Preventing retinal detachment by averting asthenopia that contributes to progressive myopia.

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Abstract

Introduction

This paper suggests that asthenopia, or eye strain, initiates a process that can lead to detachment. Asthenopia can be induced in the myopic eye at the near range with a minus lens; and under those conditions, it creates the tendency for one’s myopia to become worse. Progressive myopia, past a certain stage, is attributed mainly to the eyeball (or sclera). An excessive elongation of the sclera can lead to detachment.

The Hypothesis

Asthenopia is often thought to be prevalent in cases of hyperopia when performing close-up work, but it can also be induced in the myopic eye at the near range with a minus lens. A minus lens projects the focal point from a close-up object farther behind the retina. The crystalline lens would have to “bulge” more to bring it into focus—more than how much it would normally “bulge” for near focusing. Under those conditions the myopic eye becomes susceptible to progressive myopia.

Evaluation of Hypothesis

This means the ciliary muscle, which controls the shape of the crystalline lens, would have to tighten up more. If the ciliary muscle tightens up excessively, the oblique muscles would also tighten up more in response. (The oblique muscles are already tense since the eye is myopic.) The excess tension of the oblique muscles can force the sclera to elongate and thereby reduce the distance between the retina and the focal point. This alleviates some of the strain on the ciliary muscle.

The crystalline lens would not have to “bulge” to its maximum—although it would still “bulge” more than how much it would normally “bulge” for near focusing.

Conclusion

It can be demonstrated that if the eye was continuously subjected to such a condition for an extended period of time, near-point asthenopia can promote progressive myopia. It is attributed to asthenopia because more than the normally required “effort to see” is generated, before a near image could be brought into focus. Not only will the crystalline lens “bulge” excessively, but the sclera will also elongate progressively. Detachment tends to occur at the area where the retina has thinned out due to the continuous elongation of the eye.

Introduction

There is a correlation between asthenopia and detachment in reference to myopia (or nearsightedness). Asthenopia, or eye strain, is often thought to be more prevalent in cases of hyperopia (or farsightedness)². The symptoms are pain in the form of headaches, fatigue, and blurred vision in the near range. The discomfort is due to the extra effort imposed on the crystalline lens when attempting to bring a near image into focus. The lens has to “bulge” more to compensate for the shorter length of the hyperopic eye. Asthenopia is not usually associated with myopia (or nearsightedness) even though the myopic eye has difficulty focusing in the distance. The contention is that if the myopic eye cannot make out a blurred image, it would just give up. The hyperopic eye, on the other hand, would continue to try to bring it into focus; its “effort to see” is greater than the myopic eye.

When the focal point is behind the retina (when wearing a minus lens to read) instead of in front of the retina (when the myopic eye attempts to bring a blurred object in the distance into focus without any visual aid), it seems that less effort is required to reposition it forward onto the retina than backwards onto the retina. Although the effort is also less compared to the hyperopic eye (when the focal point is also behind the retina), near-point asthenopia due to a minus lens produces a higher refractive error. Also, unlike hyperopia, there is usually the absence of discomfort. The eye becomes progressively myopic almost unnoticed. As an image approaches closer towards the naked eye, the light rays become divergent instead of parallel. The focal point is projected behind the retina when the crystalline lens is in a neutral shape—when it does not “bulge” for near focusing or becomes “flat” for distant focusing. It is the shape it would assume, for example, when the eye is occluded. A minus lens, however, diverges the rays of light from a close object even more. It projects the focal point farther behind the retina as illustrated in figure 1. The crystalline lens would have to “bulge” more to bring it into focus—more than how much it would normally “bulge” for near focusing. That means the ciliary muscle, the muscle that controls the shape of the crystalline lens, would have to increase its tension.

If the ciliary muscle continues to be subjected to such a condition for an extended period of time, near-point asthenopia can promote progressive myopia. It is attributed to asthenopia because an excessive “effort to see” needs to be generated before a near image could be brought into focus. An excessive “effort to see” is required to close the gap between the retina and the focal point.

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1. The symptoms are pain in the form of headaches, fatigue, and blurred vision in the near range. The discomfort is due to the extra effort imposed on the crystalline lens when attempting to bring a near image into focus. The lens has to “bulge” more to compensate for the shorter length of the hyperopic eye. Asthenopia is not usually associated with myopia (or nearsightedness) even though the myopic eye has difficulty focusing in the distance.

