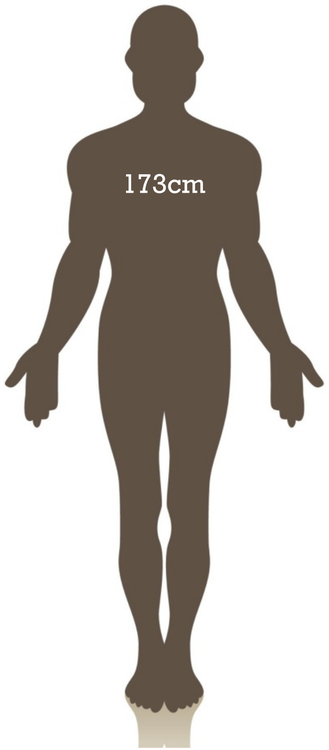
simulating the evolution of height in the Netherlands in recent history

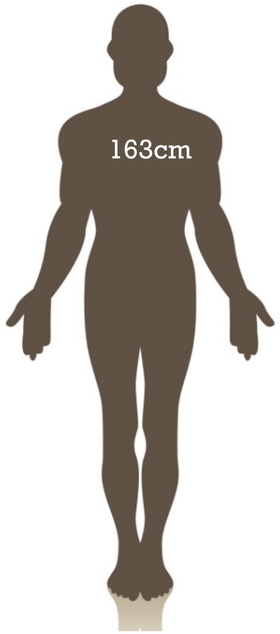
gert stulp
tyler bonnell
louise barrett

The Curious Dutch:

1850 rank: 1/12

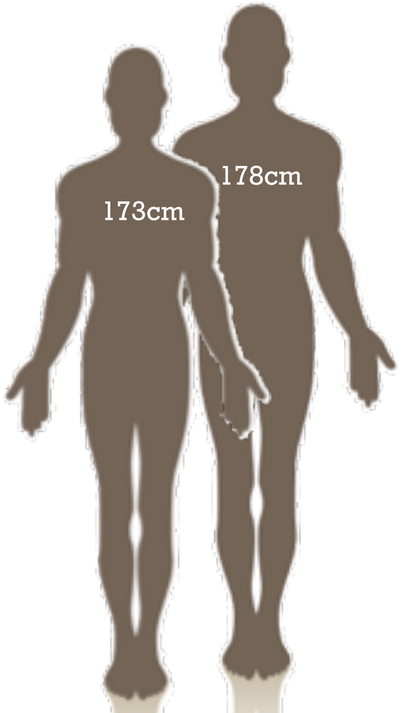
1850 rank: 11/12



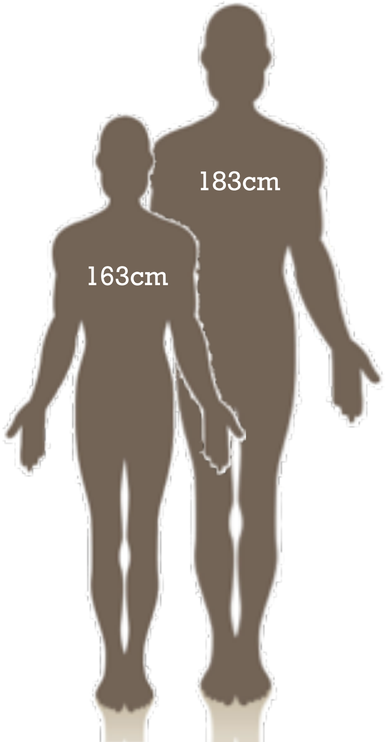


The Curious Dutch:

1850 rank: 1/12
2000 rank: 9/12



1850 rank: 11/12
2000 rank: 1/12



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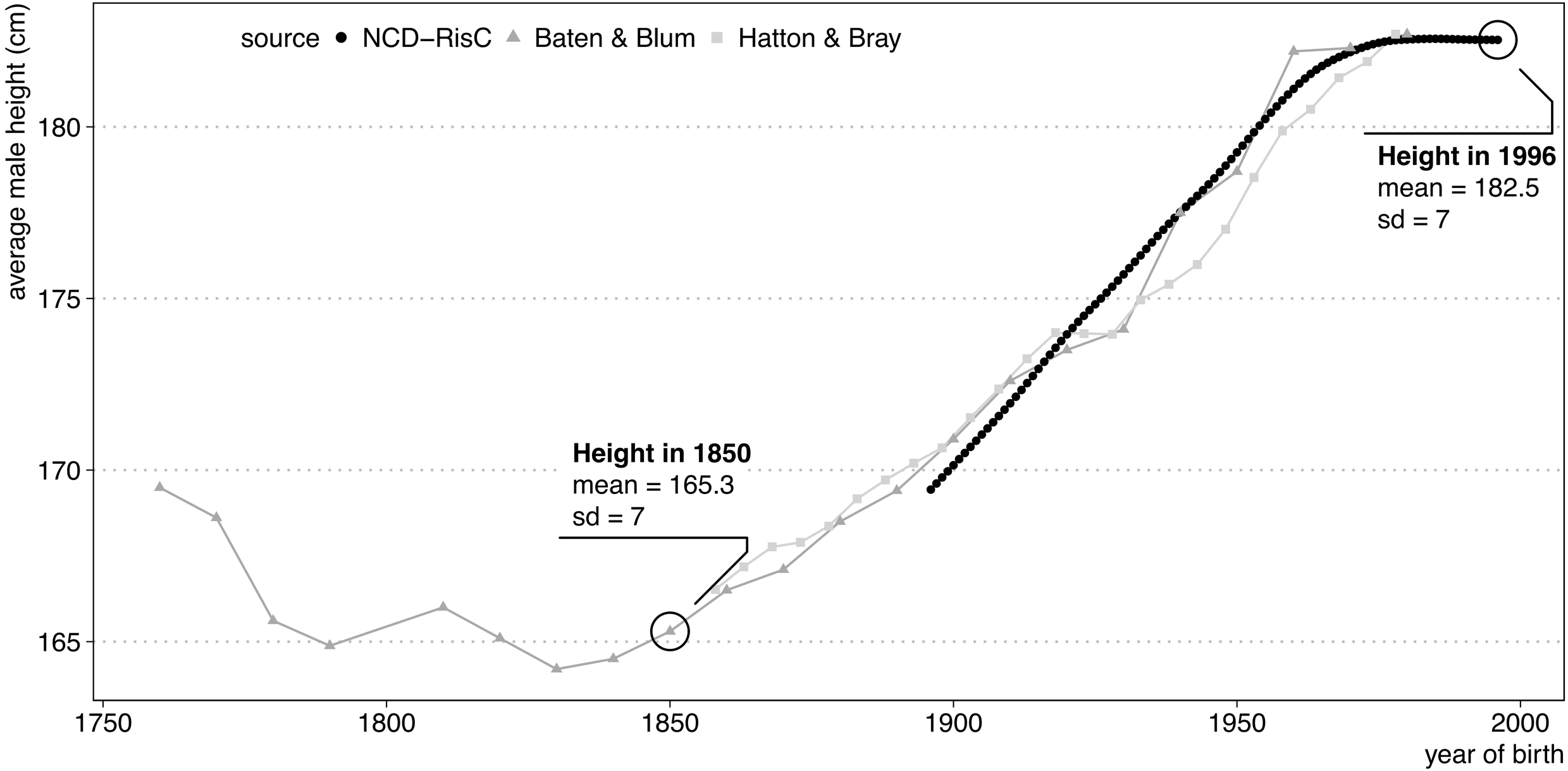


