Runnin' in the Rain Formula

~~~How wetness vary between running and walking in the rain?~~~

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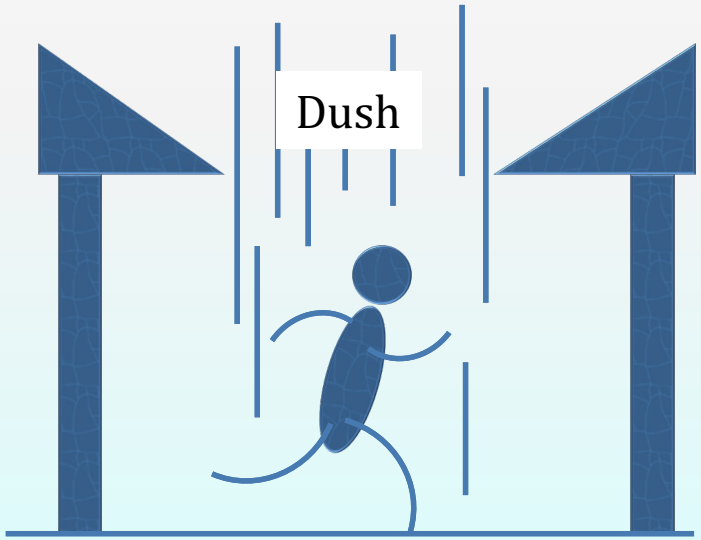
In a TV program …

- There was a question “Is it true that the amount of wetness is the same whether you walk or run in the rain?”
- Clearly it is not true. We can find it by an easy thought experiment:



Not very wet

Soaked!

Why such a superstition appeared?

- We minded that the folk belief asserts “the same.”
- → A logical ground should exist!

then

- We considered.

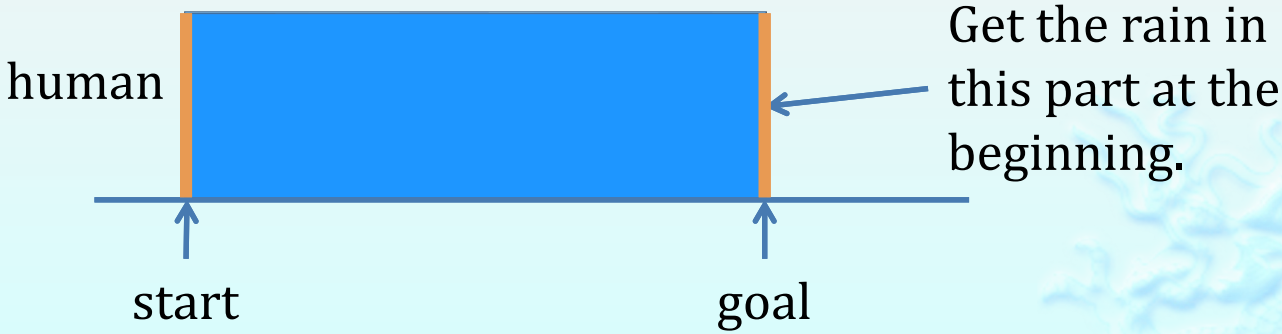
as a result

- We obtained a **very simple formula** approximating the relation of the amount of wetness between walking and running in the rain.
