Challenges in Forensic Individual Age Predictions

ZSOLT PÁDÁR, ZSOLT KOZMA

DEPARTMENT OF FORENSIC MEDICINE, MEDICAL SCHOOL, UNIVERSITY OF PÉCS

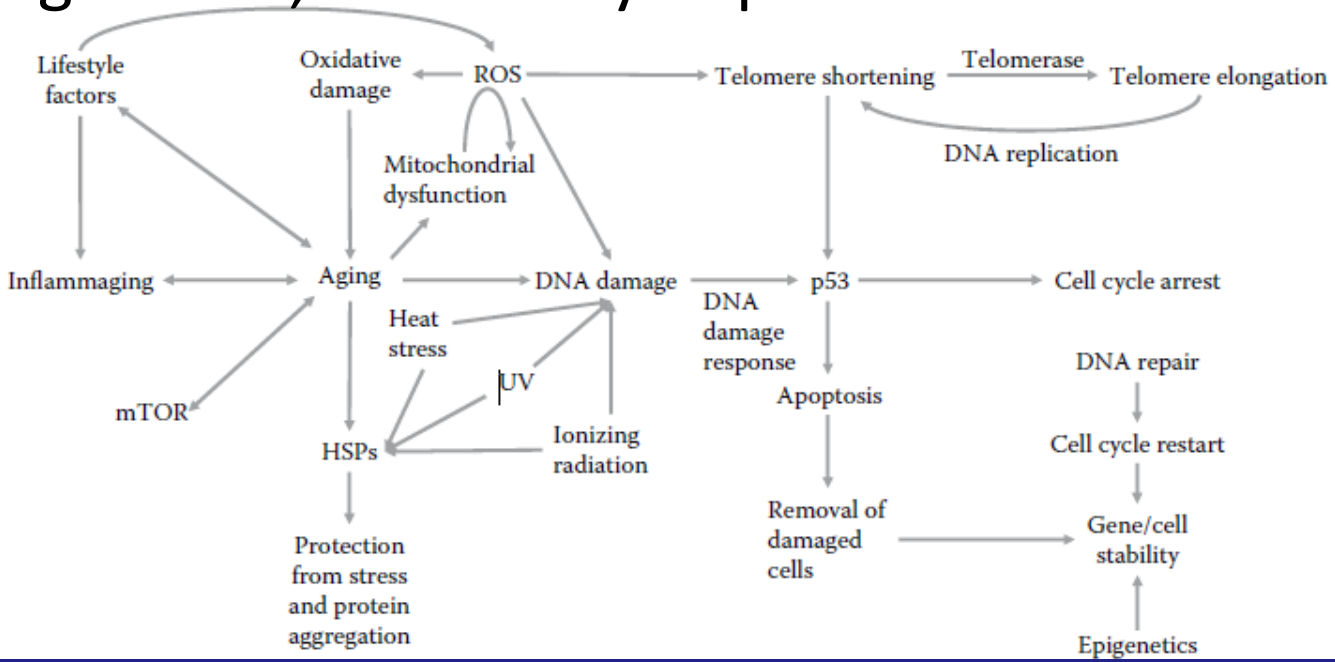
Migrant health, public health challenges and responses - Consensus conference Pécs, Hungary, 07-08 October, 2019

The Basic Question and Approaches…

- „Who wants to live forever?"
  - ageing / senescence a „neverending story"…
    - spiritual, mythical, fictional, artistic, medical, popular considerations…
  - ageing is a complex phenomenon
    - complex questions require complex approaches and models
  - recently >300 scientific theories and > 400.000th papers
- Importance in criminal and civil law
  - forensic contexts
    - human trafficking - examination of living individuals
    - crime scene - unknown donors of recovered biological material

Level # 1 - Complexity

- Mutations, modifications, adaptations, variations, patterns over the course of a lifetime…
  - molecular, metabolic, psychical, morphological, structural, physiological, functional and mental levels
    - morphological/skeletal age, dental age, epigenetic clock…
- Dynamic progression/regression, with many dependent and independent variables