Why Are The Dutch So Tall?

improving environment

Why Are The Dutch So Tall?

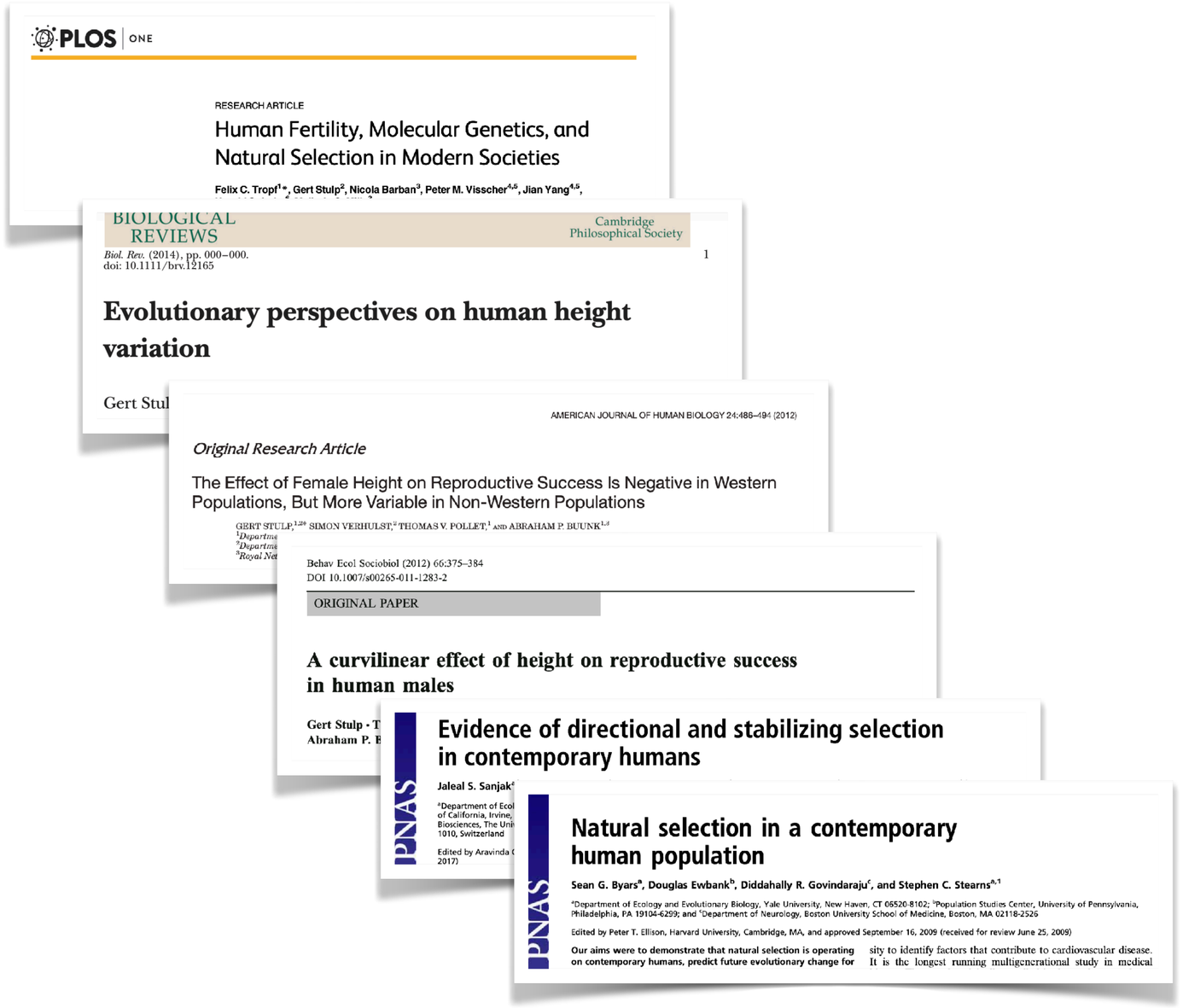
natural selection?

Why Natural Selection?

Natural selection could act on height through:

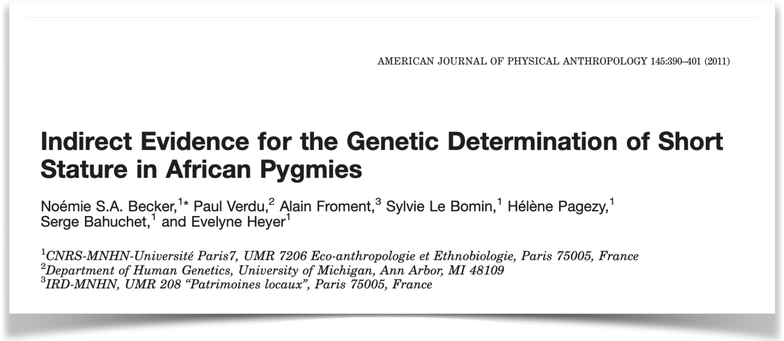
- sexual maturity
- education
- income
- health
- ease of giving birth
- child mortality
- mate choice
- longevity

...



Why Natural Selection?