- This talk is just such a (very easy) story …

First: a simplest model

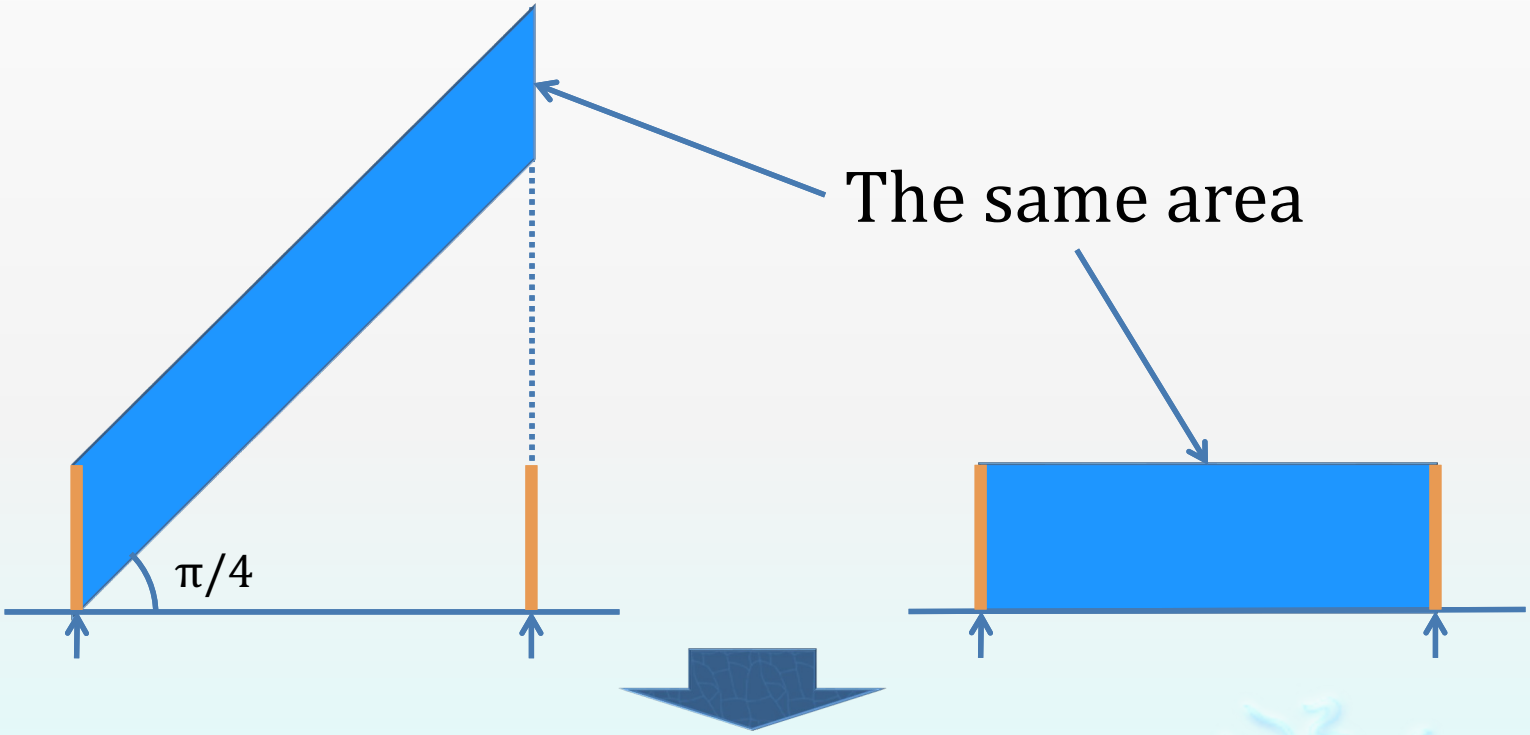
- A human is represented by a vertical line segment.

- If you run through in an instant, …



First: a simplest model

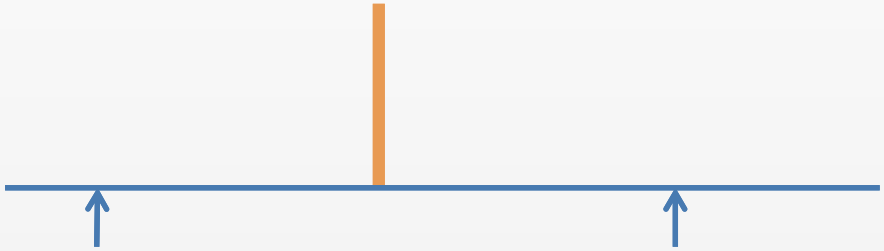
