Optics of Ageing Emmetropic Eyes

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Introduction

- Based on a recent study of the optics of emmetropic eyes as a function of age.
- Includes some other information on accommodation and pupil miosis

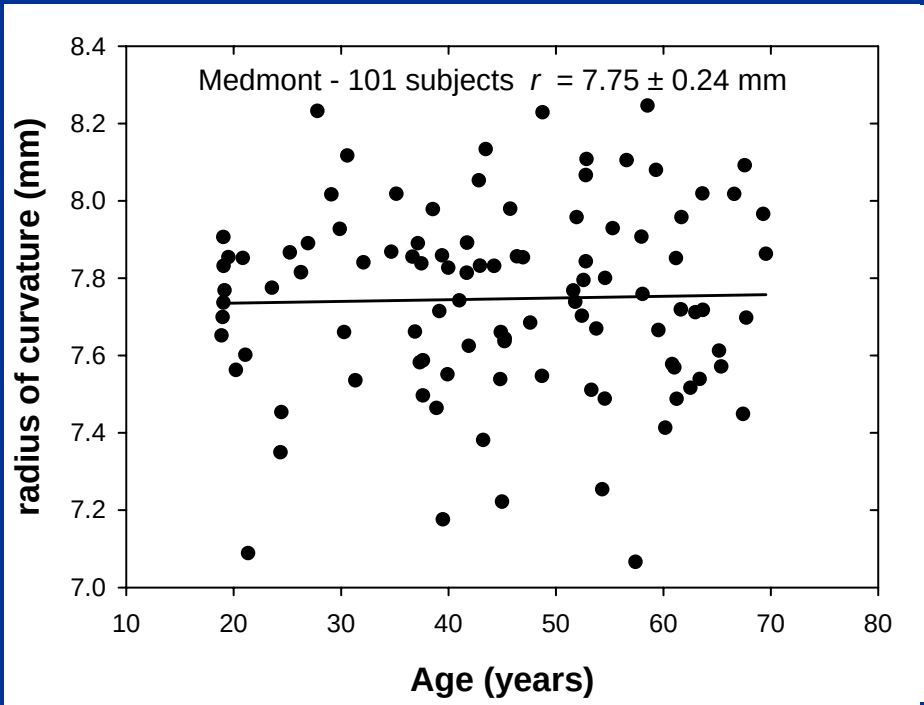
Methodology

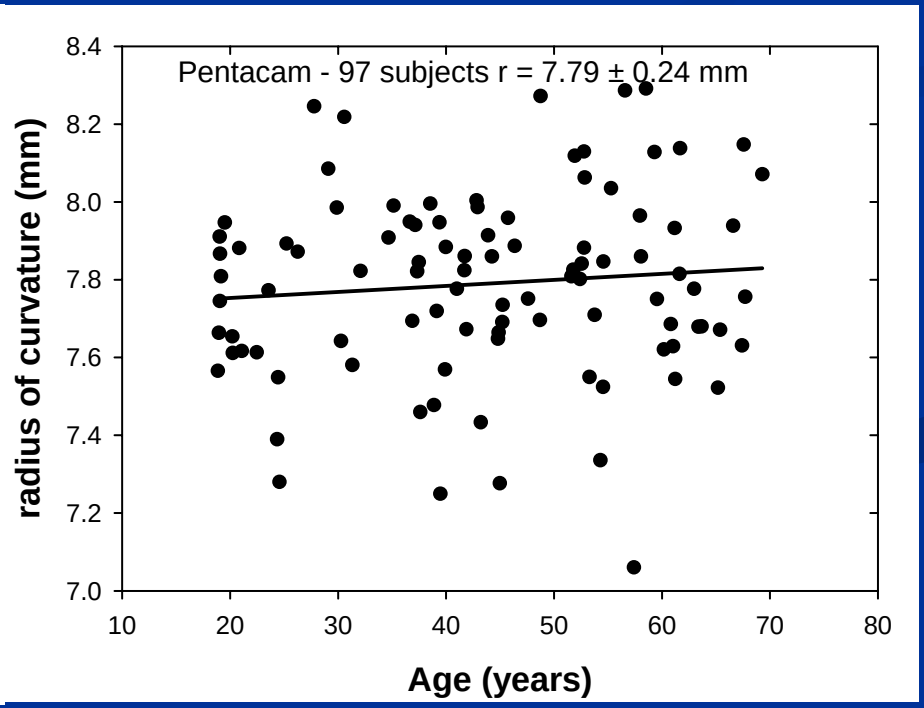
- Subjects of study
  - Emmetropes (-0.88 D to +0.75 D spherical equivalent)
  - Age groups: 20-29 years, 30-39 yrs, 40-49 years, 50-59 yrs, 60-69 yrs. Approximately 10 males and 10 females in each group (106 total)
  - Good ocular & general health
  - Refractive astigmatism $\leq$ 0.50 D
  - R eyes (unless outside Rx range, amblyopic)
- Measurements
  - central and peripheral refraction, central aberrations, videokeratography (Medmont), ultrasound, magnetic resonance imaging, Scheimpflug photography (Pentacam), Purkinje image analysis