Evidence for genetic differences between populations underlying height differences

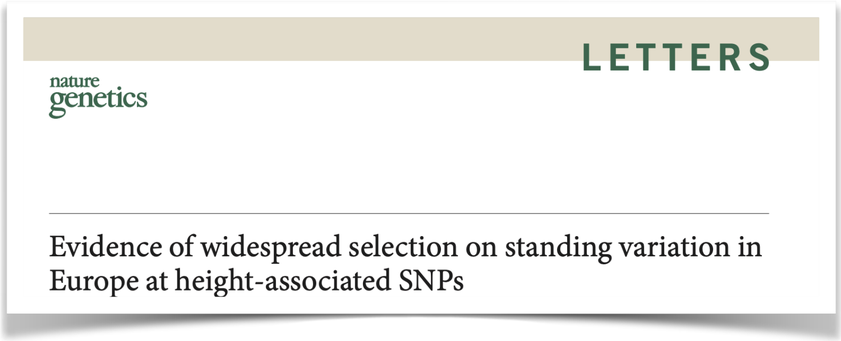


AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 145:390–401 (2011)

Indirect Evidence for the Genetic Determination of Short Stature in African Pygmies

Noémie S.A. Becker,[1]* Paul Verdu,[2] Alain Froment,[3] Sylvie Le Bomin,[1] Hélène Pagezy,[1] Serge Bahuchet,[1] and Evelyne Heyer[1]

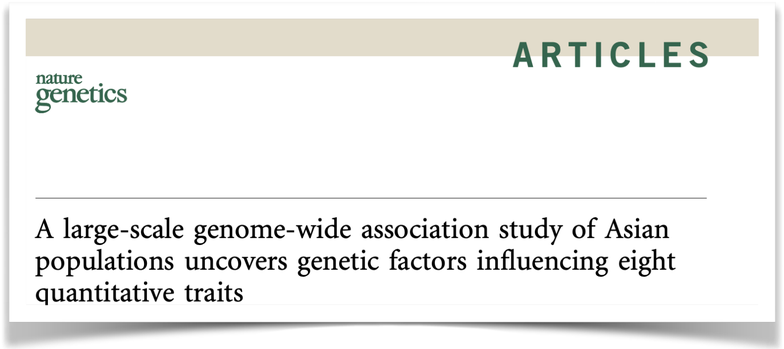
[1]*CNRS-MNHN-Université Paris7, UMR 7206 Eco-anthropologie et Ethnobiologie, Paris 75005, France*
[2]*Department of Human Genetics, University of Michigan, Ann Arbor, MI 48109*
[3]*IRD-MNHN, UMR 208 "Patrimoines locaux", Paris 75005, France*



LETTERS

nature genetics

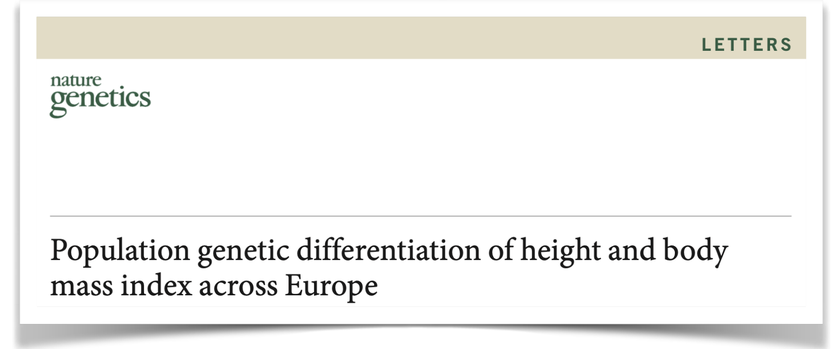
Evidence of widespread selection on standing variation in Europe at height-associated SNPs



ARTICLES

nature genetics

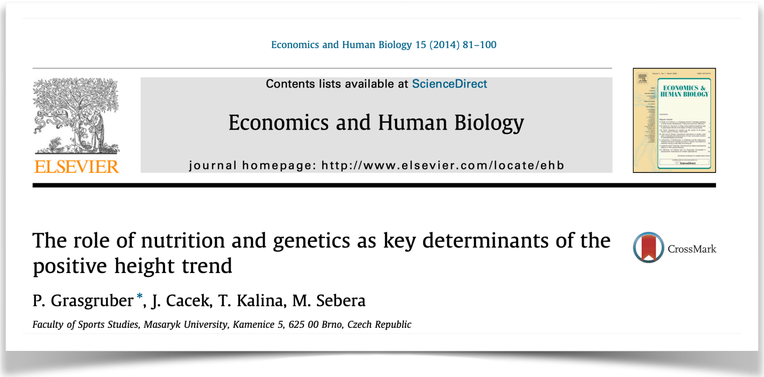
A large-scale genome-wide association study of Asian populations uncovers genetic factors influencing eight quantitative traits



LETTERS

nature genetics

Population genetic differentiation of height and body mass index across Europe



Economics and Human Biology 15 (2014) 81–100

Contents lists available at ScienceDirect

Economics and Human Biology

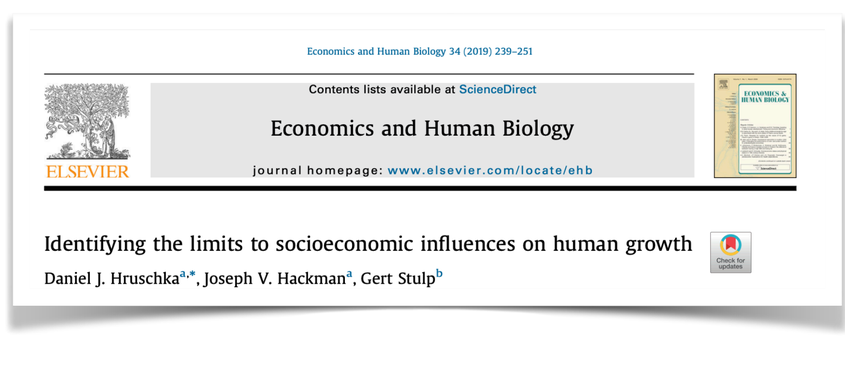
journal homepage: http://www.elsevier.com/locate/ehb

ELSEVIER

The role of nutrition and genetics as key determinants of the positive height trend

P. Grasgruber*, J. Cacek, T. Kalina, M. Sebera

Faculty of Sports Studies, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic



Economics and Human Biology 34 (2019) 239–251

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Economics and Human Biology

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ELSEVIER

Identifying the limits to socioeconomic influences on human growth

Daniel J. Hruschka[a,*], Joseph V. Hackman[a], Gert Stulp[b]

PROCEEDINGS B

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Research

Cite this article: Stulp G, Barrett L, Tropf FC, Mills M. 2015 Does natural selection favour taller stature among the tallest people on earth? *Proc. R. Soc. B* **282**: 20150211.

