



Data mining and time-series analysis as two complementary approaches to study body temperature in obesity

Chris Stephens, C3 y ICN, UNAM

Digital Health 2017,
London 3rd-5th July 2017

Work in collaboration with: Ruben Fossion, Karla Garcia, Lorena Garcia

The Problem: The Obesity Pandemic



THE WORLD IS GETTING FATTER



HOW DO I KNOW WHETHER I AM OVERWEIGHT?

Calculate your body mass index (BMI) using this formula



OBESITY KILLS!

- 7 common diseases due to obesity:
- Arthritis
 - Back Pain
 - Cancer
 - Diabetes
 - Infertility
 - Stroke
 - Heart Diseases



A B C TO OBESITY PREVENTION

SIMPLE RULES TO STAY IN SHAPE

A dopt New Healthy Habits



B alance Your Calorie Intake

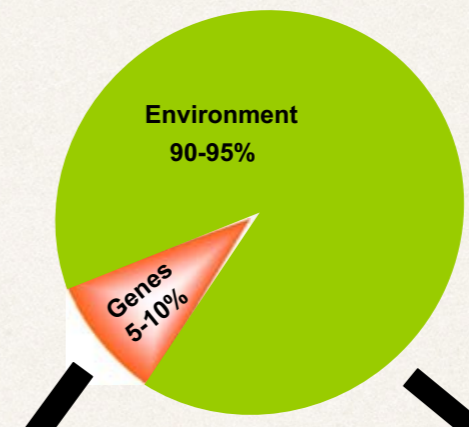


C ontrol Your Weight Gain



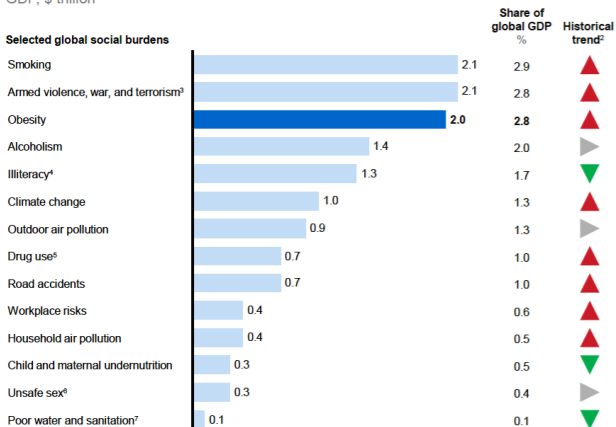
source: World Health Organization ©2014 Health Buzz www.healthbuzz.asia

Obesity, type 2 diabetes, heart disease, strokes etc. are diseases associated with “lifestyle” and arise partly from **nature** and partly from **nurture**



Obesity is one of the top three global social burdens generated by human beings

Estimated annual global direct economic impact and investment to mitigate selected global burdens, 2012¹



¹ Based on 2010 disability-adjusted life years (DALY) data from the Global Burden of Disease database and 2012 economic indicators from the World Bank, excluding associated revenue or taxes, including lost productivity due to disability and death, direct cost, e.g., for health care, and direct investment to mitigate; GDP data on purchasing power parity basis.

² Based on historical development between 1990 and 2010 of total global DALYs lost (Global Burden of Disease).

³ Includes military budget.

⁴ Includes functional illiteracy.

⁵ Includes associated crime and imprisonment.

⁶ Includes sexually transmitted diseases. Excludes unwanted pregnancies.

⁷ Excludes lost time to access clean water source.

SOURCE: Literature review, World Health Organization Global Burden of Disease database, McKinsey Global Institute analysis

Nature: Genetic susceptibilities are known to play an important role - multi-genic.

Nurture: They are **behavioral** diseases, i.e. diseases arising from **decision making**.

Human behavior and physiology is **complex** and requires **“deep data”**.