2. The symptoms are pain in the form of headaches, fatigue, and blurred vision in the near range. The discomfort is due to the extra effort imposed on the crystalline lens when attempting to bring a near image into focus. The lens has to “bulge” more to compensate for the shorter length of the hyperopic eye. Asthenopia is not usually associated with myopia (or nearsightedness) even though the myopic eye has difficulty focusing in the distance.

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Progressive myopia can lead to detachment. Not only will the crystalline lens “bulge” excessively due to the tension of the ciliary muscle, but the sclera will also elongate progressively. Detachment tends to occur at the area where the retina has thinned out due to the elongation of the eye.

**The Hypothesis**

Engaging in close-up work for hours without taking a break while wearing a pair of minus lenses designed to correct myopia can induce asthenopia. It contributes to progressive myopia. And that in turn can lead to detachment.

The rays of light from a close-up image are divergent instead of parallel, but a minus lens would diverge the rays of light even more. The focal point would be projected farther behind the retina. The crystalline lens would then have to “bulge” more than normal for close-up work to compensate for the longer focal length. This means the ciliary muscle, which controls the shape of the crystalline lens, would have to tighten up more. If the ciliary muscle tightens up excessively, the oblique muscles that directly control the shape of the sclera (as well as rotating the eye), would tighten up more in response. The oblique muscles are 90 degrees in relation to the axial length of the eye as in figure 1; the increase in tension can induce further elongation by strangling the eye along the vertical axis. (The oblique muscles are already tense since the eye is myopic.) The increase in elongation would reduce the distance between the retina and the focal point. This alleviates the strain on the ciliary muscle. The drawback, however, is that the oblique muscles may not flex back to a relaxed state under normal conditions. Those muscles can eventually spasm if excess tension is maintained, and the spasm would lock in the myopic shape of the crystalline lens and sclera. The original prescription will not be able to correct the refractive error due to progressive myopia.

When fitted with a new prescription, the process starts over again. Asthenopia is induced when the focal point is again displaced behind the retina during near focusing. If the crystalline lens has “bulged” to it maximum, then just the sclera would be subjected to elongate progressively. The danger of continuous increase in the length of the eye due to successive increase in prescription is that the integrity of the retina would be compromised. It can detach along the centre of the eye where it would thin out the most.

**Evaluation of Hypothesis**

The author has referenced some of his own studies in this hypothesis. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

**The theory on the etiology of asthenopia**

*When the crystalline lens is mainly affected*

During extensive close-up work prior to the onset of myopia, the ciliary muscle, which directly influences the shape of the crystalline lens, can be subjected to an increase in “effort to see”. The extra effort is derived from attempting to maintain near focusing for an extended period of time. It is also due to the closeness of the object; the closer the object, the longer the focal length. The focal point would end up behind the retina as in figure 1. The “effort to see” affects the crystalline lens first by causing it to “bulge” in order to bring the focal point onto the retina. It can induce asthenopia if the effort is continuous.

The oblique muscles would tighten up to alleviate the tension of the ciliary muscle if necessary by creating the tendency to elongate the sclera to reduce the gap between the focal point and the retina for close-up focusing. The tension of the ciliary muscle may not immediately trigger the oblique muscles to tighten up to the extent that it would affect the axial length of the sclera. If the oblique muscles spasm at this point, they would produce just the right amount of tension to cause the crystalline lens to deviate—but not enough tension to cause the eyeball to deviate.

There is no physical connection between the oblique muscles and the crystalline lens to deviate. The traction from the ciliary muscle may affect the shape of the crystalline lens enough to cause it to “bulge” in order to bring the focal point onto the retina as in figure 1. The “effort to see” affects the crystalline lens first by causing it to “bulge” in order to bring the focal point onto the retina. It can induce asthenopia if the effort is continuous.

**Figure 1:** Effect of a minus lens when focusing on a near object.
crystalline lens. The spasm of the oblique muscles would maintain the tension of the ciliary muscle neurologically—and thus only indirectly affect the shape of the crystalline lens. The increase in the tension of the oblique muscles may take place later to directly affect the shape of the sclera if the ciliary muscle tightens up some more. The spasm of the oblique muscles seems to trigger the visual cortex to interpret the eye to be in near focus mode. The visual cortex will limit the ciliary muscle’s ability to relax and thus how much the crystalline lens can “flatten”. (Refer to the section A Different Model for Near Focusing for more information.)