- If you run at the same speed as the falling rain, …



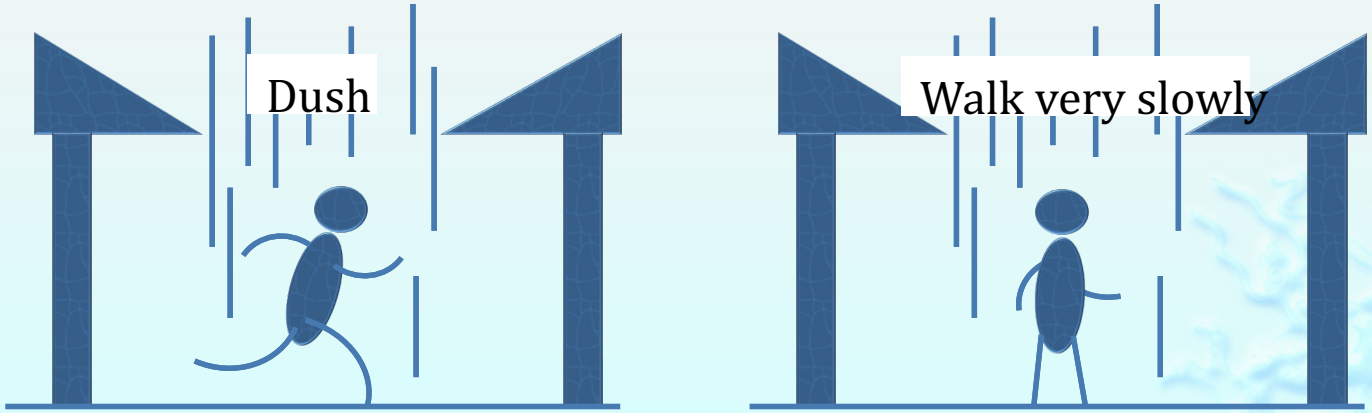
- Regardless of how fast you walk, the area of the parallelogram is the same, and thus the wet amount is the same.

Clearly this model is not appropriate.