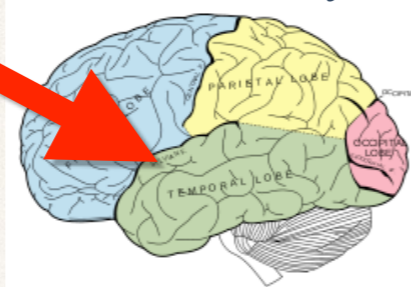
Deep Data and the Data Revolution



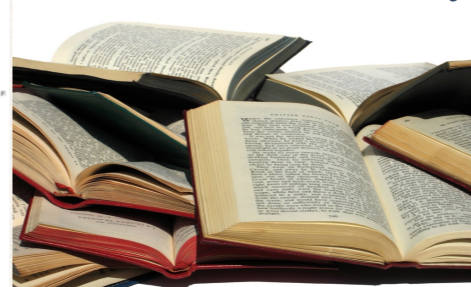
A revolution in the generation of data



Human brain
10-100 Terrabytes



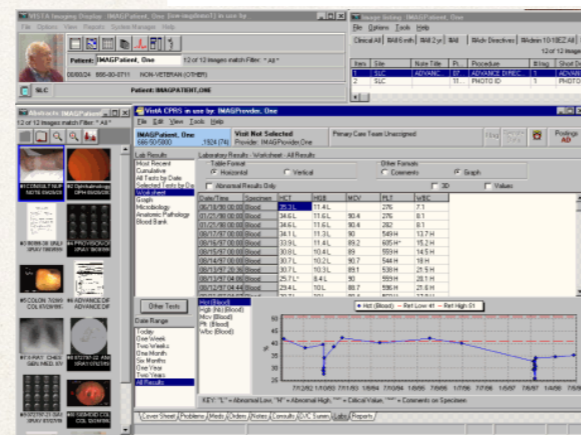
All the books in the world
30-50 Terrabytes



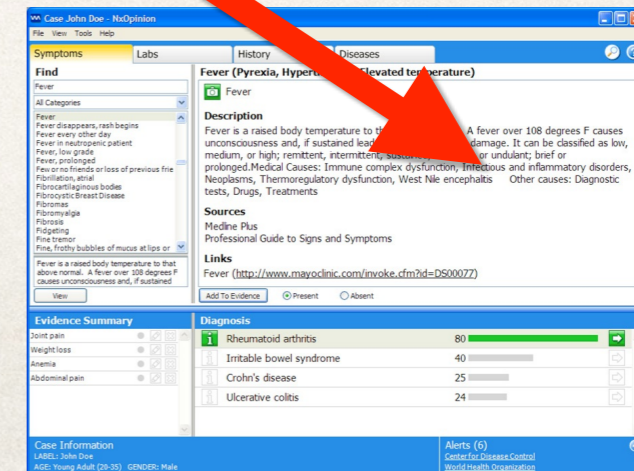
A revolution in data analysis



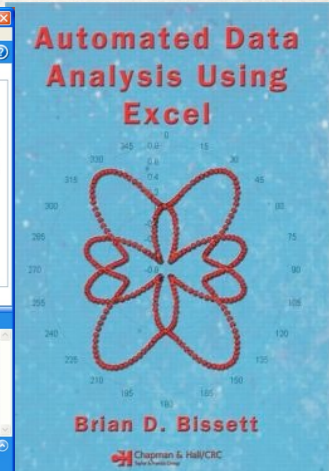
1 human genome
= 1GB (200)
CT image
= 10MB
MRI image
= 40MB



