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Modeling the Differences between the Genders in Olympic Weightlifting Performance

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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Abstract

This article studies Weightlifting results from the 2000-2016 Olympic Games for both males and females to determine the differences between gender performance. The data showed that there are considerable differences in the competitive level between male and female lifters. This article compares the results of winners in a weight class with a given lifter in the weight class from year to year. This article shows that males in every competition studied had a lower mean percent difference from first than the same comparison for women. This article also compares the winner from each weight class to the weight class above them and observes the place that they would have received. Overall we see that for males, a winner in a weight class would be around 6th place in the weight class above them, while for females, a winner in a weight class would be around 4th in a weight class above them. We observe that as place increases, the difference between male and female results as well as the standard deviation between the results increases. We show that females are less competitive than males as the place that the lifter attained increases. There appears to be no association between weight class and mean percentage difference of the fifth place from first place for females. For males, there appears to be a decrease in the average percentage difference of the fifth place from first place as the weight class increases, meaning that the higher weight classes for males are more competitive than the lower weight classes.

Keywords: Weightlifting; performance difference; Olympic; gold medalist; modeling differences.

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1 Introduction

Over the last 15 years, participation in Olympic Weightlifting has been growing rapidly worldwide and has seen especially large growth in the United States. The creation of a new popular fitness craze, Crossfit, which combines the movements of weightlifting with powerlifting, gymnastics, and cardiovascular exercise has brought more attention worldwide to the sport of weightlifting which was once relatively unknown. Crossfit also has a large growing population of female participants which leads to more women learning the movements of Olympic Weighting and has increased competition for both American female weightlifting as well as increasing competitiveness in International competition. See [1, 2]. Weightlifting measures overall strength, flexibility, and athleticism and includes two lifts for which each lifter gets three attempts. The highest successful lift for each attempt is recorded and makes up the athlete's total. Men have a much longer history in the sport of weightlifting. Men began lifting in the first Olympic Games in 1896, while women first appeared in the Olympics in 2000. "Women have been in weightlifting for a very short time, when you consider the long history of men dominating the sport. So on the competitive side of things, weightlifting is at a level for women where participants could actually achieve a lot more and go further [3]". This study analyzed weightlifting performance differences between males and females from the 2000-2016 Olympic Games. See [4] for the 2012 Olympic results. The significance level (α) is 0.05.

2 Materials and Methods

2.1 Data

In this study, weightlifting data was collected from the 2000-2016 Olympic games. For each lifter, name, gender, country, total, actual bodyweight, place, event, and weight class were recorded. We also then determined the percentage difference each lifter lifted from first place in their event that year and recorded this for each lifter. The data set included 902 lifters with 346 females and 556 males. We used the top 10 lifters in each weight class and year. The data used for a particular chart, graph, or calculation is specified below. Irene Ajambo was removed from the data set because her performance was an extreme outlier [5]. There are 15 bodyweight categories with 8 for males and 7 for females [6].

3 Results

First, we will observe the relationship of place a lifter attains on the mean percent difference from the Gold medalist in their event. Comparing the slopes bellow, for each increase in place, the mean percent difference that the lifter is on average from first place grows about twice as fast for females as for males. For males, each increase in place corresponds to about a one percent increase in mean percent difference from first. We can conclude that as place increases, women are increasingly less competitive than males. Notice also the following graph which compares the standard deviations of the percent differences from first as place increases. We can see that both of these relationships are highly linear with R^2 value very close to 1.

Comparing the fits of standard deviations, we can see that the standard deviation of the percent difference of the lifters from first place of the female data grows at a rate about three times as quickly as that of male performance. We can again conclude from this, that female performance is increasingly variable as place increases.

Next, we want to see if percent difference of the 5th place lifter from a Gold medalist is dependant on the weight class. We want to see if certain weight classes are more competitive or have more homogeneity in their data.

The box-plot bellow clearly shows the mean percentage difference of 5th place lifters to the Gold medalists decreases as weight class level increases.

