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What's
The
Story?

Principles of Complex Systems, Vols. 1, 2, & 3D
CSYS/MATH 300, 303, & 394
University of Vermont, Fall 2022
Solutions to Assignment 01
"I Aten't Dead"

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1. An amuse-bouche for scaling, to signal the flavors ahead:

   Examine current weight lifting records for the snatch, clean and jerk, and the total for scaling with body mass (three regressions). Do so for both women and men's records.

   For weight classes, take the upper limit for the mass of the lifter.

   Wikipedia is an excellent source.

   (a) How well does 2/3 scaling hold up?

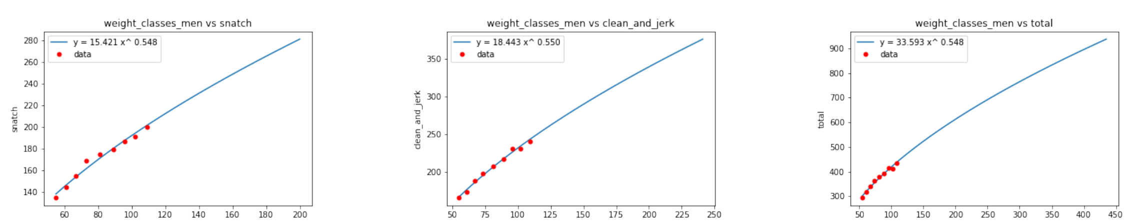
   (b) Normalized by the scaling you determine, who holds the overall, rescaled world record?

   Normalization here means relative:

$$100 \times \left(\frac{M_{\text{worldrecord}}}{c M^{\beta}_{\text{weightclass}}} - 1 \right),$$

   where c and β are the parameters determined from a linear fit.

   Solution:(a)

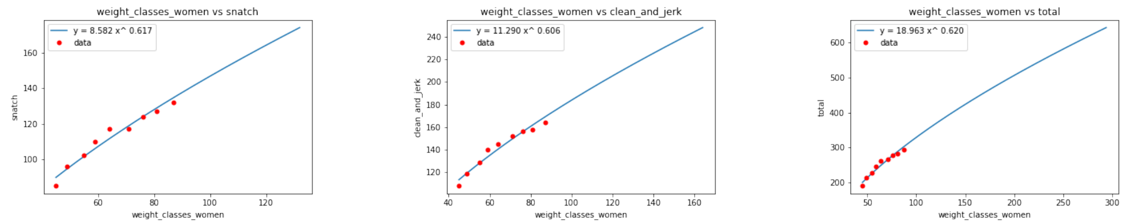


(a) weight classes men vs snatch

(b) weight classes men vs clean and jerk

(c) weight classes men vs total

Figure 1: Men weight lifting records



(a) weight classes women vs snatch

(b) weight classes women vs clean and jerk

(c) weight classes women vs total

Figure 2: Women weight lifting records

2/3 scaling implies

$$y = cx^{0.66}$$

For men, the exponent obtained from the dataset seem to follow 0.55 scaling as opposed to 0.66. While for women, it follows closer to 2/3 scaling law at 0.62 in total. 2/3 Power law does not describe the data that well. Note: numpy polyfit function of order 1 was used to find the best line that explains the log10 transformed data.

(b) Based on the parameters obtained from best linear fit to each of 6 dataset, normalizing using the scale, these are record holders that do well above the scaling law predicted.

Category	Snatch	Clean and Jerk	Total
Men	Shi Zhiyong : 169 at 73	Tian Tao : 231 at 96	Shi Zhiyong: 364 at 73
Women	Deng Wei: 117 at 64	Kuo Hsing-chun - 140 at 59	Deng Wei - 261 at 59

□

2. Some kitchen table preparation for for power-law size distributions:

Consider a random variable X with a probability distribution given by

$$P(x) = cx^{-\gamma}$$

where c is a normalization constant, and $0 < a \leq x \leq b$. (a and b are the lower and upper cutoffs respectively.) A Perishing Monk tells you to assume that $\gamma > 1$, that $a > 0$ always, and allow for the possibility that $b \to \infty$. And then the Monk disappears.

(a) Determine c.

Solution:

Given,

$$P(x) = cx^{-\gamma}$$

is a probability distribution,

Then,

$$\int_a^b cx^{-\gamma} dx = 1$$

With $a > 1$, $b \to \infty$,

$$\left. \frac{cx^{-\gamma+1}}{-\gamma+1} \right|_a^b = 1$$

$$c(\frac{b^{-\gamma+1} - a^{-\gamma+1}}{-\gamma+1}) = 1$$

$$c = \frac{-\gamma+1}{b^{-\gamma+1} - a^{-\gamma+1}}$$

if $b \to \infty$, and $\gamma > 1$
We know that

$$\lim_{x\to\infty} \frac{1}{x} = 0$$

$$\lim_{b\to\infty} b^{-\gamma+1} = \lim_{b\to\infty} (\frac{1}{b})^{\gamma-1} = 0$$

Hence,

$$c = (\gamma - 1)a^{\gamma-1}$$

where $a > 0$ and $\gamma > 1$.

□

(b) Why did the Perishing Monk tell us to assume $\gamma > 1$?

Think about what happens as $b \to \infty$.

Solution:

if we assume $\gamma = 1$, Then Probability distribution

$$P(x) = cx^{-\gamma}$$

does not satisfy

$$\int_a^b cx^{-\gamma} dx = 1$$

$\gamma = 1$ leads to

$$c = 0$$

which does not make sense.

Hence $\gamma > 1$ has to hold for the probability distribution to make sense. $\square$