LifeLines

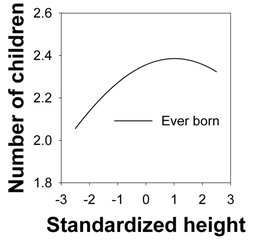
Does natural selection favour taller stature among the tallest people on earth?

Gert Stulp[1,2], Louise Barrett[3,4], Felix C. Tropf[2] and Melinda Mills[5]

[1]Department of Population Health, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK
[2]Department of Sociology, University of Groningen, Grote Rozenstraat 31, Groningen 9712 TG, The Netherlands
[3]Department of Psychology, University of Lethbridge, 4401 University Drive West, Lethbridge, Alberta, Canada T1 K 3M4
[4]Applied Behavioural Ecology and Ecosystems Research Unit, University of South Africa, Private Bag X6 Florida 1710, Johannesburg, South Africa
[5]Nuffield College/Department of Sociology, Manor Road, Oxford OX1 3UQ, UK

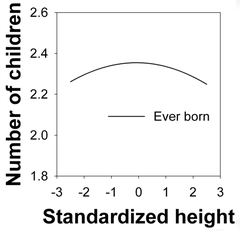
GS, 0000-0003-0173-5554; MM, 0000-0003-1704-0001

MAYBE,
YES?



Taller men have higher fertility partly because of increased likelihood of having a partner. Moreover, in those men that had a partner, height was positively related to fertility.

Taller women probably have lower fertility partly because of lower likelihood and higher age of finding a partner, despite higher ‘fecundity’. Average height women most likely to have partner, and at youngest age



doi:10.1111/evo.12803

Did natural selection make the Dutch taller? A cautionary note on the importance of quantification in understanding evolution

Maja Tarka,[1,2] Geir H. Bolstad,[3] Sebastian Wacker,[4] Katja Räsänen,[5,6] Thomas F. Hansen,[7] and Christophe Pélabon[1]

> Here, we provide a quantitative interpretation of these results using standard evolutionary theory to show that natural selection has had a minuscule effect.
>
> the predicted evolutionary change in mean height would be ... 0.38 mm per generation

Aims

What would we see if the increase in stature was *ALL* due to natural selection?

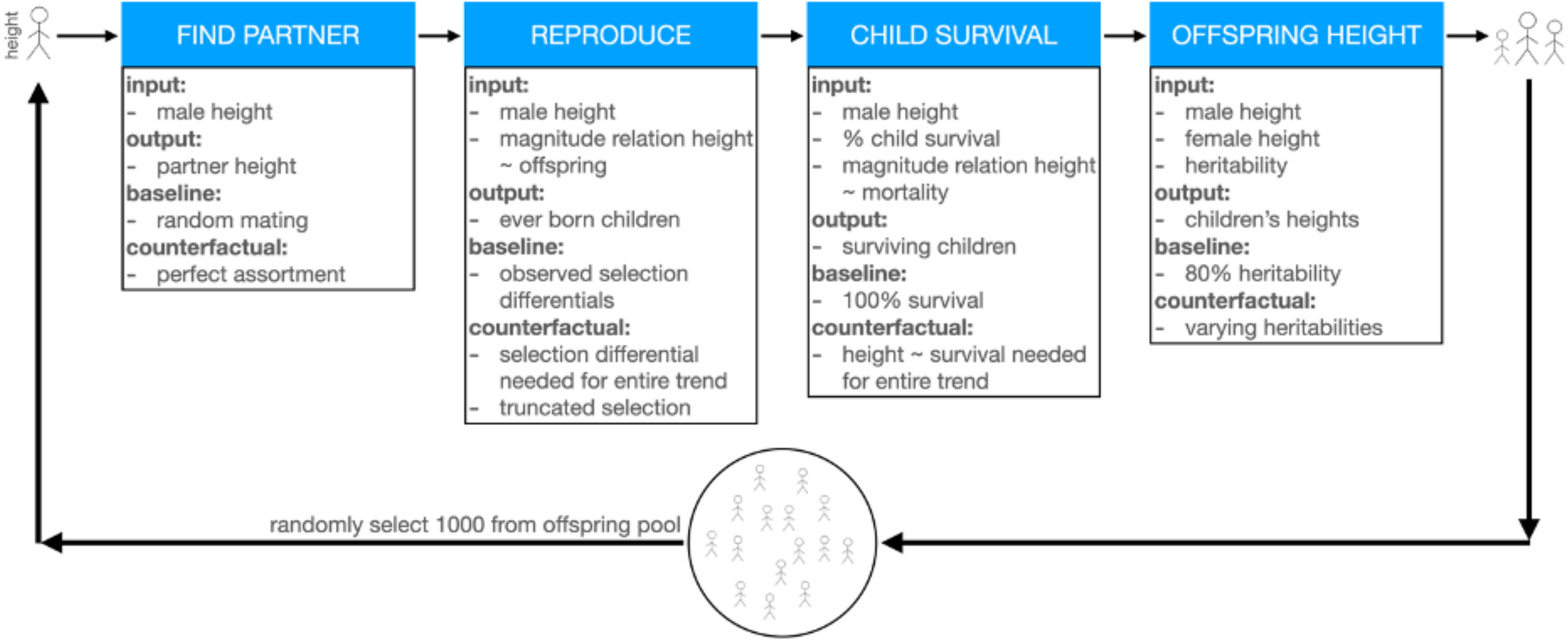
- how many children should taller men have?
- how should height affect child mortality?
- what % of the height distribution is allowed to reproduce?