In electronic form
1 zettabyte



A revolution in data storage



The Data



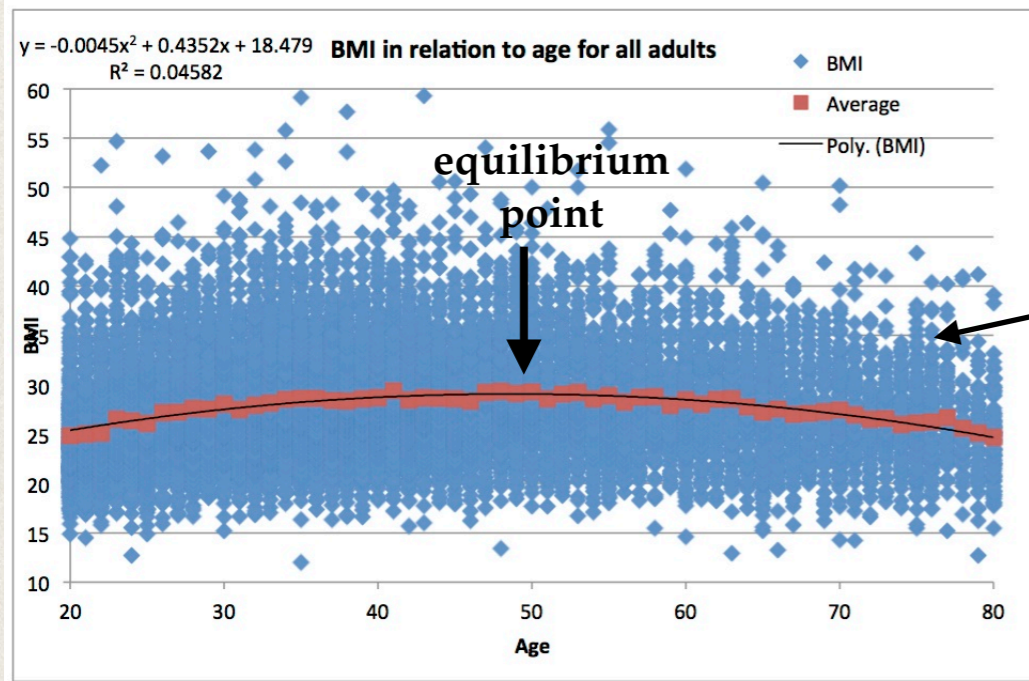
- ❖ **Study 1: Population - 1076 academics and staff of the Universidad Nacional Autonoma de Mexico**
 - ❖ Measurement: Axillary temperature was taken at a single time moment between 9am and 11am by qualified medical practitioners using a standard thermometer and registered visually to 0.1C accuracy.
 - ❖ Notes: Participants were seated and had fasted for at least 8 hours. Measurements were taken in different buildings of the university and as much as possible it was attempted to recreate the same conditions in each session. Typically, 20-30 subjects were tested that daily in a three hour session. For BMI, weight was measured using a standard scale and height using a stadiometer. Both measurements were taken by qualified medical professionals and in the same session temperature was measured.
- ❖ **Study 2: Population - 22 male young adult volunteers (20-40yo) from the general university population.**
 - ❖ Measurement: Wrist temperature continuously measured for one week using a Thermocron iButton with a sampling frequency of 1 / 3min, a resolution of 0.0625C and an accuracy of 0.5C.
 - ❖ Notes: Climatic season (rainy season August-October 2016) The model DS1922L was fixed to the non-dominant wrist using medical tape. Weight and height were recorded. In this pilot study, we focused on males because in females the timing of the 1-week monitoring period with respect to the monthly menstrual cycle is important and requires a separate investigation.



The Hypothesis:

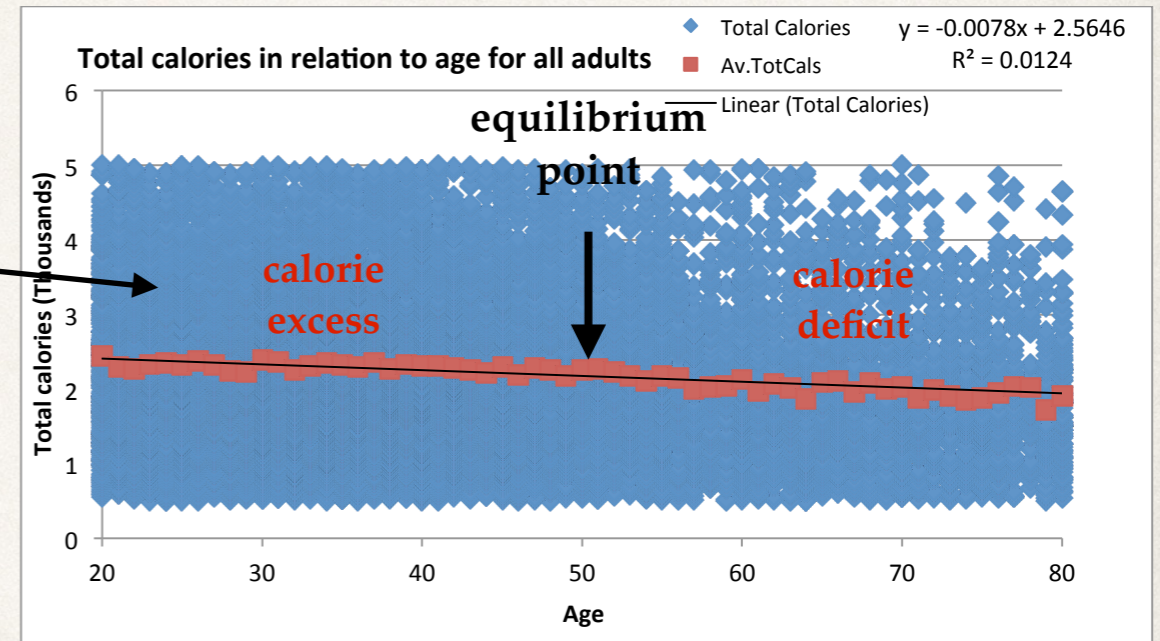
You aren't what you eat you become what you eat but...

