Brien Holden Vision Institute

HYPEROPIA, MYOPIA AND ASTIGMATISM

THINK

Have you noticed that some people have problems seeing far away – but can see clearly at a closer distance, while other people have problems seeing things that are close to them – but can see things in the distance very easily?

Different refractive errors affect vision at different distances. Depending on the type of refractive error, vision for distance, near, or both distance and near may be affected.

AIM

This unit shows you why some people with healthy eyes do not see clearly or comfortably, and explains how spectacle lenses can help these people see clearly.

LEARNING OUTCOMES

When you have worked through this unit you should be able to:

- describe the causes of hyperopia, myopia and astigmatism
- know the visual symptoms of hyperopia, myopia or astigmatism
- identify which lenses correct hyperopia, myopia and astigmatism
- recognise complications that are associated with hyperopia and myopia
- understand how and why the symptoms of refractive errors change as people age.

REVIEW: HYPEROPIA, MYOPIA AND ASTIGMATISM

PARTS OF THE EYE	**Cornea:** • Like the window of the eye. • Transparent, so that it can let light into the eyeball to allow us to see. • Helps to focus light that enters the eye. **Crystalline lens (or simply "lens"):** • Transparent in a normal eye. • Changes shape to change the eye's focus from distance to near. **Retina:** • The inside layer at the back of the eye. • Catches the light that comes into the eye and changes it into nerve messages that are sent to the brain.
HOW IS LIGHT RECEIVED BY THE NORMAL EYE?	• Light from an object enters the eye in the form of light rays. • Light passes through the tear film, cornea, anterior chamber, pupil, crystalline lens and vitreous, before arriving at the retina. • Light rays are converged (focused) by the cornea and the crystalline lens. • If the light focuses correctly on the retina, a clear image will be formed. • At the retina, light is changed into electrical signals (nerve messages). • Information received by the retina is sent to the brain via the optic nerve.
FOCUSING LIGHT IN THE EYE	• In an eye without refractive error, light that enters the eye is focused on the retina because: - the cornea and the lens are the correct shape; and - the eyeball is the correct length. • If an eye does not have the correct shape or length to focus light on the retina, it is said to have refractive error.
VISUAL ACUITY	• Visual acuity (VA) is a measure of how clearly a person sees when they are looking directly (straight) at an object. • Aided VA is a person's VA when they are wearing their spectacles. Unaided VA is a person's VA when they are not wearing spectacles. • Common causes of poor VA are: - Refractive error (this person needs spectacles to see clearly) - Eye health problem (this person has a problem with the health of their eyes).
WHAT IS REFRACTIVE ERROR?	• A person who has a refractive error will need to wear spectacles (glasses) or contact lenses so that they can see clearly and comfortably. This is because their eye is not the correct size and/or shape. • There are four main types of refractive error: myopia, hyperopia, astigmatism and presbyopia. • The amount of refractive error an eye has depends on: - the steepness of the cornea; and/or - the steepness of the crystalline lens; and/or - the length of the eyeball. • A person with a refractive error will have eyes that look normal, but they will not see well. • An eye examination that tests for refractive error is called a refraction.

REVIEW: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

WHAT IS ACCOMMODATION?	• Accommodation occurs when the ciliary muscle contracts and changes the shape of the crystalline lens (makes it thicker). • This changes the optical focus of the eye so that close objects can be seen clearly. • When accommodation in a normal eye (an eye without refractive error) is relaxed, objects in the distance are seen clearly. • Presbyopia is the natural aging change in the eye where the crystalline lens hardens with age. When this happens, the lens cannot change shape easily when the ciliary muscle contracts. This means that an older person cannot accommodate as much or as easily as a younger person. • If a normal eye cannot accommodate (if a person has presbyopia), close objects will appear blurry. • The amplitude of accommodation is the total amount of accommodation that is available to change the focus of the eye. • Amplitude of accommodation decreases with age. • To avoid asthenopic (visual fatigue) symptoms during long periods of near work, usually only half the amplitude of accommodation should be used.

REFRACTIVE ERRORS

There are four types of refractive error:

- hyperopia
- myopia
- astigmatism; and
- presbyopia.

In this unit we will discuss three of these refractive errors (hyperopia, myopia and astigmatism).

Presbyopia is discussed in other units.

HYPEROPIA ("Longsightedness")

WHAT IS HYPEROPIA?

When light rays from a distant object (6 m or further away) come into focus behind the retina in an unaccommodated eye, we say that the eye is hyperopic (or hypermetropic), or that the person is hyperopic. Hyperopia is sometimes also called "longsightedness" or "farsightedness".

Figure 12.1 shows light from a distant object focussing at a focal point behind the retina of a relaxed, hyperopic eye.

The light does not truly focus behind the eyeball, but it would if the back of the eye did not block the light rays.

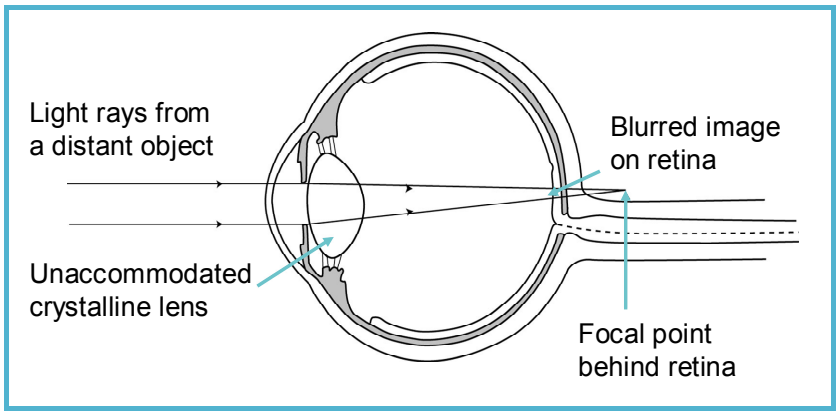


Figure 12.1: *The focal point in a relaxed hyperopic eye is behind the retina*

CAUSES OF HYPEROPIA

Hyperopia may be caused by:

- an eye that is shorter than average (called axial hyperopia)
- a cornea and/or crystalline lens that is too flat (not curved enough) and, therefore, too weak in power (called refractive hyperopia)

THE EFFECT OF ACCOMMODATION ON HYPEROPIA

Figure 12.1 shows how light from a distant object comes into focus behind the retina in a relaxed hyperopic eye.

Figure 12.2 shows the same eye when it accommodates just enough to bring the focal point onto the retina and makes the distance vision clear. In this way, a person with hyperopia may be able to accommodate enough to see clearly without spectacles.

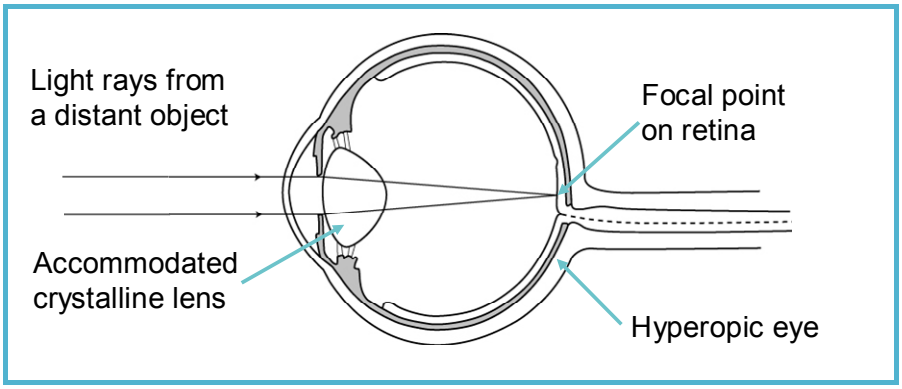


Figure 12.2: *The focal point of the accommodated hyperopic eye is now on the retina*

The symptoms of hyperopia vary depending on how much accommodation can be used (how old the person is), and the amount of hyperopia they have.

However, most people with hyperopia complain of difficulty seeing at near – usually they tell you that their near vision is worse than their distance vision.

