ALBERTA WEIGHTLIFTING ASSOCIATION

AFFILIATED WITH THE C.W.F.H.C. AND I.W.F.

Canadian Weightlifting Federation
Haltérophile Canadienne (CWFHC)

SINCLAIR BODYWEIGHT CORRECTION FORMULA

1. Introduction

In Olympic Weightlifting in the current year of 2012 there are 8 bodyweight categories for men and 7 for 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 and +75.

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 men and 7 for women the summations are represented as going from i=1 to i=m (i=index) where m=7 for women and m=8 for men. 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.

2. Procedure

Our m data points (recall that m=7 for women and m=8 for men) 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:

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

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

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

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.

3. 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.

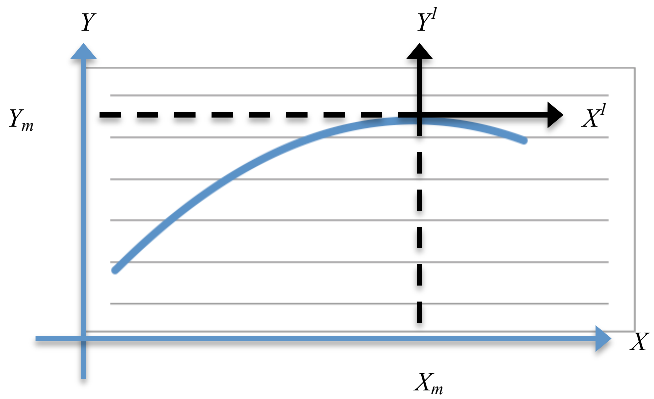
$$\frac{\partial Y}{\partial X} = 0 = -2AX + B \qquad \therefore X = \frac{B}{2A}$$

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

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 $Y = Y^1 + Y_m = Y^1 + C + \frac{B^2}{4A} = -AX^2 + BX + C = -A(X^1 + X_m)^2 + B(X^1 + X_m) + C$

$$\therefore Y^1 = -C - \frac{B^2}{4A} - A\left({X^1}^2 + 2X^1\frac{B}{2A} + \left[\frac{B}{2A}\right]^2\right) + B\left(X^1 + \frac{B}{2A}\right) + C$$

$$= -A{X^1}^2$$

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

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 $= 10^{A[lc(x_m/x)]^2}$

Actual Total $= ky$ for some constant k>0 where k=1 means that the 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 $ky \; x \; 10^{A[lc(x_m/x)]^2} = ky_m$

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.

4. Commentary

We have for men 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:

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

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, (with Rezazadeh's 2 performances included) and one for women (with Kashirina's 2012 performance included)

WRT	305	327	357	379	394	418	436	472.5	472.5
Bwt.	56	62	69	77	85	94	105	147.45	162.95
Ratio	5.45	5.27	5.17	4.92	4.64	4.45	4.15	3.20	2.90

WRT	217	230	251	257	286	296	332	333
Bwt.	48	53	58	63	69	75	102.31	130.83
Ratio	4.52	4.34	4.33	4.08	4.14	3.95	3.25	2.35

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 present choices for the women's bodyweight categories do not permit a good estimate for the value of A. I would like to suggest the following bodyweight categories:

48 56 65 75 86 100 +100

5. Calculations for Men (August 31, 2012)

1.

ACTUAL				CALCULATED		
x_i	$X_i = Log\left(^{x_i}/_{52}\right)$	y_i^1	$Y_i^1 = Log\left(^{y_i}/_{240}\right)$	$Y_i = -AX_i^2 + BX_i + C$	y_i	$y_i^1 - y_i$
56	0.032184683371	305.0	0.104088597635	0.103882094881	304.86	0.14
62	0.076388345863	327.0	0.134336510949	0.136975807189	328.99	-1.99
69	0.122845747102	357.0	0.172456974401	0.168411074549	353.69	3.31
77	0.170487381538	379.0	0.198427968256	0.197086517055	377.83	1.17
85	0.213415582079	394.0	0.215284980114	0.219836484884	398.15	-4.15
94	0.257124509965	418.0	0.240965040063	0.239992114108	417.06	0.94
105	0.305185955435	436.0	0.259275247557	0.258651223485	435.37	0.63
+105	log(b/52)	472.0	0.293730756922	0.293730759746	472.00	0.00