- Under this model, even if you stand all day in a heavy rain, you never wet!?

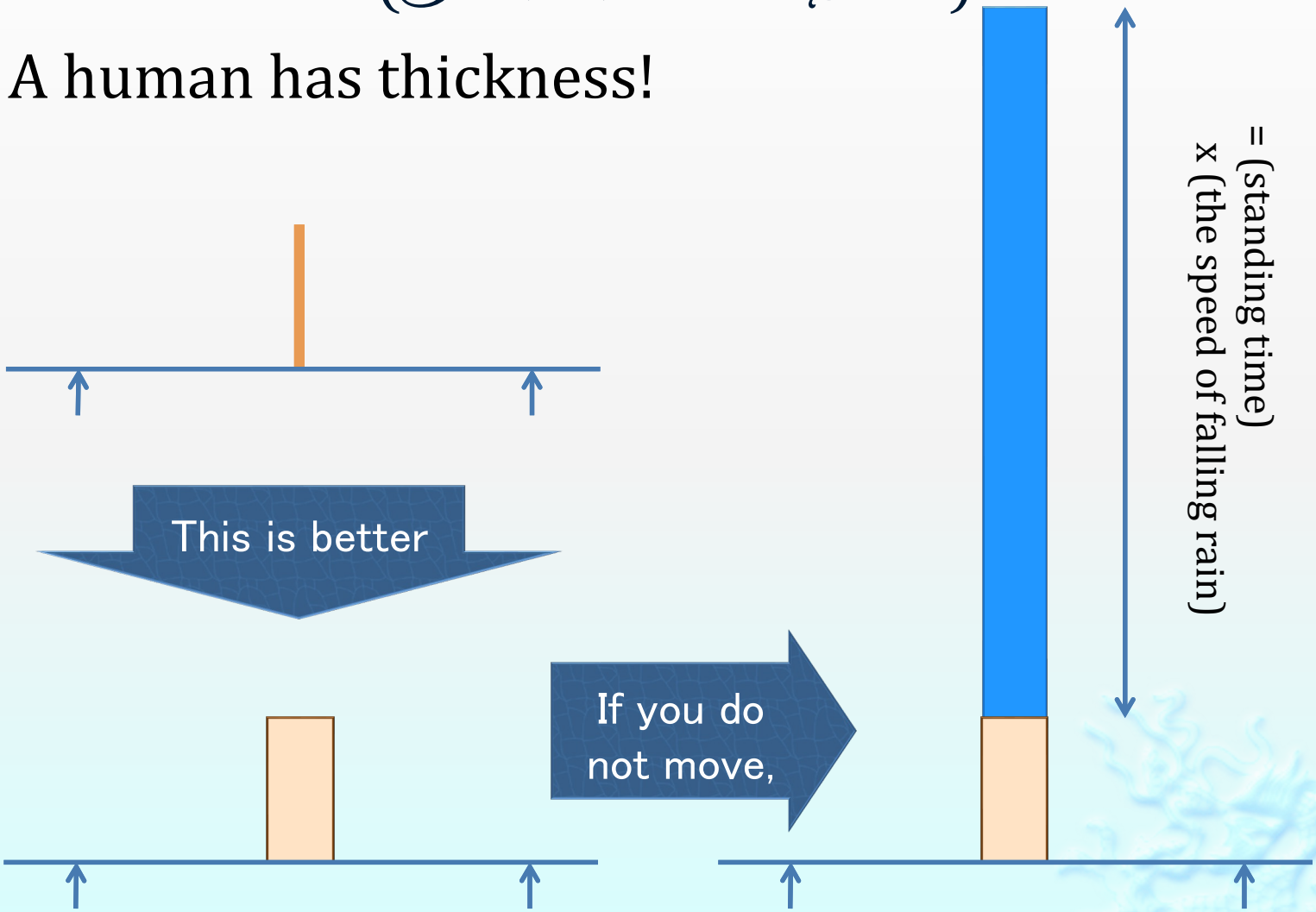


- The same phenomenon as this



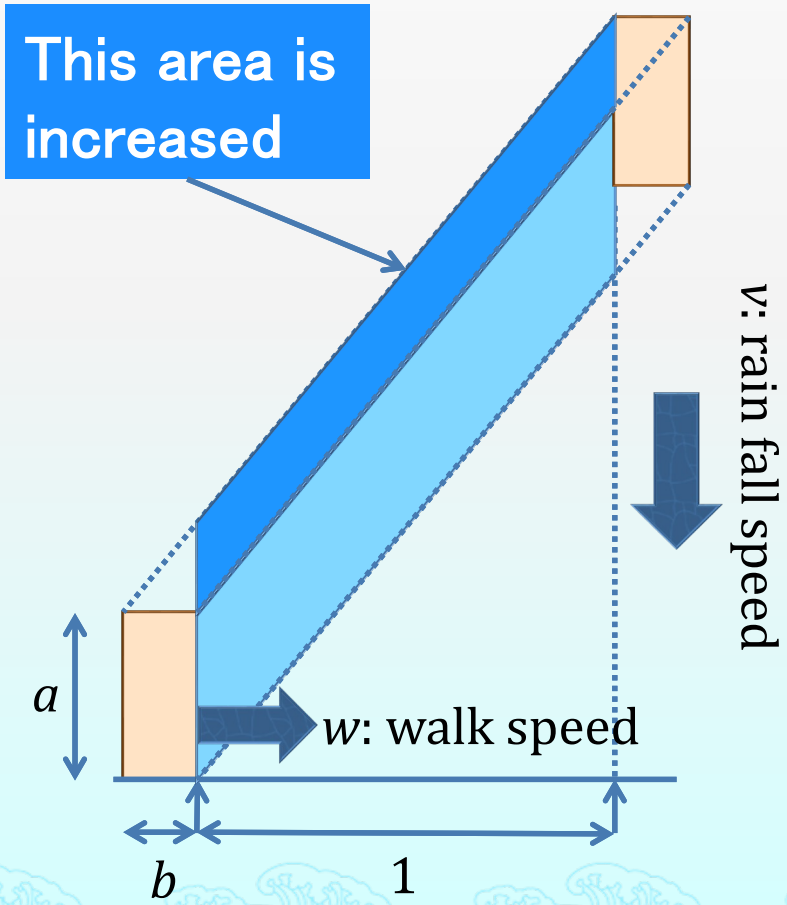
Why that model was wrong? (But it is clear!)