Epidemiological data from ENSANUT 2006

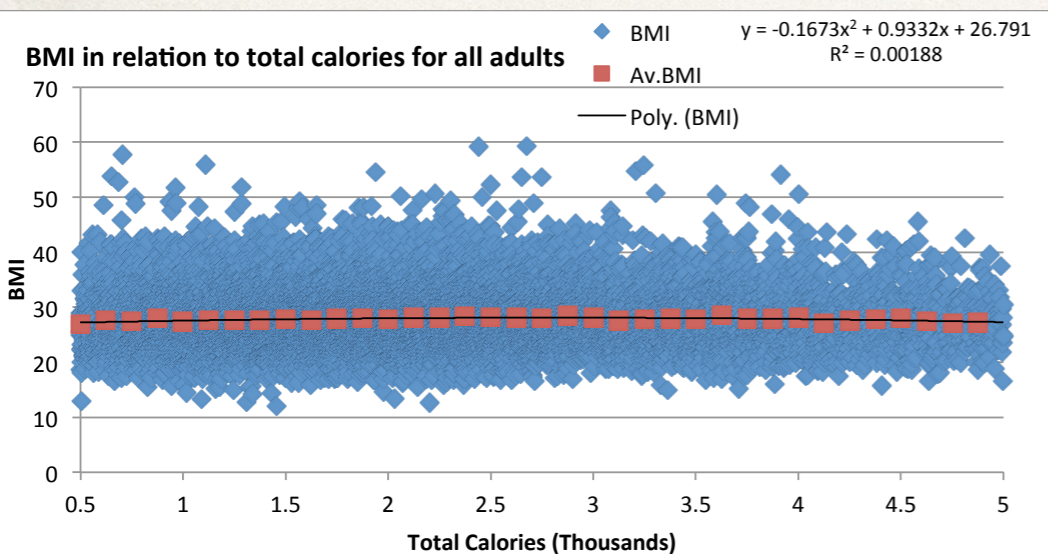


We get fatter then we get thinner

Its not "noise" its multifactoriality



We eat less the older we get



The obese eat as much as the thin

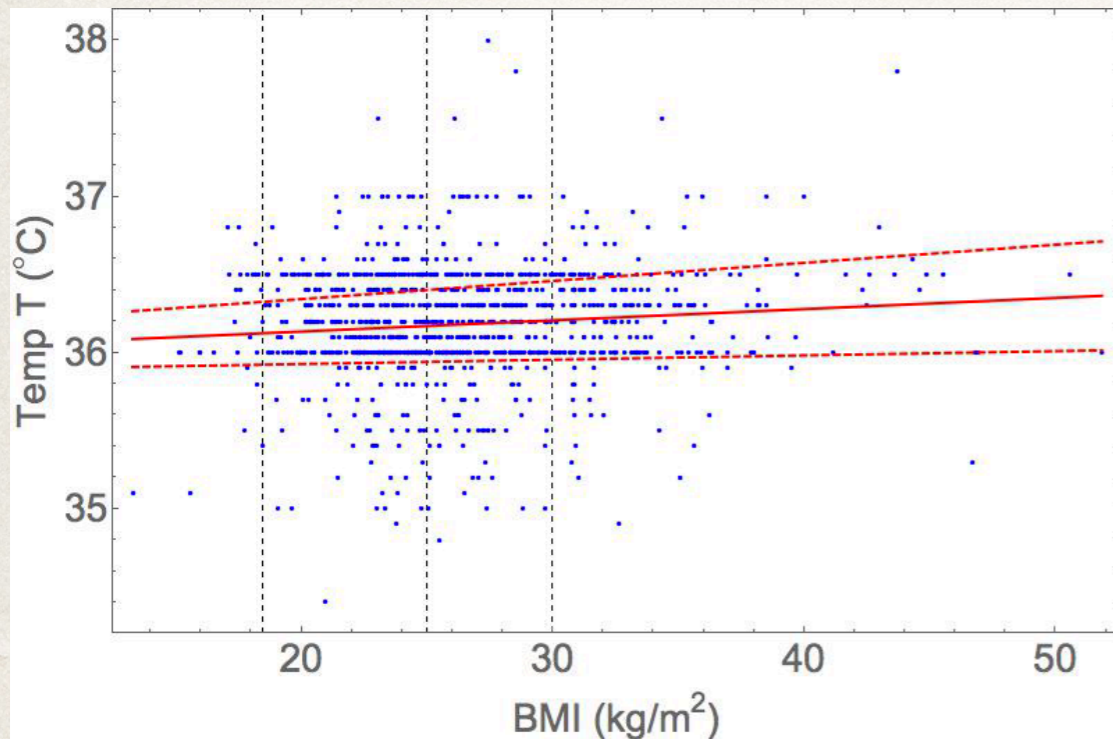
The data shows an overconsumption of 200-300 Cals/day at age 20-30. 8 Cal/day is enough (naively through the famous/infamous 3500 cal rule) to generate the observed increase in BMI. Where do the other calories go?

Why aren't we even fatter?



Do you become what you eat?