Anterior cornea – radius of curvature

Referenced to the pupil centre for aberration measurements

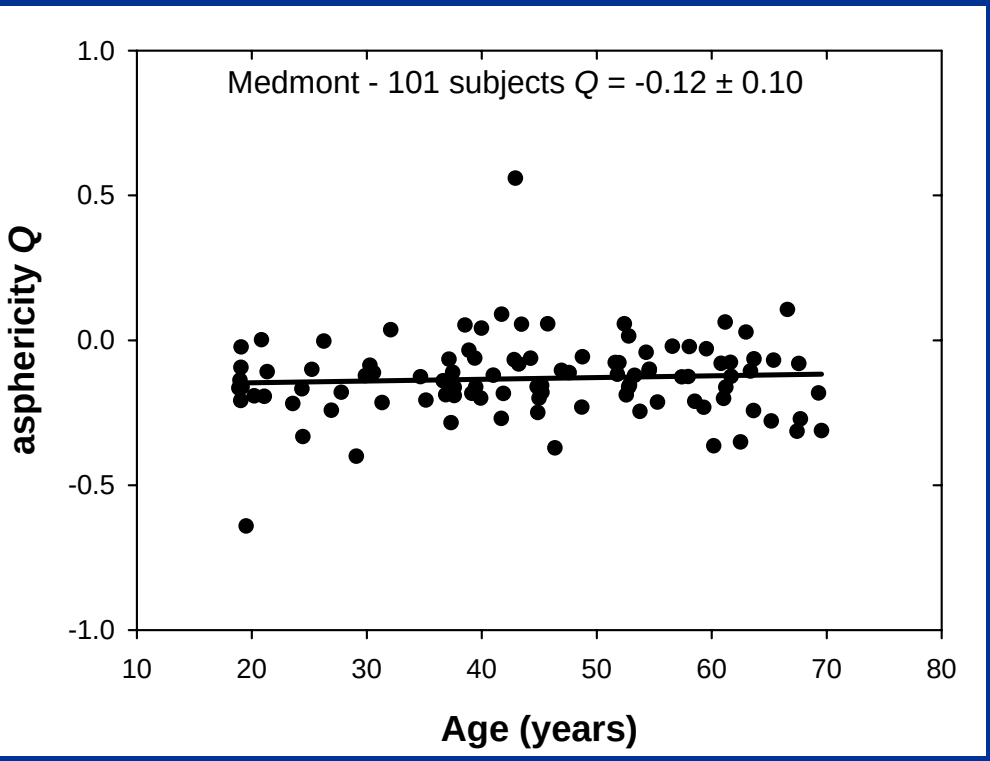
Not significantly affected by age

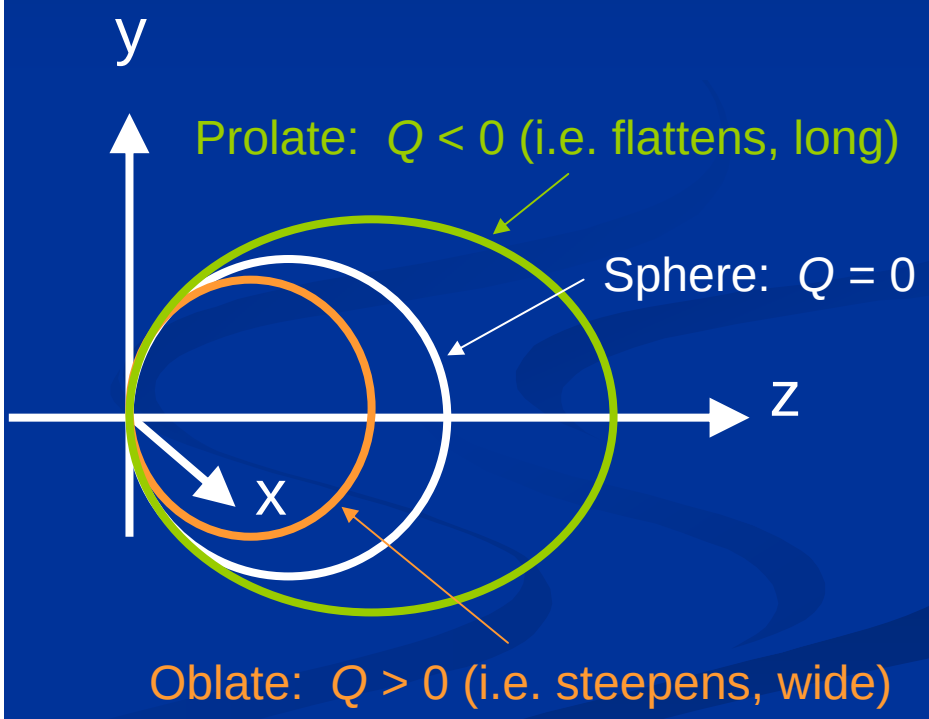




Anterior cornea – asphericity

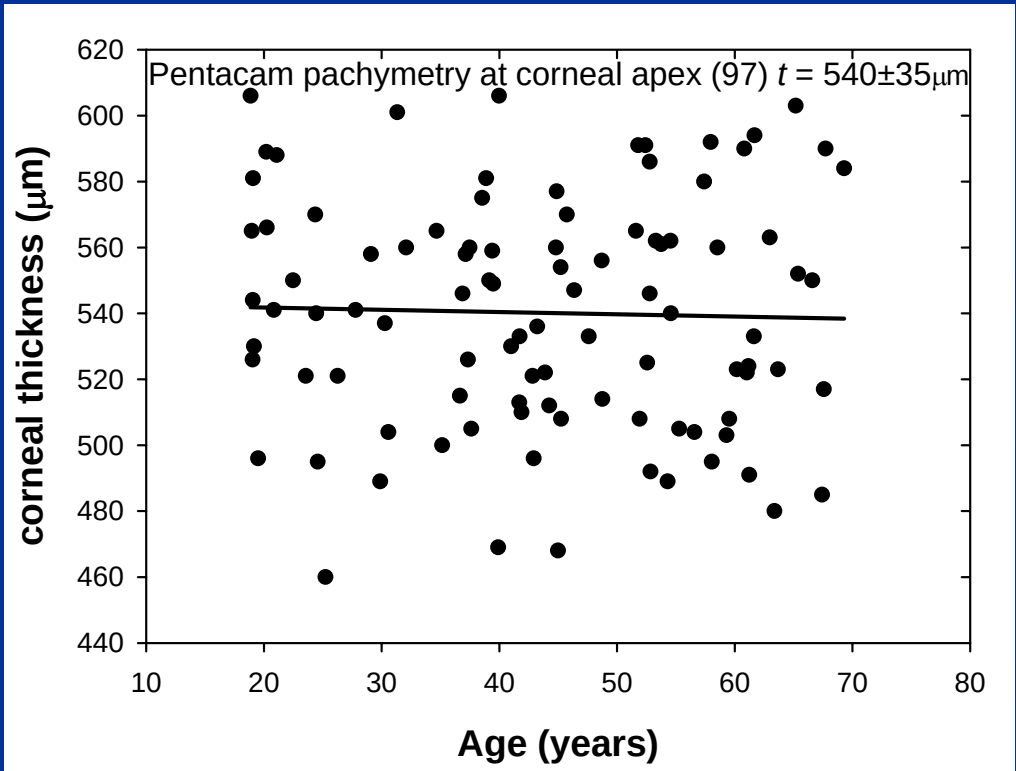
Not significantly affected by age





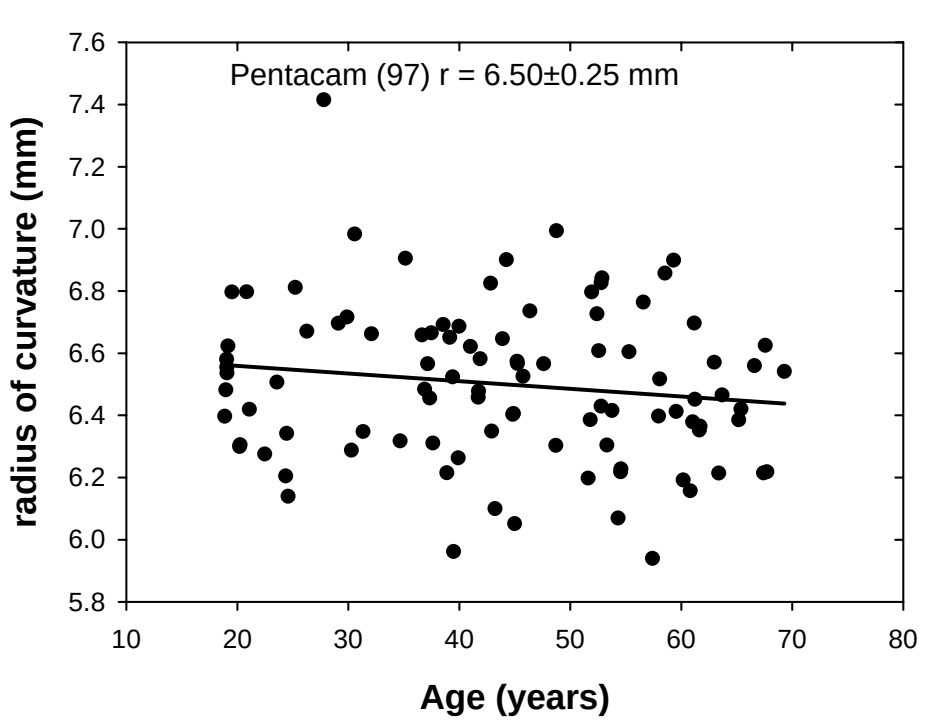
Cornea
– central thickness

Not significantly affected by age



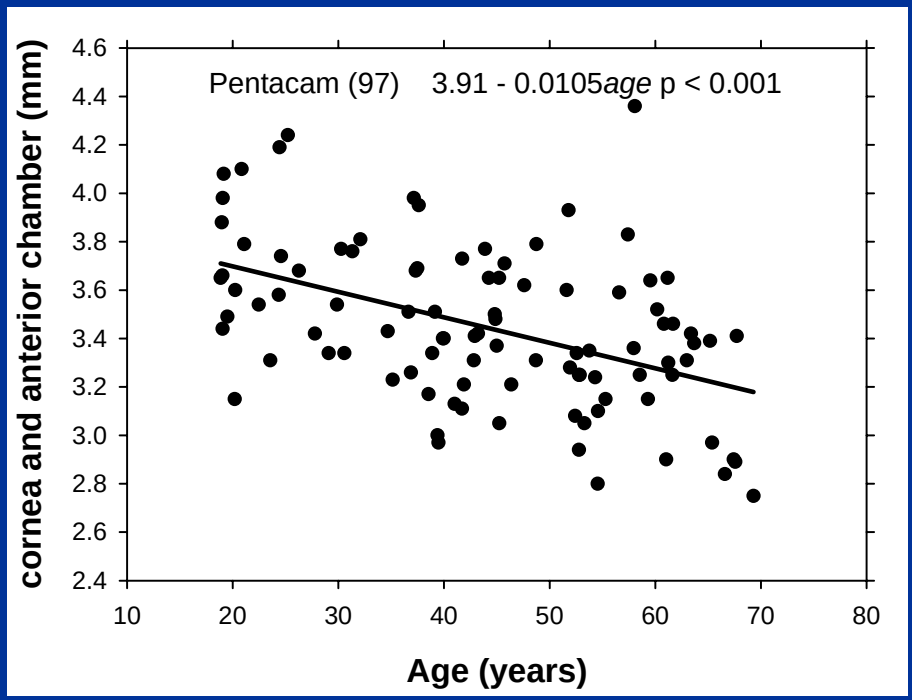
Posterior cornea – radius of curvature