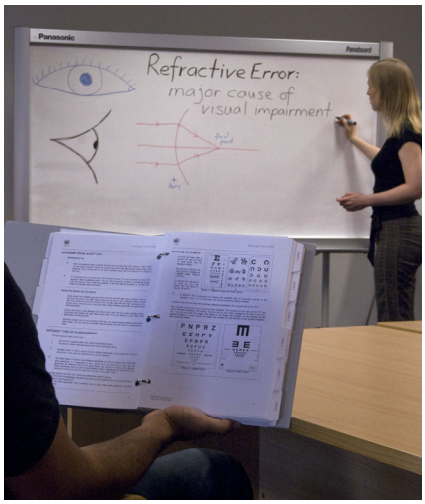
Hyperopic people (sometimes called "hyperopes") often find that their vision seems worse at night or in dim light.

HYPEROPIA ("Longsightedness") (cont.)

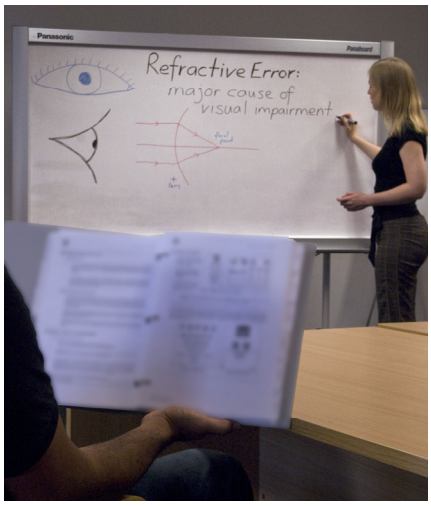
SYMPTOMS OF UNCORRECTED HYPEROPIA	**As a guide we can say:** • If the amount of hyperopia is small (low hyperopia), the person may be able to accommodate enough to compensate for (make up for) their hyperopia – in this case they will have clear vision, both in the distance and at near, without spectacles. People with low hyperopia may (or may not) complain that their eyes feel tired or sore, or that they get headaches if they do a lot of close work such as reading or sewing. these pathways. These symptoms are sometimes called "asthenopia" (eye strain or visual fatigue) and are caused by fatigue (tiredness) of the ciliary muscle which works to make the lens accommodate. People with asthenopia may also have poor concentration when doing near work, or avoid near work if they can. • If the amount of hyperopia is of a medium amount **(moderate hyperopia),** the person may complain of blurry near vision, but might tell you that their distance vision is clear. • If the amount of hyperopia is large **(high hyperopia),** the person may tell you that both their distance and near vision is blurred. • A large amount of hyperopia may cause crossed or turned eyes (also called strabismus or squint). We will talk more about strabismus later in this unit.
WHAT HAPPENS WHEN HYPEROPES GET OLDER?	As seen in Figure 12.2, accommodation can move the focal point from behind the retina onto the retina so that a clear image is formed. With age, the symptoms of hyperopia usually get worse, even though the *amount* of hyperopia does not necessarily change). This is because, as we get older, the crystalline lens in the eye becomes harder and less flexible, which makes it more difficult for the ciliary muscle to change the shape of the lens – this makes accommodation more difficult. When this happens it is more difficult for the eye to compensate for the hyperopia by accommodating. The crystalline lens of a child is very soft and flexible, and a child can accommodate a lot. This means that even a child who has high hyperopia may tell you that they have no difficulty seeing (at distance or at near) – they may have clear vision at all distances. However, such a child may have other symptoms because they have to make their ciliary muscle work so much to see clearly. Symptoms that a child with high hyperopia might have include sore or tired eyes, eye rubbing, vision that is only sometimes blurry, or difficulty concentrating whilst doing near work. A child with high hyperopia might also have an eye that turns to the side instead of pointing straight ahead (this is called a strabismus – there will be more on that below). Eventually, as we get older, the crystalline lens becomes completely solid and is no longer flexible enough to accommodate – this is part of the natural ageing process, and happens to all of us around the age of 40 or 45. When this happens, no matter how much the ciliary muscle works, it cannot change the shape of the lens, and the eye can no longer accommodate. Most people who have hyperopia only require spectacles for close work in the beginning (because more accommodation is needed to see things up close than far away). However, as they get older, many hyperopes will need spectacles for their distance vision too. This is because as we get older we have less accommodation and even the small amount of accommodation needed to make a low or moderate hyperope's distance vision clear, is too much.

HYPEROPIA ("Longsightedness") (cont.)

HOW A PERSON WITH HYPEROPIA MAY SEE



Low hyperopia:
May have good distance vision and good near vision, but may have eyestrain and headaches.



Moderate hyperopia:
Near vision blurred, but good distance vision.

High hyperopia:
Both distance and near vision blurred (near vision is worse than distance vision).

Figure 12.3: *How a person with low, moderate and high hyperopia might see*

CORRECTION OF HYPEROPIA

Hyperopia is corrected with convex (or "plus") spherical lenses. When we correct hyperopia, we are decreasing the need for the eye to accommodate by using positive spectacle lenses.

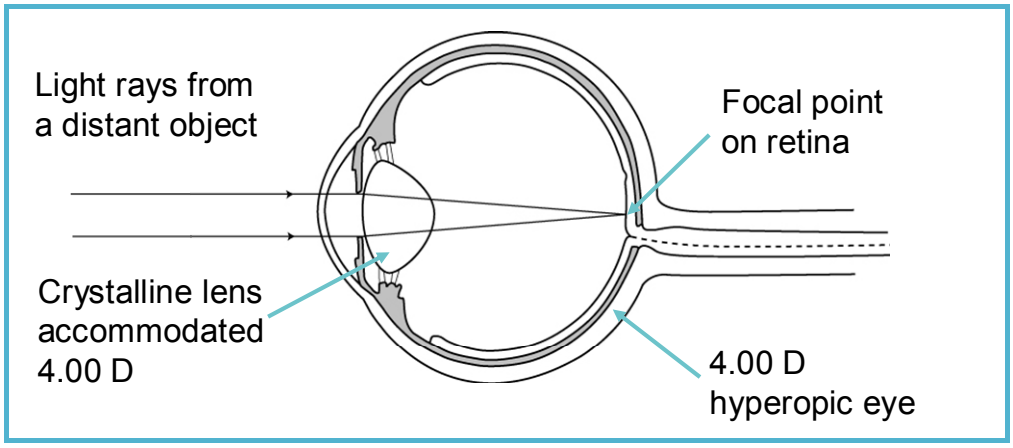


Figure 12.4: *The eye of a young 4.00 D hyperope which is accommodating by 4.00 D; the focal point is on the retina and the distance vision is clear*

In this case (Figure 12.4), if the person is younger than 20, you may prescribe only half of the refractive error amount (thus +2.00 D – as seen in Figure 12.5) because this person is young and still has a lot of accommodation.

HYPEROPIA ("Longsightedness") (cont.)

CORRECTION OF HYPEROPIA (cont.)

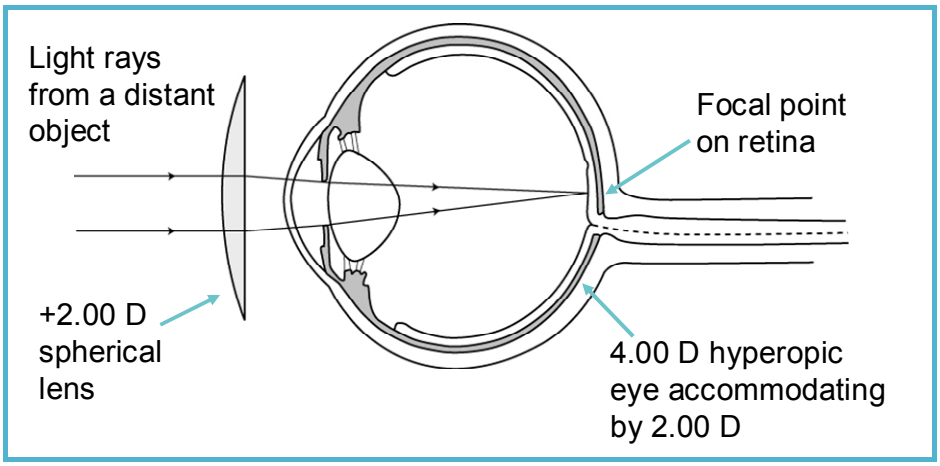


Figure 12.5: *The same eye as above with a +2.00 D spectacle lens in front of it. Now the eye only has to accommodate 2.00 D to have clear distance vision. This will make the person's eyes feel more comfortable, especially when looking at near, because they do not have to accommodate as much.*

If the person is 30 years old or older, you will probably prescribe the full +4.00 D (as seen in Figure 12.6) because their ability to accommodate is decreasing.

