SINCLAIR BODYWEIGHT CORRECTION FORMULA

1. Forward

It is with a heavy heart that I put together this current Sinclair Coefficients (S.C.) package. It feels just like yesterday when Dr. Roy Sinclair asked if I could provide some assistance in putting the 1997-2000 S.C. package together. His ask was simple, could I use my computer skills to produce a Sinclair Coefficient chart. (which we have included in every S.C. package since) I had no idea what I was getting myself into… looking back, I'm sure he had ulterior motives… and so my mentoring began. Skip forward a couple of years, 1998 I moved to a new city for work and kept in touch with Roy and told him to call when he would like to discuss the plans for the next S.C. package. While at work in June/July of 2000, I was called to the front of the office as someone was there to see me, it was Dr. Roy Sinclair, he tracked me down, drove to town and wanted to discuss the 2001-2004 S.C. package. That was Roy. We talked for over 3 hours in a conference room. It was impossible to keep our conversations short. Roy was the humblest individual I've ever met and had a great deal of patience as I got up to speed with his S.C. Formula. Recall that Roy has a PHD in Mathematics and just assumed that I understood everything that we discussed. He challenged me intellectually and pushed my understanding of mathematics to a completely new level. His brilliance went well beyond his PHD in Mathematics, Roy was also an avid reader and extremely well read. Combining these traits, he naturally dabbled in the stock market and did quite well. Little did I know that our conversations around market trends and how to interpret the "data" would lend itself to working on the Sinclair Bodyweight Correction Formula. I am very grateful for his guidance over the years.

A little-known fact is that Roy worked out all of his calculations by hand with paper and pencil. For the vast amount of calculations, he left this up to his trusty HP-48SX calculator with his programs written in Reverse Polish Notation (RPN). The complete regression of calculations for the S.C. package for all bodyweight classes originally took him over 3 months. Over the years Roy upgraded his HP calculator… to bigger HP Calculators, this was where he was most comfortable and left me trying to decipher his RPN so that we could compare calculations. But when all else failed, we had his trusty pencil and paper, solving matrix math equations and plotting on lined paper.

Dr. Roy Sinclair was a sportsman in his day and he fell in love with the sport of Olympic Weightlifting which was evident in every conversation that one had with him. His passion for Mathematics, his ability to interpret data and the simple question that started his journey "What would be the total of an athlete weighing *x* kg if he/she were an athlete in the heaviest category of the same level of ability?"

On behalf of Dr. Roy Sinclair's Daughter and grand Daughter, it is my pleasure and honor to maintain the Sinclair Bodyweight Correction Formula. You are greatly missed my friend.

2. Introduction

In Olympic Weightlifting in the current year of 2017 there are 8 bodyweight categories for both men and women. For men the upper bodyweight limits for the 7 lighter categories are (in kilograms) 56, 62, 69, 77, 85, 94 and 105 while the heaviest category has, NOT an upper bound, but rather a lower bound of 105 kg (which must be exceeded) and, in referring to this heaviest category, it is designated by +105. Similarly, for the women, the relevant bodyweights being 48, 53, 58, 63, 75, 90 and +90.

Since the heavier athletes usually lift more than the lighter athletes, we assume that for the lighter categories, the World Record Total (abbreviated to WRT) was produced by an athlete very close to the upper bodyweight limit. But for the heaviest bodyweight category there is a lower bodyweight limit but NO upper bodyweight limit.

Consequently if we arbitrarily ASSIGN a bodyweight to the heaviest category (call it b kg for convenience) then we can use the mathematical Method of Least Squares to find the curve representing the 'best fit' quadratic curve (selected by employing Dimensional Analysis) corresponding to the selection made for b kg. But note that this selection of b kg also yields a sum (designated below by S) where S is the sum of squares of the differences of the 'best fit' curve from the observed data. So by plotting S against b and choosing the b that corresponds to the minimum value obtained for S, we can arrive at the most suitable bodyweight (b kg) to assign to the heaviest bodyweight category.

