students on their bicep strength, and it also showed significant difference between Asian male and female students in the arm curl exercise. Caucasian females only have 37% of the biceps strength of their male counterparts, while Asian females only have 58% of biceps strength of their male classmates.

Table 1. Bicep strength in arm-curl (both arms)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	43	30.8	12.9	91	82.4	20.41	49.6	<.00**	37.4%
Asian	9	35.3	14.7	41	60.8	17.6	25.5	<.00**	58.1%

Results in Table 2 demonstrated significant difference between Caucasian female and males on the triceps strength, and significant difference between Asian females and males in the arm extension exercise. Caucasian females have about 53% of the triceps strength of their male counterparts, while Asian females only have 48% of triceps strength of their male counterparts.

Table 2. Triceps strength in arm-extension (both arms)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	55	46.2	14.6	81	87.4	23.1	41.2	<.00**	52.9%
Asian	11	39.6	10.1	38	82.1	29.8	42.5	<.00**	48.2%

B. Upper-back and chest strength

Results in Table 3 demonstrated significant difference between Caucasian female and males on the chest muscle (Pectoralis) strength, and significant difference between Asian females and males in the bench press exercise. Caucasian females have about 41% of the chest strength of their male counterparts, while Asian females only have about 39% of chest strength of their male counterparts.

Table 3. Pectoralis strength in bench-press (both arms)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	49	74.6	20.5	124	182.8	52.8	108.2	<.00**	40.8%
Asian	6	65.8	10.7	48	169.8	43.5	104.0	<.00**	38.8%

Results in Table 4 demonstrated significant difference between Caucasian female and males on the Upper-body muscle (Rhomboids and Teres Major) strength, and significant difference between Asian females and males in the seated rowing exercise. Caucasian females have about 50% of the upper-back strength of their male counterparts, while Asian females only have about 64% of upper-back strength of their male counterparts.

Table 4. Upper-back strength in seated-rowing of both arms

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	8	80.6	27.8	23	162.2	39.5	79.6	<.00**	49.7%
Asian	4	95.0	10.8	15	148	28.1	53.9	<.00**	63.8%

C. Shoulder strength

Results in Table 5 indicated significant difference between Caucasian female and males on the Upper-shoulder muscle (Deltoid and Trapezius) strength, and significant difference between Asian females and males in the shoulder press exercise. Caucasian females have about 49% of the deltoid strength of their male counterparts, while Asian females only have about 40% of deltoid strength of their male counterparts.

Table 5. Upper-shoulder strength in shoulder press (both arms)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	23	65.7	20.1	53	133.8	40.4	68.1	<.00**	49.1%
Asian	8	53.1	15.6	22	133.9	43.6	80.6	<.00**	39.7%

Results in Table 6 indicated significant difference between Caucasian females and males on the lower-shoulder muscle (Latissimus) strength, and significant difference between Asian females and males in the lateral pull-down exercise. Caucasian females have about 52% of the lower-shoulder strength of their male counterparts, while Asian females only have about 56% of low-shoulder strength of their male counterparts.

Table 6. Lower-shoulder and Latissimus strength in lateral pull-down of both arms

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	36	79.8	18.6	81	152.7	34.6	72.9	<.00**	52.3%
Asian	7	77.1	10.7	36	137.7	37.7	60.6	<.00**	56.0%

D. Leg strength

Results in Table 7 indicated significant difference between Caucasian females and males on the back-thigh muscle (Hamstring) strength, and significant difference between Asian females and males in the leg curl exercise. Caucasian females have about 59% of the hamstring strength of their male counterparts, while Asian females only have about 64% of hamstring strength of their male counterparts.

Table 7. Hamstring strength in leg curl (both legs)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	49	48.3	13.7	29	81.3	23.4	33.0	<.00**	59.4%
Asian	7	39.7	15.0	8	61.1	23.2	21.4	<.05**	64.4%

Results in Table 8 indicated significant difference between Caucasian females and males on the frontal thigh muscle (Quadriceps) strength, and significant difference between Asian females and males in the leg press exercise. Caucasian females have about 60% of the quadriceps strength of their male counterparts, while Asian females only have about 68% of front-thigh strength of their male counterparts. In leg extension exercise, Caucasian females have about 63% of the front-thigh strength of their male counterparts (Table 9).