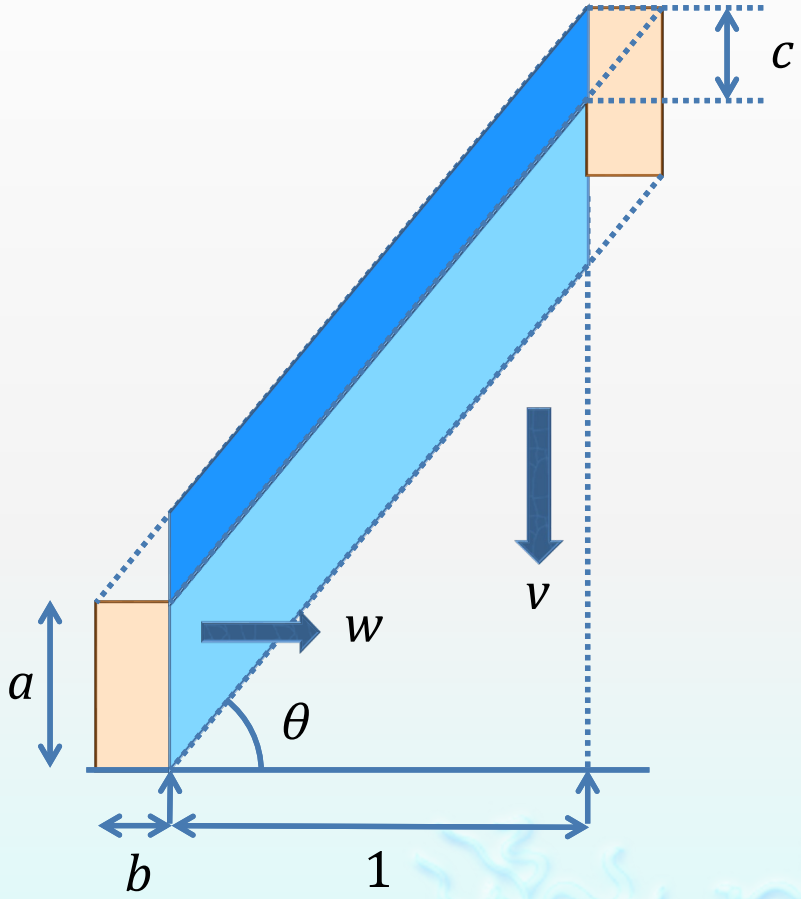
- A human has thickness!



A rectangle model

- A human is approximated by a rectangle.

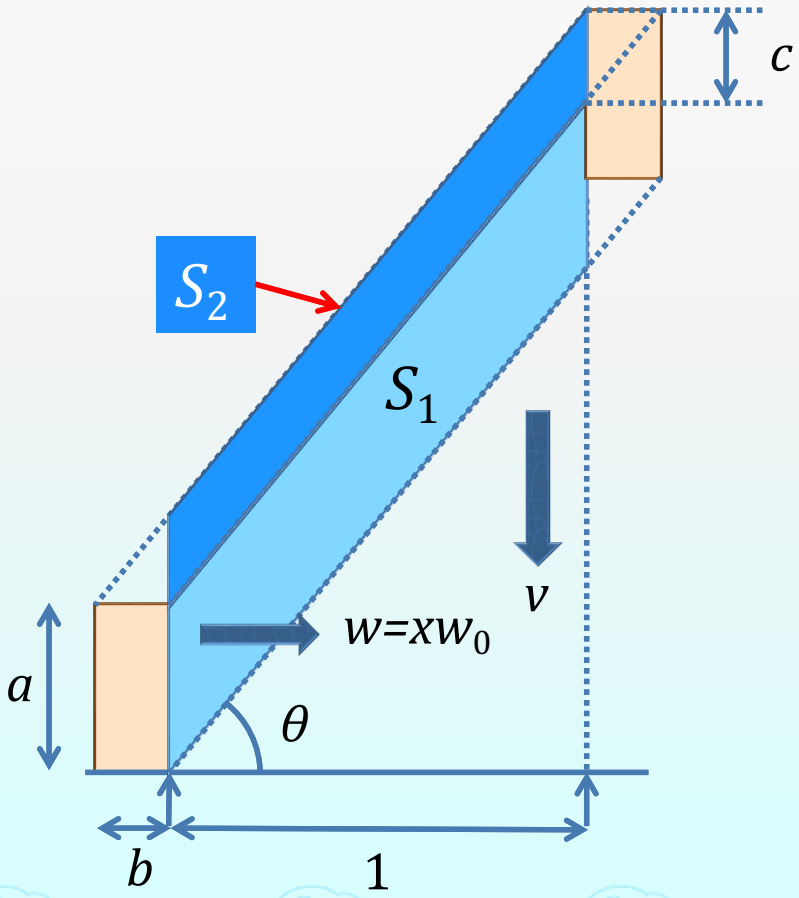




$\tan\theta = v/w$

$c = b\tan\theta = bv/w$

A rectangle model



$\tan\theta = v/w$

$c = b\tan\theta = bv/w$

$S_1 = a$

$S_2 = c = bv/w$

$S = S_1 + S_2 = a + bv/w$

$$S = a + \frac{bv}{w} = \cancel{a}\left(1 + \frac{bv}{aw}\right)$$

$$\boxed{S = 1 + \frac{bv}{aw}}$$

Try to substitute actual values

w_0: normal walking speed, $w = xw_0$

$$S = 1 + \frac{bv}{aw} = 1 + \frac{bv}{aw_0 x}$$

- Substitute actual values for *a*, *b*, *v*, and w_0.

