Statistical Visualization of Strength Measurement Formulas Across Powerlifting

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Project Summary

The purpose of this project is to show the differences in strength systems that are used to measure strength of lifters across different genders and weight classes. To this day, there are ongoing conversations of how to measure strength of a lifter in order to dictate what feats are considered "best". This project serves to provide a brief overview of the current systems in place and choose the best system overall based on the data points worked with.

Contents

1 Summary of Powerlifting

Powerlifting is an up and coming popular sport that has been gaining traction in the last few decades. It is considered a strength sport that involves a barbell, similar to olympic weightlifting, expect it focuses on the 3 compound lifts: squat, bench press, and deadlift. In a typical competition, powerlifters come together in a meet and have a total of 9 attempts, 3 for each lift, in order to acheive the maximum total possible. A 4th lift is permitted if the 4th lift is an attempt at breaking a current record but it does not count towards the lifters total. The compeititors are placed into respective weight classes and these weight classes differ depending on the federation that they compete in. The federation that we are focusing on in this paper is the USA Powerlifting (USAPL). The type of powerlifting we are focusing on is classic raw, which refers to the type of equipment that is allowed to be used in competition and the number of lifts that are expected to be done at the meet in this case, all three of them. The only equipment that is allowed is a lifting belt and wrist wraps.

Squat

The squat is the first lift in a typical powerlifting meet. It requires a lift to place a bar on their back and squatting to the point where the top of their knee is in line with their hip crease (the hip crease can be lower but it must reach the top of the knee at minimum) in order to be considered a "good" lift. This is a standard that is required for all lifters to do, otherwise the lift is disqualified from counting towards their total.

Bench Press

The bench press is the second lift in a typical powerlifting meet. It requires to be in a face-up prone position on a bench. The lifter takes a bar in their hands and has the bar descend until the bar touches a point on their torso (wherever that may be). The lifter must hold the bar in that position until given a command to press by a ref. If the command is not followed, the lift is disqualified from counting towards their total.

Deadlift

The deadlift is the third and last lift in a typical powerlifting meet. The standards for this lift aren't as rigourous as the others. A lifter simply has to reach down and lift a bar until they are completely upright. If the bar shows any downward movement during the lift, it is disqualified from counting towards their total.

Rankings

At the end of a meet, the lifter with the highest total in their weight class wins for their respective weight class. However, the lifter with the highest score based on a strength formula to calculate the highest relative strength can be given whichever lifter has the highest relative score. The current metric that USAPL uses is IPF formula. Prior to 2019, USAPL used the Wilks Coefficients to generate a Wilks score.

2 The Different Strength Metrics

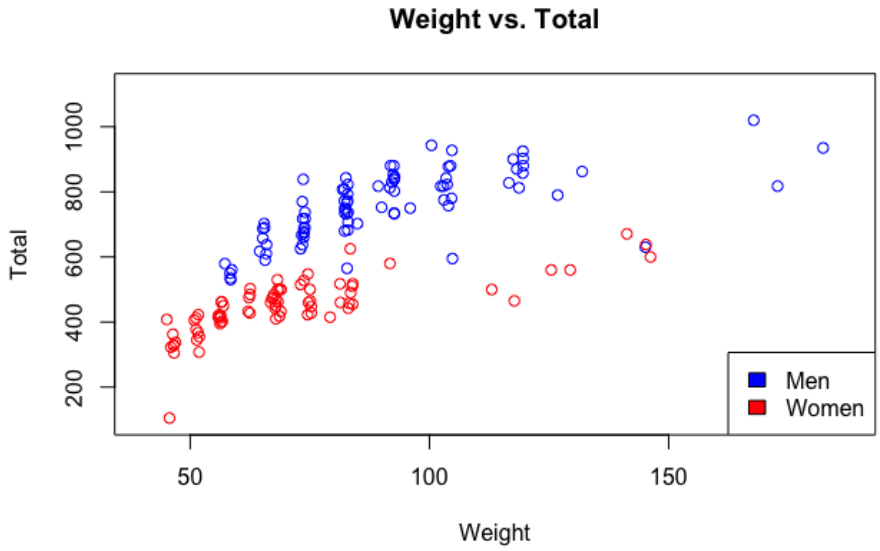
There are various strength metrics that have been used to judge relative strength scores across weight classes. They have primarily been used to give awards for "best" lifter all around at a particular meet. The need for strength scores are necessary. Using absolute total, i.e. whoever lifts the highest total, regardless of weight class, is the best lifter, or using a bodyweight multiplier score, i.e. whoever has the highest ratio of total to bodyweight is the best lifter, can easily be shown to be skewed to heavier lifters and lighter lifters, respectively. The goal of this system to provide a fair metric where there are no advantages whether you are a lightweight or superheavy weight, male or female, etc. For any graphs, we do not want to see any type of linear relationship.