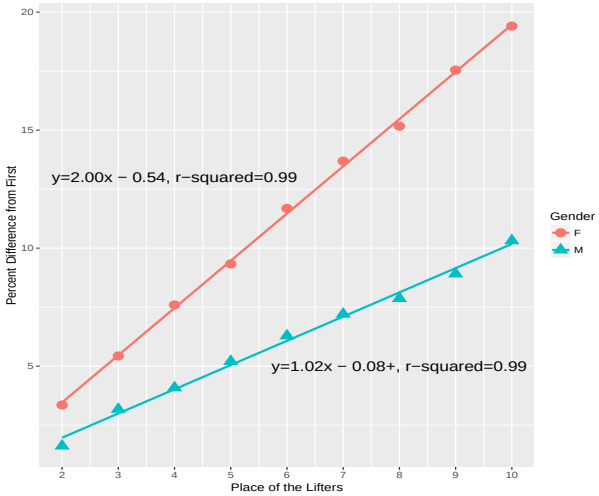

Fig. 1. Scatterplot of mean percent difference from a first place lifter and place a lifter attains

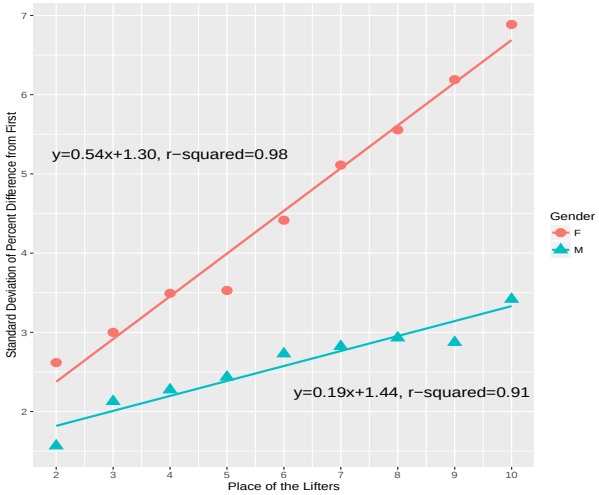

Fig. 2. Standard deviation of the percent difference from first as the place a lifter attains changes

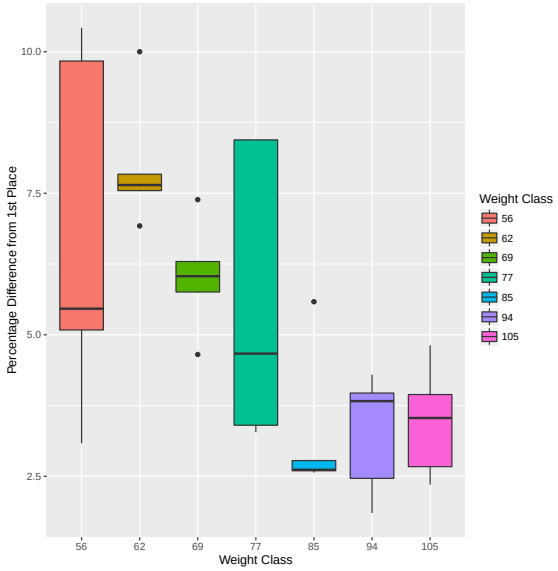

Fig. 3. Percent difference of 5th place lifters from Gold medalist for male weight classes

First, we run an analysis of variance (ANOVA) to determine if the percentage difference depends on weight class for males. Following is the null hypothesis that we are testing:

$$H_0 : \mu_{56} = \mu_{62} = \mu_{69} = \mu_{77} = \mu_{85} = \mu_{94} = \mu_{105}$$

where μ_{56} is the mean percent difference for the 5th place lifters in the 56kg weight class to the Gold medalists in the 56kg weight class and μ_{62} is the mean percent difference for the 5th place lifters in the 62 kg weight class to the Gold medalists in the 62kg weight class and so on. First, we checked the normality and constant variance assumption of ANOVA. The normality assumption is satisfied since the p-value on the Shapiro-Wilk test is 0.1045, but Levene's test for homogeneity of variance shows we don't have the constant variance assumption (p-value = 0.0226). From the analysis of variance (not assuming equal variances), we obtain a p-value of 0.00098 and can conclude that they are not all the same. Next, we run a Tukey Honestly pairwise significant differences for male weight classes.

Following is a table including p-values for which our pairwise test yielded a p-value less than 0.05. These results are also significant at the significance level of 0.01.

Table 1. Significant p-values of pairwise comparison for male weight classes

Weight classes compared	p-value
62 and 85	0.0037
62 and 94	0.0042
62 and 105	0.0061

From this, we can conclude that there is a decrease in percent difference from first as the weight class increases. From our ANOVA, we also saw that there is no statistical difference between the 85,94, and 105kg weight classes, the 69 and 77kg weight classes, and the 56 and 62kg weight classes.