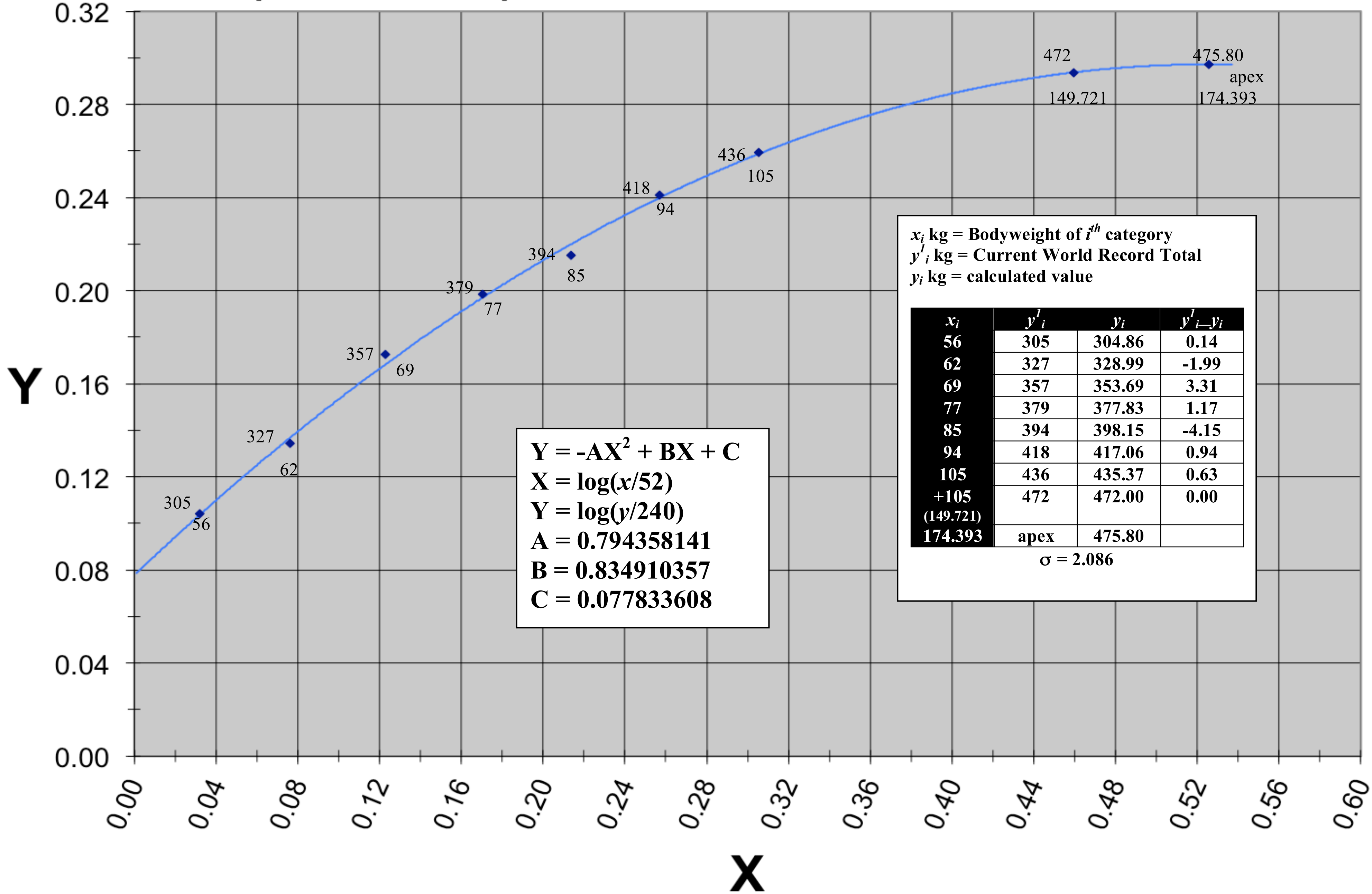
2. For men we have as input 7 points (X_i, Y_i^1) plus Y_8^1 but not X_8. By choosing various values for the superheavyweight (b kg) and monitoring the value of the sum S of least squares resulting we have $b = 149.721$ and $S = 4.722\,951\,159 \text{ x } 10^{-5}$ for which

$A = 0.794\,358\,140\,57$
$B = 0.834\,910\,356\,73$
$C = 0.077\,833\,608\,34$

3. For each bodyweight category X_i $(i = 1, 2, \dots, 7, 8)$ 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

$$\sigma = \left[\frac{1}{8}\sum_{i=1}^{8}(y_i^1 - y_i)^2\right]^{1/2} = 2.086$$

Men (2013-2016)