We will be looking at 7 different graphs. The x-axis will be the weight of the lifter in kilograms and the y-axis will be the proposed method of measuring strength. The variables for the y-axis are: total, body weight multiplier, wilks score, wilks-2 score, DOTS score, IPF, and GL.

The data used for the creation of these graphs was obtained at [2]. This is a database where USAPL stores all data regarding powerlifitng meets. The meet we are looking at was Raw Nationals that took place on June 14, 2021. This meet provided 84 data points for men and 74 data points for women for a total of 158 data points.

2.1 Strength Metric: Absolute Total

The first metric we will look at is simply the total that a lifter achieves. As mentioned before, using this metric becomes noticeably skewed towards the heavier lifters at a meet. A graph of bodyweight versus total is shown below.



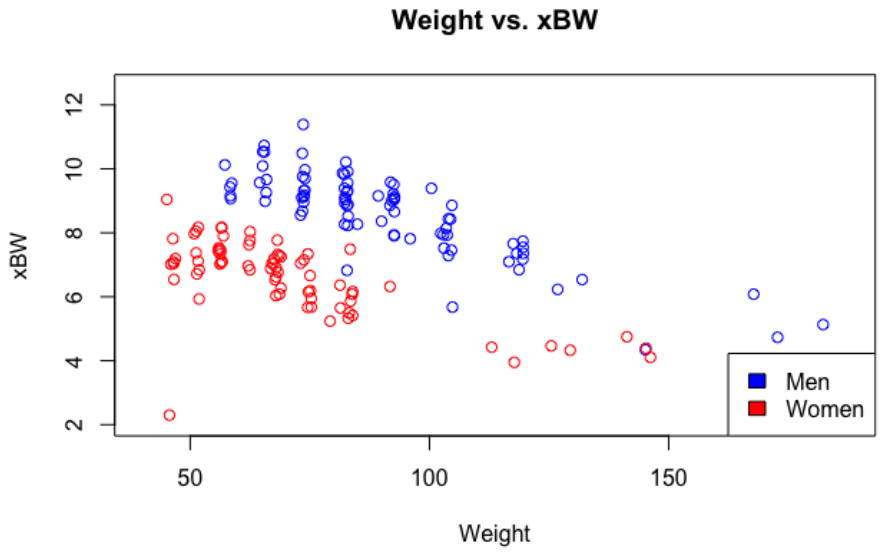
It is noticeable that there is an increasing linear relationship between weight and total. The higher the weight, the higher the total, typically. You can also see that men almost always have higher totals than women. Thus, it would not be fair towards lighter lifters and women to use absolute total as a strength metric.

2.2 Strength Metric: Bodyweight Multiplier

The second metric we will look at is a bodyweight multipler of amount of weight lifter compared to body weight. The formula for calculating the bodyweight multiplier is:

$$xBW = \frac{Total}{BW}$$

where $Total$ and BW are measured in kilograms. A graphic of bodyweight versus bodyweight multiplier is shown below.



It is noticeable that there is a decreasing linear relationship between weight and bodyweight multiplier. The lower the weight, the higher the bodyweight multiplier score, typically. You can also see that men almost always have a higher bodyweight multiplier than women. Thus, it would not be fair towards heaiver lifters and women to use a bodyweight multiplier score as a strength metric.

2.3 Strength Metric: Wilks Formula

The third metric we will look at is the Wilks Formula or the Wilks Coefficients. The formula for calculating the wilks score is

$$Wilks\ Score = Total \cdot \frac{500}{A \cdot BW^5 + B \cdot BW^4 + C \cdot BW^3 + D \cdot BW^2 + E \cdot BW + F}$$