Since there are 8 bodyweight categories for both men and women the summations are represented as going from i=1 to i=m (i=index) where m=8 for both men and women. So for convenience in writing summation we write:

$$\sum = \sum_{i=1}^{m}$$

Furthermore, reflecting the bodyweights x kg and the totals y kg common in earlier days when the theory was developed, we define the dimensionless quantities X and Y by:

	MEN	WOMEN
X	$lc(x/52)$	$lc(x/44)$
Y	$lc(y/240)$	$lc(y/140)$

Where lc means the common logarithm (i.e. to base 10). Note also that the final formulations are independent of these choices.

3. Procedure

Our *m* data points (recall that *m*=8 for both men and women) are employed (after arbitrarily assigning a value to *b*) in finding the 'best fit' co-efficients *A, B, C* to the parabola:

$$Y = -AX^2 + BX + C$$

This is accomplished by finding the values of *A, B* and *C* that minimize the sum:

$$S = \sum \left(-AX_i{}^2 + BX_i + C - Y_i\right)^2$$

And this is accomplished by solving the following linear system:

$$\frac{1}{2}\cdot\frac{\partial S}{\partial A} = 0 = \sum(-AX_i^2 + BX_i + C - Y_i)X_i^2$$

$$\frac{1}{2}\cdot\frac{\partial S}{\partial B} = 0 = \sum(-AX_i^2 + BX_i + C - Y_i)X_i$$

$$\frac{1}{2}\cdot\frac{\partial S}{\partial C} = 0 = \sum(-AX_i^2 + BX_i + C - Y_i)$$

where for men $\begin{cases} X_i = lc(x_i/52) \\ Y_i = lc(y_i/240) \end{cases}$ and for women $\begin{cases} X_i = lc(x_i/44) \\ Y_i = lc(y_i/140) \end{cases}$

This can be written more compactly in matrix notation as:

$$\begin{pmatrix} u_4 & u_3 & u_2 \\ u_3 & u_2 & u_1 \\ u_2 & u_1 & m \end{pmatrix} \begin{pmatrix} -A \\ B \\ C \end{pmatrix} = \begin{pmatrix} v_2 \\ v_1 \\ v_0 \end{pmatrix}$$

where: $u_4 = \sum X_i^4$ $\quad v_2 = \sum Y_i X_i^2$

$u_3 = \sum X_i^3$ $\quad v_1 = \sum Y_i X_i$

$u_2 = \sum X_i^2$ $\quad v_0 = \sum Y_i$

$u_1 = \sum X_i$

By plotting the values obtained for *S* against the various values assigned to *b*, we finally arrive at a value for *b* that yields minimum value for *S*.

4. Application

Suppose that we have now found the value of b that minimizes S and have also found the corresponding values of A, B and C. The apex of the downward-opening parabola is now easily obtained.

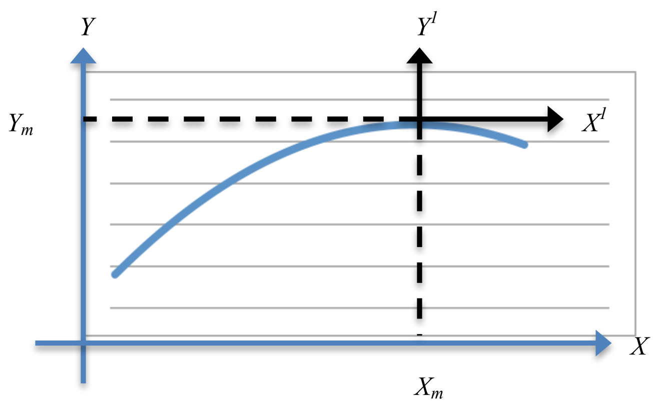
$$\frac{\partial Y}{\partial X} = 0 = -2AX + B \qquad \therefore X = \frac{-B}{2A}$$

$$Y = -A\left(\frac{-B}{2A}\right)^2 + B\left(\frac{-B}{2A}\right) + C = C - \frac{B^2}{4A}$$

Call this point (X_m, Y_m) where m denotes the maximum of the parabola. We now set up a new co-ordinate system with its origin at the apex of the parabola.