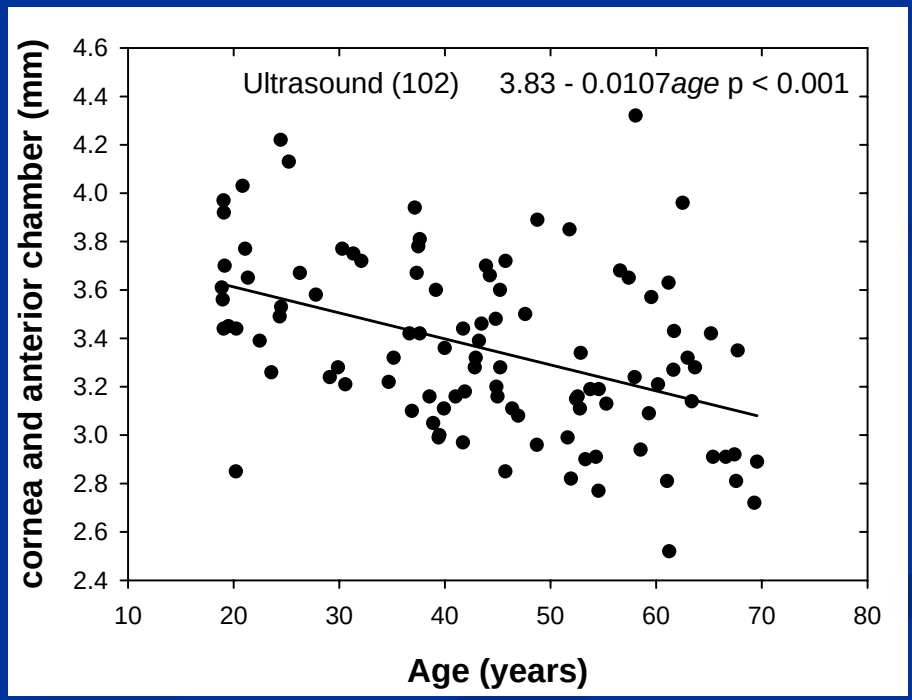
Not significantly affected by age



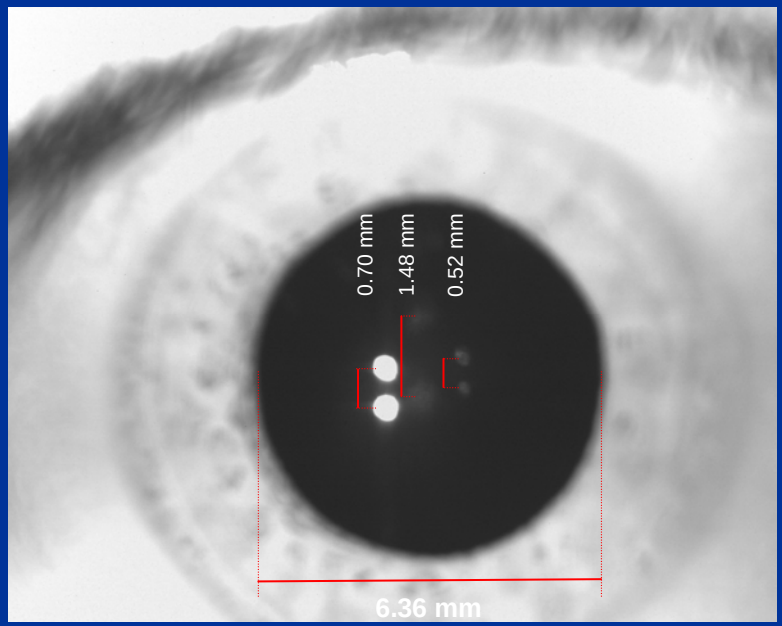
Anterior chamber
- depth

Reduces significantly with age

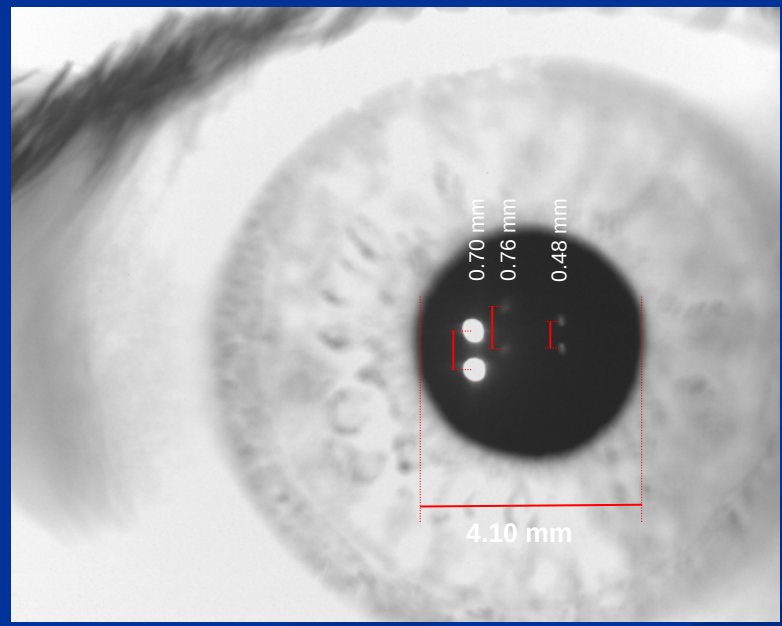




Lens
- radii of curvature



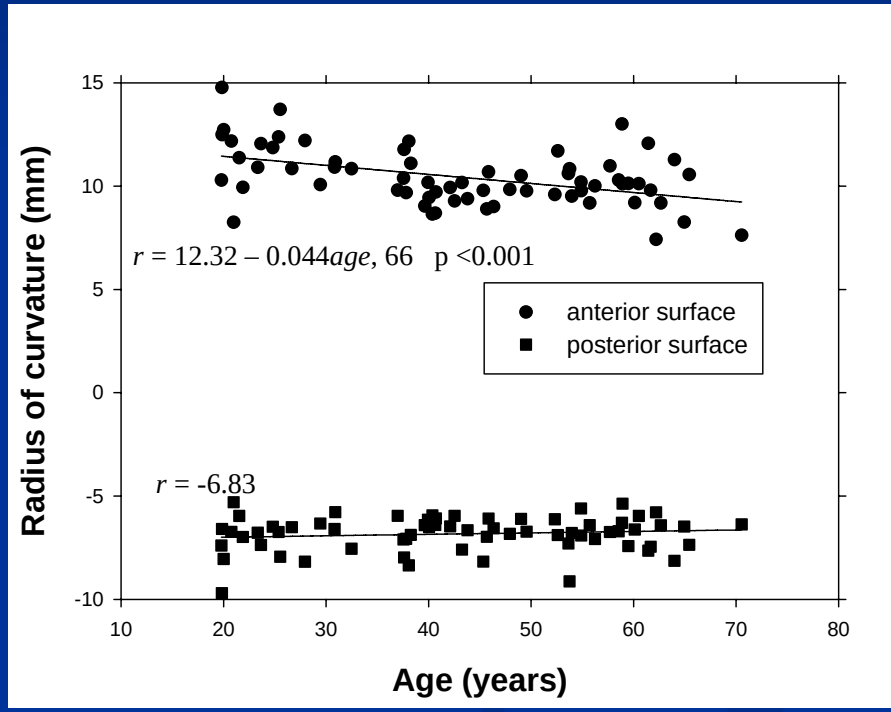
Unaccommodated Eye



Accommodated Eye

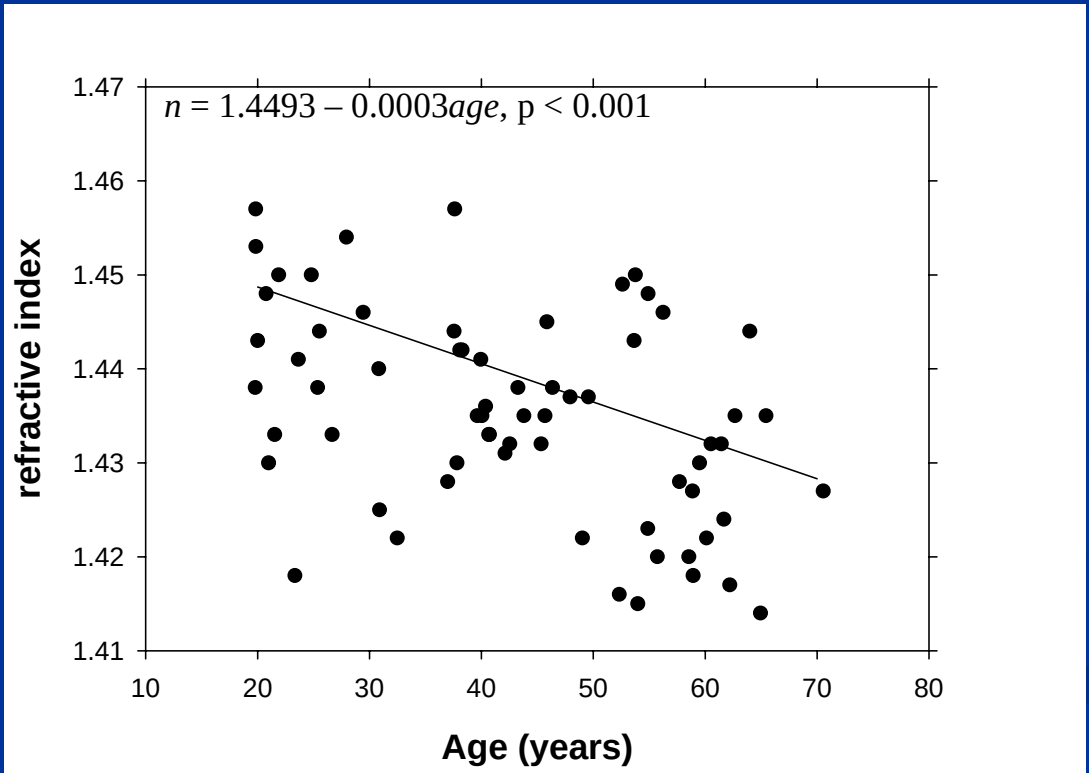
Lens
- radii of curvature

- Purkinje technique
- Anterior radius of curvature ↓ as age↑
- Posterior radius of curvature unaffected by age
- Lens paradox