$Y = -AX^2 + BX + C$
$X = \log(x/52)$
$Y = \log(y/240)$
A = 0.794358141
B = 0.834910357
C = 0.077833608

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	305	304.86	0.14
62	327	328.99	-1.99
69	357	353.69	3.31
77	379	377.83	1.17
85	394	398.15	-4.15
94	418	417.06	0.94
105	436	435.37	0.63
+105 (149.721)	472	472.00	0.00
174.393	apex	475.80	

$\sigma = 2.086$

6. Calculations for Women (August 31, 2012)

1.

ACTUAL					CALCULATED		
x_i	$X_i = Log(x_i/44)$	ΔX_i	y_i^1	$Y_i^1 = Log(y_i/140)$	$Y_i = -AX_i^2 + BX_i + C$	y_i	$y_i^1 - y_i$
48	0.037788560889		217.0	0.190331698170	0.189062636590	216.37	0.63
53	0.080823193115	0.0430	230.0	0.215599800339	0.219338394613	231.99	-1.99
58	0.119975317077	0.0392	251.0	0.253545685803	0.247201992343	247.36	3.64
63	0.155887872967	0.0359	257.0	0.263805087653	0.273027540230	262.52	-5.52
69	0.195396414251	0.0395	286.0	0.310237997451	0.301734694239	280.45	5.55
75	0.231608586906	0.0362	296.0	0.325163675381	0.328318745279	298.16	-2.16
+75	log(b/44)	0.0645	333.0	0.376316197828	0.376316139332	333.00	0.00

2. Here $\Delta X_i = X_i - X_{i-1}$

$b = 87.009$
$S = 2.2314431 \times 10^{-4}$

$A = -0.099\ 218\ 824$
$B = 0.691\ 752\ 261$
$C = 0.162\ 780\ 632$

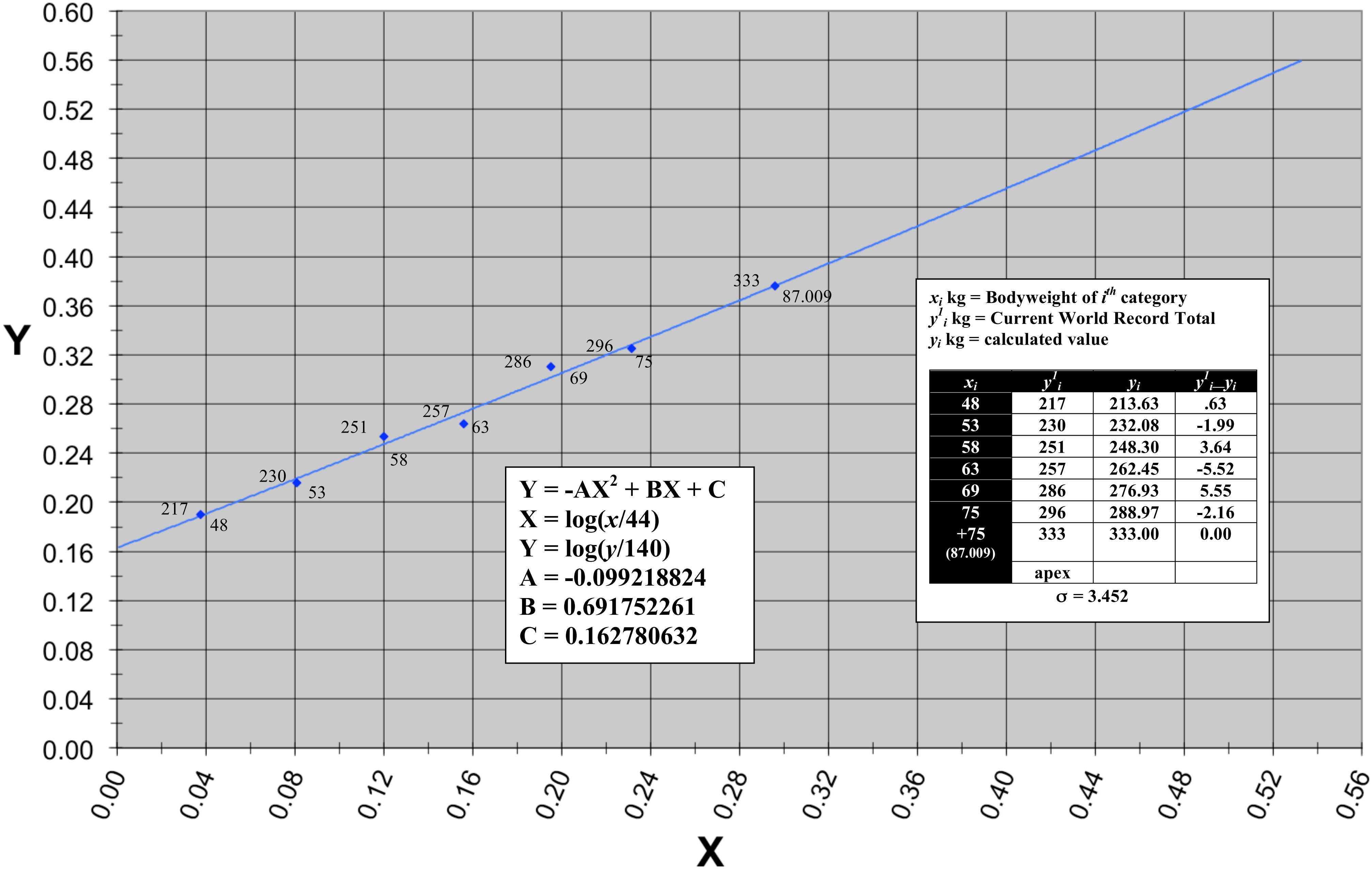
Since $Y = -AX^2 + BX + C$
then $\frac{dy}{dx} = -2AX + B$
For the vertex of the parabola
Set $\frac{dy}{dx} = 0$ to get