Compare parameters to historical findings to set upper boundaries on height effects

Modelling plausible outcomes

- imposing observed selection differentials
- modelling mate choice

The Model


height
FIND PARTNER
input:
- male height
output:
- partner height
baseline:
- random mating
counterfactual:
- perfect assortment
REPRODUCE
input:
- male height
- magnitude relation height ~ offspring
output:
- ever born children
baseline:
- observed selection differentials
counterfactual:
- selection differential needed for entire trend
- truncated selection
CHILD SURVIVAL
input:
- male height
- % child survival
- magnitude relation height ~ mortality
output:
- surviving children
baseline:
- 100% survival
counterfactual:
- height ~ survival needed for entire trend
OFFSPRING HEIGHT
input:
- male height
- female height
- heritability
output:
- children's heights
baseline:
- 80% heritability
counterfactual:
- varying heritabilities
randomly select 1000 from offspring pool

Assumptions

1. heritability is 80% (mostly)
2. mating is random (mostly)
3. generation time is 25 years
4. starting population is 1000 agents
5. 1000 agents drawn from offspring

ALL Selection I

Breeder's equation:

$$R = h^2 S$$

$$R = h^2 \sigma_p(z, w)$$

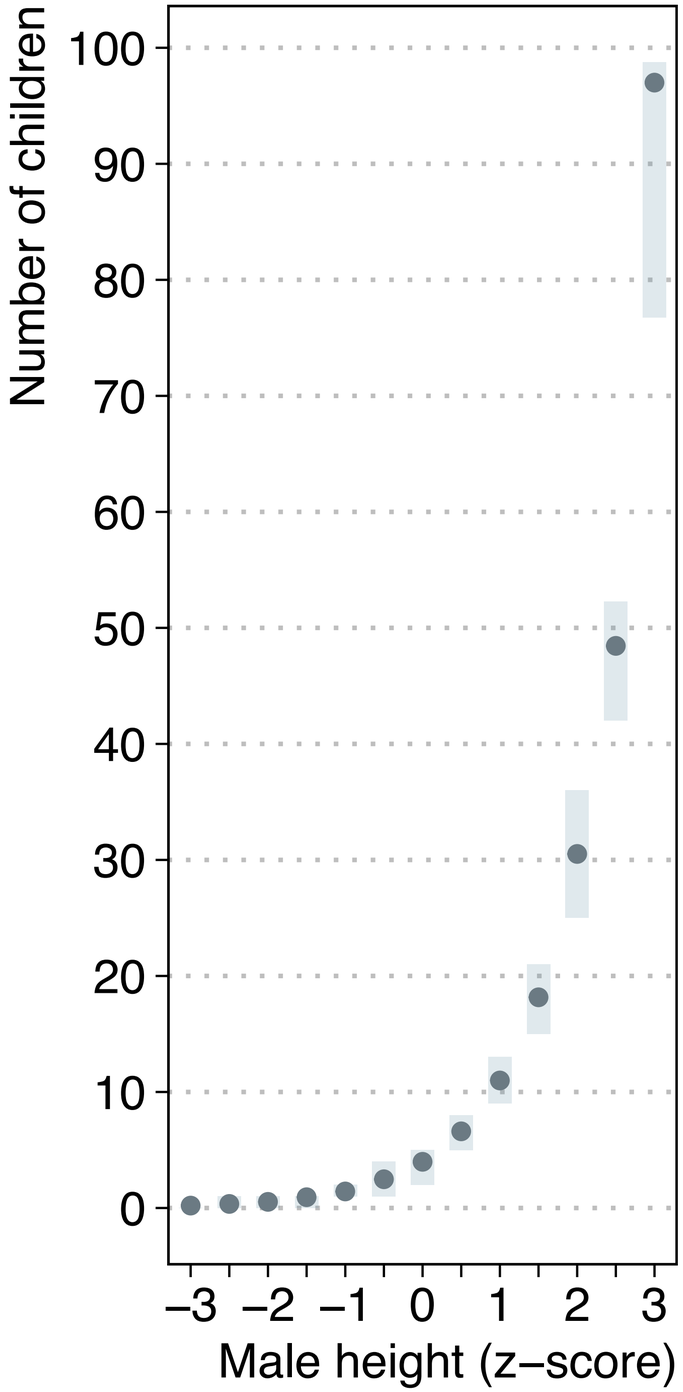
$$R = \frac{1}{2} h^2 \sigma_p(z, w)$$

$$\frac{182.5 - 165.3}{6} = \frac{1}{2} 0.8 \sigma_p(z, w)$$

$$\frac{2.87}{7} = 0.4 \sigma_p(z, w)$$

$$\sigma_p(z, w) = 1.02$$

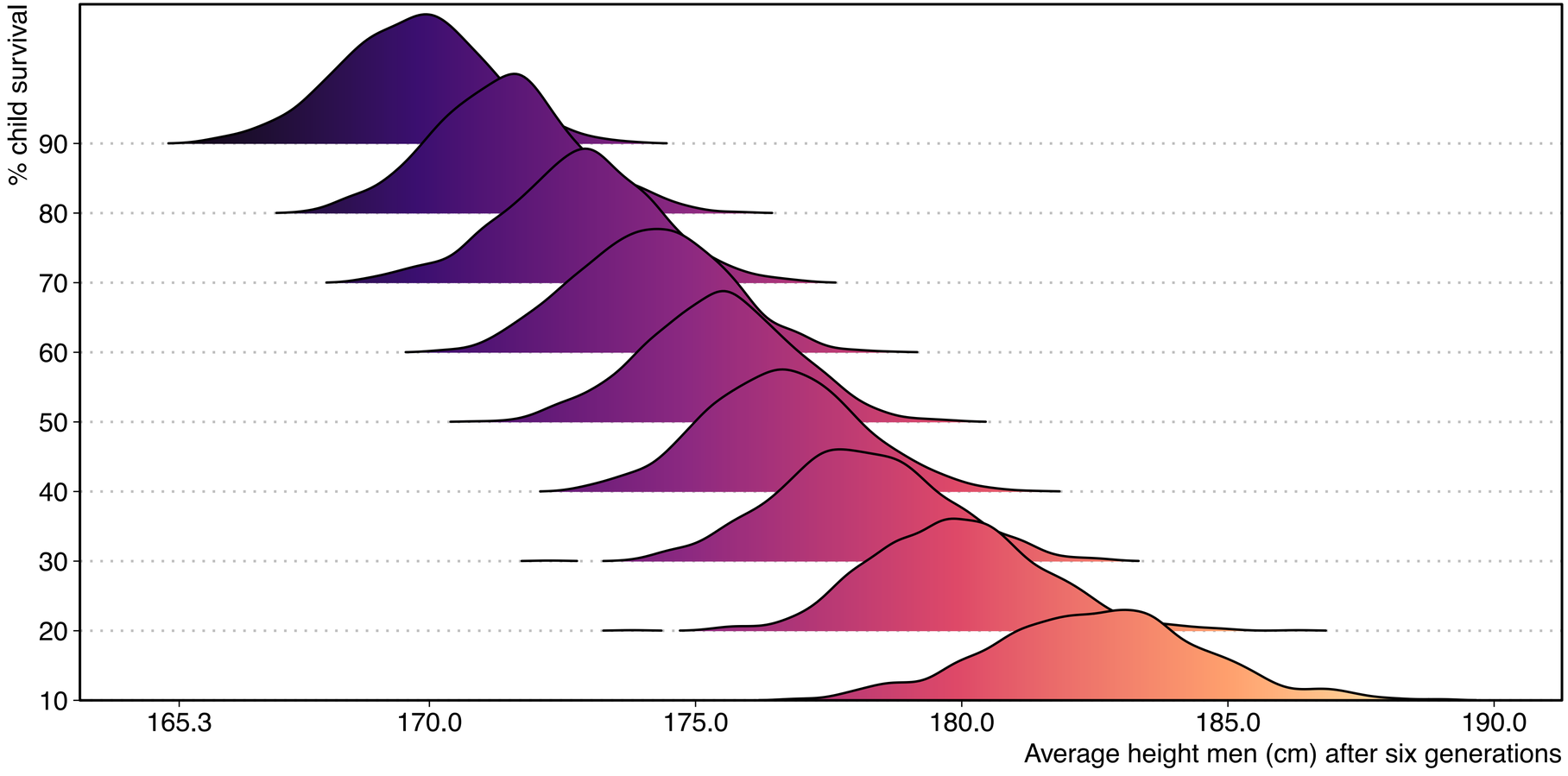
requires a covariance between standardized height and relative fitness of 1.02