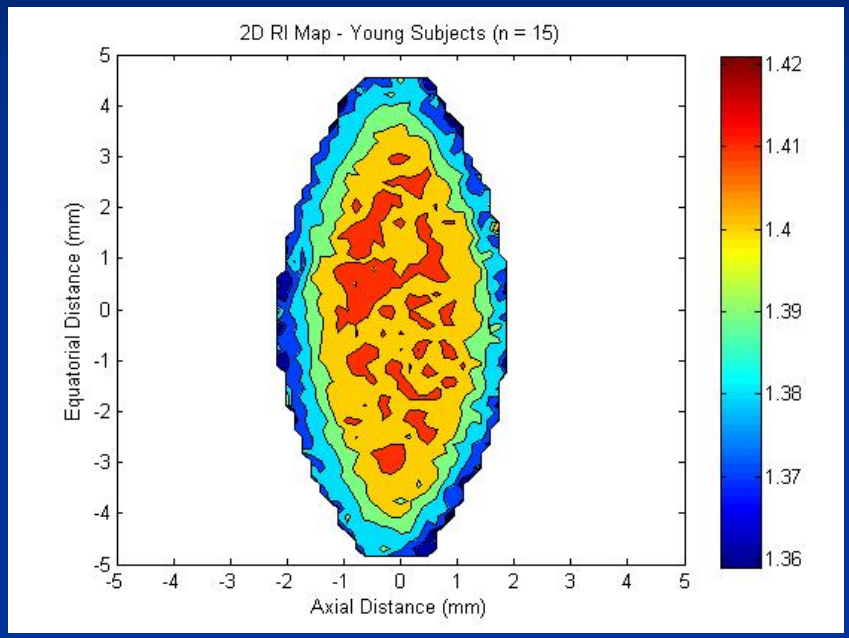


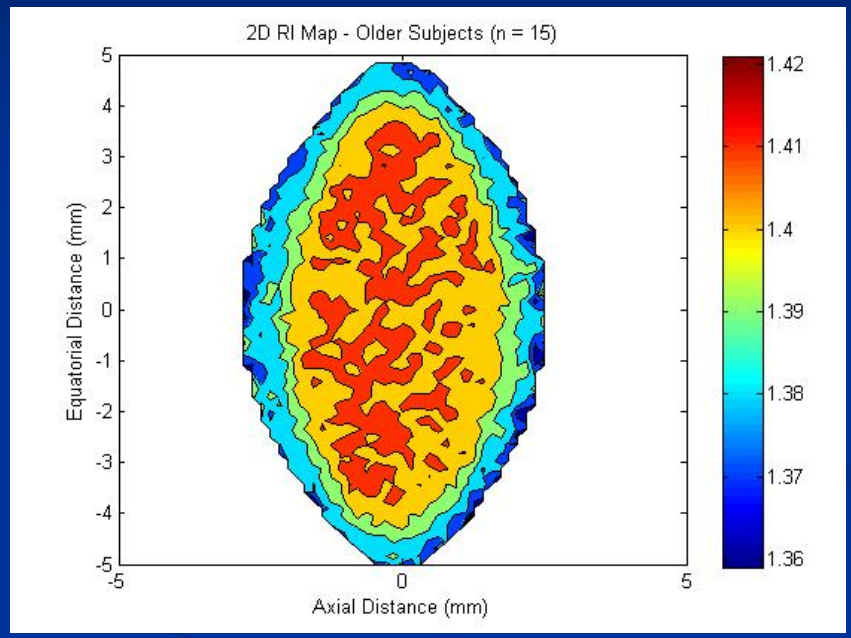
Lens
- equivalent refractive index

Reduces significantly
with age

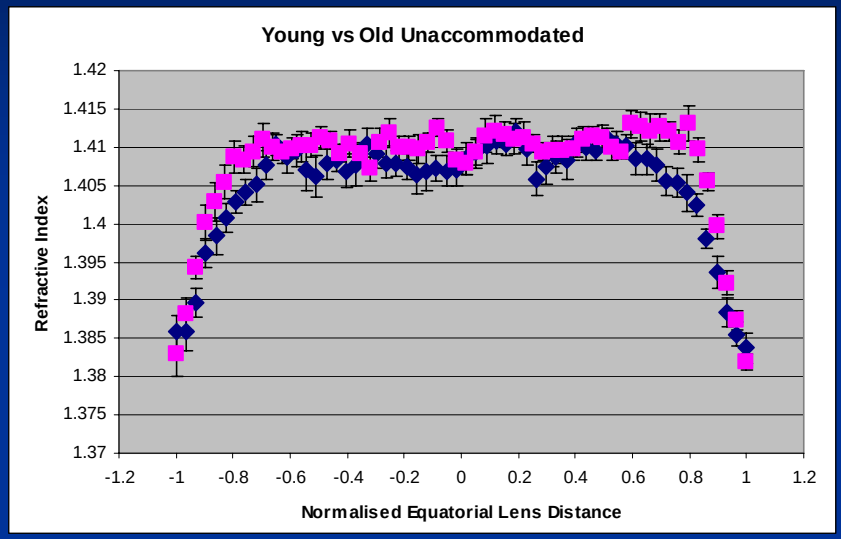


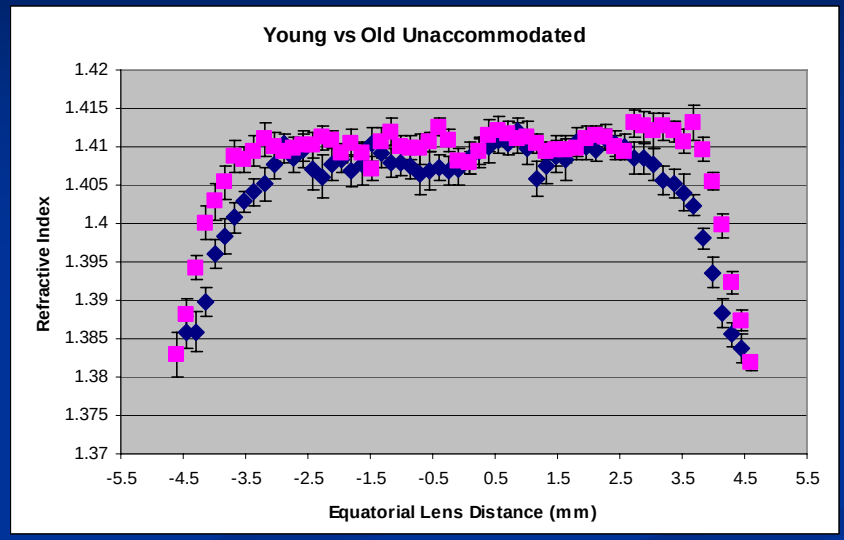
Lens
- refractive index distribution

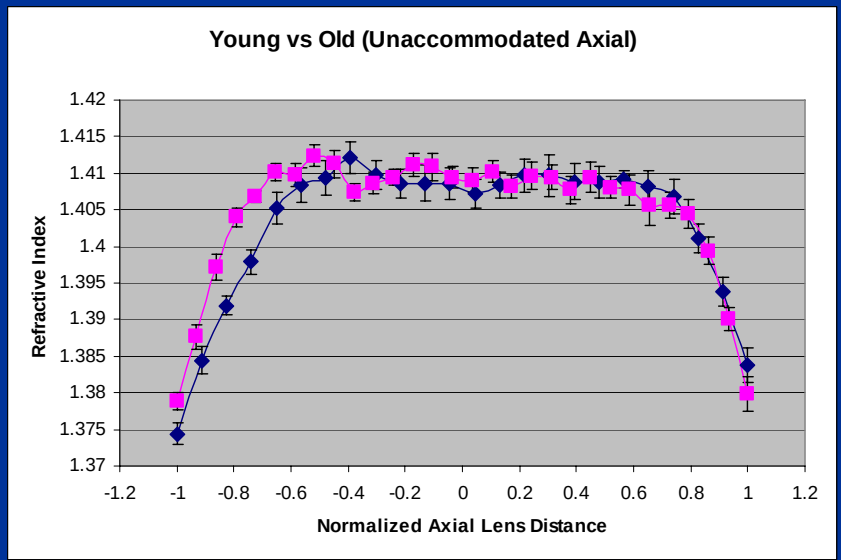


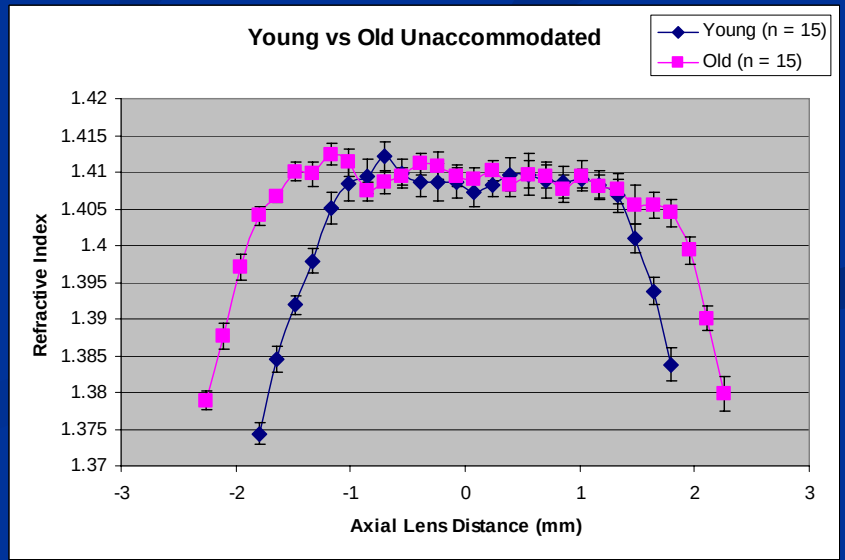


Lens
- refractive index distribution



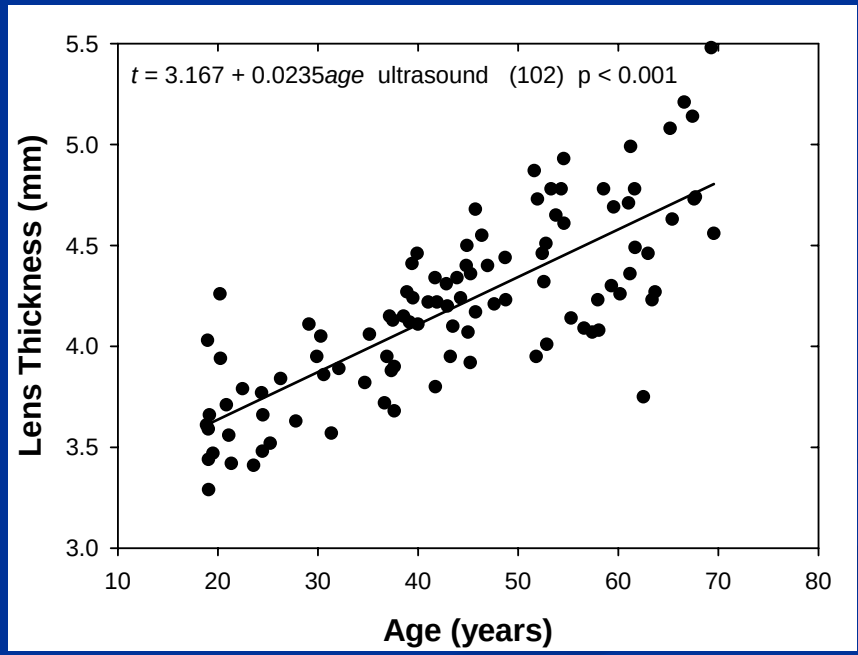






Lens
- centre thickness