$X = B/2A = -3.485\ 993\ 058\ 361$
$x = 0.014\ 370\ 094\ 30$
$\sigma = 3.45$

3. The parabolic curve is concave upwards instead of downwards. That is due to too many lighter categories and not enough heavier categories; that is, the term $-AX^2$ in the equation $Y = -AX^2 + BX + C$ is initially small in magnitude for the lighter categories but becomes the dominant term as the bodyweight "handicap" categories increase.

4. These results are not really acceptable.

Women (2013-2016)



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

$X = \log(x/44)$

$Y = \log(y/140)$

$A = -0.099218824$

$B = 0.691752261$

$C = 0.162780632$

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	213.63	.63
53	230	232.08	-1.99
58	251	248.30	3.64
63	257	262.45	-5.52
69	286	276.93	5.55
75	296	288.97	-2.16
+75 (87.009)	333	333.00	0.00
	apex		

$\sigma = 3.452$

7. Calculations for Women (August 31, 2012)

1.

ACTUAL				CALCULATED		
x_i	$X_i = Log(x_i/44)$	y_i^1	$Y_i^1 = Log(y_i/140)$	$Y_i = -AX_i^2 + BX_i + C$	y_i	$y_i^1 - y_i$
48	0.037788560889	217.0	0.190331698170	0.185195715540	214.45	2.55
53	0.080823193115	230.0	0.215599800339	0.221305276962	233.04	-3.04
58	0.119975317077	251.0	0.253545685803	0.251269904632	249.69	1.31
63	0.155887872967	257.0	0.263805087653	0.276336362487	264.52	-7.52
69	0.195396414251	286.0	0.310237997451	0.301239130073	280.13	5.87
75	0.231608586906	296.0	0.325163675381	0.321603852630	293.58	2.42
102.31*	0.366465408180	332.0	0.375010048026	0.376743947965	333.33	-1.33
+75	log(b/44)	333.0	0.376316197828	0.376316000362	333.00	0.00

* NOTE: The result of T. Kashirina is incorporated into the analysis. Weighing 102.31 kg, she had a total of 332 kg.