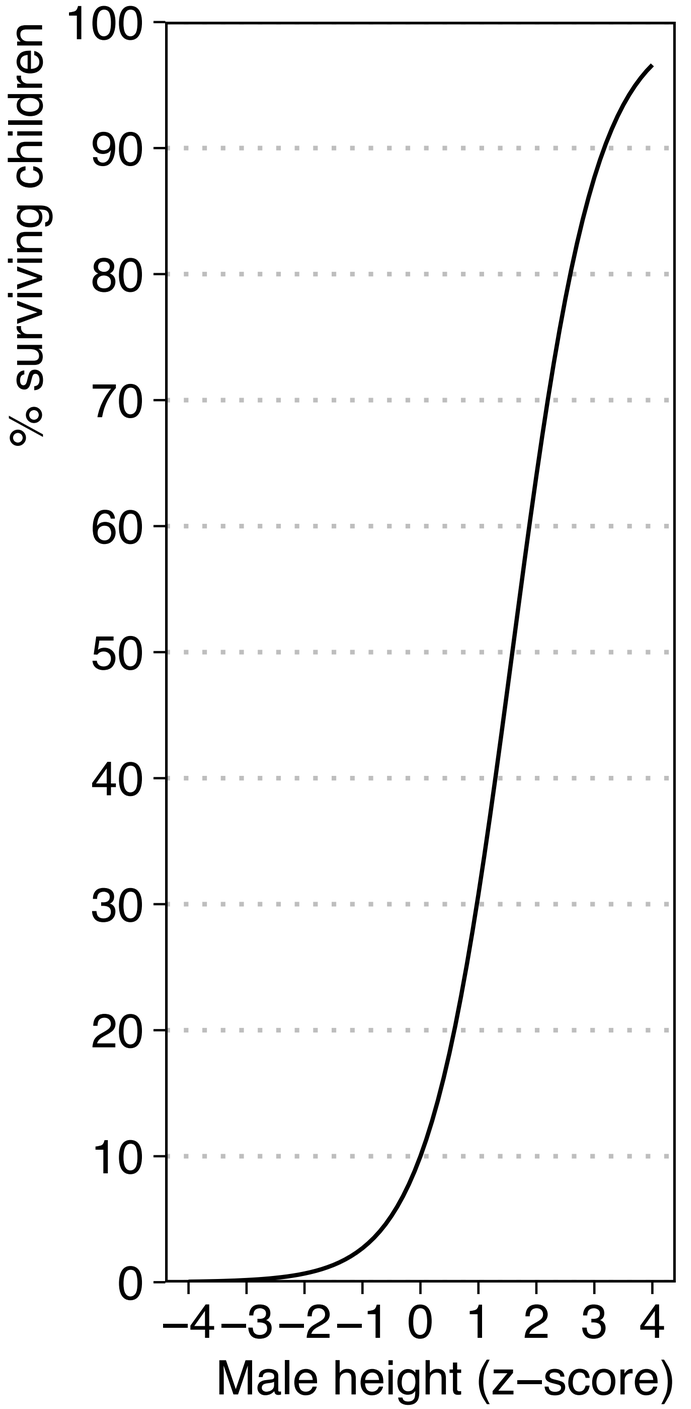


clearly unrealistic, but even in simulations hard to 'pull off' because it depends on the high fertility of the very-very-very-very-tall and it requires similar levels of variation in each new generation