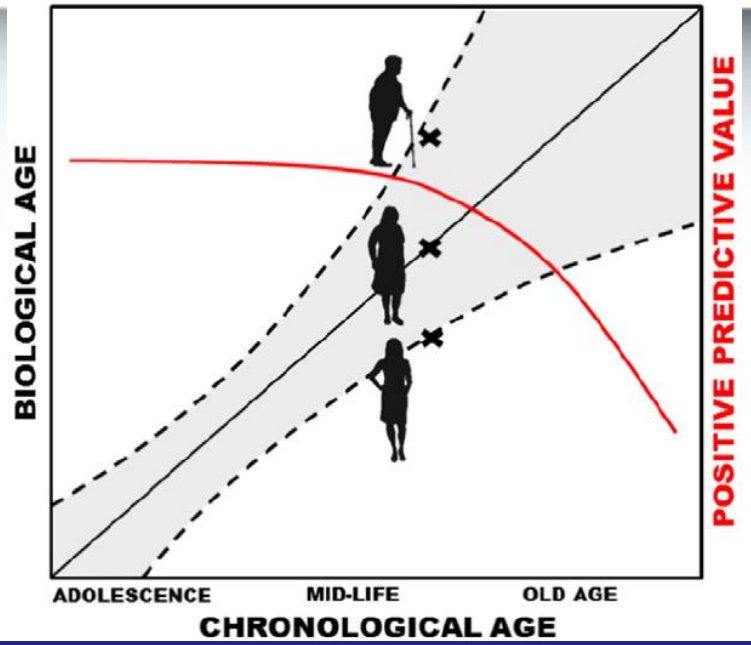
Source: Shamim I. Ahmad (Ed.) Aging: Exploring a Complex Phenomenon. CRC Press. (2018) ISBN 9781138196971

Level #2 – Data Sources - Biological Age Predictors #1

- Physical development, constitutional type of body
  - complex sports physiology and performance
    - skeleton, muscles, thermoregulation, metabolism, enzymes, …
- Skeletal development, maturation
  - ossification rate at symphysis, epiphysis, sacropelvic surface, fourth rib and clavicle…
- Dental development
  - root translucency from teeth, degree of mineralization, and eruption of the third molars, mandibular condyle…
- Psychological development
  - neuropsychological (and cognitive) assessment tests

Level #2 – Data Sources - Biological age Predictors #2

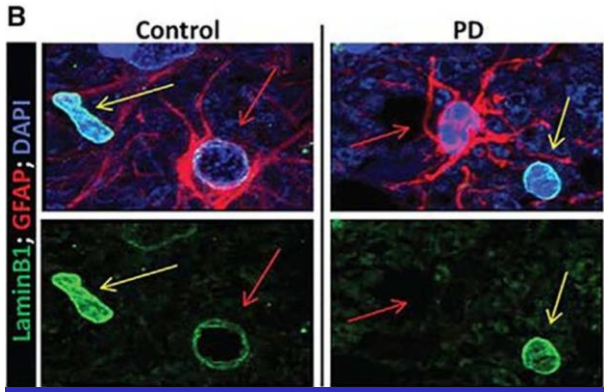
- Molecular development
  - signaling pathways and markers
    - autophagy
    - age related genes
  - mtDNA deletion
  - shortening of telomeres
  - mobile genetic elements
    - transposon activity
  - epigenome
    - transcriptomic predictors, histone code, miRNA
    - DNA methylation patterns is recently known to be the most promising
      - cytosine – transcriptionally inactive region
      - adenine – transcriptionally active region, MGE association



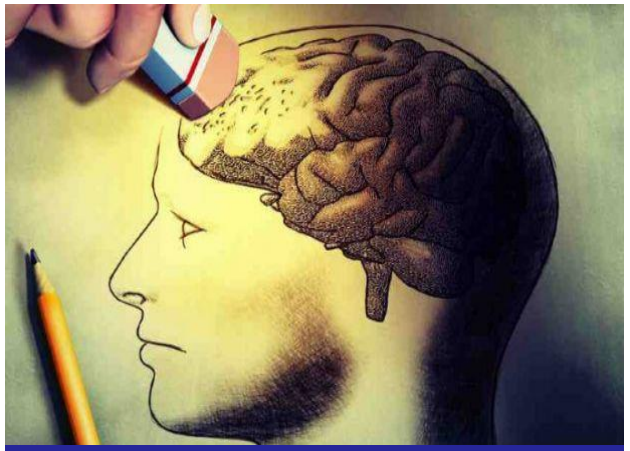
Jylhävä et al, (2017) EBioMedicine. doi: 10.1016/j.ebiom.2017.03.046.