a (hight): 150～180cm -> 165cm = 1.65m

b (body thickness): 25～30cm -> 27.5cm = 0.275m

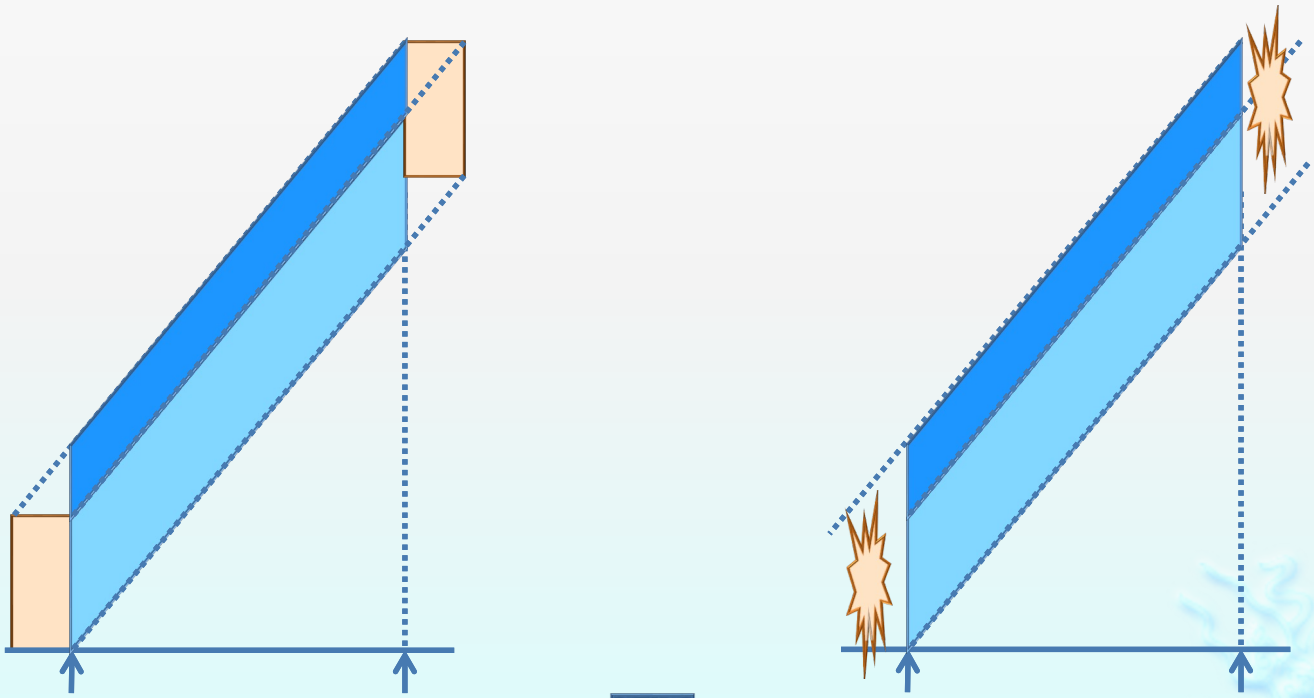
w_0 (walking speed): 4km/h -> 1.11m/s

v (rain fall speed): 6～8m/s -> 7m/s

$$S = 1 + \frac{bv}{aw_0 x} = 1 + \frac{0.275 \times 7}{1.65 \times 1.11x} = 1 + \frac{1.051\ldots}{x} \approx 1 + \frac{1}{x}$$

Does any problem remain?