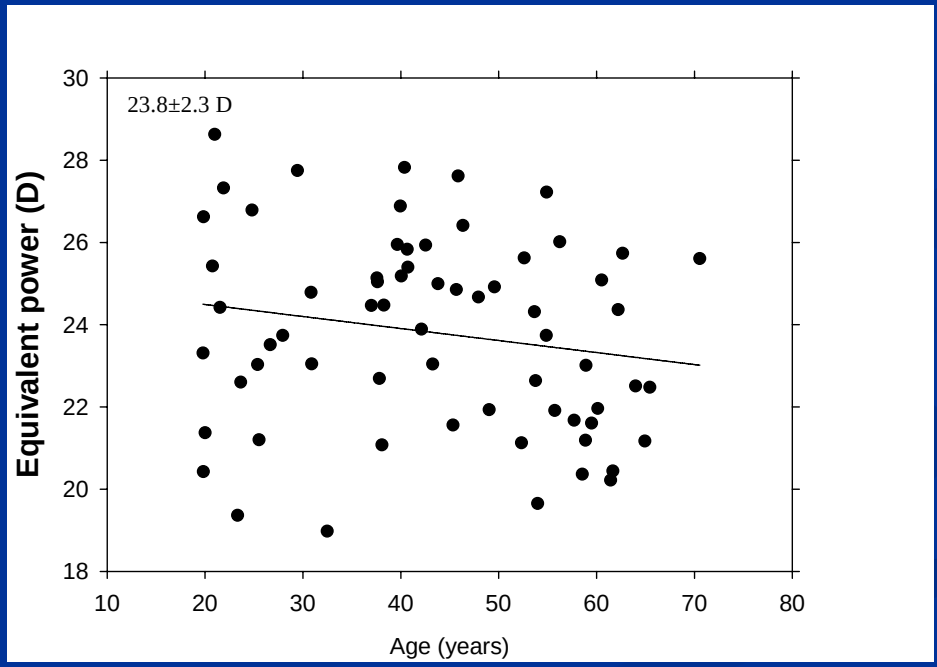
- ultrasound
- thickness ↑ as age↑



Lens
- equivalent power

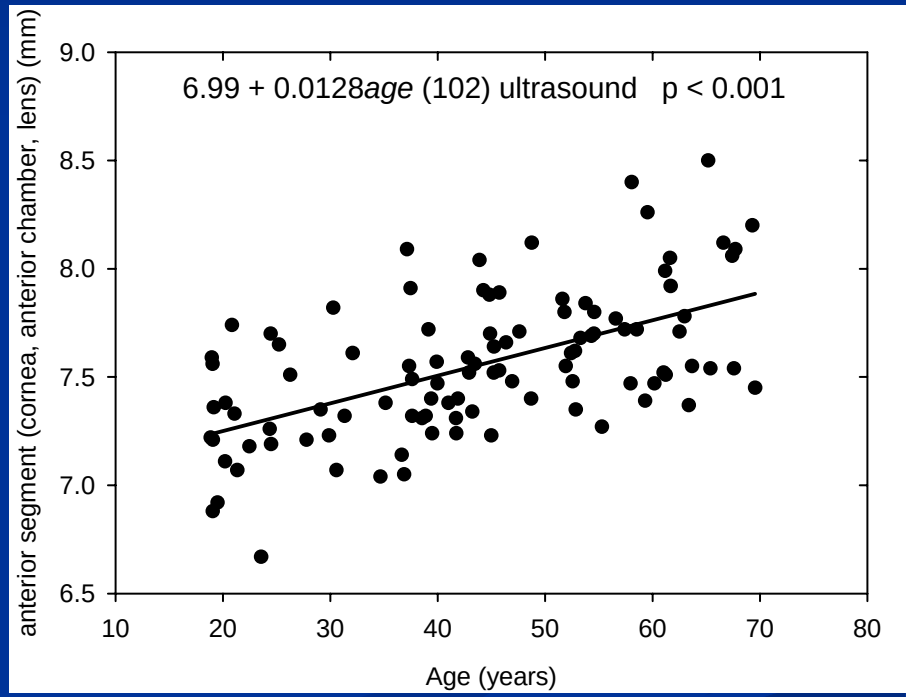
Determined from surface radii and equivalent refractive index

No change with age



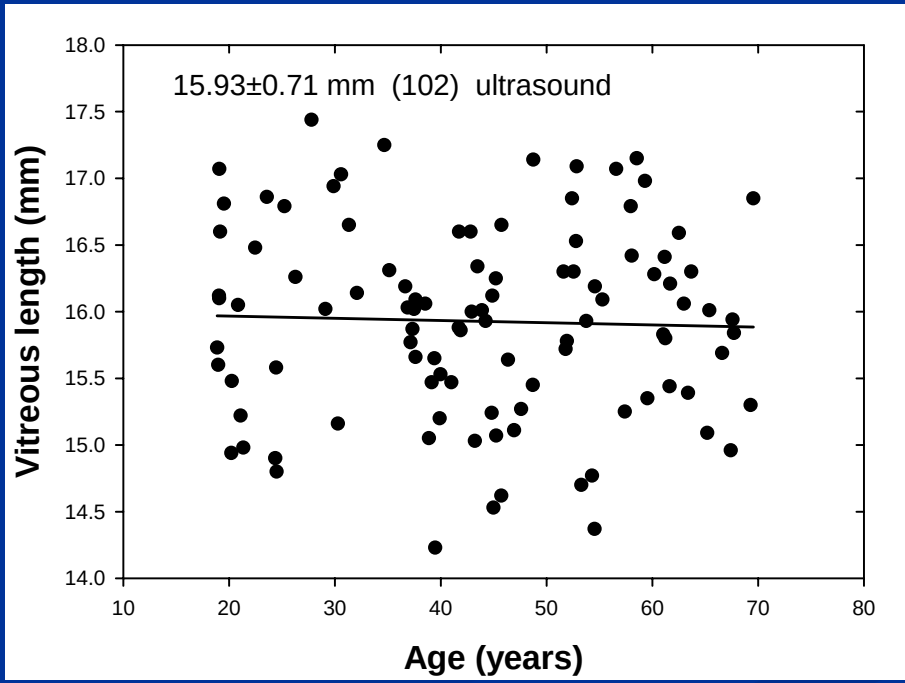
Anterior segment

- Add corneal thickness, anterior chamber and lens thickness with ultrasound
- ↑ as age ↑
- Not previously reported
- Similar to anterior chamber depth ↓
- Half the lens thickness ↑