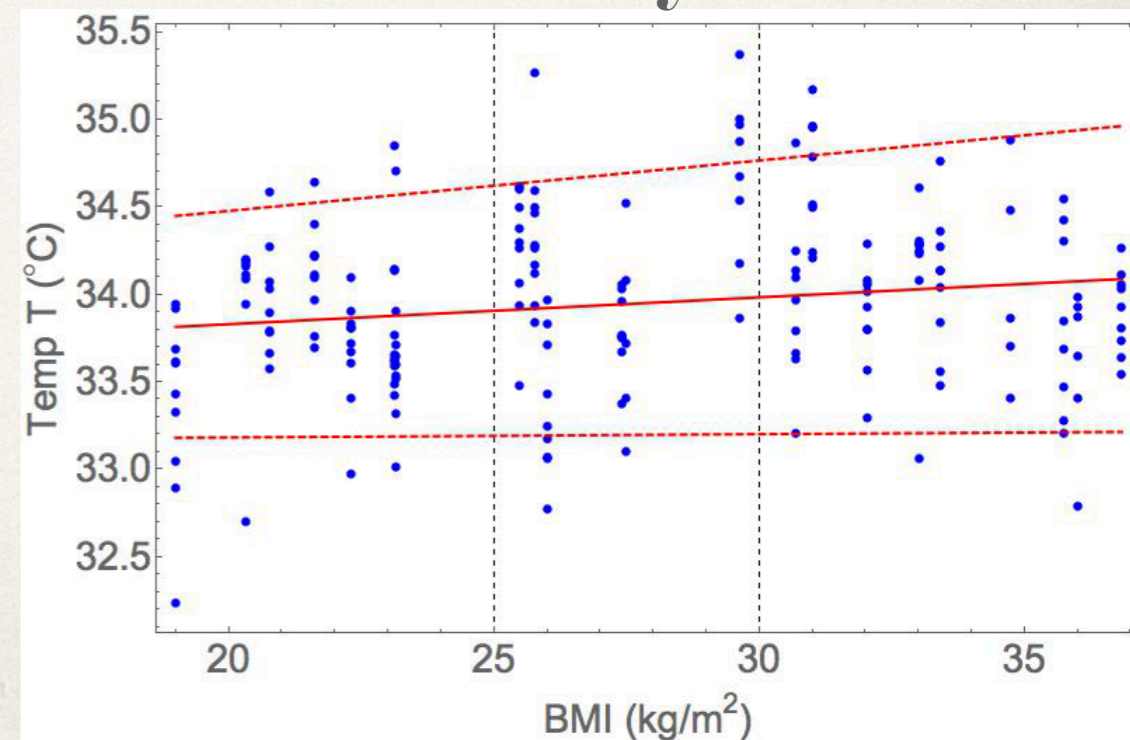
Relation between temperature and BMI



Study 1

	Study 1		Study 2	
	points	deciles	7-day mean	1-day mean
slope	0.0072	0.0067	0.0093	0.015
intercept	35.99	36.00	33.69	33.524
CI slope	0.0028	0.0024	-0.019	0.0019
	0.012	0.011	0.038	0.029
CI intercept	35.88	35.89	32.88	33.15
	36.11	36.12	34.51	33.90
tslope	3.18	3.56	0.68	2.25
tintercept	590.34	708.93	86.9	174.92