Let $\begin{cases} X^1 = X - X_m \\ Y^1 = Y - Y_m \end{cases}$

Then $\begin{cases} X = X^1 + X_m \\ Y = Y^1 + Y_m \end{cases}$



So $Y^1 = Y - Y_m$

$$= -AX^2 + BX + C - Y_m$$

$$= -A(X^1 + X_m)^2 + B(X^1 + X_m) + C - Y_m$$

$$= -AX^{1^2} + (2AX_m + B)X^1 + (AX_m^2 + BX_m + C - Y_m)$$

where $(2AX_m + B)X^1 = 0$ and $(AX_m^2 + BX_m + C - Y_m) = 0$

$$= -AX^{1^2}$$

Thus $X^1 = X - X_m = lc(x/52) - lc(x_m/52) = lc(x/x_m)$

$Y^1 = Y - Y_m = lc(y/240) - lc(y_m/240) = lc(y/y_m)$

And $Y^1 = -AX^{1^2}$ becomes $\quad lc(y/y_m) = -A[lc(x/x_m)]^2 \quad \rightarrow \quad y_m/y = 10^{-A[lc(x/x_m)]^2}$

Canadian Weightlifting Federation
Haltérophile Canadienne (CWFHC)

This is the relationship we are seeking. It states the relationship between two ratios at the elite level, namely the ratio of bodyweights x_m/x and the ratio of WRT's y_m/y. So if an athlete in the *x* kg category totals *y* kg, that would correspond to an athlete in the super-heavyweight category $(x_m = b)$ doing y_m/y times as much. Stated differently, we have:

Actual Total x Sinclair Coefficient = Sinclair Total

Where Sinclair Coefficient $= 10^{-AX^2}$ and $X = log_{10}(x/b)$
(S.C. is equal to 1 if the athletes bodyweight of *x* kg exceeds *b* kg)

Actual Total $= y$ athlete has achieved y kg in total.

Sinclair Total $= ky_m$ is the total of an equally talented lifter in the super-heavyweight category

Or $y \times 10^{-AX^2} = ky_m$

Note that *x* and *y* in the development of this work are continuous variables. Also this work enables one to compare athletes in different bodyweight categories by comparing their totals as if they were both in the superheavyweight category.

5. Commentary

We have for both men and women the 7 data points (X_1, Y_1) to (X_7, Y_7) and only Y_8 for the heaviest category as X_8 is a widely varying quantity. We have shown above a way of achieving a reasonable estimate for the bodyweight, *b* kg, of the superheavyweight. In this regard note that Rezazadeh had the SAME total, 472.5 kg, in the 2000 Sydney Olympic Games and again in the 2004 Athens Olympic Games. But he weighed 147.45 kg in 2000 and 162.95 kg in 2004, a variation in bodyweight not possible in the lighter bodyweight categories. Hence the necessity of assigning a bodyweight *b* kg to the superheavyweight category.

In the development of the theory we noted that a curve of shape:

$$Y = -AX^2 + BX + C$$

fitted the data very well. This is a parabola concave downwards (indicated by the negative sign).

This implies higher totals with increasing bodyweight until we have:

$$\frac{\partial Y}{\partial X} = 0 = -2AX + B \rightarrow X = -B/2A$$

i.e. until the vertex of the parabola where $Y = C - B/4A$

The question "To what does the presence of the term with the minus sign imply?" can at least partially be answered by the following observations:

1. The larger athletes have longer bones and consequently have to lift the loaded bar a greater distance than their shorter smaller competitors.

2. In order to adjust their foot spacing, the athlete is momentarily in the air with the loaded bar. His need to lift his higher bodyweight as well as the loaded bar is considered irrelevant; only the weight on the bar counts.

3. Olympic weightlifting is not the only sport where body shape is important: consider basketball or gymnastics.

In support of these observations consider the following two tables, one for men, and one for women (with T. Kashirina's 2009 at a bodyweight of 90.90 kg included)

Male Ratios								
WRT	307	333	359	380	396	412	437	473
Bwt.	56	62	69	77	85	94	105	157.34
Ratio	5.48	5.37	5.20	4.94	4.66	4.38	4.16	3.01

Female Ratios									
WRT	217	233	252	262	286	296	283	303	348
Bwt.	48	53	58	63	69	75	90	90.9	106.21
Ratio	4.52	4.40	4.34	4.16	4.14	3.95	3.14	3.33	3.28

Mathematically, three points should be considered:

1. In calculating the 'best-fit' curve over a given range, it is always desirable to have the data points as evenly spread out as possible – in our case this means the X_i, not x_i. In our case, in desiring to obtain the best choices for the quantities X in obtaining the 'best-fit' parabola
$$Y = -AX^2 + BX + C$$
the range is (a) for men $56 < x < 160$ which is $0.0323 < X < 0.4881$
(b) for women $48 < x < 120$ which is $0.0377 < X < 0.4351$

2. The term $-AX^2$ is initially quite small in absolute terms relative to the terms $BX + C$ but becomes the dominant term near the apex of the parabola, and incidentally is the only term that remains when the parabola is expressed as a quadratic in a co-ordinate system with its origin at the apex of the parabola.

3. The addition of the 90 kg bodyweight category for women is welcome but still suffer from too many lower bodyweight categories not spaced far enough apart which does not permit a good estimate for the value of A. This is evident when you look at the standard deviation of the best fit curve for women over time.

6. Calculations for Men (December 31, 2016)

1.

ACTUAL				CALCULATED		
x_i	X_i = log(x_i / 52)	y^1_i	Y^1_i = log(y^1_i / 240)	$Y_i = -AX_i^2+BX_i+C$	y_i	$y^1_i - y_i$
56	0.032184683371	307.0	0.106927133766	0.109489887640	308.82	-1.82
62	0.076388345863	333.0	0.142232991795	0.141000670023	332.06	0.94
69	0.122845747102	359.0	0.174883206867	0.170950940061	355.76	3.24
77	0.170487381538	380.0	0.199572354905	0.198293670902	378.88	1.12
85	0.213415582079	396.0	0.217483944214	0.220007681318	398.31	-2.31
94	0.257124509965	412.0	0.234685974322	0.239269123007	416.37	-4.37
105	0.305185955435	437.0	0.260270195259	0.257132069990	433.85	3.15
+105	log(b/52)	473.0	0.294649899026	0.294561657211	472.90	0.10

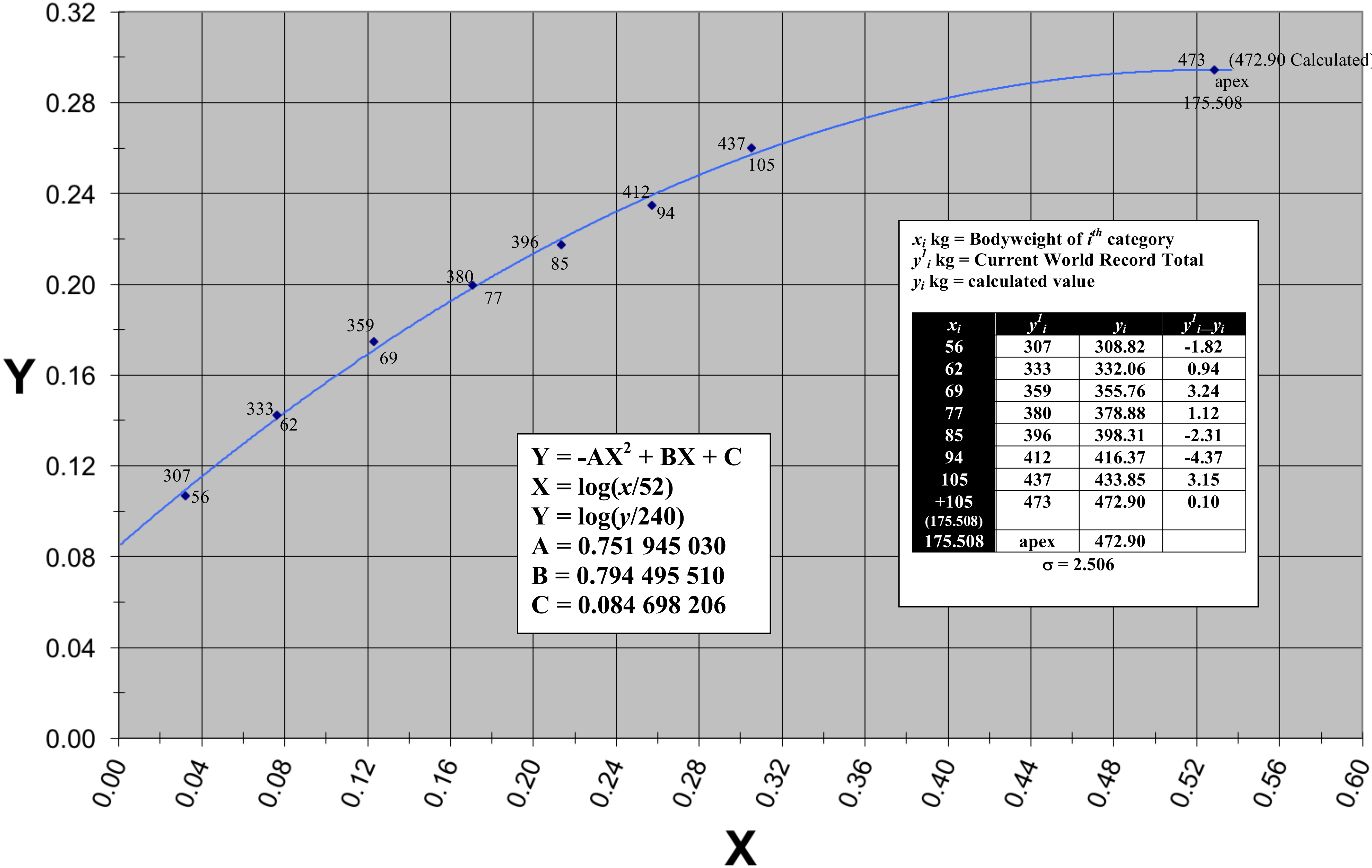
2. For men we have as input 7 points (X_i, Y_i^1) plus Y_8^1 but not X_8. By choosing various values for the superheavyweight (*b* kg) and monitoring the value of the sum *S* of least squares resulting we have *b* = 175.508 and $S = 6.241\ 419\ 704 \text{ x } 10^{-5}$ for which