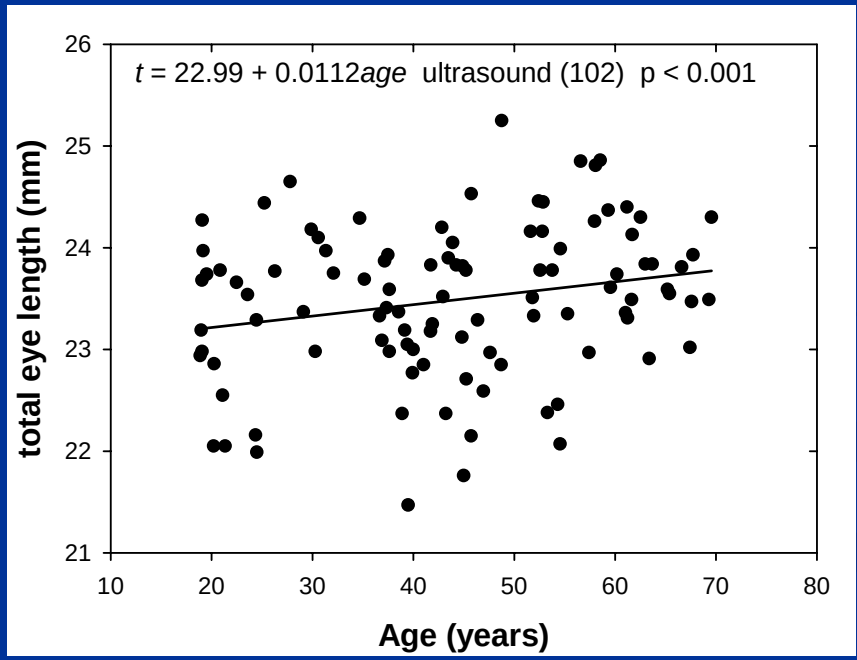
Vitreous chamber depth

- No change with age



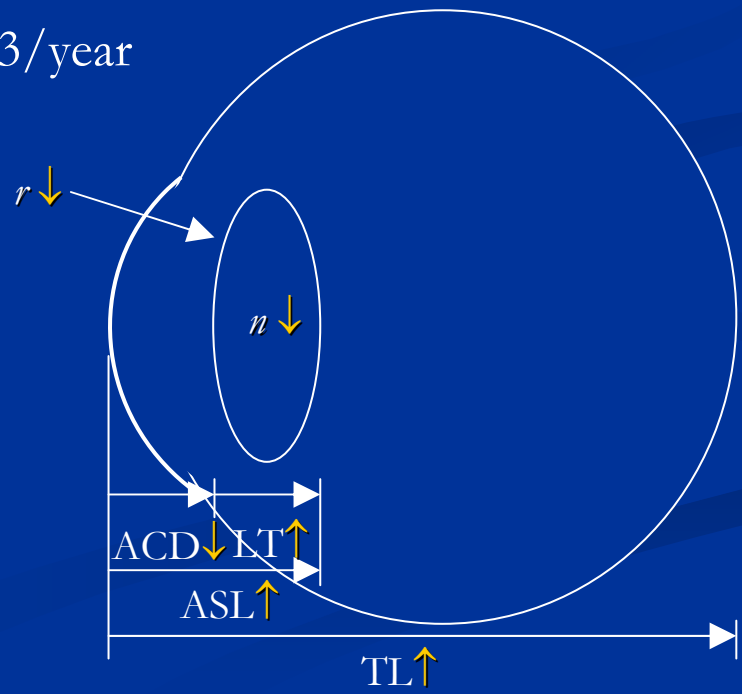
Length of eye

- ↑ as age ↑
- Predicts eye length ↑ as you get older??
- Similar to anterior segment ↑ (0.0112mm/year v 0.0128 mm/year)

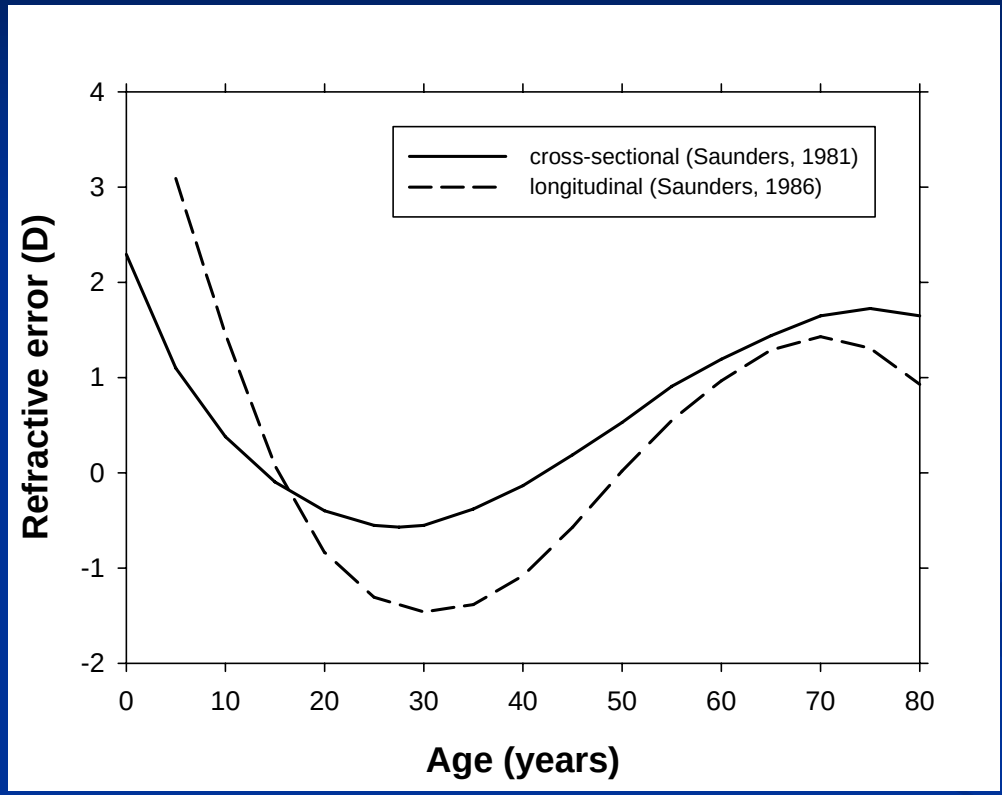


Parameters that change with age

Anterior chamber depth	-0.011mm/year	
Lens thickness	+0.024 mm/year	
Anterior segment length	+0.013 mm/year	
Total length	+0.011 mm/year	>0.5 mm or >1.5 D in 50 yrs
Anterior lens radius of curvature	-0.044 mm/year	
Equivalent lens refractive index	-0.0003/year	



What might be happening?