In this case, myopia is likely due to the “bulged” shape of the crystalline lens. The ciliary muscle does not spasm in the strict sense. The crystalline lens can still flex within a certain range. It can still assume a “bulged” shape for near focusing, and it can “flatten” out partially for distant focusing. Perhaps the spasm of oblique muscles places a ceiling on the flexibility of the crystalline lens by limiting how much the ciliary muscle can relax for distant focusing. This determines the myopic shape of the crystalline lens.

Goss and Jackson2 found that one year prior to the onset of myopia, there was no difference in the axial length of the sclera of children who became myopic compared to those who did not. According to Mutti et al., the cornea, which is the other refractive medium, brings in no noteworthy change in children who became myopic compared to those who did not. Perhaps the findings of Goss and Jackson are a predictor of mild myopia where the crystalline lens “bulges” excessively—or a moderate degree of myopia where most of the refractive error is attributed to the crystalline lens while the sclera is affected slightly.

The tension of the oblique muscles affects the sclera less than the crystalline lens. This phenomenon is noticeable when a type 1 ortho C lens is initially worn. The improvement in visual acuity would be more pronounced compared to cases where the tension of the oblique muscles affects the sclera more than the crystalline lens. (A type 1 lens is designed to target just the crystalline lens.)

When the sclera as well as the crystalline lens is mainly affected

When the ciliary muscle becomes weary from maintaining the “bulged” shape of the crystalline lens when engaging in extensive close-up work, it indirectly stimulates the oblique muscles neurologically to tighten up more around the sclera. It may tighten up to the extent that it causes the sclera to elongate. To allow the sclera to elongate, the rectus muscles (the four muscles that run laterally across the eye as illustrated in diagram 1) would tend to relax. The elongation of the sclera alleviates the tension of the ciliary muscle by bringing the focal point closer to the retina. If the eye is continuously kept in this position, the oblique muscles can spasm. In this case, the spasm of the oblique muscles would lock in the myopic shape of the sclera as well as the crystalline lens. The visual cortex will also interpret such an eye to be in near focus mode. (Refer to the section A Different Model for Near Focusing for more information.)

According to Mutti et al., it is possible for the crystalline lens of children to become less “flat” one year prior to the onset of myopia while the axial length of the eye continues to change. Myopia sets in during development when the lens does not “flatten” out enough in response to the increase in axial length of the sclera. This is not necessarily a conflict in comparison to the research done by Goss and Jackson who found that there is no increase in the axial length of children one year prior to the onset of myopia. Perhaps the findings of Mutti et al. are a predictor of a different type of myopia where the tension of the oblique muscles affects the sclera as well as the crystalline lens.

There can be three possible outcomes. One possibility is that the lens deviated more than the sclera, and the sclera may not elongate extensively beyond its normal shape. It is the crystalline lens that mainly produces the longer focal length. The bulk of the refractive error is due to the lens. Another outcome is that the crystalline lens and the sclera deviated equally. They both contribute to the longer focal length. And another possibility is that the sclera elongated extensively beyond its normal shape. It may deviate more than the crystalline lens. In this case, it is the sclera that mainly produces the longer focal length. The bulk of the refractive error is due to the sclera. The latter scenario is noticeable when a type 1 ortho C lens is initially worn. The improvement in visual acuity would be less pronounced compared to cases where the tension of the oblique muscles affects the sclera less than the crystalline lens or where it affects the sclera and crystalline lens equally or almost equally. (The visual acuity results from wearing a type 1 lens would then be factored into the design of a type 2 lens to target the sclera more efficiently.)

A different model for near focusing

Neurologically, the oblique muscles are affected by asthenopia even before spasm occurs. The excessive tension of the ciliary muscle causes the oblique muscles to tighten up first. The sclera may or may not elongate to alleviate the tension of the ciliary muscle. The tension of the oblique muscles is reversible if the conditions that induced asthenopia are temporary. If the conditions remain adverse, the oblique muscles can spasm. Once those muscles spasm, a different model for near focusing seems to take place. The oblique muscles would then take precedence in the outcome of visual acuity (whereas before, it was determined by the ciliary muscle).