F	10.15	12.64	0.46	5.06
p	0.0015 (*)	0.0074 (*)	0.50	0.026 (*)
R2	0.0094	0.61	0.022	0.027

Study 2



Body temperature found to increase with BMI using two different populations and two completely different measuring protocols



0.07°C doesn't sound like
much, but...

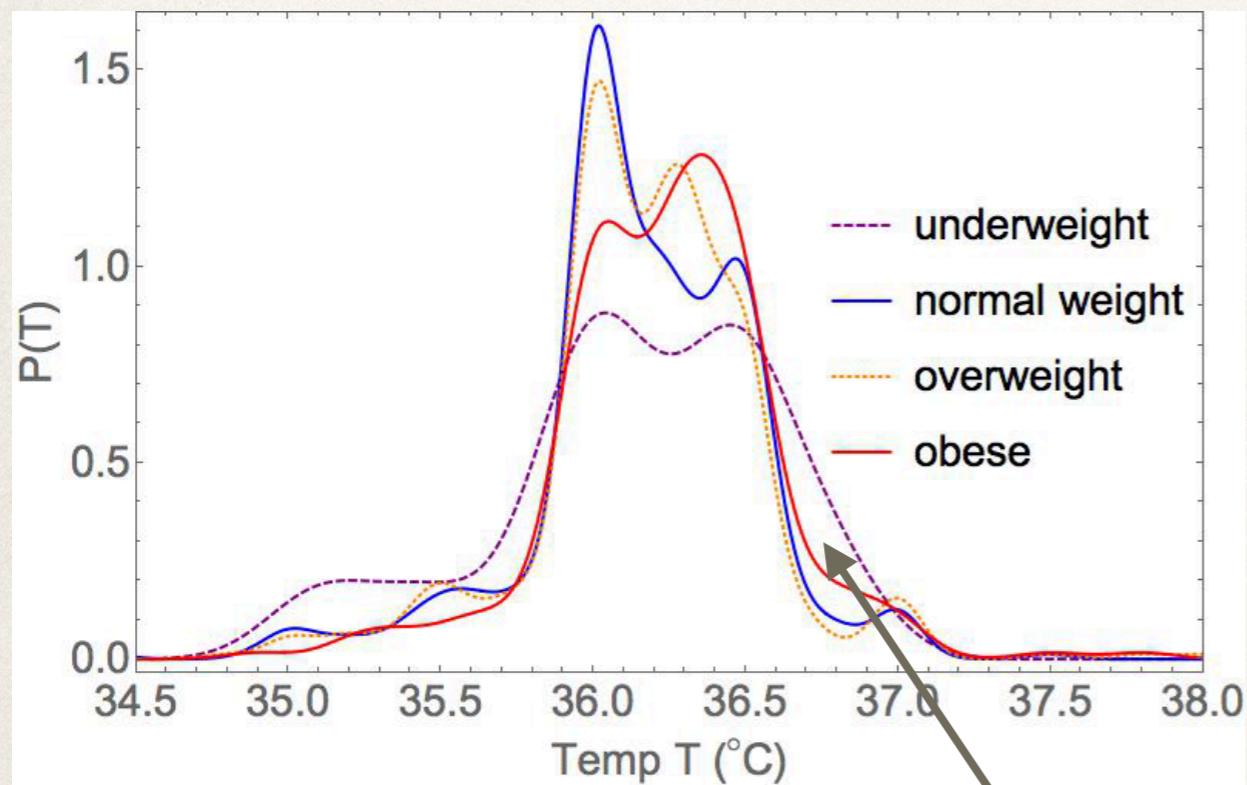
can make a difference of
500-1200 cal per day in
energy radiated!