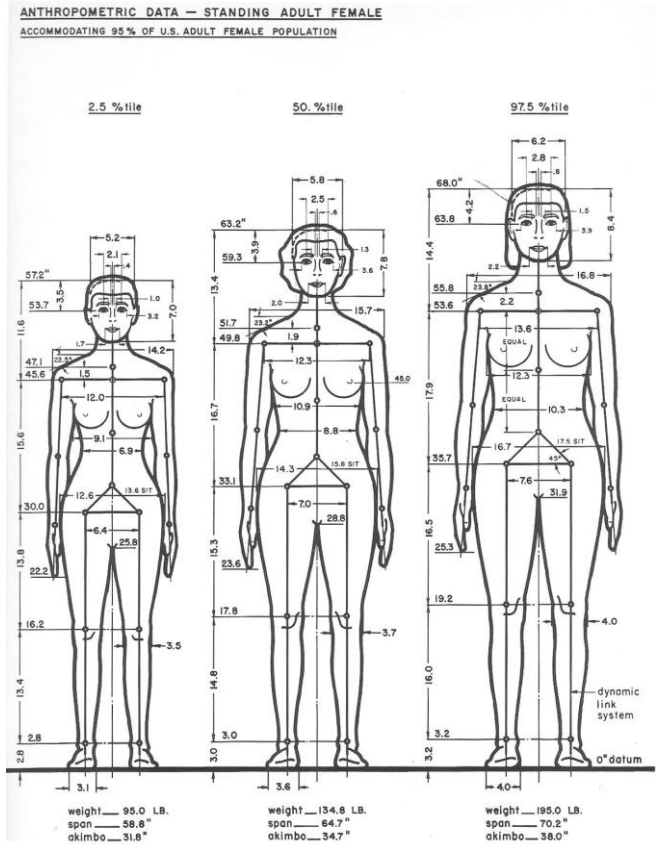
Level #2 – Data Sources – Methods

- Anthropometric examinations
- Performance analysis, ergometry during exertion
- Physiological examinations
- Radiology
- Molecular analyses, whole genome sequencing
- Psychological examinations
- Data analyses



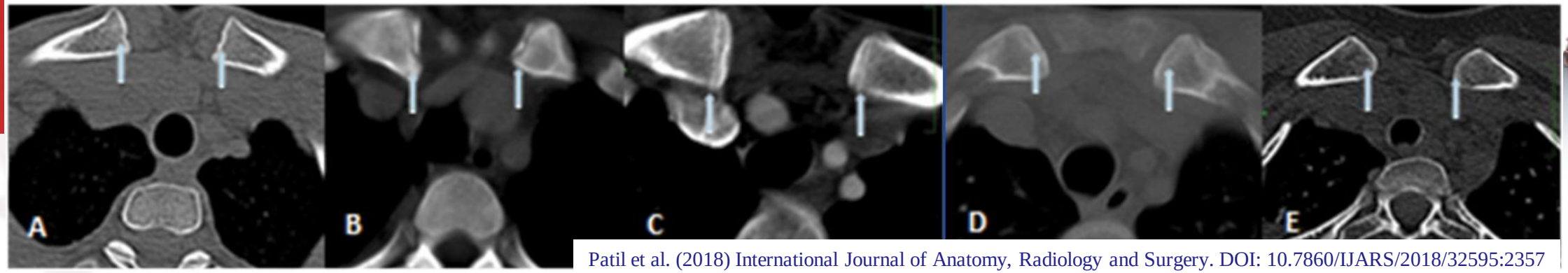
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5806534/


https://www.health.harvard.edu/mind-and-mood/could-changes-in-thinking-skills-be-reversible-dementia