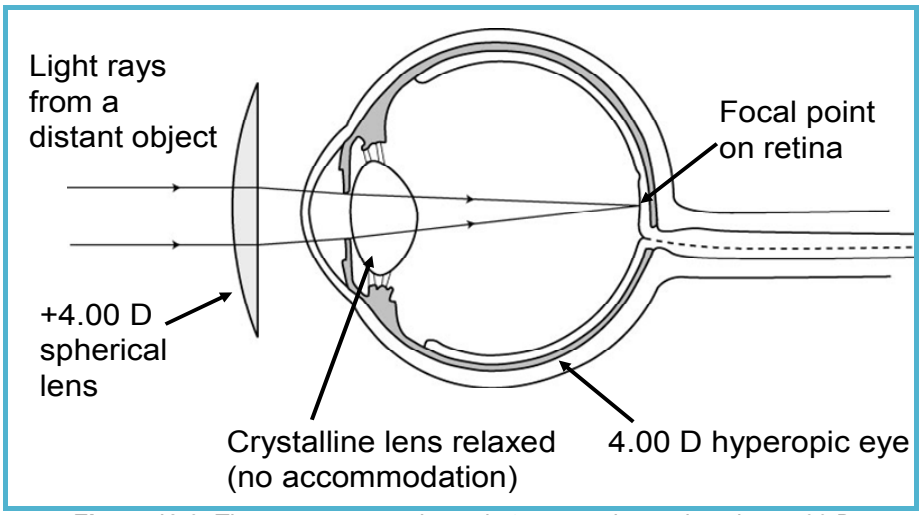


Figure 12.6: *The same eye as above, but now we have placed a +4.00 D spectacle lens in front of it. Now the eye does not need to accommodate at all to keep the distance vision clear.*

A full correction of the hyperopic refractive error is not needed in all cases. Younger people are usually more comfortable if only part of the hyperopia is corrected and some accommodation is used, because their eyes are used to accommodating. It is sometimes unwise to fully correct hyperopia because a younger person may complain of blurred vision at distance with the full correction – simply because they are unable to relax all of their accommodation. An example of a partial correction of hyperopia is seen in Figure 12.5.

As a hyperopic person gets older and has less accommodation, a positive spectacle lens of greater power is needed to make the vision clear.

By the time a person is about 60 years of age, there is little or no accommodation remaining and the hyperopia must be fully corrected (Figure 12.6).

HYPEROPIA ("Longsightedness") (cont.)

HYPEROPIA AND CONVERGENT STRABISMUS

Although we have said that a full correction of hyperopia may not be necessary for all young people, there are times when it is extremely important that all of the hyperopic error is corrected – even in young people.

Hyperopia in children may cause an eye to turn. This problem has several names:

- convergent strabismus
- eye turn
- crossed eyes
- convergent squint.

If we give these children their full correction for hyperopia, it will usually relax their accommodation and straighten their eyes – but often other treatment is also needed.

Children who have eyes that do not look straight (an eye may turn in, out, up or down), should always be referred to a person who is specially trained to treat this condition.

It is very important that these children are treated whilst they are still very young, so it is important to refer them promptly.

If treatment is not received whilst the child is young, the problem may become permanent.

Children have very active accommodation and usually cannot relax their accommodation even if they try. To test children's eyes for hyperopia, accommodation must be fully relaxed, so a person who is trained to do so will use special eye drops called "cycloplegic drops". These drops paralyse the ciliary muscles for several hours so that the child cannot accommodate and the full amount of hyperopia can be measured.

Note: Not all cases of strabismus are caused by uncorrected hyperopia, so spectacles will not help all types of strabismus.

Figure 12.7: *A child with a strabismus (eye turn) should always be referred to a person who is trained to treat this condition*

MYOPIA ("Shortsightedness")

WHAT IS MYOPIA?

When light rays from a distant object (6 m or further away) come into focus in front of the retina of an unaccommodated eye, we say that the eye is myopic, or that the person has myopia.

In Figure 12.8 you can see that the parallel light rays from a distant object come to a sharp focus before they reach the retina. The light rays are diverging when they reach the retina. This means that the unaided distance vision will be blurred.

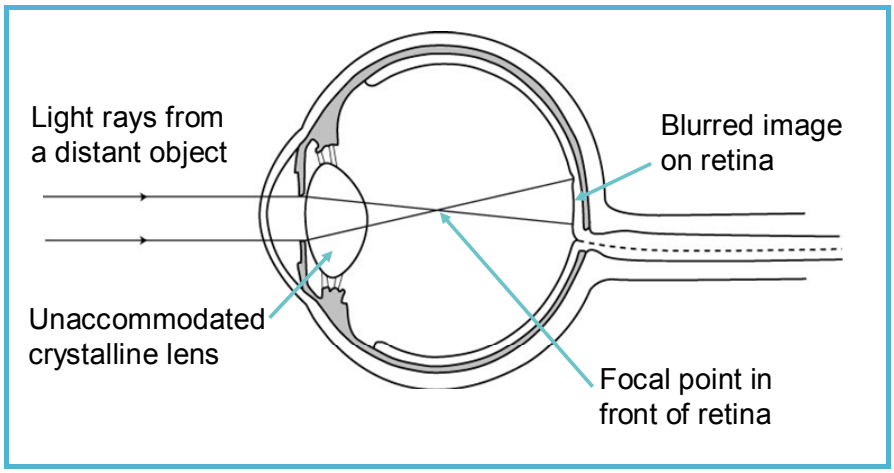


Figure 12.8: *The focal point in a relaxed myopic eye is in front of the retina*

CAUSES OF MYOPIA

Myopia may be caused by:

- an eye that is longer than average (this is called *axial myopia*)
- a cornea and/or a crystalline lens that is curved too much and, therefore, too strong in power (this is called *refractive myopia*).

THE EFFECT OF ACCOMMODATION ON MYOPIA

Accommodation has no effect on myopia.

A hyperopic person can use accommodation to make their distance vision clear. Why then does accommodation not help make distance vision clear in myopia?

If you look at Figures 12-2 and 12-4 you can see that when the hyperopic eye accommodates, the focal point moves closer to the crystalline lens. Accommodation only works in this direction.

Now look at Figures 12-9 and 12-10. You can see that when an uncorrected myopic eye accommodates while viewing a distant object, the focal point moves even further away from the retina. The blur on the retina will be even worse, so a person with myopia will not be able to see more clearly if they accommodate.

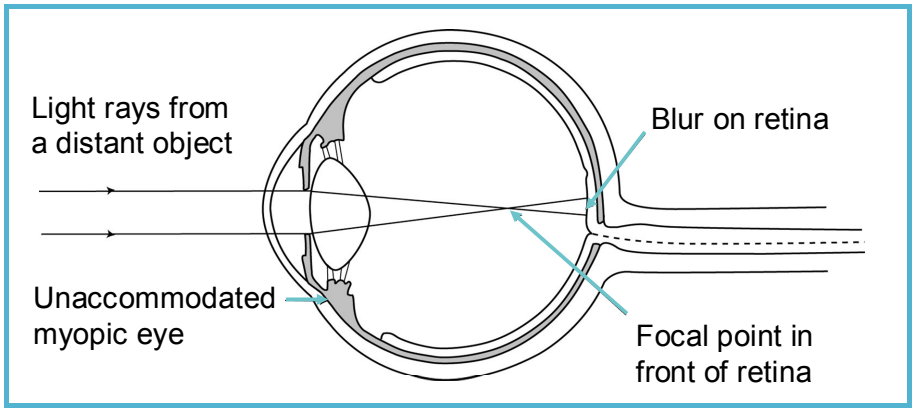


Figure 12.9: *The focal point in a relaxed myopic eye is in front of the retina*

MYOPIA ("Shortsightedness") (cont.)