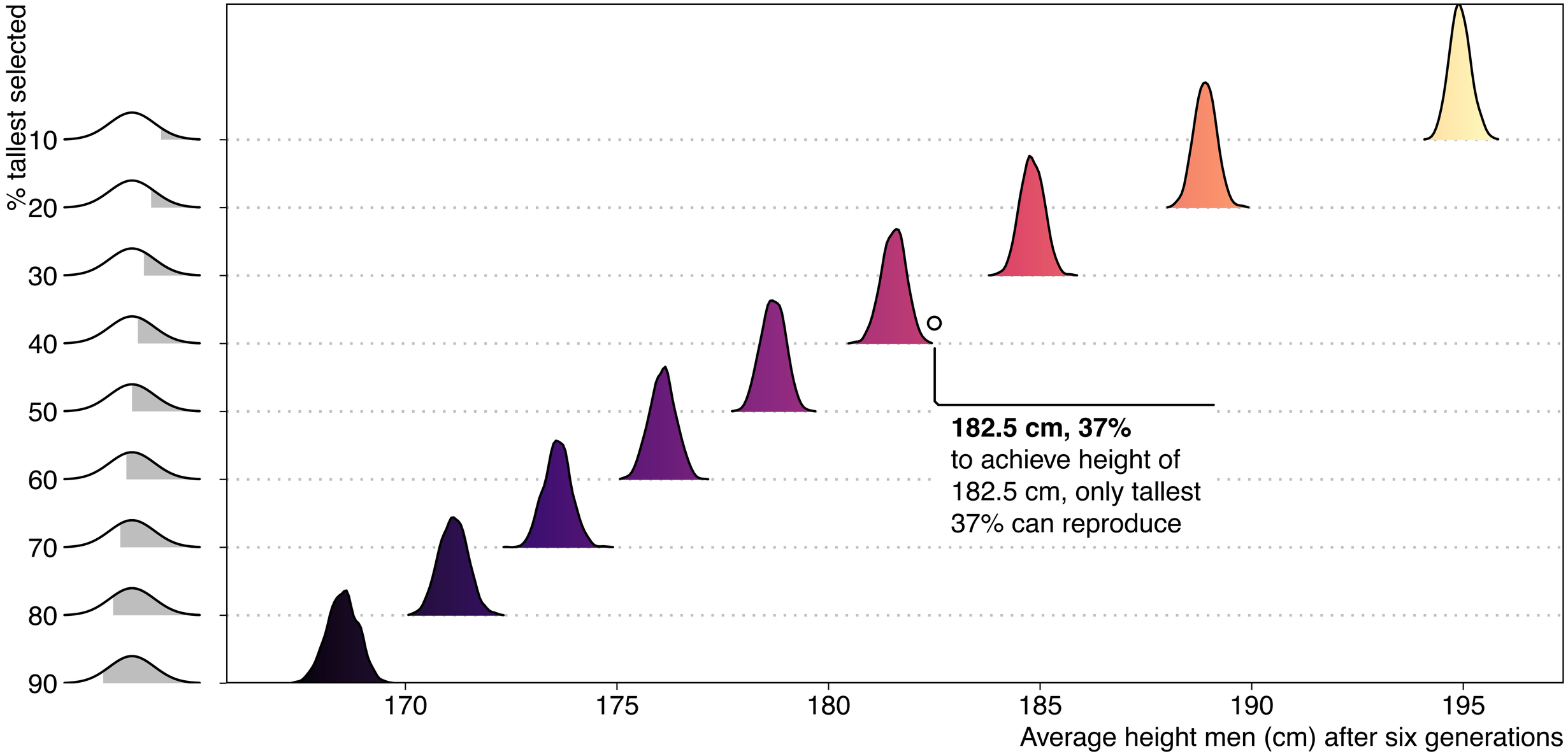
ALL Selection II

to achieve height of 182.5, child survival needs to be 10% or less, and each sd increase in height 700% higher odds of surviving child





ALL Selection III

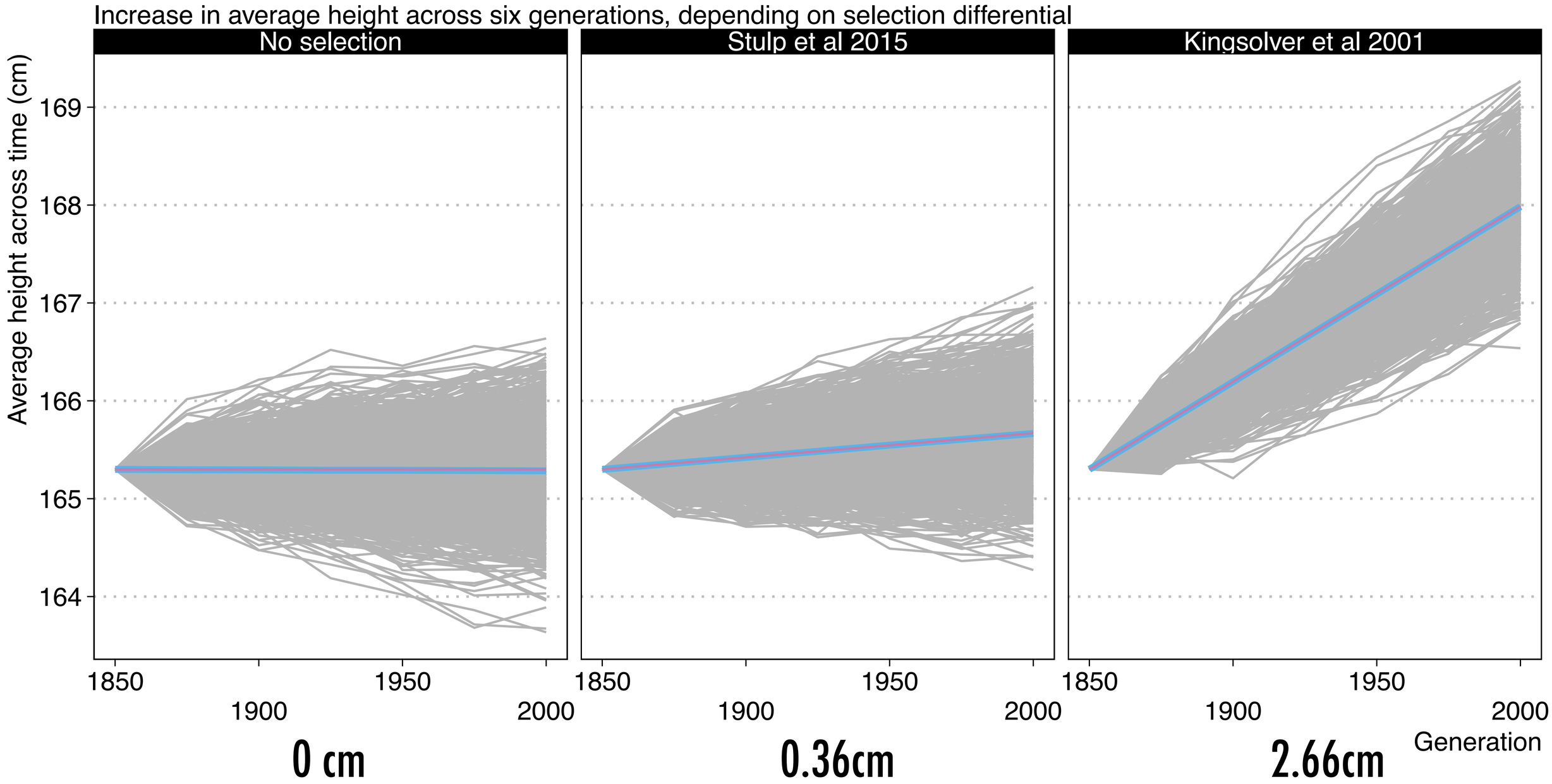


Lessons From Counterfactuals

If the increase in stature was *ALL*
due to natural selection, then...