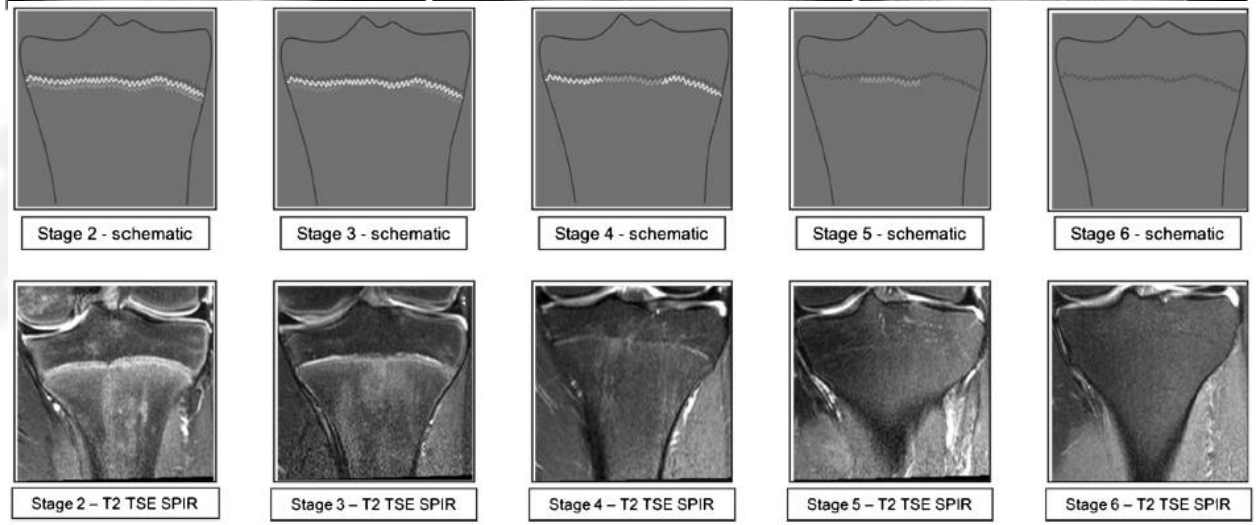


https://www.pinterest.com/pin/557320522627876084/

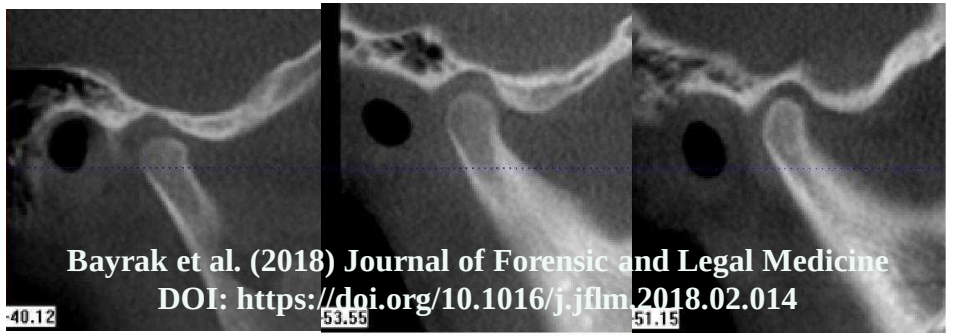
Level #2 – Data Sources – Methods # 2 - Radiology



Patil et al. (2018) International Journal of Anatomy, Radiology and Surgery. DOI: 10.7860/IJARS/2018/32595:2357



Vieth et al. (2018) European Radiology DOI: 10.1007/s00330-017-5281-2



Bayrak et al. (2018) Journal of Forensic and Legal Medicine
DOI: https://doi.org/10.1016/j.jflm.2018.02.014