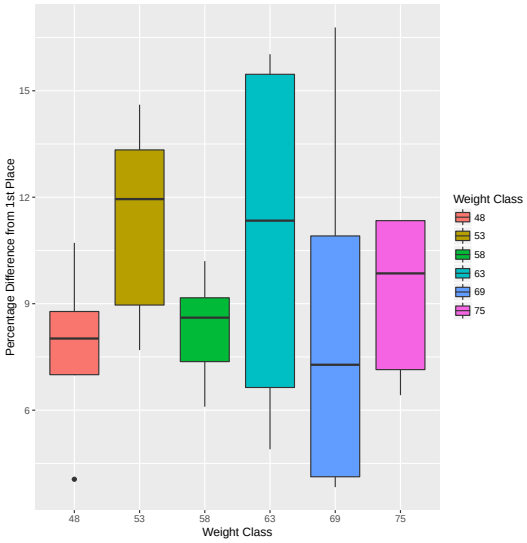

Fig. 4. Boxplot of the percent difference of 5th place lifters from Gold medalist for female weight classes

This boxplot was made using the percentage difference of the 5th place lifters from the Gold medalist. The normality assumption of ANOVA for females is also satisfied (the Shapiro-Wilk normality test p-value = 0.8258), but Levene's test shows the constant variance assumption is not satisfied (p-value = 0.03664). ANOVA test (not assuming equal variances) shows there is no significant differences between weight class for females with respect to the percentage difference of the 5th place lifters from the Gold medalist (p-value = 0.4635). This tells us that for females, the mean percent difference of 5th place from first does not depend on weight class.

We can see that for men, there appears to be a negative association between weight class and percentage difference from first place. We can conclude that for males, the heavier weight classes are more competitive than the lower weight classes. For women, there seems to be no association between weight class and percentage difference from first.

Next, this research observe how competitive a winner can be in a weight class above them. Since we have small sample sizes, for the following tests we will use the Mann-Whitney U-Statistic as our test to compare these populations. This test is nonparametric and does not assume constant variance and normality.

First, for males and for females, we want to test the winner of a weight class with the winner of the weight class above them to see if there is a difference in performance. We want to know if a winner in one weight class could also be a winner in the weight class above them. Since the p-values for these tests are low compared to 0.05 we reject the null hypothesis and can conclude that a winner in a weight class cannot also be a winner in the weight class above them for both males and females.

Table 2. Comparing a Gold medalist to a Gold medalist in the weight class above them for both males and females

Gender	U Statistics	P-Value
M	312	0.00382
F	384	0.0001372

We want to see where a winner would perform in the weight class above them. Following is a chart showing the average winner of a weight class' total and their average place in the weight class above them for males.

Table 3. Average performance of male winners in a weight class and place they would attain in the weight class above

Weight class	Average Winner's Total	Average Place In weight class Above
56	298.4	5
62	322.8	7
69	349.8	6
77	373.3	6
85	389.5	8
94	407.9	6
Average:	**357**	**6.33**

Using the performance of winners from 2000-2016, we determine that for males, on average, a winner of a weight class would be 6.33 place in the weight class above them. Next, we will compare a winner of a weight class to the 6th place lifter in the weight class above them. From the table bellowe, we see that our p-value is high and we can conclude that a winner in a weight class would attain 6th place in the weight class above them for males.

Table 4. Comparing a male Gold medalist to 6th place in the weight class above

U Statistics	p-value
447	0.9705

Following is the average performance of lifters that attained 6th place in the weight classes that have at least one weight class directly below them. Note that the average of 6th place lifters with a weight class below them, 356.6kg, is very close to the average of all first place lifters with at least one weight class above them, 357kg. Comparing male winners to 6th place in the weight class above them, we can conclude that being a winner of a male weight class is the same of being 6th place in the weight class above.

Similarly, we want to see how female winners perform in the weight class above them. For women, on average, Gold medalists obtain 3.8 place.

Table 5. Average weight lifted by 6th place males

Weight class	Average Performance 6th Place
62	294.7
69	324.1
77	348.9
85	372.7
94	392.9
105	406.6
Average	**356.6**

Table 6. Average performance of female winners in a weight class and place they would attain in the weight class above

Weight classes Compared	Average Winner's Total	Average Place In weight class
48	202.4	4
53	221.3	5
58	238.6	3
63	246.6	4
69	265.1	3
Average:	**234.8**	**3.8**

Next, we will compare Gold medalist females with 4th place lifters in the weight class above them. As given bellow, we have a high p-value which means a Gold medalist would be expected to attain 4th place if they were to compete one weight class up.