2. For b = 101.962, the minimum for S = 3.178011711 x 10^{-4} and

A = 0.897 260 739 69
B = 0.945 507 115 82
C = 0.150 747 628 53

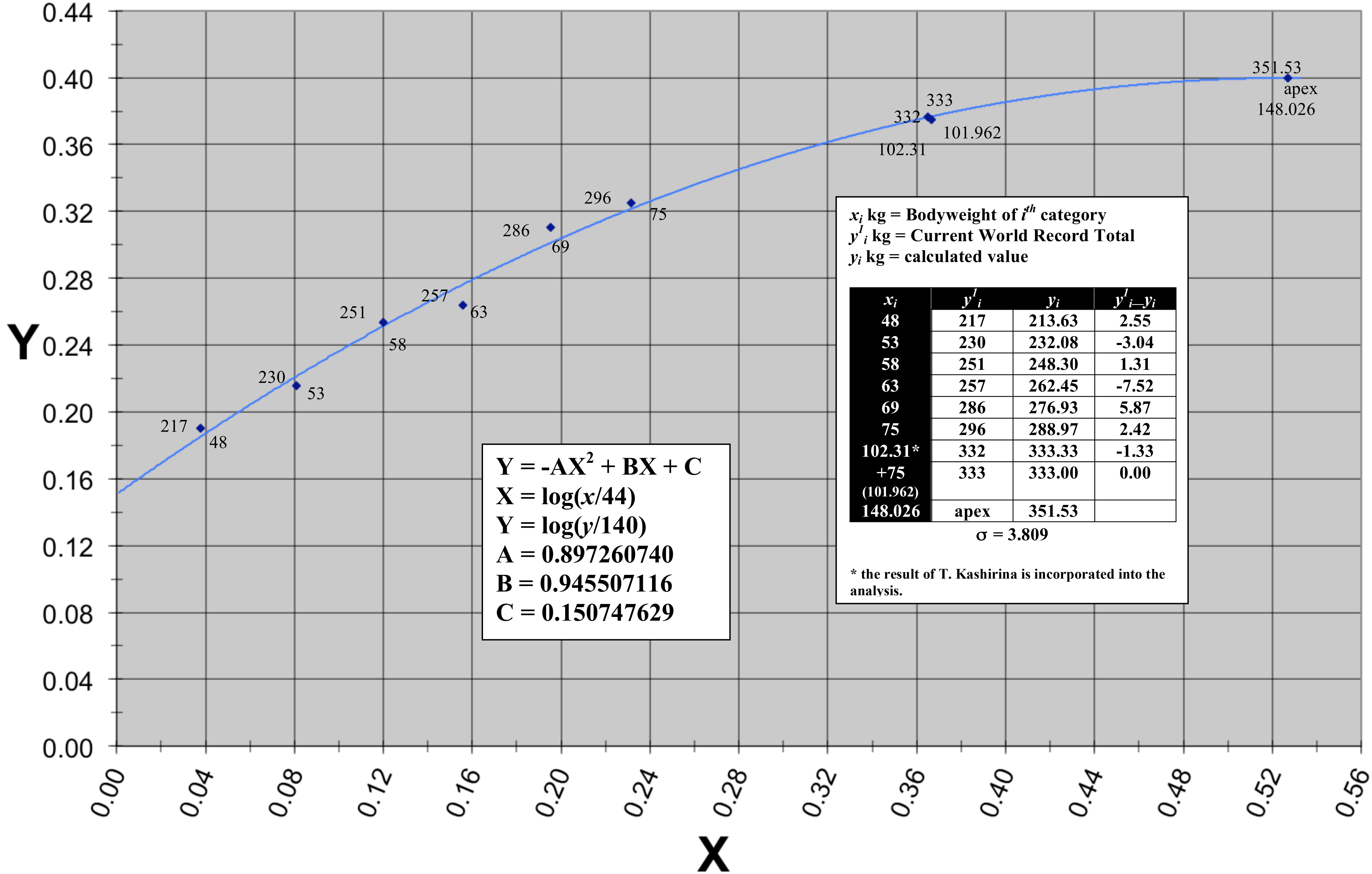
Also

$$\sigma = \left[\frac{1}{8}\sum_{i=1}^{8}(y_i^1 - y_i)^2\right]^{1/2} = 3.809$$

3. This graph shows very clearly that, even with the (unauthorized) addition of T. Kashirina's bodyweight and total, there are still too many lighter bodyweight categories and not enough heavier bodyweight categories.

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

Women (2013-2016)



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

$X = \log(x/44)$

$Y = \log(y/140)$

$A = 0.897260740$

$B = 0.945507116$

$C = 0.150747629$

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	213.63	2.55
53	230	232.08	-3.04
58	251	248.30	1.31
63	257	262.45	-7.52
69	286	276.93	5.87
75	296	288.97	2.42
102.31*	332	333.33	-1.33
+75 (101.962)	333	333.00	0.00
148.026	apex	351.53	

$\sigma = 3.809$

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