Variability in height and body shape since the 19th century

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**Background & Aim**

- **Public health surveillance**: Based on ongoing, systematic collection, analysis, and interpretation of data.

- Continuous monitoring of nutritional status and body shape will remain a cornerstone in future non-communicable diseases (NCD) strategies.

- **Aim**: Extend the time context of body shape-monitoring from the most up-to-date data not only until the 1990s but further back covering the last 140 years.

- **Approach**: The distribution (and not only the population mean) of a morphological feature best reflects the range of existing phenotypes and variability.

- In order to accurately monitor changes in body shape over a longer time, comparable data are essential. **Example: Swiss conscripts over the last 140 years.**
Data: Conscription in Switzerland 1875 until today

- **Standardized and universal recruitment procedure** since 1875 (remained unchanged).

- All young men are called to **conscription in the year they turn 19**.

- **High coverage**: Population of conscripts is >90% identical with Swiss resident male population at age ca. 19.

- Body measurements (taken by medics) for **all conscripts** (irrelevant if capable to serve or not).

- 2004-2014: 65% of conscripts agreed to having blood samples taken.
Height: +15cm in 140y, no more increase since 20-30y

- Average height: +15cm in 140 years, start in the 1870s
- From low Southern-European level to Central-European level by WW1
- Large regional differences
- Plateau: No more height increase since 2-3 decades

- Height distribution shifted to the right on the x-axis
- > 175 cm - 1878/79: 5.48%, 2008/09: 71.13%
- 19th century: ca. 6% < 150cm, height was slightly left-skewed (-0.8), SD was 7.5cm, and very short men were over-represented!
- Main reasons: Widespread iodine deficiency and low living standard?
Weight/BMI: Increase, plateau only in the last 4-6 y

Floris et al., Bericht BAG, 2016; Staub et al., Obes Facts, 2016
BMI: From under-nutrition to over-nutrition

- Weight and BMI became increasingly right-skewed.

- Underweight in the 19th century vs. overweight in the 21st century.

- BMI relations between the upper and the lower end of the socio-economic strata changed inversely from the 19th century to modern times.
Evolutionary aspects…

- The body of young men adapted differently to varying living conditions (life history theory):
  1. Less investment in height and weight under conditions of under-nutrition and food uncertainty (before 1870s).
  2. More investment in height under more stable nutritional conditions (1870s-1970s).
  3. Development of obesity during conditions of plateaued height growth, over-nutrition, and decreasing physical activity (the last 20-30 years).

- Phenotypical plasticity (adaptively responding to the environment).

- Thrifty-Gene Hypothesis: Mismatch between evolved biology of human body and modern life. The survival advantages of the ability to store fat in the unstable agrarian society became a disadvantage in modern and stable consumer society.

Staub et al., Obes Facts, 2016
BMI distribution became broader at both ends

- BMI: Distance from median steadily increased at lower and upper end
- For some metabolic parameters today: Underweight is as bad as overweight

Staub et al., Evol Med Public Health, in review
Groups at risk: Small area clusters of obesity

- SEP of neighborhood is important as well
- Small area clusters: Patterns do not follow administrative boundaries
Discussion

- **Limitations**: Conscription data depict only young men with Swiss citizenship!

- **Multifactorial causes for changes in height and body shape**: Genetics, epigenetics, environment, behavior, etc., but also evolutionary aspects.

- Focus on shape and position of distributions (variability) adds information

- **Groups at risk** can change over time, and they do not necessarily follow administrative categories (cantons, etc.) > Need for personalization

- **Hypothesis**: Advances in medicine > reduced premature mortality and increased probability of reaching reproductive age (>99%) > **Relaxed natural selection** > accelerated genetic change, higher variability, accumulation of harmful mutations, altered genes affecting energy balance and metabolism?

- **BMI is not ideal** (weight by muscle or fat?), additional information is needed…
After a successful pilot study in 2016 waist circumference will be introduced as additional standard measurement in the conscription process of the Swiss Armed Forces from 2018 onwards.
**Outlook beyond BMI II: 3D Full Body Scans**

**Figure 1** Raw scan outputs of five selected test subjects showing the full range of observed body shapes. Subject (A) was the thinnest (scanned BMI = 16.85 kg/m\(^2\)) and subject (E) was the heaviest (BMI = 29.48 kg/m\(^2\)). Subject (B) represented the “healthy” body shape type with a BMI of 20.95 kg/m\(^2\). Subjects (C and D) had a similar BMI (27.94 vs. 27.73 kg/m\(^2\)), but in contrast to subject (C), subject (D) represented the athletic body shape type (reporting 17 h of sport per week). The faces of the subjects have been pixelated and anonymised.

- Not only conscripts: Assess body shape *in toto* via 3D full body scans
Thank you!

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