A = 0.751 945 029 76
B = 0.794 495 509 85
C = 0.084 698 206 37

3. For each bodyweight category X_i $(i = 1, 2, \ldots, 7, 8)$ we can now calculate y_i and compare it to the actual y_i^1. A measure of the goodness of fit is the standard deviation

$$\sigma = \left[\frac{1}{8}\sum_{i=1}^{8}(y_i^1 - y_i)^2\right]^{1/2} = 2.506$$

Men (2017-2020)



$Y = -AX^2 + BX + C$
$X = \log(x/52)$
$Y = \log(y/240)$
$A = 0.751\ 945\ 030$
$B = 0.794\ 495\ 510$
$C = 0.084\ 698\ 206$

x_i kg = Bodyweight of i^{th} category
y^1_i kg = Current World Record Total
y_i kg = calculated value

x_i	y^1_i	y_i	$y^1_i - y_i$
56	307	308.82	-1.82
62	333	332.06	0.94
69	359	355.76	3.24
77	380	378.88	1.12
85	396	398.31	-2.31
94	412	416.37	-4.37
105	437	433.85	3.15
+105 (175.508)	473	472.90	0.10
175.508	apex	472.90	

$\sigma = 2.506$

7. Calculations for Women (December 31, 2016)

1.

ACTUAL				CALCULATED		
x_i	$X_i = \log(x_i / 44)$	y^1_i	$Y^1_i = \log(y^1_i / 140)$	$Y_i = -AX_i^2+BX_i+C$	y_i	$y^1_i - y_i$
48	0.037788560889	217.0	0.190331698170	0.198951753567	221.35	-4.35
53	0.080823193115	233.0	0.221227885348	0.226907307858	236.07	-3.07
58	0.119975317077	252.0	0.255272505103	0.250436303022	249.21	2.79
63	0.155887872967	262.0	0.272173255642	0.270422938038	260.95	1.05
69	0.195396414251	286.0	0.310237997451	0.290647276536	273.39	12.61
75	0.231608586906	296.0	0.325163675381	0.307561341262	284.24	11.76
90	0.310789832953	283.0	0.305658399846	0.339137735412	305.68	-22.68
+90	log(b/44)	348.0	0.395451208268	0.391451969514	344.81	3.19