1. above average height men should have dozens of children on average
   fertility rate of prairie dog
2. above average height men should have ten-fold higher child survival, with child survival at 10%
   child survival is much higher (>70%)
3. only 37% tallest men
   % childless men around 10-20%

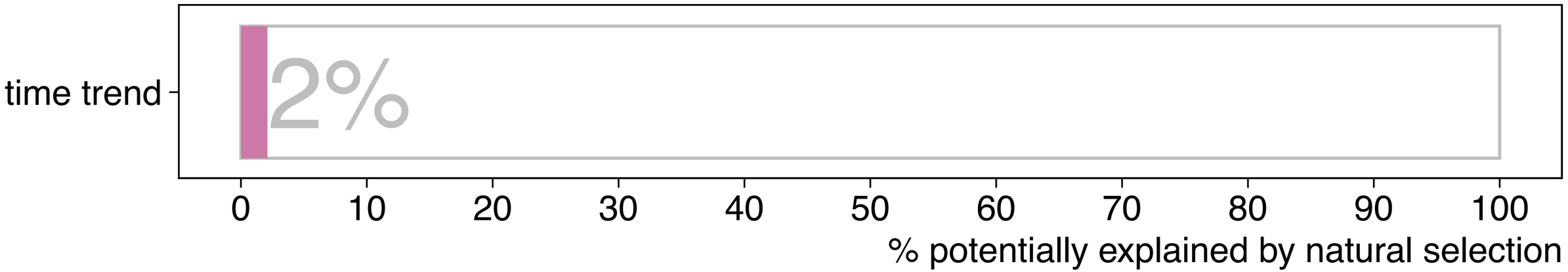
Plausible Estimates



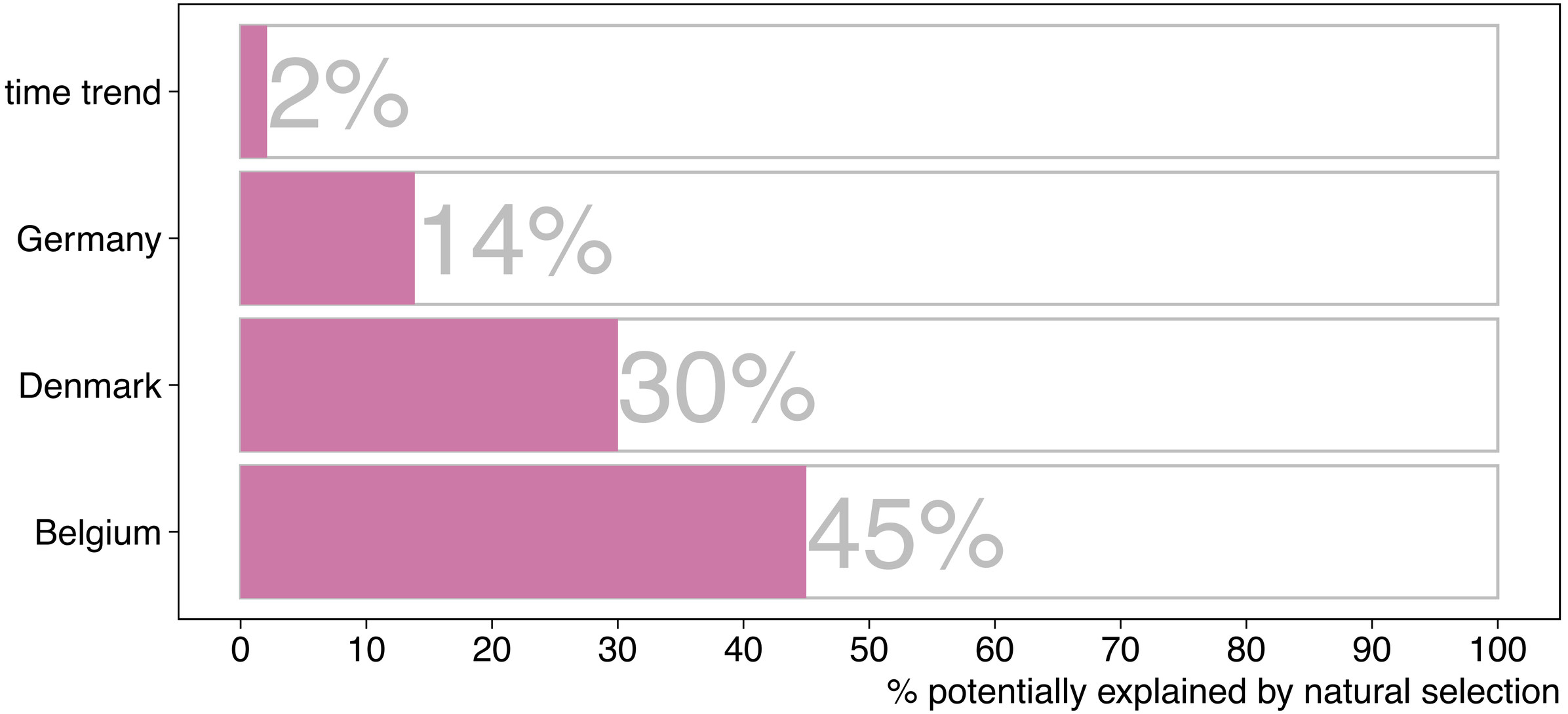
0.36cm Is Upper Estimate

1. heritability historically lower than 80%
2. absence of selection on women
3. generation time rather low (25 years)
4. timing of births irrelevant in model

Selection Potentially Explains…



Selection Potentially Explains…



What Next?

Shiny app as educational resource

https://primatemovement.shinyapps.io/shinyHeights/

Ideas for additional simulations?

e.g., counterfactuals, mate choice

simulating the evolution of height in the Netherlands in recent history

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