THE EFFECT OF ACCOMMODATION ON MYOPIA (cont.)

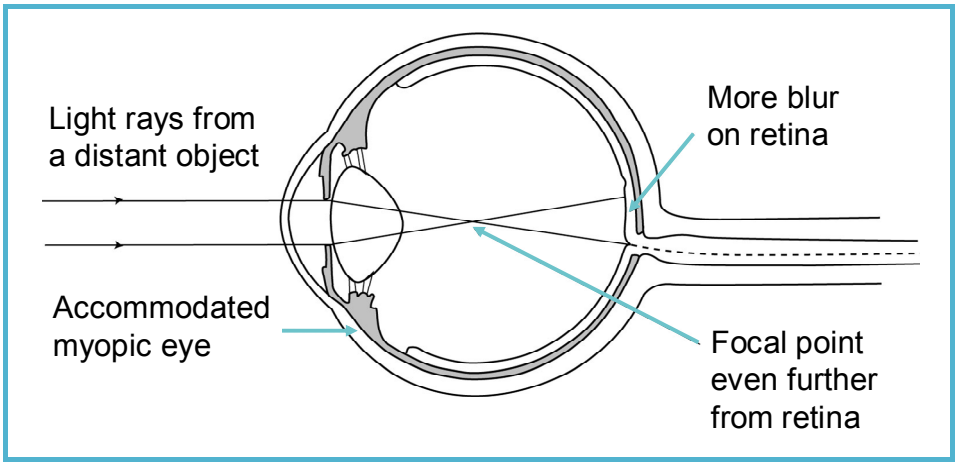


Figure 12.10: *The focal point in an accommodated myopic eye is further away from the retina*

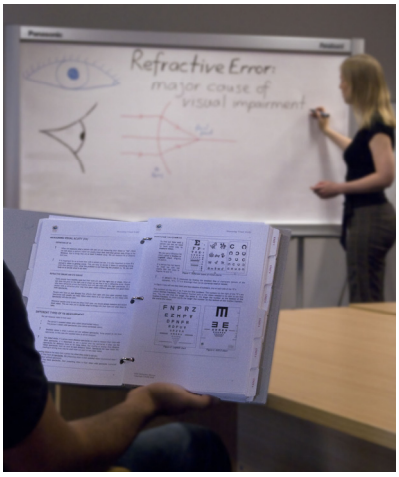
SYMPTOMS OF UNCORRECTED MYOPIA

Myopia is often called "shortsightedness". The reason for this is that a person with myopia will have near vision that is better than their distance vision, no matter what age they are.

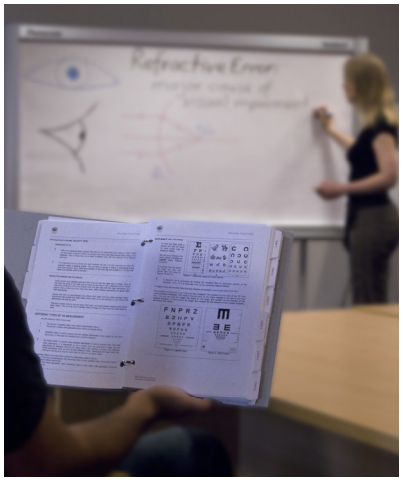
People with myopia (also called myopes) usually complain of blurry distance vision, or say that they cannot recognise people who are far away. They may tell you, or you may notice, that they see better when they almost close their eyes ("screw up" or "squint" their eyes).

Myopic people often find that their vision seems worse at night or in dim light.

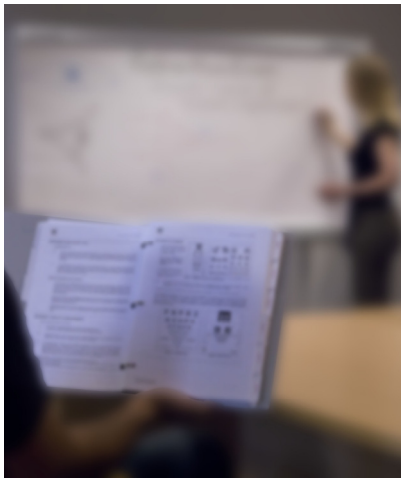
HOW A PERSON WITH MYOPIA WILL SEE



Low myopia:
Distance vision blurred, but good near vision.



Moderate myopia:
Distance vision blurred, but good near vision.



High myopia:
Both distance and near vision blurred (distance vision is worse than near vision).

Figure 12.11: *How a person with low, moderate and high myopia might see*

MYOPIA ("Shortsightedness") (cont.)

CORRECTION OF MYOPIA

Concave (or "minus") spherical lenses correct myopia. The next three figures will help explain how minus spheres do this.

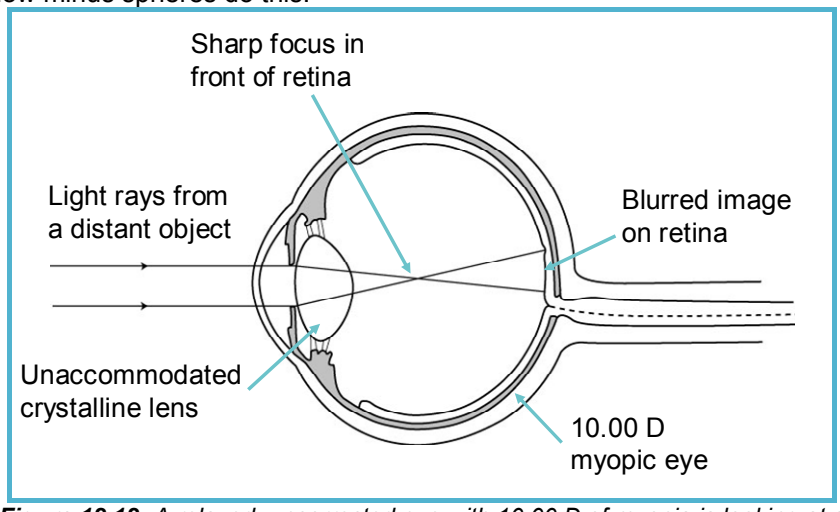


Figure 12.12: *A relaxed, uncorrected eye with 10.00 D of myopia is looking at a distant object. The focal point is in front of the retina. The rays of light are diverging as they reach the retina and so the distance vision is blurred.*

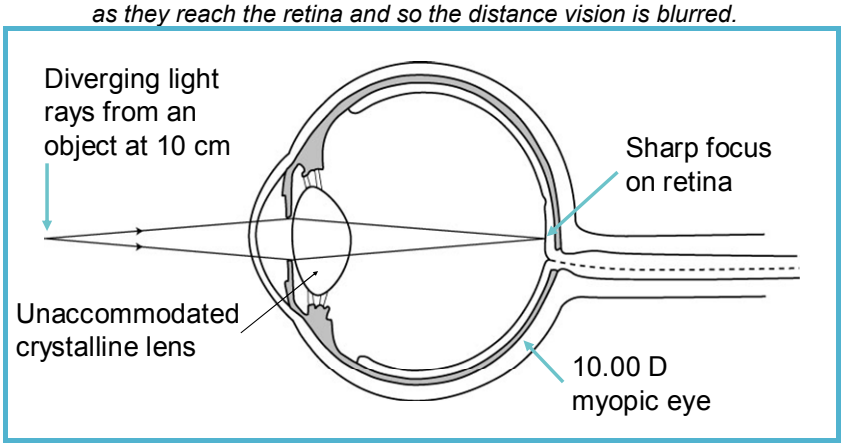


Figure 12.13: *The same eye as above but this time looking at an object 10 cm in front of it. Now the focal point is on the retina so the near vision is clear. This eye will see objects clearly at 10 cm or closer.*