2. For women we have as input 7 points (X_i, Y_i^1) plus Y_8^1 but not X_8. By choosing various values for the superheavyweight (b kg) and monitoring the value of the sum S of least squares resulting we have b = 178.463, the minimum for S = 1.963511990 x 10^{-3} and

A = 0.591 853 689 30
B = 0.719 806 780 71
C = 0.172 596 443 68

Also

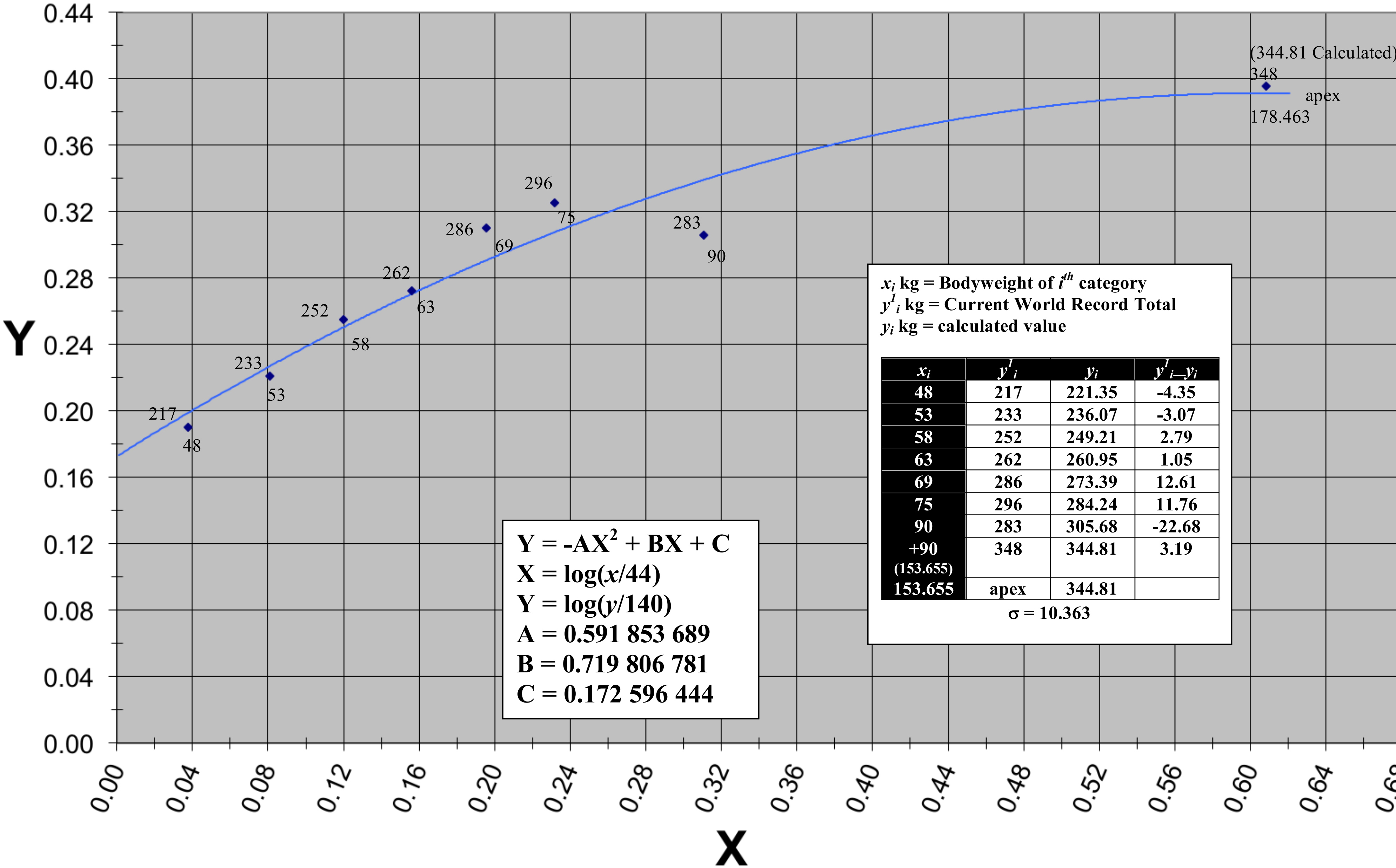
$$\sigma = \left[\frac{1}{8}\sum_{i=1}^{8}(y_i^1 - y_i)^2\right]^{1/2} = 10.363$$