The visual cortex interprets the eye to be in near focus mode even when the focal length is shortened by looking away into the distance. The visual cortex disregards the neurosensory message relayed by depth perception—that the object of regard is in the distance instead of close-up. The neurosensory message from the tension of the oblique muscles overrides the message from depth perception4. The neuromotor message in response to the...
perception of a distant object is revised. The visual cortex regards that object to be in the near range. The amount of revision depends on the tension of the oblique muscles. If those muscles are partially tight, as in cases of mild myopia, it would send a partially revised message. When those muscles become tighter, as in more severe cases of myopia, the visual cortex would attend to this neurosensory message more than the message from depth perception; and the neuromotor message would activate near focus more than distant mode.

It appears that asthenopia triggers a different model for near focusing. According to conventional theory, the oblique muscles do not participate in near or distant focusing. The crystalline lens is the only part of the eye that changes shape to bring an image into focus. It "flattens" out for distant focusing when the ciliary muscle relaxes, and it "bulges" for near focusing when the ciliary muscle tightens up.

Barnes noticed that progressive myopia can occur not just during childhood development, but also in adulthood. He gave an example where an individual became mildly myopic during childhood but refrained from relying on the minus lenses unless there was the need to make something out in the distance. His myopia did not become progressively worse. But he relied on the minus lenses later as an adult for all ranges of ocular work. His myopia became worse. In the following section, it is possible to simulate this phenomenon during all stages of development.

Simulating asthenopia

Inducing a relapse

The correlation between close-up work and asthenopia can be demonstrated by simulating the effect of asthenopia on the myopic eye by wearing a minus lens indiscriminately. After “reducing” myopia by orthoptics, some clients accidentally induced a relapse by wearing the new prescription for extensive close-up or computer work instead of just relying on them mainly for the distance. Although the new prescription is weaker than the original prescription (and even slightly undercorrected for the distance to 20/25), it is still overcorrected in the near or intermediate range. Thus the focal point is behind the retina. The extra effort required to deal with the disparity simulates near-point asthenopia.

The patients who had relapses were youths, teens, young adults, and older adults. The patients affected were those with mild, moderate, midrange, and severe myopia. When this became a frequent occurrence, the problem was rectified by instructing them to wear a minus pair of glasses only for distant focusing. A myopic eye is capable of bringing a near image into focus without any visual aid, so it is not necessary to wear them during close-up work. If those glasses were worn mainly for distant work such as taking notes from a blackboard (where near work is not as extensive) or driving, the corrective lenses would not have an adverse effect on the improved visual acuity due to ortho C.

The light rays from a distant object beyond 20 feet are parallel, and the focal point is on the retina—not behind it. A severe myopic eye may experience difficult reading at the near and intermediate range, but it is due to progressive myopia. This problem did not occur during the onset of myopia. For the severe myopic eye due to progressive myopia, undercorrected minus lenses were given for reading and computer glasses were given for the intermediate range.

A relapse during the initial phase of ortho C

During the initial phase of ortho C, a reduction in severe myopia was made possible with a type 1 lens. It only attended to the myopic shape of the crystalline lens, and the cornea curvature was not affected. There was only a partial correction because the shape of the sclera was still myopic. This would have been attended to by a type 2 lens, but it was not utilised prior to the relapse. The tension of the oblique muscles was relaxed to the extent that it only “flattened” the crystalline lens. When some of these patients came back for a follow-up after two weeks during this phase, their visual acuity had relapsed back to the preortho C state due to wearing a minus prescription extensively for close-up and computer work as well as for the distance. The new prescription was undercorrected to give a distant visual acuity of 20/25. The projection of the focal point behind the retina for near focusing affected just the crystalline lens. That means the tension of the oblique muscles did not increase beyond its original tension prior to ortho C. Although the increase in tension of the oblique muscles was not sufficient to elongate the sclera further, it was enough to restrict how much the ciliary muscle can relax. The crystalline lens lost the flexibility to “flatten” adequately for distant focus. The degree of relapse in visual acuity is equal to the visual acuity prior to ortho C. It was verified by testing the visual acuity with trial lenses.

A relapse during the second phase of ortho C

There were also cases where some clients with severe myopia had a relapse during the second phase after a type 1 and type 2 lens were worn. The relapse was harder to reset. It affected the sclera as well as the crystalline lens. There were a few cases of high myopia where the relapse could not be totally reset because a resistance to ortho C was built up. These were the variety where most of the refractive error was due to the sclera.