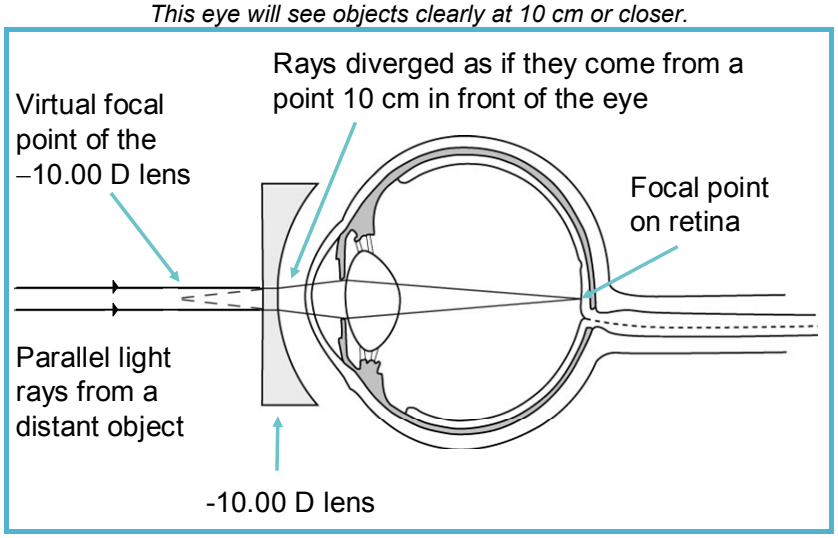


Figure 12.14: *The same eye again, but this time looking at a distant object through a –10.00 D lens. You can see that the –10.00 D lens diverges the light rays before they reach the eye – as if they were coming from a point 10 cm in front of the eye. This is the same point at which the unaided myopic eye sees an object clearly. So with a –10.00 D lens in front of it, this myopic eye will see clearly at a distance.*

MYOPIA ("Shortsightedness") (cont.)

ESTIMATING THE POWER OF THE LENS NEEDED FOR A MYOPIC EYE

The unaided vision of a healthy, young myopic eye will be perfectly clear when an object is at a certain distance and also when the object is closer than that distance. But their vision will be blurred at any distance further away.

The table below can be used to estimate (guess) the power of the lens that a person may need to see clearly in the distance.

Table 12-1: *The distance at which a myopic eye can see clearly helps us to estimate the lens power they need.*

Can see clearly at this distance	Approximate power of lens needed to see clearly at 6 m
2 m	**-0.50 D**
1 m	**-1.00 D**
66 cm	**-1.50 D**
50 cm	**-2.00 D**
40 cm	**-2.50 D**
33 cm	**-3.00 D**
25 cm	**-4.00 D**
20 cm	**-5.00 D**
10 cm	**-10.00 D**

REMEMBER:

A "distant object" is something that is 6 m or more away from the eye.

From this table we can work out that if someone can see an object clearly at:

- **1 m** and closer they may need **–1.00 D** to see a distant object clearly.
- **50 cm** and closer they may need **–2.00 D** to see a distant object clearly.
- **25 cm** and closer they may need **–4.00 D** to see a distant object clearly.

If you bring an object closer and measure the distance at which a myopic person says they start to see it clearly, you can use the table above to estimate which power minus lenses they may need.

You will need to do a refraction examination for a person to get the exact power of the lens (or lenses) that will give them the best vision.

CALCULATIONS: THE DISTANCE AT WHICH A MYOPIC EYE CAN SEE CLEARLY

If you do not want to use the table, and want to know how to estimate the myopic refractive error yourself, you can use this formula:

F = 100/f
where **f = distance (measured in cm)**
and **F = lens power (measured in D)**

Example:
A boy can see clearly if things are 40 cm from his eyes or closer.
What refractive error would you estimate for this boy?

F = 100/f = 100/40 = 2.50 D

From the boy's symptoms you know that he is a myope, so he needs a minus lens to correct his refractive error. The power of the minus lens needed to give him clear distance vision will be approximately –2.50 D.

MYOPIA ("Shortsightedness") (cont.)

PATHOLOGICAL MYOPIA

The eyeball of a myopic person is usually longer (and larger) than the eyeball of a person with a normal eye. Very myopic eyes sometimes grow so much longer than a normal eye that the sclera and the retina are stretched.

For this reason, some very myopic eyes have a thin sclera and retina. This is called myopic degeneration. Eyes with myopic degeneration have pathological myopia and their vision may still be poor even if the myopia is corrected with spectacles. This is because the retina has been damaged.

In some myopic eyes, the retina is stretched so tightly that it tears and detaches from the back of the eye. This is called a retinal detachment, and it can cause irreversible blindness if, it is not treated by an ophthalmologist within 24 hours. The symptoms of a retinal detachment are flashing lights (like lightning) and/or floating spots in the person's vision.

If a person tells you that they are seeing flashing lights or that they have suddenly noticed floating spots in their vision, it is an ocular emergency.

These people must be referred urgently (immediately) to an ophthalmologist for treatment.

Retinal detachments can happen to anyone, but they are more common in myopes.

WHAT IS ASTIGMATISM?

An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point.

CAUSES OF ASTIGMATISM

The surfaces of the cornea and crystalline lens are the major refracting (focusing) surfaces of the eye. Normal eyes (those without refractive error) as well as hyperopic and myopic eyes all have spherical refracting surfaces. A spherical surface is like that of a round ball, and has the same curvature in all meridians (directions) on its surface.

In astigmatism, the refracting surfaces of the eye do not have the same curvature in all meridians (directions).

The refracting surfaces of an astigmatic eye are more like the surfaces of a rugby ball or an egg. A surface that is like that of a rugby ball or egg – not equally round or curved in all directions – is called a toric surface.

A toric surface has two meridians: one meridian is steeper (more curved), the other meridian is flatter (less curved).

MYOPIA ("Shortsightedness") (cont.)

CAUSES OF ASTIGMATISM (cont.)

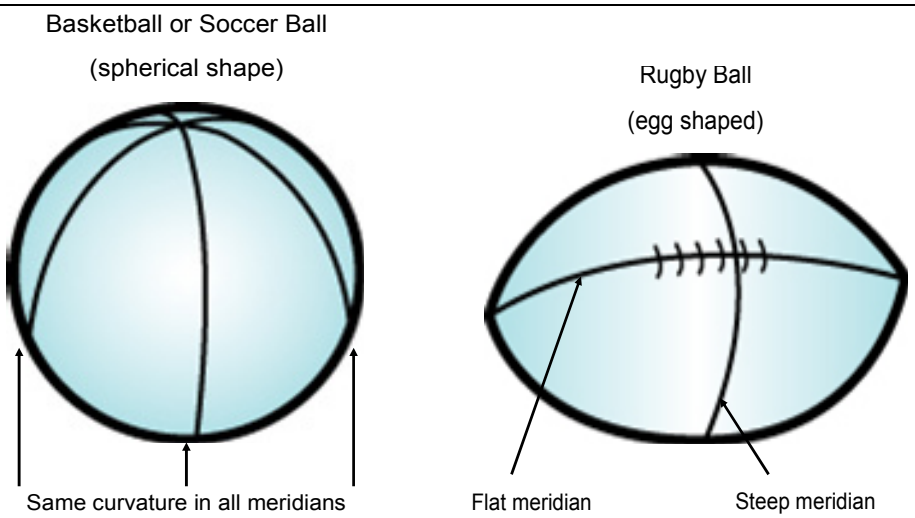


Figure 12.15: *A soccer ball has a spherical surface. A rugby ball (egg shaped) has a toric surface.*

The two meridians of a toric surface are usually perpendicular to each other. Perpendicular lines are at an angle of 90° to each other.

Examples:

- One meridian can be horizontal (at 180°) and the other vertical (at 90°)
  → 180° – 90° = 90°
- One meridian can be at 45° and the other at 135°
  → 135° – 45° = 90°

The most common cause of astigmatism is a toric cornea. This is because the cornea is the eye's main refracting (light bending) surface.

