Aging, Eye Disease, and Pilot Performance

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Learning objectives

At the end of the presentation the learner will:

• Understand the difference between age related eye disease and normal aging
• Understand key terms related to eyes and eye health
• Relate changes in vision with potential pilot performance
What is “normal” aging?

Changes in visual function (eye)
Changes in visual perception (brain)

It’s pretty easy to describe the first, but we don’t know enough about the second.
What goes wrong with vision?
Media Opacities
Macular dystrophies and degenerations
Peripheral retinal degenerations
Optic nerve anomalies
Visual cortex (brain) damage
Ocular Anatomy

Neuro-Anatomy
Normal Vision
Media Opacities

What

• Anything that prevents light from reaching the retina (receptor layer) of the eye
• Fuchs’ Corneal Endothelial Dystrophy
  • Clouding of the front-most layer of the eye
• Cataracts
  • Cloudy lens behind the pupil
  • Generally age-associated, but can be congenital, trauma, or medication related
Media Opacities

Effect

• Generally a hazy view of the world
• “Dirty windshield” effect
• Light scattering
• Worse when viewing bright point sources of light
• Reflected light can by-pass filters and visors
Media Opacities
Age-Related Macular Degeneration

- Can be dry or wet
- Leading cause of blindness in the US among persons over 65
- 10 percent of the population over 52, 33 percent over 75
- Of those who are not legally blind, 90 percent have the dry variety
Age-Related Macular Degeneration

Effect

• Loss of central vision
• Peripheral vision is intact
• Acuity loss in the range of near perfect to 5/125
• Difficulty reading, identifying faces, driving
Age-Related Macular Degeneration
Diabetic Retinopathy

What

• Number one cause of new blindness in the 20-74 year old age group
• Responsible for 10 percent of the blind population of the US
• Breakdown of retinal vessels leads to hemorrhage, edema and retinal detachments
Diabetic Retinopathy

Effect

• Multiple small blind spots from hemorrhage and laser treatment
• Macular edema distorts central vision
• Vitreous hemorrhage causes significant reduction in vision
• Retinal detachments can lead to total blindness
Diabetic Retinopathy
Retinitis Pigmentosa

What

• Hereditary condition which includes:
  • Progressive visual field loss
  • Night blindness
  • Abnormal electro-retinogram
  • Characteristic pigmentary pattern
  • Many syndromes associated with RP
Retinitis Pigmentosa

Effect

• Gradual peripheral vision loss
• Cataracts
• Ultimate loss of central vision
Retinitis Pigmentosa
Optic Nerve Anomalies

Damage to the nerve fibers blocks signals to the visual center of the brain

- Glaucoma
- Vascular occlusions
- Multiple sclerosis
Glaucoma

What

• Optic nerve atrophy caused by intolerance to intraocular pressure

Risk factors

• Age
• Family history
• Race
• Myopia
Visual Cortex

What

• Cerebro-vascular events (strokes)
• Traumatic Brain Injury (TBI)
• Leads to infarct (damage) to brain tissue that processes the information it gets from the eyes
Visual Cortex

Effect

• Minor events
  • TIA’s
  • Headaches
  • Resolving field loss

• Major events
  • Significant visual field loss
  • Cortical blindness
  • Diplopia
Visual Cortex
Visual perceptual changes across the life span
Spatial Contrast Sensitivity

• The ability to distinguish between two objects in the visual field under varying levels of contrast
• Differs from visual acuity; Va assumes high contrast
• Affected by cataracts, AMD, small pupils
• Even when the optics variables are removed, there is still an age-related decline with age
Spatial Contrast Sensitivity

Vision Research

Contrast sensitivity throughout adulthood

Cynthia Owsley¹, Robert Sekuler², Dennis Siemsen³

Show more
Scotopic Contrast Sensitivity

- Difficulty seeing under low light conditions
- Some linkage between low light and
  - Increased risk of falls
  - Increased risk of car crashes
- Older adults may need 2-3 times more contrast than a younger observer
- This occurs even when optical factors are controlled
- Mechanism is unclear
Dark Adaptation

• Very early (1940’s) studies show decreased light sensitivity in older adults
• Lens and pupil miosis commonly associated
• Recent decade of research suggests more neural involvement
• Rhodopsin (pigment) regeneration is impaired
• 70 YO may take 10 min longer to reach pre-bleach threshold than 20 YO
Processing of Time-Varying Targets

- Slower visual processing speed increases risk of MV crashes
- Spatial motion of targets is impaired with age
- Visual cortex processing is decreased with age
- Older adults have difficulty ignoring background activity to identify and react to a figure
- These processing changes affect many everyday tasks
Visual Processing Speed

- Aging = slower VP speed
- Contributes to higher order cognitive processing
- Independent of Alzheimer’s or dementia
- This slowing is *not inevitable*
Deep thoughts...

- Is Retraining Possible?
- Does any of this make a difference in the real world?
Vision and aviation
How did we get the vision regulations we have?

Mostly dating back to the early days of aviation
Not much scientific basis
“Expert” opinion by Dr. W.H. Wilmer

Key elements:
• Visual acuity
• Stereopsis
• Refractive error
• Two-eyed vision

What are the aspects of vision to be considered?

Visual acuity
Visual field
Binocularity and stereopsis
Contrast sensitivity
Color vision
Visual Acuity

Theoretically, it should be an indication of the ability to see detail.

In reality, it measures the ability to see a certain sized letter at a specific distance.

How does this translate into pilot performance?

What are the critical distances for clear vision?
Visual Field

Measures peripheral vision

Testing consists of moving a light source of a particular size and intensity from the periphery to the center of vision

This can be automated or manually presented

Gross tests can detect large defects

Static vs. dynamic testing

How does visual field affect pilot performance?
Binocularity/Stereopsis

How do the two eyes work together?
Is the vision about the same in both eyes?

Levels of binocularity
• Simultaneous perception
• Bi-ocular vision
• Bin-ocular/stereopsis

At what distance does stereopsis have no impact?

How does this affect pilot performance?
Contrast Sensitivity

The ability to detect the margins of one object with another
100% contrast is pure black and white
Our world is not 100%
All the standardized tests present different shades of gray
Is color contrast a factor?
How does contrast affect pilot performance?
Color Vision

Many pilot-critical tasks require good color perception
• Signal lights
• Runway lights
• Cockpit gauges and warning lights
• Maps and charts

What does the FAA require?
What is the best way to test this?
questions/discussion