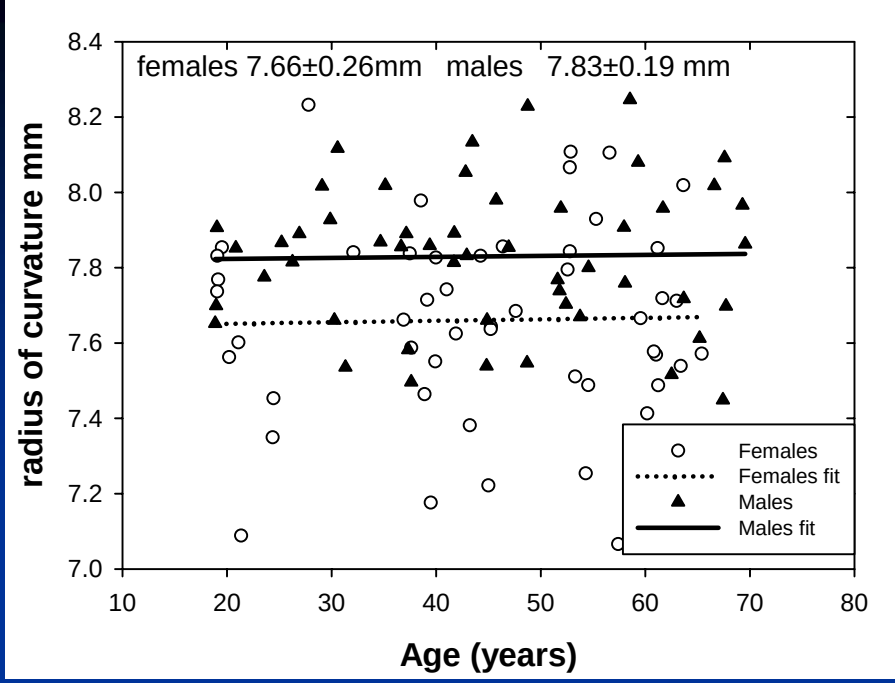


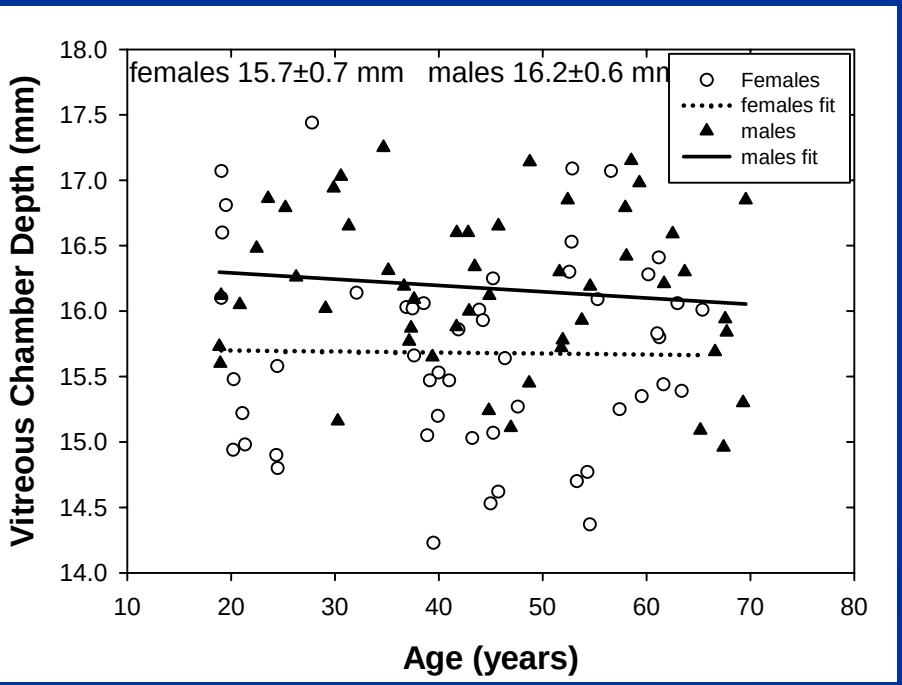
Young emmetropes will tend to be hypermetropes when older?

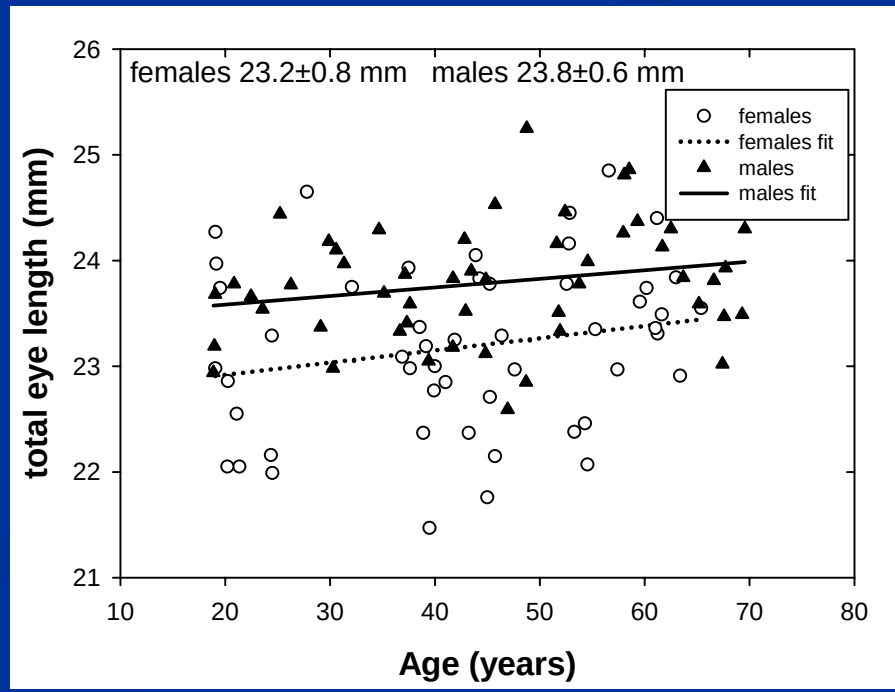
Older emmetropes were low myopes when younger?

Gender differences

- anterior cornea radius of curvature
  M > F by 0.17 mm (~1.0 D)
- vitreous and total length
  M > F by 0.6 mm (~1.8 D)