4. The assigned WRT for the 90 kg bodyweight class is far below where the anticipated WRT should be. This can be attributed to the fact that since there was no upper bodyweight limit in the now retired 75+ kg bodyweight category, athletes did not worry about keeping their bodyweight down. Over time as athletes train specifically for the 90 kg bodyweight category, it is anticipated that the WRT for the 90 kg bodyweight category will fall in line with the rest of the WRT.

5. This graph shows very clearly that the shape of the curve has been impacted by the introduction of the 90 kg bodyweight category which is yet to mature.

4. These results are not really acceptable.

Women (2017-2020)



$Y = -AX^2 + BX + C$
$X = \log(x/44)$
$Y = \log(y/140)$
A = 0.591 853 689
B = 0.719 806 781
C = 0.172 596 444

x_i kg = Bodyweight of i^{th} category
y^1_i kg = Current World Record Total
y_i kg = calculated value

x_i	y^1_i	y_i	$y^1_i - y_i$
48	217	221.35	-4.35
53	233	236.07	-3.07
58	252	249.21	2.79
63	262	260.95	1.05
69	286	273.39	12.61
75	296	284.24	11.76
90	283	305.68	-22.68
+90 (153.655)	348	344.81	3.19
153.655	apex	344.81	

σ = 10.363

8. Calculations for Women (December 31, 2016)

1.

ACTUAL				CALCULATED		
x_i	$X_i = \log(x_i / 44)$	y^1_i	$Y^1_i = \log(y^1_i / 140)$	$Y_i = -AX_i^2+BX_i+C$	y_i	$y^1_i - y_i$
48	0.037788560889	217.0	0.190331698170	0.192678500506	218.18	-1.18
53	0.080823193115	233.0	0.221227885348	0.225302758932	235.20	-2.20
58	0.119975317077	252.0	0.255272505103	0.252462587310	250.37	1.63
63	0.155887872967	262.0	0.272173255642	0.275263002628	263.87	-1.87
69	0.195396414251	286.0	0.310237997451	0.298011814193	278.06	7.94
75	0.231608586906	296.0	0.325163675381	0.316714234789	290.30	5.70
90.9*	0.315111206736	303.0	0.335314592824	0.352008416300	314.87	-11.87
+90	log(b/44)	348.0	0.395451208268	0.392731503529	345.83	2.17

* NOTE: The result of T. Kashirina is incorporated into the analysis. Weighing 90.90 kg., she had a total of 303 kg.

2. To better represent the 90 kg bodyweight WRT data point, the results (unauthorized) of T. Kashirina from 2009 with a bodyweight of 90.90 kg and a total of 303 kg were used in place of the assigned WRT of 283 kg.