During this stage, the reduction in severe myopia was made with a type 1 and type 2 lenses. It attended to the myopic shape of the crystalline lens and sclera. It was still only a partial correction because it is difficult for ortho C to completely “correct” the elongated shape of the sclera and crystalline lens in the short term. Ortho C can only “reduce” midrange or severe myopia in the short term. Unlike mild or moderate myopia, the muscles were compromised. There is the need for...
physiotherapy as well as resetting the correct neuromuscular message. When they came back for a follow-up after two weeks, their visual acuity had relapsed due to wearing a minus prescription extensively for close-up and computer work as well as for the distance. Although the new prescription was undercorrected, it was still a high prescription. The positioning of the focal point behind the retina during near focusing affected the sclera as well as the crystalline lens. The increase in tension of the oblique muscles elongated the crystalline lens and sclera back to their former shapes. The degree of relapse in visual acuity is equal to the visual acuity prior to ortho C. This is confirmed by testing the visual acuity with trial lenses.

Resetting the relapse
It is possible to reset the relapse to achieve the same degree of visual acuity experienced before the relapse. The variable that was introduced to produce a relapse was the reliance of a minus lens for close-up work. When that variable was removed, ortho C was able to reset the relapsed myopic shape of the crystalline lens and/or sclera by relaxing the oblique muscles.

Consequences of Hypothesis
By introducing a minus lens to simulate progressive myopia, ortho C did not work. The strain induced by a minus lens during close-up work was able to overcome the relaxation generated by the ortho C lens. The myopia eye became progressively worse. Once the minus lens was removed during extensive close-up work, ortho C was able to reset the relapse. Resetting the myopic eye back to its former improvement in visual acuity presupposes that asthenopia contributes to progressive myopia.

Discussion
The changes in the crystalline lens and the axial length of the sclera have to be synchronised during their development. Those changes do not stabilize until the child is around 10 years of age. At birth, the crystalline lens is around +2.00 or +3.00 diopters, and the axial length of the eye is 17 mm. The thickness of the lens is necessary because the eye would grow, and the lens would have to “flatten” or “thinned” out to compensate for the growth of the eye which would develop to 24 mm in adulthood. The “thinning” of the lens occurs at the same interval as the increase in the axial length of the eye to offset any discrepancy in distant focusing.

Even after the development of the eye during childhood, there is still a neurological relationship between the crystalline lens and sclera prior to the onset of myopia. The expected change in the shape of the crystalline lens and sclera during the post-developmental phase is the reverse of the expected changes during the developmental phase. Grosvenor found that the axial length of the eye decreases with age after 20, and the crystalline lens assumes a “bulged” shape. The changes ensure that proper distant focusing is intact. The post development stage can be thought of as a later development of the sclera to compensate for the “bulged” shape of the crystalline lens. In this sense, the development of the eye is ongoing during the different phases in the life cycle.

Perhaps ortho C can trigger the visual cortex to establish a different relationship between the crystalline lens and sclera. Instead of the growth of the eyeball stimulating the crystalline lens to simultaneously “flatten” (during childhood development) or a “rounder” crystalline lens stimulating the sclera to simultaneously shorten (during adult development), it is possible for a “flatter” crystalline lens to stimulate the sclera to simultaneously “flatten” for distant focusing and vice versa (after ortho C resets the correct neuromuscular message). Establishing this new relationship is necessary to stem progressive myopia because asthenopia cancelled the previous relationship during the childhood development stage or post-childhood development stage due to the imposition of near-point stress. In the myopic relationship, the tension of the ciliary muscle stimulates the oblique muscles to become tense and vice versa; and this promotes progressive myopia.

Conclusion
A minus lens prescribed to correct myopia should only be worn for the distance—not for continuous close-up work. It was designed to bring a distant image into focus. It was not intended to bring a near image into focus. A myopic eye is still capable of bringing a near image into focus without any visual aid, so it is not necessary to wear a minus lens. A severely myopic individual may experience difficult reading unless the naked eye is positioned inches away from the text, but this problem occurred after progressive myopia has set in—not during the onset of myopia. Since wearing a minus lens at the near range tends to promote progressive myopia and since progressive myopia poses the risk of detachment by subjecting the sclera to elongate continuously, it is possible to reduce this risk by not wearing a minus lens for extensive close-up work.

References

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