Table 7. Comparing a female Gold medalist to 4th place in the weight class above them

U Statistics	p-value
214.5	0.7048

Following is the average weight lifted by 4th place lifters for all the weight classes that have at least one weight class below them.

Table 8. Average weight lifted by 4th place females

Weight class	Average Performance 4th Place
53	198.8
58	222.4
63	226.9
69	246.3
75	252.9
Average	**229.5**

From this we see that the average weight lifted by 4th place females with at least one weight class below them, 229.5kg, is close to the average weight lifted by first place females with at least one weight class above them, 234.8kg. Comparing winners to 4th place in the weight class above them, we can conclude that a winner of a female weight class would be expected to place 4th in the weight class above them. We can see that men are much more competitive between weight classes. While on average male winner are three spots away from being a medalist in the weight class above them, we see that women are only one place away from being a medalist even when competing with other heavier women. We can also see that on average, for the years studies, in the 58kg and 96kg weight class for females, the winner of this weight class could also be a Bronze medalist in the weight class above them.

It is of interest to observe how similar weight classes between genders compare. Due to structural differences in the anatomy of males and females, we know that males and females of the same weight will lift differently. We want to see how differently the genders perform. There is only one weight class that is the same for both males and females (69kg), there are however many similar weight classes. Following are the comparable weight classes as well as the average weight lifted by the winners.

Table 9. Comparable weight classes and average weight lifted by each weight class' Gold medalists

Male	Average Total (kg)	Female	Average Total (kg)
56	298.4	58	238.6
62	322.8	63	246.6
69	349.8	69	265.1
77	373.3	75	272.9

For each of these comparisons, we compare winners for each year and for each individual weight class. First we want to see if there is a difference between men and women with similar masses. Following is the test between males and females:

Table 10. Comparison of Gold medalist males and Gold medalist females of comparable sizes

U Statistics	p-value
400	6.72e-8

From this, we can conclude that men and women of similar weights do not lift the same. Next, we want to compare how differently the genders of similar sizes perform. Looking at Table 11, on average, over the time period observed, male winners lifted 80.28 kilograms more than female winners of similar size. Observing only the most recent Olympic competition, Rio 2016, we see that one average males lifted 79.75 kilograms more than women and the average weight difference is possibly decreasing.

Next, we will observe the gender difference of similar size lifters over the years 2000-2016. As we can see from Table 12, from 2000 to 2004 there is a very large drop in the percent difference in the amount of weight lifted by the strongest men and women in similar weight classes. Again, from 2004 to 2008 there is a decrease in the percent difference. But, from 2008 to 2012 and 2012 to 2016, we can see that the difference increases again. We can see though that the percent changes in these two year combined are less than the drop from 2004 to 2008. We should consider the possibility

that we are seeing the average percent difference leveling out as we get farther from 2000, when women first began competing. "The results in female weightlifting today have much higher level than 15-20 years ago...in the case of female competitors, there are no well balanced results, the non homogeneity is high; there are huge differences between the results of the winners and the others[4]"

Table 11. Gender performance difference over all years studied and the most recent event

Year	Average Weight Difference Between Male and Female (kg)	Standard Deviation	Average % Difference Between Male and Female
2000-2016	80.28	37.83	23.25
2016	79.75	44.84	22.77

Table 12. Change in gender performance difference over time. n/a means no value

Year	Avg Weight Difference	Avg% Difference	Avg%Diff Previous Year
2000	99.9	29.236	n/a
2004	78.75	23.26	-5.97
2008	66.5	20.42	-2.84
2012	75	22.12	1.7
2016	79.75	23.24	1.12

Observing the 2012 Beijing Olympic Games, we noticed that performance of the winner in the 62kg category for males was very similar to performance in the 75+ kilogram category for females.

Table 13. Comparing winners of the 62kg male weight class to the 75+kg female weight class

Year	62kg Male Winner	75+kg Female Winner
2000	325	300
2004	325	305
2008	319	326
2012	327	333
2016	318	307
Average:	**322.8**	**314.2**

Comparing these two weight classes from 2000-2016, we obtain p-value of 0.2594. Therefore, we can conclude that a winner of the 62kg weight class for males performs the same as a winner of the 75+kg weight class for females.

We also observed that winning the 56kg category for males may be comparable to winning the 75kg for females.