3. for b = 153.65, and the minimum for S = 5.465073899 x 10^{-4} and

A = 0.783 497 476 14
B = 0.851 025 125 58
C = 0.161 638 300 80

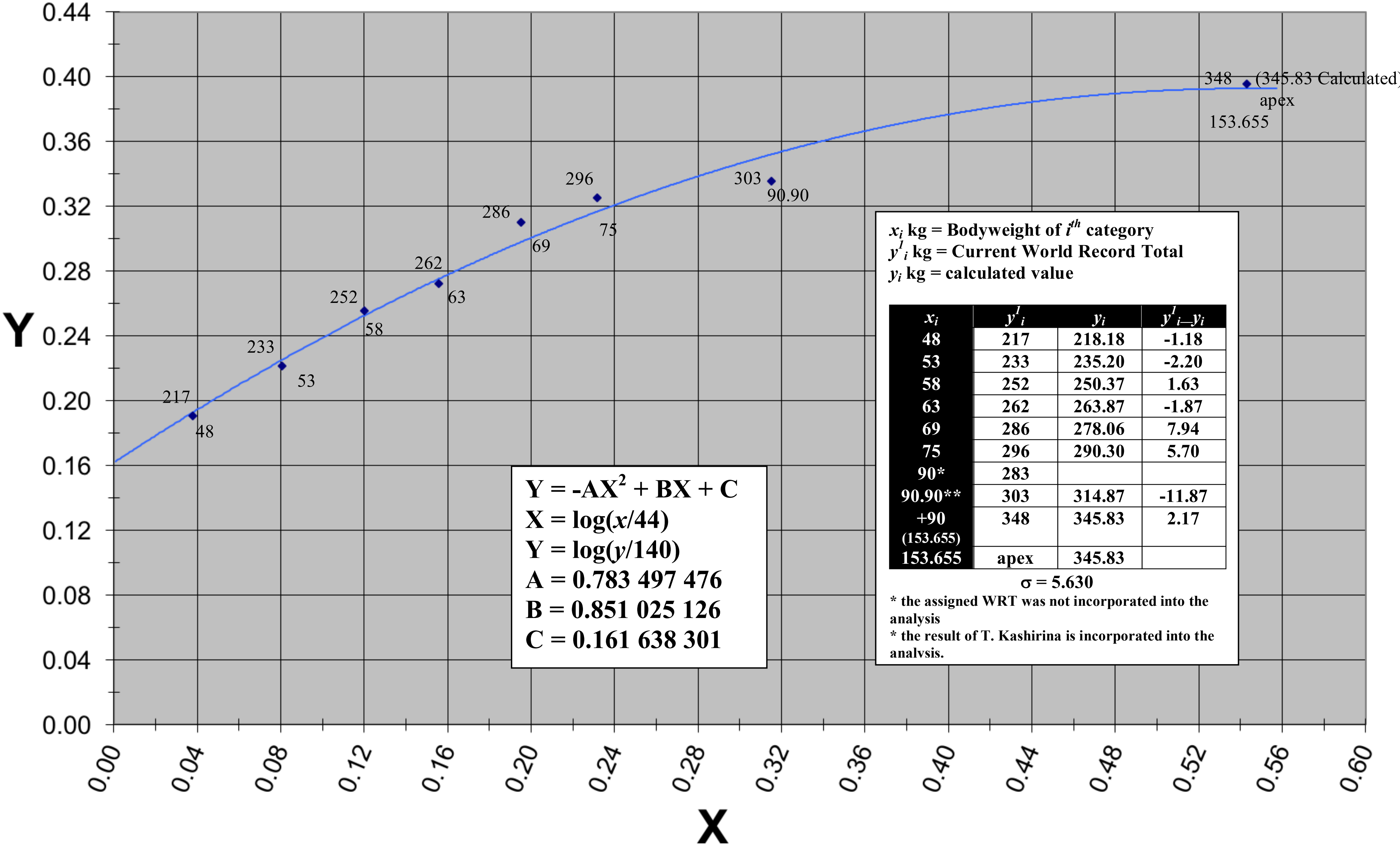
Also

$$\sigma = \left[\frac{1}{8}\sum_{i=1}^{8}(y_i^1 - y_i)^2\right]^{1/2} = 5.630$$

4. This graph shows very clearly that, even with the (unauthorized) addition of T. Kashirina's bodyweight and total in place of the assigned WRT for the 90 kg bodyweight category, there are still too many lighter bodyweight categories and not enough heavier bodyweight categories.

5. Nevertheless, these results are more meaningful and acceptable.

Women (2017-2020)



$Y = -AX^2 + BX + C$

$X = \log(x/44)$

$Y = \log(y/140)$

$A = 0.783\ 497\ 476$

$B = 0.851\ 025\ 126$

$C = 0.161\ 638\ 301$

x_i kg = Bodyweight of i^{th} category
y^1_i kg = Current World Record Total
y_i kg = calculated value

x_i	y^1_i	y_i	$y^1_i – y_i$
48	217	218.18	-1.18
53	233	235.20	-2.20
58	252	250.37	1.63
63	262	263.87	-1.87
69	286	278.06	7.94
75	296	290.30	5.70
90*	283		
90.90**	303	314.87	-11.87
+90 (153.655)	348	345.83	2.17
153.655	apex	345.83	

σ = 5.630

*** the assigned WRT was not incorporated into the analysis**

*** the result of T. Kashirina is incorporated into the analysis.**