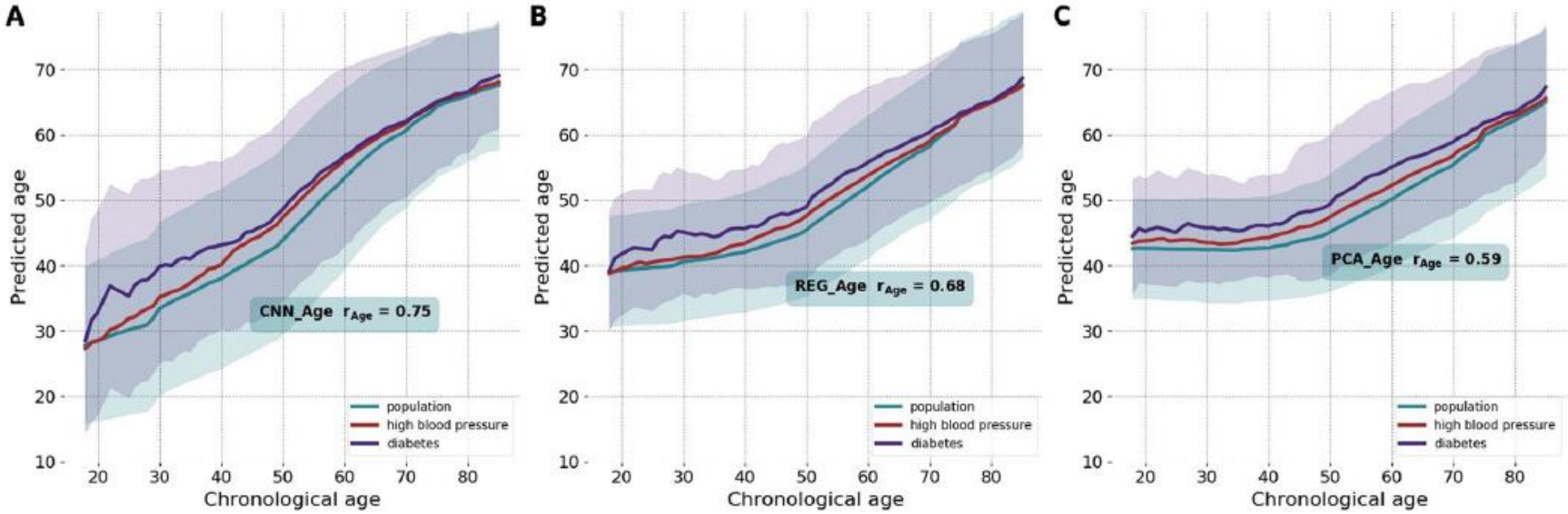
Timme et al. (2017) Int J Legal Med, DOI: 10.1007/s00414-016-1502-5

Frank et al. (2018) Orv Hetil. 159(35): 1423–1432.

Level # 3 – Data evaluation

- Several age prediction models
  - various statistical approaches ranging from
    - simple or multiple linear regression…
    - multiple types of complex artificial neural networks …
  - deep learning is a powerful tool in pattern recognition

Convolutional Neural Network (CNN) | Multivariate Regression (REG) | Principal Components Analysis (PCA)



Pyrkov et al. Scientific REPORTS | (2018) 8:5210 | DOI:10.1038/s41598-018-23534-9

Forensic Individual Age Prediction - Major challenges

- Multidisciplinarity
  - scientist usually are biased towards their disciplines…
    - relatively few integrated multidisciplinary research
    - scientific mainstreams…
- Legal and ethical consideration, requirements
  - important range of ages
    - ages 14, 16, 18 and 21 are important
    - from 12 to 15, 15 to 18 and 21 are important
  - legal basis for authorization
    - age dependent legal procedures for undocumented young people
    - permission for examinations, data sensitivity
      - imaging systems, genetic analysis

Forensic Individual Age Prediction - Major challenges

- Different traits which are not categorical but can be quantitative…
  - multiple candidate body parts, organs, biological tissue, markers (loci)
    - e. g. most appropriate methylation sites
- Different (DNA methylation) technologies…
  - quantitative and semi-quantitative technologies
    - differences in detection
      - microarrays/sequencing platforms (or e. g. X-ray/CT/MRI/EOS Imaging technology)
- Different ethnicity, population-specific reference, socio-economic status…
- Diverse statistical methods…
  - diverse data
  - retrospectivity
    - (partially overlapping) databases
    - environmental factors, population/lifestyle differences
- Large-scale biochemical or genomic profiling is possible, but is logistically difficult and expensive
  - costs and budget

THANK YOU

http://sciencenordic.com/ageing-theory-needs-be-revised

need to work together…