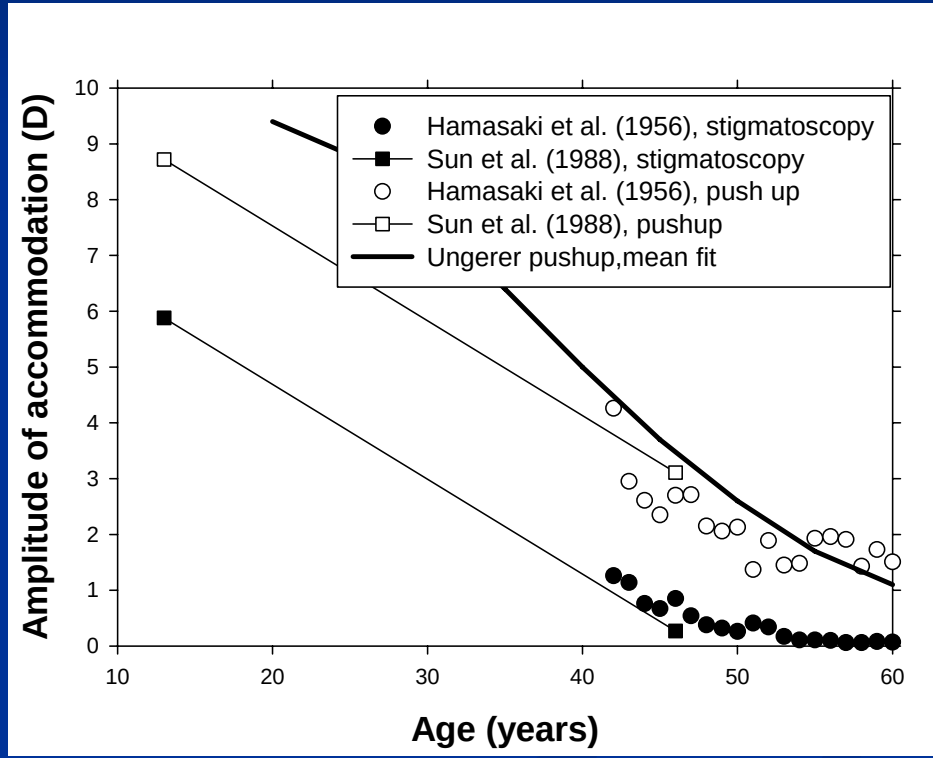






Amplitude of accommodation

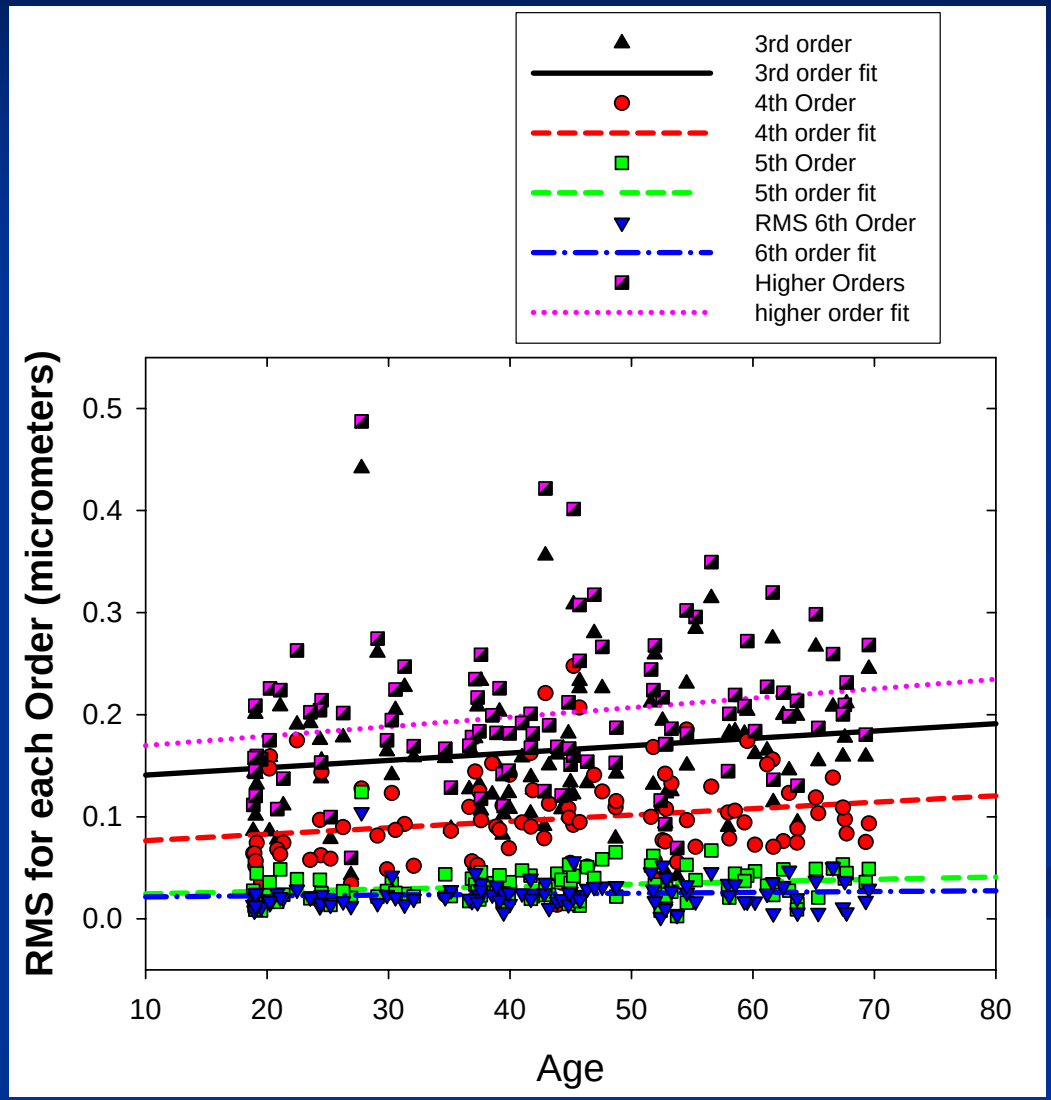
- Push-up study of Ungerer
  - Overestimates amplitudes – depth-of-focus
- Hamasaki et al, Sun studies using stigmatoscopy
  - Accommodation ceases after mid 50s



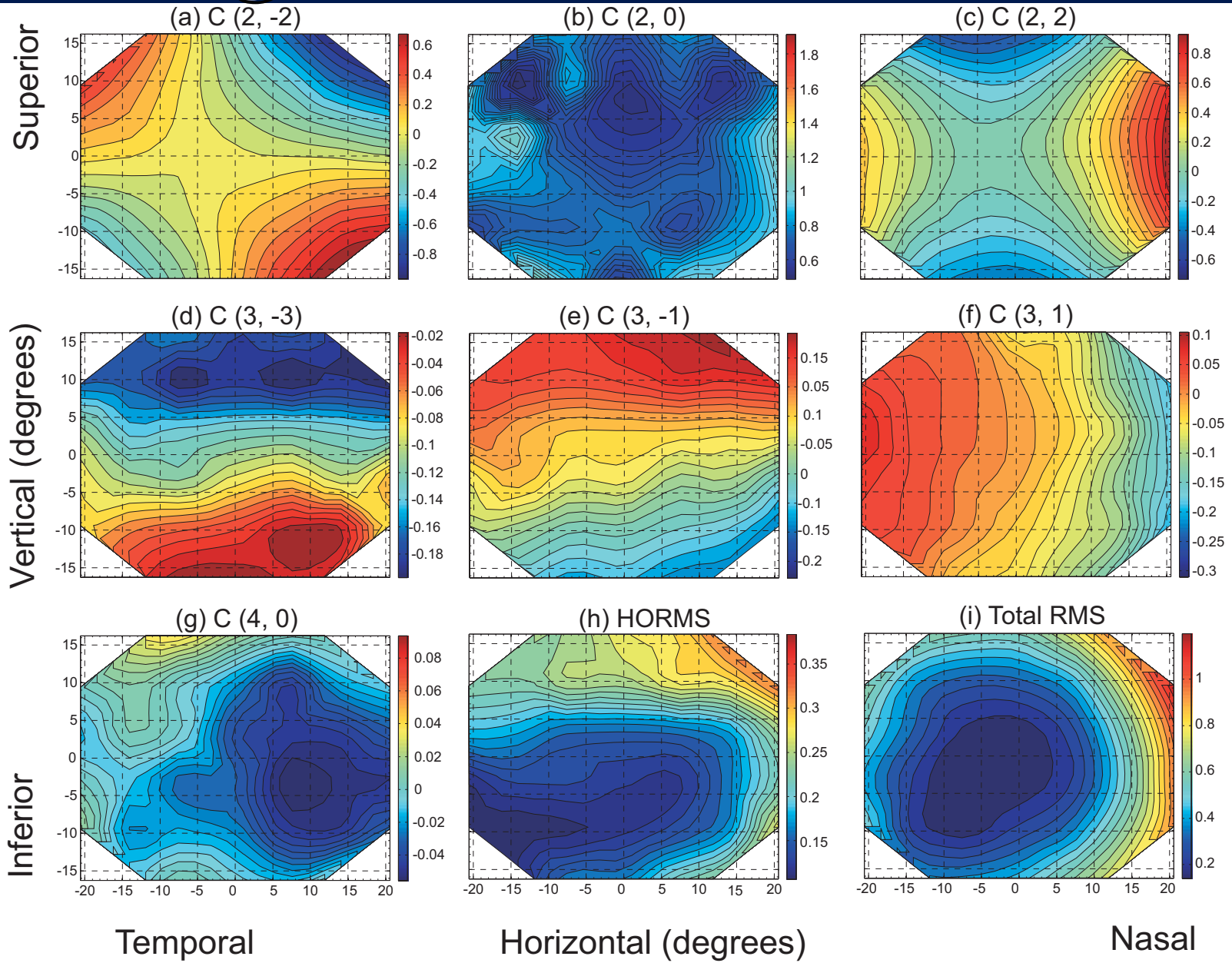
Higher order aberrations

5 mm pupil, COAS (Wavefront Sciences) relative pupil centre

- 4th and 5th order rms aberrations ↑ sig as age ↑
- Total HO rms p= 0.054

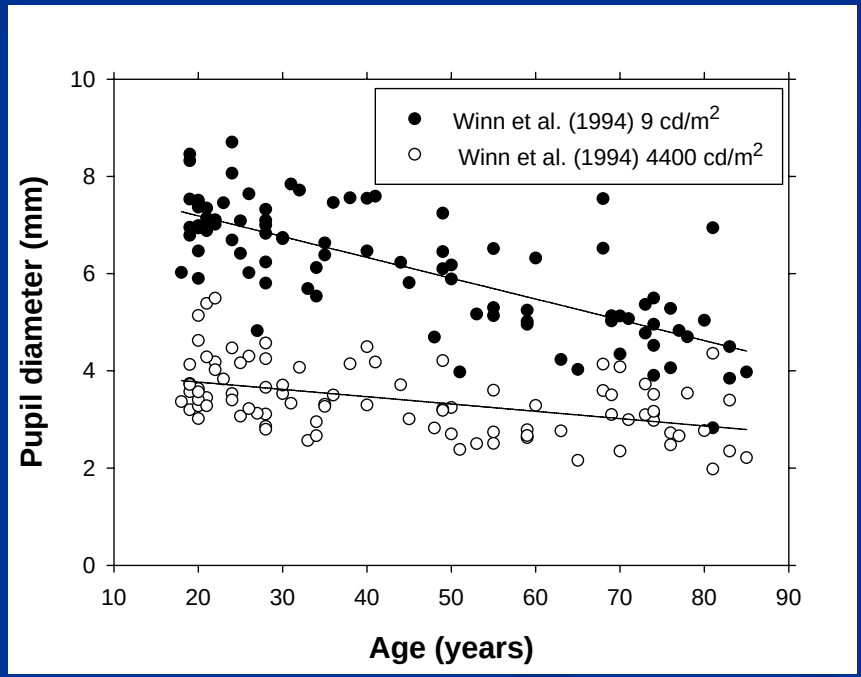


Higher order aberrations



Pupil miosis

- Interaction with aberrations



Summary of age related changes in emmetropic eyes

Anterior chamber depth	0.5mm ↓ over 50 year period
Lens thickness	1.2 mm ↑
Anterior segment length	0.6 mm ↑
Total length	0.6 mm ↑
Anterior lens radius of curvature	2.2 mm ↓
Equivalent lens refractive index	0.015 ↓

Central RI plateau ↑

Young emmetropic eyes to become older hypermetropic eyes?

Older emmetropic eyes were young myopic eyes?

Summary of age related changes in emmetropic eyes (cont.)

Central aberrations ↑ as age ↑

Peripheral aberrations ?

Pupil size ↓ as age ↑ - interaction with aberrations

Amplitude of accommodation ↓ as age ↑ – lost by mid 50s