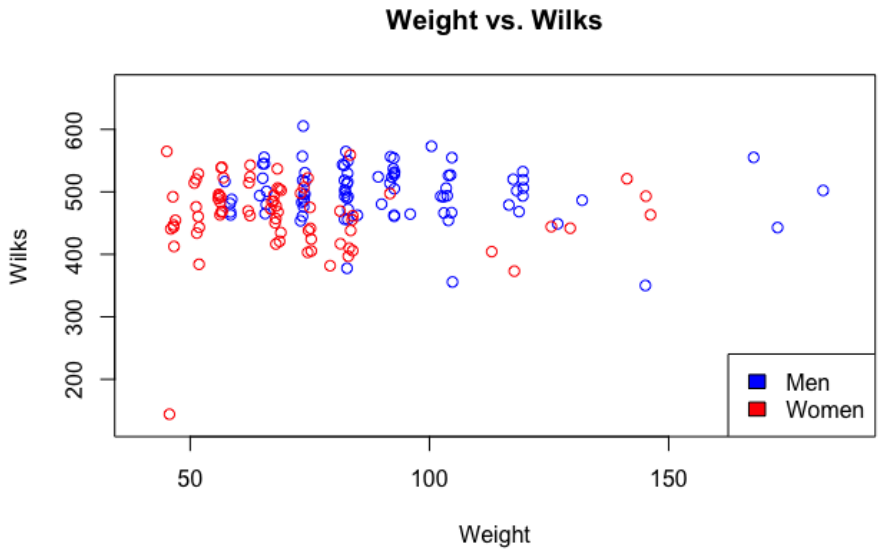
where coefficients for men are:

$A = -0.00000001291$
$B = 0.00000701863$
$C = -0.00113732$
$D = -0.002388645$
$E = 16.2606339$
$F = -216.0475144$

and coefficients for women are:

$A = -0.0000009054$
$B = 0.00004731582$
$C = -0.00930733913$
$D = 0.82112226871$
$E = 27.23842536447$
$F = 594.31747775582$

A graph of bodyweight versus wilks score is found below.



You can see in this figure that any linear relationship that we have seen before has reduced greatly. You can also see that scores amongst men and women are now more similar to one another than they were before. Thus, the wilks formula would be a much better metric to use than absolute total or body weight multiplier.

2.4 Strength Metric: Wilks-2 Formula

The fourth metric we will look at is the Wilks-2 formula. This is an update to the previous Wilks formula. I suspect that this update occurred because more and more elite level athletes kept brekaing records and thus the coefficients needed to take into account the new data points. The formula for calculting the wilks-2 score is:

$$Wilks - 2\ Score = Total \cdot \frac{600}{A \cdot BW^5 + B \cdot BW^4 + C \cdot BW^3 + D \cdot BW^2 + E \cdot BW + F}$$

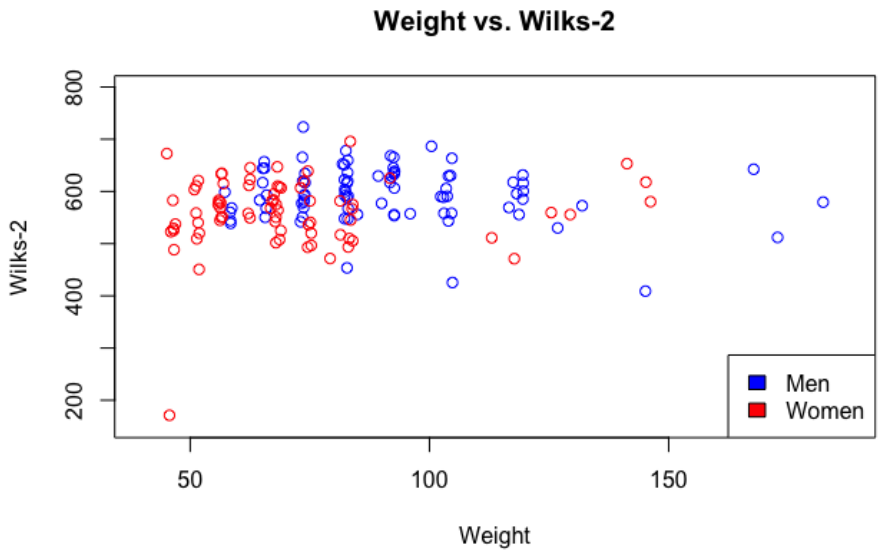
where coefficients for men are:

$A = -0.0000000120804336482315$
$B = 0.00000707665973070743$
$C = -0.00139583381094385$
$D = 0.073694103462609$
$E = 8.47206137941125$
$F = 47.4617885411949$

and coefficients for women are:

$A = -0.000000023334613884954$
$B = 0.00000938773881462799$
$C = -0.0010504000506583$
$D = -0.0330725063103405$
$E = 13.7121941940668$
$F = -125.425539779509$

A graph of bodyweight versus wilks-2 score is found below.