- **Q1:** Is a rectangle OK?
- **A1:** OK. The body shape does not matter much!



No problem!

Any other problem?

- **Q2:** Does your body lean forward when you run?
- **A2:** No! Almost upright!

Photos of the 100m final in the Rio Olympic games
from NHK video
(deleted due to rights).

No problem!

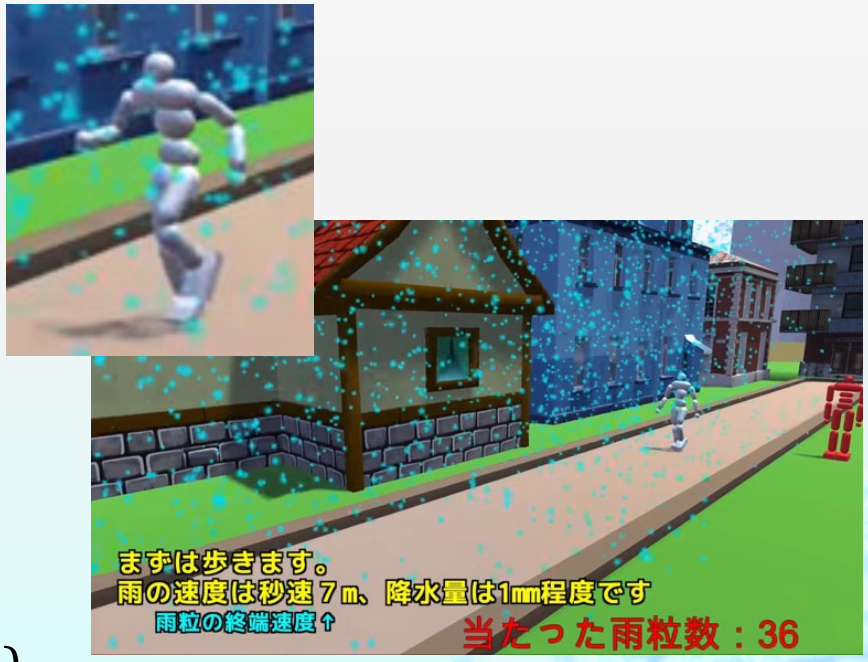
Runnin' in the Rain Formula

- The wet amount of an average sized person walking at normal speed in the rain (not drizzle) without strong wind is normalized as one. Then the wet amount of him/her running/walking x times faster in the same condition is approximated as

$$\mathrm{RiR}(x) = 0.5 \times \left(1 + \frac{1}{x} \right).$$

Related research

- A webpage:「雨のときは「歩く」「走る」のどちらが、ぬれにくいの？　同じかと思いきやまったく違う結果に」（こーじ／YouTubeチャンネル）
- https://nlab.itmedia.co.jp/nl/articles/1801/24/news105.html
- simulation : comparing walking (4km/h) and running (16km/h), i.e., x=4.



- Result:
- Walking: 246+328=574(drops)
- Running (x=4): 252+99=341(drops)
- 341/574=0.594.
- From our formula:
- 0.5(1+1/4)=0.625.
- Almost the same!
- (by considering the significant digits.)

Importance of the Runnin' in the Rain Formula

- Certainly obtaining a similar formula is not difficult. In fact, we can find many results on this topic on the web.
- Any result, however, has not derived simple formulae as ours.
- The importance of Runnin' in the Rain Formula is that **the relation can be approximated in such a simple formula** in the average case. We consider that this has not been given so far.

$$\mathrm{RiR}(x) = 0.5 \times \left(1 + \frac{1}{x}\right)$$

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- **Obs. 1:** No matter how fast you run (even at the speed of light), you will only get half as wet at most. (Thus we may say "the amount of wetness is **not so different** whether you walk or run in the rain.")
- **Obs. 2:** From $\lim_{x \to 0} \mathrm{RiR}(x) = \infty$, you will get wet as much as you want by walking slowly.