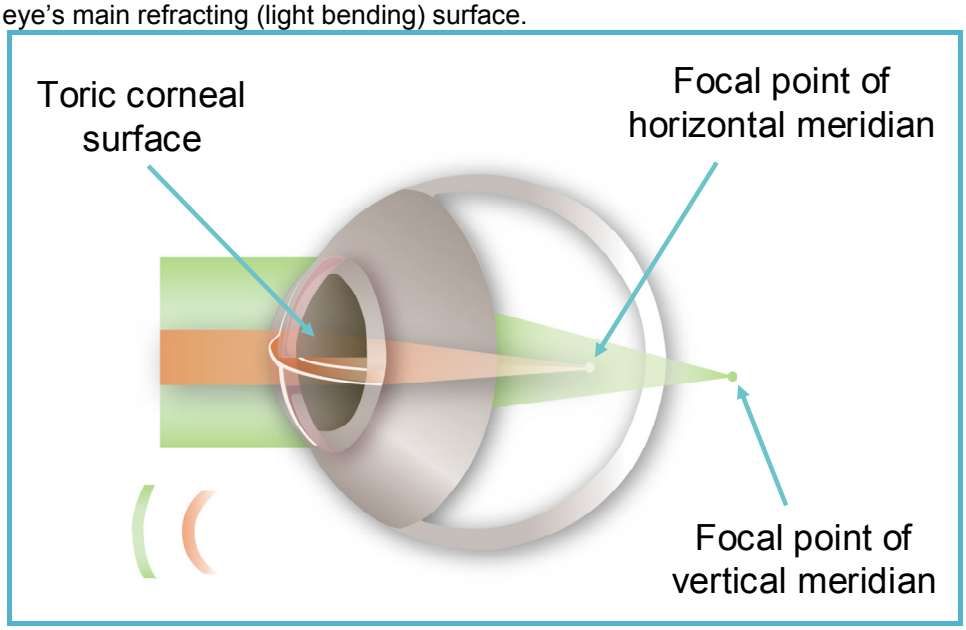


Figure 12.16: *This cornea is not spherical so it does not focus light at one single point causing astigmatism in this eye. A surface which makes two focal points like this is called a toric surface.*

MYOPIA ("Shortsightedness") (cont.)

CAUSES OF ASTIGMATISM (cont.)

Because the two meridians of an astigmatic eye have different powers, the spectacle lens needed to correct astigmatism must also have different powers in different meridians. Each meridian can be corrected by a cylindrical lens. Usually two cylindrical lenses are needed (one for each meridian), and these cylindrical lenses are joined together to make a single sphero-cylindrical lens.

Sometimes it is easier to think of a toric eyeball as simply being like a soccer football that has been squashed a little bit.

A person with astigmatism usually has a corneal surface that is toric, but this will not be noticeable just by looking at them. Special instruments can measure a toric corneal surface, but if you just look at an astigmatic eye it will look perfectly round like a normal eye.

This is because the amount of corneal toricity only needs to be very small in order to create significant amounts of astigmatism.

SYMPTOMS OF UNCORRECTED ASTIGMATISM

A person with astigmatism (sometimes called an "astigmat") may tell you they have problems with both distance and near vision, because there is no distance at which a clear retinal image can form. This is especially true for older people and for people with large amounts of astigmatism.

If the amount of astigmatism is small, and the person is young, unaided vision might be alright (but still not perfect) for both distance and near. However, in this case, the young person with astigmatism often has asthenopia (eye strain) or headaches. This is because young people have very active accommodation and often try to use their accommodation to compensate for (make up for) their poor vision (however using accommodation to compensate for astigmatism will not work and vision will remain poor).

REMEMBER:

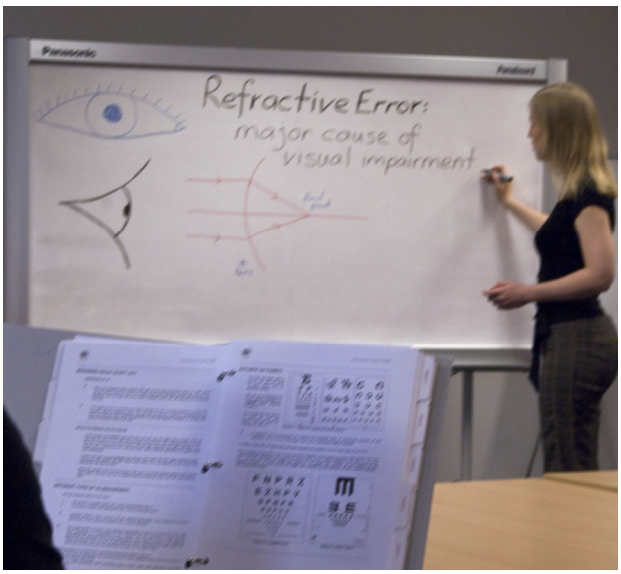
When people accommodate they are almost always unaware that they are doing so.

A young person with astigmatism who tries to make their vision clear by using their accommodation will do so subconsciously (without thinking about it). They will not realise that they are fatiguing (tiring) their ciliary muscle by accommodating too much.

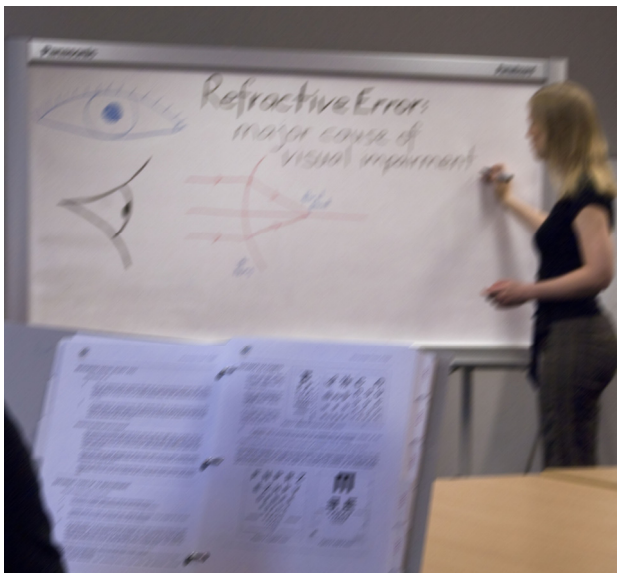
A person with a large amount of astigmatism usually has difficulty seeing both in the distance and at a close working distance.

MYOPIA ("Shortsightedness") (cont.)

HOW A PERSON WITH ASTIGMATISM MAY SEE



Moderate astigmatism:
Distance and near vision slightly blurred.



High astigmatism:
Distance and near vision more blurred.

Figure 12.17: *How a person with moderate and high astigmatism might see*

CORRECTION OF ASTIGMATISM	Astigmatism cannot be corrected with convex or concave spherical lenses only. This is because the refractive error of astigmatism is not the same in all directions. To correct astigmatism, an astigmatic lens is needed. There are two types of astigmatic lenses – namely cylindrical and sphero-cylindrical lenses. • **Cylindrical lenses:** A cylindrical lens has power in just one meridian, while the other meridian has no power. This sort of lens is used for a person who only has astigmatism without another refractive error (such as hyperopia or myopia). A cylindrical lens is put in front of the eye at a specific angle so that the power of the lens (along its power meridian) matches the meridian of the astigmatism in the eye. An example of a cylindrical correction is: –2.00 DC x 90 DC This means a minus two dioptre cylinder lens is located with its axis at ninety degrees. And we could say: "minus two cyl, axis ninety". • **Sphero-cylindrical lens:** You can think of a sphero-cylindrical lens as a cylindrical lens that has been combined with a spherical lens. It has different powers in different meridians (unlike a spherical lens which has the same power in all meridians of the lens). Some people have a refractive error with a spherical part (like hyperopia or myopia), *and* an astigmatic part. These people will need *both* a spherical lens and a cylindrical lens to correct their refractive error. Fortunately, this does not mean that the person has to wear two spectacle lenses on top of each other. A sphero-cylindrical lens is a special lens which combines a spherical and a toric lens into one lens. Usually it is the front surface of the lens that is spherical, and the back surface that is cylindrical.

MYOPIA ("Shortsightedness") (cont.)

CORRECTION OF ASTIGMATISM (cont.)