This graph looks somewhat similar to 2.3 however women tend to have a higher score with the wilks-2 formula, perhaps making it a more fair metric for women compared to the original wilks formula. We can still conclude that the wilks metric would make a better metric than the absolute total or body weight multiplier.

2.5 Strenght Metric: DOTS Formula

The fifth metric we will look at is the DOTS formula. It looks similar to the wilks formula. The formula for calculating the DOTS score is:

$$DOTS\ Score = Total \cdot \frac{500}{A \cdot BW^4 + B \cdot BW^3 + C \cdot BW^2 + D \cdot BW + E}$$

where coefficients for men are:

$A = -0.000001093$

$B = 0.0007391293$

$C = -0.1918759221$

$D = 24.0900756$

$E = -307.75076$

and coefficients for women are:

$A = -0.0000010706$

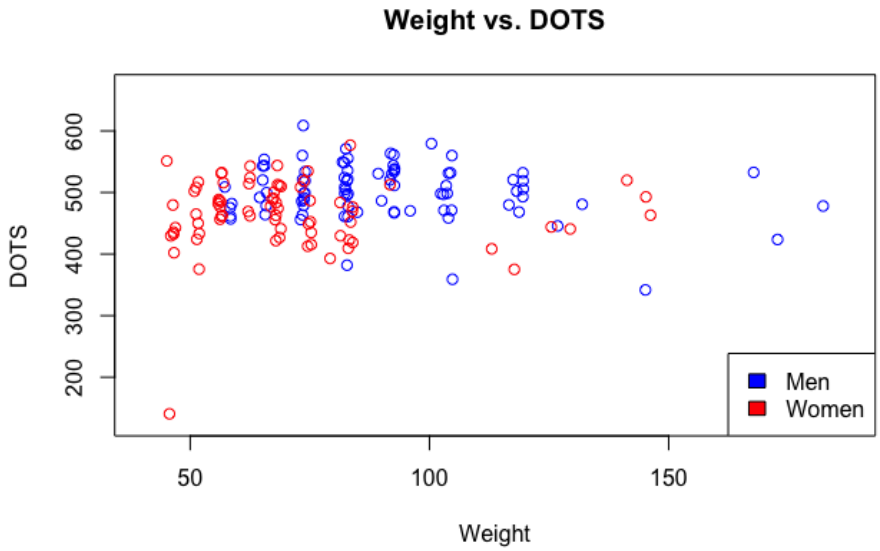
$B = 0.0005158568$

$C = -0.1126655495$

$D = 13.6175032$

$E = -57.96288$

A graph of bodyweight versus DOTS score is found below.



This graph and the original wilks graph 2.3 look nearly identical. Considering the formulas are also very similar, it is probably safe to say that the two aren't that different.

2.6 Strength Metric: IPF Formula

The sixth metric we will look at is the IPF Formula. This is the current metric that is used in USAPL meets as well as IPF competitions. The formula for this metric also looks greatly different compared to the ones

we have seen before. The formula for calculating an IPF score is:

$$IPF\ Score = 500 + 100 \cdot \frac{Total - (A \cdot \ln(BW) - B)}{C \cdot \ln(BW) - D}$$

The coefficients for men and women are based on the type of competition that is being done. In this case, we will use the coefficients for classic powerlifting or raw powerlifting. The coefficients for men are:

$A = 310.6700$

$B = 857.7850$

$C = 53.2160$

$D = 147.0835$

and the coefficients for women are:

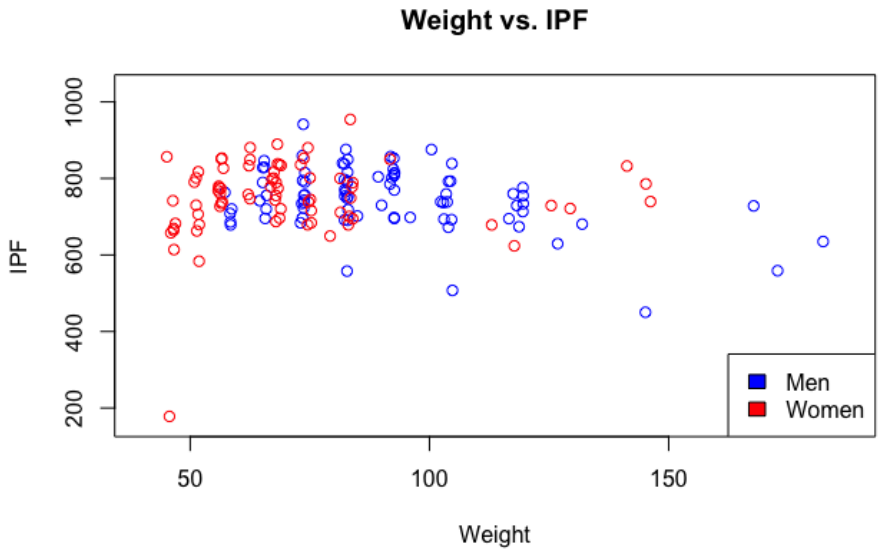
$A = 125.1435$

$B = 228.0300$

$C = 34.5246$

$D = 86.8301$

A graph of bodyweight versus IPF score is found below:



This graph shows a noticeable increase of scores for women compared to men. In all previous graphs, the highest score belong to a man. In this graph, that score now belongs to a woman. Again, perhaps this is in an effort to make it more fair towards women. More in the discussion section later.

2.7 Strength Metric: GL Formula

The seventh and last metric we will look at is the GL Formula. This formula also looks different than the rest and is the first to introduce an exponential. The formula is:

$$GL\ Score = Total \cdot \frac{100}{A - B \cdot e^{-C \cdot BW}}$$

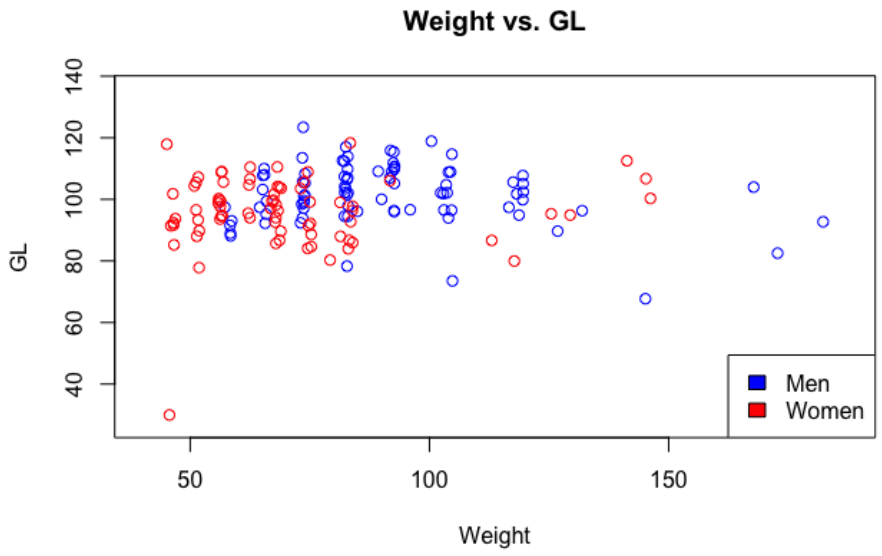
The coefficients for classic powerlifting for men are:

$A = 1199.72839$
$B = 1025.18162$
$C = 0.00921$

and the coefficients for women are:

$A = 610.32796$
$B = 1045.59282$
$C = 0.03048$

A graph of bodyweight versus GL score is found below:



This graph shows simlar results to the Wilks-2 graph 2.4. No notable observations can be made that is different than the previous graphs other than this metric would serve as a better one than the first two.

3 Discussion of Results

In the previous section, we looked at the different strength metrics that one could use. We quickly saw that the first two, absolute total 2.1 and body weight multiplier 2.2, showed a largeskewed that favored heaiver and light lifters, respectively. Both favored men over women as the stronger relative lifter.

All the other metrics seemed to serve as much better metrics in comparison to the first two. However, if you look closely, all graphs except the IPF graph 2.6 show clusters of women scoring noticeably below men in their respective weight classes. Whether this means that men are typically stronger relative lifters in comparison than women, I am not sure of but this could show a potential bias towards men in these formulas.

However, looking at the IPF Formula, it seems to be the one that looks most fair across weight classes and men and women. Although we are only looking at one particular meet, it makes sense that this metric is currently being used for USAPL competitions.

References

[1] Oleksandr Kopayev, Borys Onyschenko, Anatoliy Stetsenko, *Evaluation of Wilks, Wilks-2, DOTS, IPF and Goodlift formulas for calculating relative scores in IPF powerlifting competitions*, Powerlift.Sport, https://www.powerlifting.sport/fileadmin/ipf/data/ipf-formula/Models-Evaluation-I-2020.pdf, Accesssed April 2022

[2] No Author Available, *USAPL*, USAPL Lifting Databases, https://usapl.liftingdatabase.com/competitions-view?id=119704, Accessed April 2022