Differences in the protocols...

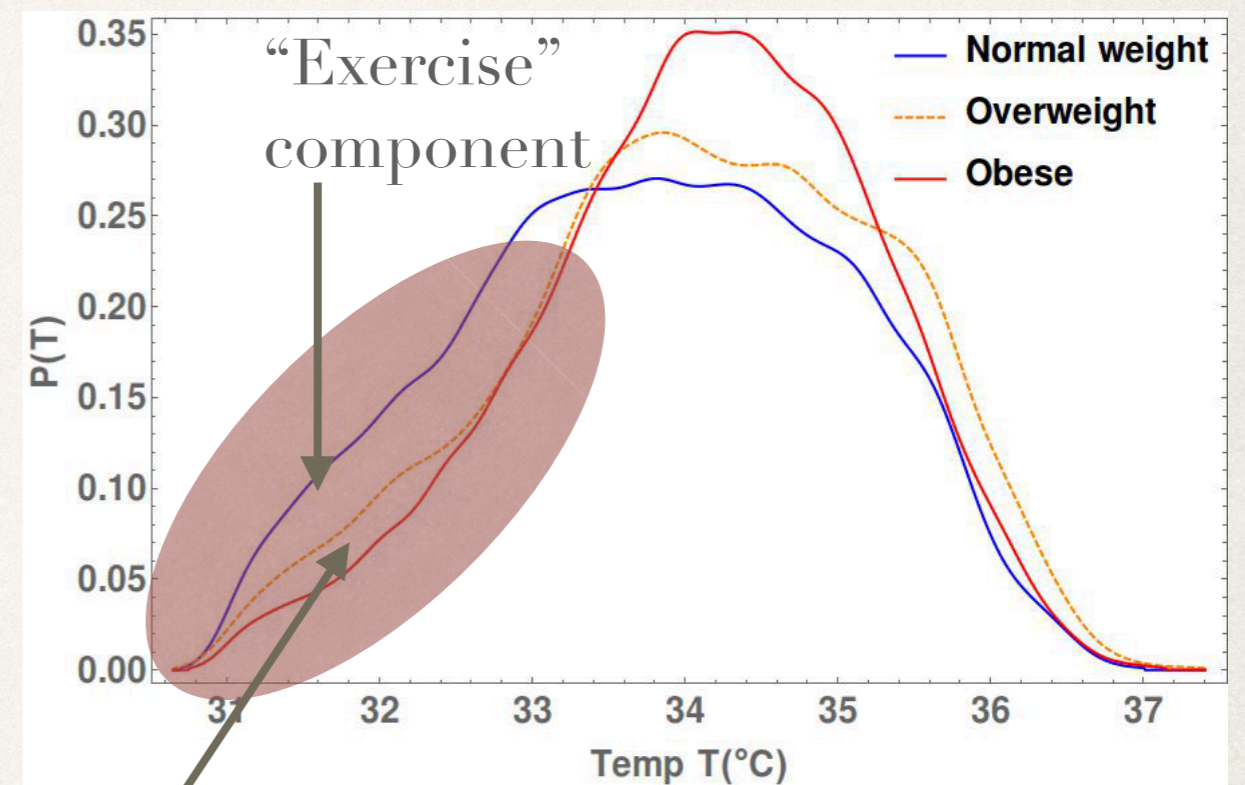
Higher moments

Study 1



Transverse

Study 2



Longitudinal

Less/More
Variance/kurtosis

Conclusions



- * Obesity is probably the world's number one health problem which, in spite of a huge investment in research and public health initiatives, is still increasing
- * It is representative of a Complex Adaptive System with a highly multifactorial, multiscale set of risk factors
- * Digital health technology offers a tremendous opportunity, especially in conjunction with traditional methods, to measure physiological and behavioural parameters
- * Temperature, in spite of being a standard physiological variable, is not as well understood as it should be and especially its link to obesity
- * We hypothesise that the obesity epidemic is not as severe as it should be and that the obese have higher temperatures as a way to offset consumption against weight gain
- * Our multi-population, multi-protocol study is consistent with this hypothesis