To correct astigmatism accurately we must make sure that the power of the astigmatic lens is correct. We must also make sure that the power or axis of the astigmatic lens is placed at the correct angle in front of the eye this angle is measured in degrees (°). This angle has to correspond with the meridians of the toric surfaces of the eye, to ensure that the power in each meridian of the eye is corrected accurately.

Instruments used to measure the refractive error of an eye will have an axis scale with markings similar to that shown in Figure 12.18. Notice that the axis of a cylinder will be somewhere between 0° and 180°. Even though 0° and 180° are the same axis direction, we always say "180°", and not "0°".

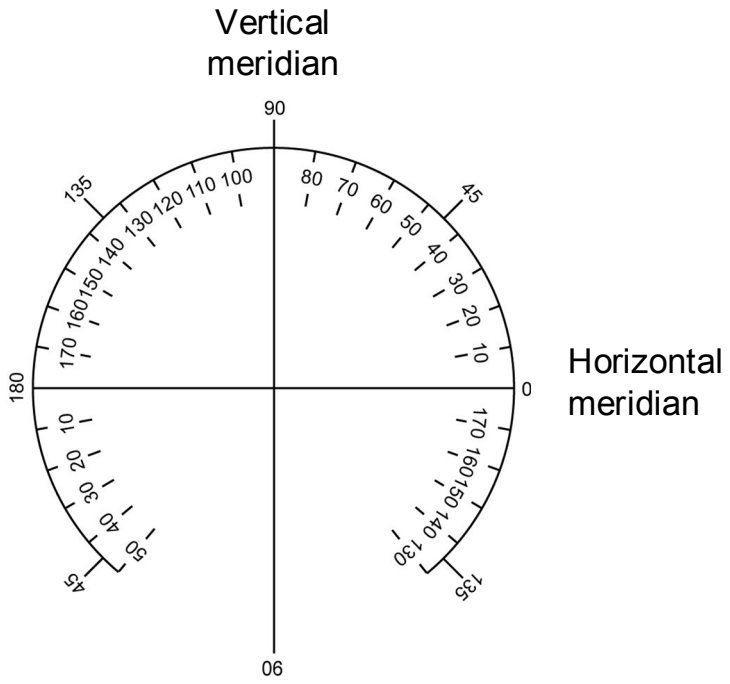


Figure 12.18: *Axis scale for measuring astigmatism. Even though 0° and 180° are both in the horizontal direction, we always say 180°*

A good way to remember the difference between "horizontal" and "vertical" is that horizontal is the same direction as the "horizon" (the line where the sky and the land meet).

EXAMPLE 1

An example of a sphero-cylindrical lens is: **+3.25 D / –1.50 DC x 180**

It can also be written as: **+3.25 / –1.50 x 180**

And we would read this as:
"plus three two five, minus one fifty, axis one hundred and eighty".

EXAMPLE 2

Another example of a sphero-cylindrical lens is: **–0.50 D / –2.00 DC x 127**

It can also be written as: **–0.50 / –2.00 x 127**

This could be read as:
"minus oh fifty, minus two, axis one twenty-seven".

MYOPIA ("Shortsightedness") (cont.)

ADAPTING TO ASTIGMATIC CORRECTION	It is often difficult for people with astigmatism to get used to wearing their new spectacles. This is especially the case if it is the first pair of spectacles that they have worn to correct their astigmatism, or if their spectacle power has changed a lot. A person who has a new pair of astigmatic spectacles might tell you that the spectacles make them feel dizzy or sick, or that the world looks distorted. For example, the floor might look like it is sloping or the walls might not look straight – even though their vision is clearer with the spectacles on. Usually a person will adapt to their new spectacles within 2 weeks. This time period is called the adaptation period. It is important that the person wears their new glasses as much as possible during the adaptation period so that their adaptation symptoms improve faster. Sometimes it is better to give a newly-diagnosed astigmat only a partial astigmatic correction (part of their total correction) at first. Their vision might not be as clear as if they had their full astigmatic correction, but they will feel better wearing their new glasses. Their full astigmatic correction could then be given at a later stage (perhaps when they next want a new pair of spectacles).
IRREGULAR ASTIGMATISM	There are two types of astigmatism: - regular astigmatism - irregular astigmatism Usually when we refer to "astigmatism" we mean "regular astigmatism". Irregular astigmatism is very rare and is usually the result of a corneal problem. Irregular astigmatism is usually caused by trauma affecting the cornea or an eye health problem called keratoconus (which means "conical cornea"). An eye with irregular astigmatism has principal meridians that are not perpendicular to each other. → Because the principal meridians are not perpendicular to each other, it cannot be completely corrected with astigmatic spectacle lenses. Sometimes poor VA from irregular astigmatism can be corrected with Rigid Gas Permeable (RGP) contact lenses (also called hard contact lenses) → This requires specialist-fitting by someone who is trained to fit hard contact lenses.

PRESBYOPIA

Unlike myopia, hyperopia, or astigmatism which affect only some people, presbyopia is a refractive error that affects all people as they get older. Presbyopia is due to the natural hardening of the crystalline lens which makes it more difficult, and eventually impossible, to accommodate. Presbyopia usually begins to be a problem after 40 or 45 years of age and slowly gets worse until about age 60.

Presbyopia is explained in more detail in other units.

REFRACTIVE ERROR – CHANGES OVER TIME

Every person is different (and in fact, every eye that you examine will be different!), but there are some refractive error changes that you can expect as a person gets older.

HYPEROPIA AND AGING	• It is normal for babies to be born with hyperopia. Hyperopia gradually decreases from birth until the age of 5 years. Usually, a child will need to wear spectacles if their hyperopia is more than +3.50 D. If the amount of hyperopia is less than +2.00 D, it is not necessary to give a child spectacles, unless they have convergent strabismus – in which case they should be referred to a person who specialises in children's eye care. Professional judgement must be used for cases between +2.00 D and +3.50 D of hyperopia. If you are not sure whether to prescribe spectacles for a child with this amount of hyperopia, you should refer the person to another eye care provider who can give another opinion. • People younger than 30 years may only need part of their hyperopia corrected (their glasses might not need to be full strength). Young hyperopes often only need to wear their spectacles for near tasks. • The symptoms of hyperopia get worse with age. This is because the eye's ability to accommodate decreases with age (as explained previously).
EXAMPLE	Imagine four people who all have +1.00 D of hyperopia – and think about which of them needs to be prescribed spectacles: **Person 1** is 8 years old. Although she has +1.00 D hyperopia, she has no problems seeing the blackboard in the classroom, no problems seeing her reading and writing at her desk, and she has no asthenopic (eye strain) symptoms. **Person 2** is 19 years old. He can see clearly in the distance and at near, but he complains of headaches and sore eyes after he has been reading for some time **Person 3** is 32 years old. She tells you that she can no longer see clearly to sew, however she has no trouble seeing the television even when it is far away. **Person 4** is 57 years old. He cannot see clearly to read, and he cannot recognise people in the street because his vision is too blurry at both near and far distances.

REFRACTIVE ERROR – CHANGES OVER TIME (cont.)