Table 8. Quadriceps strength in leg press (both legs)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	55	240.9	73.4	53	402.2	23.4	161.3	.00**	59.9%
Asian	10	213	63.7	16	312.0	93.1	99.0	.01**	68.3%

Table 9. Quadriceps strength in leg extension (both legs)

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	28	81.2	26.6	23	129.7	44.1	48.5	.00**	62.6%

Results in Table 10 indicated significant difference between Caucasian females and males on the calf muscle (Gastrocnemius and Soleus) strength. Caucasian females have less than 60% of the calf strength of their male counterparts.

Table 10. Calf strength in toe press of both legs

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	13	241.2	105.8	12	420.7	91.7	179.5	.00**	57.3%

E. Abdominal strength

Results in Table 11 indicated significant difference between Caucasian females and males on the abdominal muscle (Rectus abdominis and Abdominal obliques) strength, and significant difference between Asian females and males in the sit-up exercise. The exercise was performed at a flat sit-up board. Caucasian females have about 58% of the abdominal strength of their male counterparts, while Asian females have about 57% of abdominal strength of their male counterparts.

Table 11. Abdominal strength in sit-up in one-set-max exercise

Race	Women			Men			Difference	t-test	Percentage of women/men
	n	mean	sd.	n	mean	sd.			
Caucasian	27	39.0	19.1	23	67.4	22.5	28.4	<.00**	57.9%
Asian	6	30.0	14.6	8	53.1	7.9	23.1	<.05**	56.5%

F. Lowest and highest ratio of women and men on different muscle strength

Table 12 listed the sequence of ratios between Caucasian women and men. The lowest muscle ratio is biceps, and the highest is leg press. Out of 11 exercises, the five lowest ratios are all upper-body muscles, and the highest ratios are all lower-body muscles. Therefore, Caucasian women are much weaker than Caucasian men on their upper-body strength.

Table 12. Order of difference among Caucasian students

	Women	Men	Difference	t-test	Percentage of women/men
	mean	mean			
1. Arm curl	30.8	82.4	49.6	<.00**	37.4%
2. Bench press	74.6	182.8	108.2	<.00**	40.8%
3. Military press	65.7	133.8	68.1	<.00**	49.1%
4. Seated row	80.6	162.2	79.6	<.00**	49.7%
5. Lateral pull-down	79.8	152.7	72.9	<.00**	52.3%
6. Arm extension	46.2	87.4	41.2	<.00**	52.9%
7. Toe press	241	420.7	179.5	<.00**	57.3%
8. Sit-up	39.0	67.4	28.4	<.00**	57.9%
9. Leg curl	48.3	81.3	33.0	<.00**	59.4%
10. Leg press	240.9	402.2	161.3	<.00**	59.9%
11. Leg extension	81.2	129.7	48.5	<.00**	62.6%

Table 13 listed the sequence of ratios between Asian women and men. The lowest muscle ratio is the chest, and the highest is leg press. Out of nine exercises, the three lowest ratios are all upper-body extension muscles, the middle four are all flexion muscles, and the two highest ratios are all leg muscles. Therefore, Asian women are much weaker than Asian men on their upper-body strength.

Table 13. Order of difference among Asian students

	Women	Men	Difference	t-test	Percentage of women/men
	mean	mean			
1. Bench press	65.8	169.8	104.0	<.00**	38.8%
2. Military press	53.1	133.9	80.8	<.00**	39.7%
3. Arm extension	39.6	82.1	42.5	<.00**	48.2%
4. Lateral pull-down	77.1	137.7	60.6	<.00**	56.0%
5. Sit-up	30.0	53.1	23.1	<.05*	56.5%
6. Arm curl	35.3	60.8	25.5	<.00**	58.1%
7. Seated row	95.0	148.9	53.9	<.00**	63.8%
8. Leg curl	39.7	61.1	21.4	<.05*	64.4%
9. Leg press	213.0	312.0	99.0	<.01**	68.3%

G. Muscle strength of American college students

Table 14 shows the average muscle strength of American college Caucasian students. Table 15 shows the average strength of Asian-American students. These numbers can be used as a reference for designing workout plans for males and females. The differences between males and females can be used as a reference or guide when designing tests or evaluation standards for males and females.