Comparing the 56kg male weight class to the 75kg female weight class, we see that our p-value is less than 0.05. Therefore, we reject the null hypothesis. We cannot conclude that a male winner

of the 56kg weight class is the same as a female winner of the 75kg female weight class. We can see from the Table 15, that Gold medalists in the 56kg male weight class are expected to lift more than 75kg female Gold medalists.

Table 14. Comparing the winners of 62kg male weight class with the winners of the 75+kg female weight class

U Statistics	p-value
417	0.2594

Table 15. Comparing winners of the 56kg male weight class to 75kg female winners

Year	56kg Male Winner	75kg Female Winner
2000	305	245
2004	295	272.5
2008	292	282
2012	293	291
2016	307	274
Average:	**298.4**	**272.9**

Table 16. Comparing the 56kg male weight class to the 75kg female weight class

U Statistics	p-value
295.5	0.026

4 Discussion

This study have shown that the competitive level of male weightlifting is considerably above female weightlifting, but the gap between the genders is closing. While we expect males to lift more due to differences in anatomy, we expect to see in the future this gap closing and female data be less spread out and more competitive. Females have a considerably shorter history in the sport with participation in only five Olympic Games so far. We expect that as time increases, women will become more competitive. Internationally, women competing in weightlifting have seen some pushback. In the beginning, Muslim nations female participation was problematic. "The problem was the over-revealing regulation lifting suits worn by women, which were unsuitable for Muslim women." This has since been dealt with and the IWF approved a "unitard" that covered everything including the hair. While some countries continue to have issues with women competing, most countries encourage women to compete. However, continues to be some negative connotations attached to weightlifting for women [7, 8, 9]. Many people picture unrealistically large, steroid-using women, which could not be farther from the reality of what female Olympic Weightlifting is. As female participation in the sport increases, the stigma of female weightlifting continues to vanish. The International Weightlifting Federation is also addressing this issue and attempting to balance the genders. See also [10]. The IWF voted on August 31, 2016, to include an additional weight class for women, which will mean there are now the same number of weight classes for men and women. The new weight class adopted is 90kg and the super heavyweight category will move up to 90+ kilograms. The first competition to adopt these weight classes was the American Open in December. It is of interest to see how these changes will affect the heterogeneity in female performance.

5 Conclusions

In this paper, we have shown that for all criteria measured in this paper, males are more competitive weightlifters. For female lifters, for each increase in place, the mean percent difference that the lifter is on average from first place increases at about twice as fast as for males. In addition, a Gold medalist in a weight class would attain 6th and 4th place in the weight class above them for males and females, respectively. Future research should continue to observe female performance over time to see if there continues to be an improvement in competitiveness as women have been competing longer and acceptance for the sport continues to increase. It should be observed how the addition of the new female weight class affects the data.

Competing Interests

Authors have declared that no competing interests exist.

References

[1] Capranica L, Piacentini M, Halson S, Myburgh KH, Ogasawara E, Millard-Stafford M. The Gender Gap in Sport Performance: Equity influences equality. International Journal of Sports Physiology & Performance. 2013;8(1):99-103.

[2] Stone M, Pierce K, Sands W, Stone M. Weightlifting: A brief overview. Strength & Conditioning Journal. 2006;28(1):50-66.

[3] Markovic G, Sekulic D. Modeling the influence of body size on weightlifting and powerlifting performance. Coll. Antropol. 2006;30:607-613.

[4] Szabo AS, Nemith-Mora A, Adamfi A, Tolnay P. Comparative analysis of balanced state of weightlifting results of male and female competitors at the London 2012 Olympic Games. Sport SPA. 2013;10(1):63-66.

[5] Olympic Sports. SportsReference.com.

[6] Results by Event. International Weightlifting Federation. iwf.net.

[7] Patton C. Rock hard: Judging the female physique. Journal of Sport and Social Issues. 2001;25(2):118-140.

[8] Salvatore J, Marecek J. Gender in the gym: Evaluation concerns as barriers to womens weight lifting. Sex Roles. 2010;63(7-8):556-567.

[9] Scott-Dixon K. Big girls don't cry: Fitness, fatness, and the production of feminist knowledge. Sociology of Sport Journal. 2008;25(1):22-47.

[10] Thibault V, Guillaume M, Berthelot G, El Helou N, Schaal K, Quinquis L, Toussaint J. Women and men in sport performance: The gender gap has not evolved since 1983. Journal of Sports Science & Medicine. 2010;9(2):214-223.

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