EXAMPLE (cont.)	• Some older people who have hyperopia become less hyperopic if they begin to get cataract. This is because a growing cataract can increase the focusing power of the crystalline lens. This is sometimes called "second sight". Unfortunately, this improved vision is only temporary – as the cataract continues to grow, the vision will get worse again. When this happens the person will need surgery to see better again. • Today when people have cataract surgery, the eye surgeon will usually remove the cataract (take out the cloudy crystalline lens) and replace it with a plastic intraocular lens. Before intraocular lenses were available, surgeons used to just remove the crystalline lens without replacing it with anything. This left the patient with very high hyperopia (approximately +11.00 or +12.00 D). A person like this who has no crystalline lens and no intraocular lens is said to have aphakia. Aphakia can also be caused if a person has a traumatic accident and loses their crystalline lens as a result. A person with aphakia will need very strong plus spectacle lenses to correct their high hyperopia.
MYOPIA AND AGING	• It is extremely rare for babies or children under the age of 5 years of age to have myopia. • Myopia usually starts in the early teenage years (13 to 16 years) and gradually increases until the person is 25 to 30 years of age. Usually myopia does not increase to more than –3.00 or –4.00 D but occasionally the myopia will continue to increase up to –10.00 or –15.00 D or more. • Some older people become myopic when they begin to get cataract (when the crystalline lens becomes cloudy), and this myopia may increase as the cataract gets worse. This is because a growing cataract can increase the focusing power of the crystalline lens. This change is sometimes called a "myopic shift". In this case, correcting the myopia will improve the distance vision in the beginning, but as the cataract gets worse the vision will become poor even with the best correcting spectacle lens. When this happens the person will need surgery to see better. • Myopia has a strong hereditary link (it runs in families). A child is much more likely to develop myopia if a parent, brother or sister is myopic.
ASTIGMATISM AND AGE	• Astigmatism does not change as much with age compared to hyperopia or myopia. • If the person only has a small amount of astigmatism, it may not be necessary for them to wear spectacles. This is especially true if the person is older than 40 years and has never worn glasses for astigmatism before. Sometimes a small amount of astigmatism can cause headaches and/or asthenopia (eyestrain) in young people – so in this case spectacles may be helpful. • In some countries it is difficult to get sphero-cylindrical spectacle lenses. In this case a person may use spectacles that give the best vision that can be obtained with spherical lenses, even though their vision would not be as good as if they were to have sphero-cylindrical lenses. • Astigmatism (especially high astigmatism) can be hereditary (it runs in families). A child is much more likely to develop astigmatism if a parent, brother or sister is astigmatic.
PRESBYOPIA AND AGE	• Presbyopia only affects older people, and usually only starts after age 40. It is impossible for a healthy child or a young adult in their 20s to have presbyopia.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM

HYPEROPIA

Definition of hyperopia:
- In an unaccommodated hyperopic eye, light from a distant object focuses behind the retina.

Causes of hyperopia:
- Axial hyperopia – eye that is shorter than average.
- Refractive hyperopia – cornea and/or crystalline lens that is too flat (not curved enough) and therefore too weak in power.

Accommodation and hyperopia:
- If a hyperope has enough accommodation he can compensate for his hyperopia and make his vision clear.

Symptoms of hyperopia:
- The symptoms of hyperopia vary depending on:
  - how much accommodation can be used (how old the person is); and
  - the amount of hyperopic refractive error a person has.
- Symptoms can include:
  - → blurred vision (near vision worse than distance vision)
  - → headaches
  - → asthenopia (eyestrain, sore eyes, tired eyes)
  - → poor concentration
  - → avoidance of near work.

- **Low hyperopia:**
  - might be able to accommodate enough to have clear distance and near vision.
  - might have asthenopic symptoms.

- **Moderate hyperopia:**
  - blurry near vision and clear distance vision.

- **High hyperopia:**
  - blurry near and distance vision
  - near vision worse than distance vision.

Ageing and hyperopia:
- Symptoms of hyperopia get worse with age.

Correction of hyperopia:
- Corrected with plus (convex) spherical lenses.
- Depending on their age and the amount of hyperopia, some hyperopes may not need to wear spectacles, or they might only need spectacles for near vision, or they may only need a partial correction.

Complications of hyperopia:
- High hyperopia can cause a convergent strabismus (inward turning eyes).
- A child with convergent strabismus must always be referred.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

MYOPIA

Definition of myopia:
- In myopia, light from a distant object focuses in front of the retina.

Causes of myopia:
- Axial myopia – eye that is longer than average.
- Refractive myopia – cornea and/or crystalline lens that is too steep (too curved) and therefore too strong in power.

Accommodation and myopia:
- Accommodation does not improve the vision of a myope.

Symptoms of myopia:
- A person with myopia has blurry distance vision.
- A person with high myopia might also have blurry near vision (but their distance vision will always be worse than their near vision).
- Myopic people (myopes) often find that their vision seems worse at night or in dim light.

Correction of myopia:
- Corrected with minus (concave) spherical lenses.

Complications of myopia:
- Pathological myopia: highly myopic people may have a thin sclera and changes to the retina. Their vision may be poor even if their myopia is corrected with spectacles.
- Retinal detachment: if a patient suddenly sees flashes of light and floaters, they could have a retinal detachment – refer urgently!

ASTIGMATISM

Definition of astigmatism:
- An eye with astigmatism has different powers in different meridians of the eye. This causes light entering the eye to focus in different places, rather than at one single point.
- Astigmatism may occur just by itself, or in an eye which also has another type of refractive error.

Causes of astigmatism:
- An astigmatic eye does not have the same curvature in all meridians (directions).
- It is helpful to imagine the corneal surface of an eye with astigmatism to be shaped like the surface of a rugby ball or an egg (this is called a toric surface) – even though if you look at the eye of a person with astigmatism it will seem round.
- There are two meridians in an astigmatic eye and these meridians are perpendicular (at 90°) to each other.

Accommodation and astigmatism:
- If the amount of accommodation is small and the person is young, the eye accommodates to try to make the vision clearer. This can cause asthenopia and/or headaches.

Symptoms of astigmatism:
- Distance and near vision may be blurred.
- Vision may be clear but the person could have asthenopia or headaches – especially young people with only a small amount of astigmatism.

SUMMARY: HYPEROPIA, MYOPIA AND ASTIGMATISM (cont.)

Correction of astigmatism:

- Corrected with astigmatic lenses.
- Astigmatic lenses can be cylindrical or sphero-cylindrical.
- Cylindrical lenses correct eyes with only astigmatism.
- Sphero-cylindrical lenses correct eyes with astigmatism and another refractive error.
- The axis of the astigmatic lens must be correct to give clear vision.
- It is often difficult for people with astigmatism to get used to wearing their new spectacles. Usually a person will adapt to their new glasses within 2 weeks.
- Sometimes it is better to give a newly-diagnosed astigmat only a partial astigmatic correction to help them adapt.

Irregular astigmatism:

- There are two types of astigmatism:
  - regular astigmatism
  - irregular astigmatism.
- Usually when we refer to “astigmatism” we mean regular astigmatism.
- Irregular astigmatism is very rare and is usually caused by:
  - corneal trauma, or
  - keratoconus (an eye health problem).
- The principal meridians of an eye with irregular astigmatism are not perpendicular to each other
- This means that irregular astigmatism cannot be completely corrected with astigmatic lenses.
- Sometimes Rigid Gas Permeable (RGP) or “hard” contact lenses can be used to correct irregular astigmatism
  - These contact lenses must be fitted by a specialist.

PRESBYOPIA

Definition of PRESBYOPIA:

- Affects all people as they get older – it usually begins to affect near vision after 40 years of age.
- Caused by the natural hardening of the crystalline lens that makes it more difficult to accommodate.
- More details on presbyopia to follow in next unit.

REFRACTIVE ERROR: CHANGES OVER TME

- Refractive errors are often hereditary.
- The symptoms of hyperopia get worse with age.
- Young hyperopes may only need a partial correction.
- Cataracts can cause a myopic shift – an increase in myopia or a decrease in hyperopia.
- Myopia usually starts early in life, and typically increases between the ages of 12 and 30.
- Astigmatism does not change much with age.

TEST YOURSELF QUESTIONS

1. **What is hyperopia? What type of lens is used to correct hyperopia?**

_____

_____

2. **What are the symptoms of hyperopia for a person who cannot accommodate?**

_____

3. **What are the symptoms of hyperopia for a person who can accommodate?**

_____

4. **What should you do if a child who has a strabismus (eye turn) comes to you for an eye examination?**

_____

5. **What is myopia? What type of lens is used to correct myopia?**

_____

_____

6. **What are the symptoms of myopia?**

_____

7. **If a person tells you that they can only see things that are 50 cm away (or closer) from their eyes, how much myopia do you think they have?**

_____

_____

8. **What should you do if a person tells you that they are seeing bright lights or suddenly floating spots in their vision?**

_____

9. **What is astigmatism? What type of lens is used to correct astigmatism?**

_____

_____

10. **What are the symptoms of astigmatism?**

_____