Both Table 14 and Table 15 listed muscle strength of opposite exercises. In both Caucasian and Asian groups, and in women and men groups, students showed following differences on opposite muscle strength: 1) triceps are stronger than biceps, 2) upper-back muscles are stronger than chest muscles, 3) lower-shoulder muscles are stronger than upper-shoulder muscles, 4) and front-thigh is much stronger than back-thigh.

Table 14. Opposite muscle strength of American college Caucasian students

	Women	Men	Difference	t-test	Percentage of women/men
	mean	mean			
1. Arm curl	30.8	82.4	49.6	<.00**	37.4%
2. Arm extension	46.2	87.4	41.2	<.00**	52.9%
3. Bench press	74.6	182.8	108.2	<.00**	40.8%
4. Seated row	80.6	162.2	79.6	<.00**	49.7%
5. Military press	65.7	133.8	68.1	<.00**	49.1%
6. Lateral pull-down	79.8	152.7	72.9	<.00**	52.3%
7. Leg curl	48.3	81.3	33.0	<.00**	59.4%
8. Leg press	240.9	402.2	161.3	<.00**	59.9%
9. Leg extension	81.2	129.7	48.5	<.00**	62.6%
10. Toe press	241	420.7	179.5	<.00**	57.3%
11. Sit-up	39.0	67.4	28.4	<.00**	57.9%

Table 15. Opposite muscle strength of American college Asian students

	Women	Men	Difference	t-test	Percentage of women/men
	mean	mean			
1. Arm curl	35.3	60.8	25.5	<.00**	58.1%
2. Arm extension	39.6	82.1	42.5	<.00**	48.2%
3. Bench press	65.8	169.8	104.0	<.00**	38.8%
4. Seated row	95.0	148.9	53.9	<.00**	63.8%
5. Military press	53.1	133.9	80.8	<.00**	39.7%
6. Lateral pull-down	77.1	137.7	60.6	<.00**	56.0%
7. Leg curl	39.7	61.1	21.4	<.05*	64.4%
8. Leg press	213.0	312.0	99.0	<.01**	68.3%
11. Sit-up	30.0	53.1	23.1	<.05*	56.5%

Conclusions

The muscle strength of both Caucasian and Asian female students is significantly lower than their counterparts on all five measurements: arm strength, upperbody and chest strength, shoulder strength, leg strength, and abdominal strength. Females have 37-68% of muscle strength of males in general.

Caucasian females have about 41-50% of males' chest and upper-back strength, and Asian females have about 48-58%. Caucasian females have about 39-64% of males' chest and upper-back strength, and Asian females have about 48-58%. Caucasian females have about 49-52% of males' shoulder strength, and Asian females have about 40-56%. Caucasian females have about 57-63% of males' leg strength, and Asian females have about 64-68%.

The difference on muscle strength between females and males is more on upper body, and less on lower body. Females are relatively stronger on their legs than arms and shoulders.

Students showed following differences on opposite muscle strength: 1) triceps are stronger than biceps, 2) upper-back muscles are stronger than chest muscles, 3) lower-shoulder muscles are stronger than upper-shoulder muscles, 4) and front-thigh is much stronger than back-thigh.

Applications

Women have significantly weaker muscle strength than men. This difference may impact many aspects in sport performance. Therefore, coaches should design different training plans and use different training methods for women in sport training.

Physical educators should apply different instructional strategies on teaching women physical activity that concerns muscle strength. The evaluation and assessment criteria should be different on women.

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