



Philippine  
Society of  
Pediatric  
Ophthalmology &  
Strabismus

# PSPOS Consensus Statement on the Importance of Cycloplegic Refraction

## EXECUTIVE SUMMARY

This consensus statement is supported by the Philippine Society of Pediatric Ophthalmology and Strabismus and the Philippine Academy of Ophthalmology. It explains the necessity of performing cycloplegic refraction in the pediatric age group, especially in younger children. Unique to this population are the high level of accommodation and variable levels of attention and cooperation which can lead to significant variations in the measurement of the refractive power of their eyes.

Among children found to have vision impairment on screening, error of refraction remains the most common cause. Despite optical correction through eyeglasses and contact lenses being perceived as “simple” modes of therapy for refractive error, they can have long term effects on ocular development. They also carry significant economic implications both to the children’s families and to the whole of society. It is therefore important to make an accurate diagnosis of refractive errors in order to avoid unnecessary or wrong prescriptions for optical correction in children.

## DEFINITION OF TERMS

**Refraction:** an examination technique to measure the focusing characteristics of an eye, performed by an ophthalmologist or an optometrist.

**Refractive error:** inability to focus an image accurately on the retina, causing one to see blurred images

**Retinoscopy:** a technique to obtain an objective measurement of the refractive error of the eye using a retinoscope<sup>1</sup>

**Subjective refraction:** determining the best corrected visual acuity by using a combination of lenses with subjective verification from the patient.

**Objective refraction:** measuring the refractive power of the eye using instruments or equipment without a subjective verification from the patient. This may be done with or without cycloplegia.

**Hyperopia (farsightedness):** a condition when light rays focus behind the retina (because the eye is either too short or has little focusing power) causing near and distant objects to be blurry<sup>2</sup>.

**Myopia (nearsightedness):** a condition in which the optical system of the eye causes incoming light rays to focus in front of the retina, instead of focusing directly on the retinal surface causing objects in the distance to appear blurry<sup>3</sup>.

**Amblyopia:** loss of vision in one or both eyes caused by conditions that impair the normal visual input during the period of development of vision<sup>3</sup>.

**Accommodative esotropia:** eye crossing that is caused by the focusing efforts of the eyes as they try to see clearly. Patients with refractive esotropia are typically farsighted<sup>4</sup>.

**Accommodative spasm:** an involuntary condition when there is greater than normal accommodative response for a given stimulus<sup>5</sup>. It is the sudden development of myopia which disappears after cycloplegia and is usually functional in origin<sup>6</sup>.

**Asthenopic symptoms:** symptoms that include blurred vision, diplopia, difficulties in performing close -up work, headache, eye pain, redness and eye strain<sup>7</sup>.

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<sup>1</sup> Retinoscopy. aapos.org. updated 11/2014. <https://aapos.org/glossary/retinoscopy>

<sup>2</sup> Refractive errors in children.aapos.org. updated 10/2016. <https://aapos.org/glossary/refractive-errors-in-children>

<sup>3</sup> Amblyopia Defined apos.org. updated March 2017 <https://aapos.org/glossary/amblyopia>

<sup>4</sup> Accommodative Esotropia. aapos.org.updated March 2019 <https://aapos.org/glossary/accommodative-esotropia>

<sup>5</sup> Vickers KS. Clinical findings and management of accommodative spasm. American Academy of Optometry 2013. Program number: R02013157

<sup>6</sup> Goldstein JH, Schneekloth BB. Spasm of the near reflex: a spectrum of anomalies. Surv Ophthalmol 1996 Jan-Feb; 40(4): 269-78

<sup>7</sup> Westman M, Liinamaa MJ. Relief of asthenopic symptoms with orthoptic exercises in convergence insufficiency is achieved in both adults and children. Journal of Optometry 2012 April; 5(2):62-67

# SIGNIFICANCE

Republic Act No. 11358 or the National Vision Screening Act was signed into law on July 31, 2019<sup>8</sup>. This law requires all public and private schools to do vision screening on all kindergarten pupils. One of its objectives is “to provide immediate attention to visually impaired kindergarten pupils and create a referral system so that they may be checked and treated by eye care practitioners”.<sup>8</sup>

Since error of refraction is one of the most common causes of visual impairment in children, it is imperative that the performance of an accurate refraction be included in the care of children found to have abnormal vision during screening. This will allow proper prescription of corrective lenses to those children that really need them.

Non-cycloplegic refraction of small children, or refracting them by means of automated refractors alone may result in over/underestimation of their true refractive state. It has been demonstrated that in children, noncycloplegic autorefraction has limited value in determining the true refractive status of the eye, overestimating myopes, and giving a high error rate for emmetropes and underestimating hyperopes<sup>9</sup>. As a result, corrective lenses may either be “overprescribed” for children who do not actually need them and “underprescribed” for those who actually need them. Should this occur, there will be significant economic implications, especially if the government will provide funds for the management of visually impaired children.

# BACKGROUND

Error of refraction is one of the most common childhood visual disorders<sup>10</sup>. There is an increasing incidence of refractive errors, particularly myopia, in the Southeast Asian pediatric population<sup>11 12</sup>. This is also observed among Filipino children in clinical practice.

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<sup>8</sup> Republic Act No. 11358: An Act Establishing a National Vision Screening Program for Kindergarten Pupils and Appropriating Funds Therefor. Retrieved from <https://www.officialgazette.gov.ph>

<sup>9</sup> Rotsos T, Grigoriou D, Kokkolaki A, Manios N. A comparison of manifest refractions, cycloplegic refractions and retinoscopy on the RMA-3000 autorefractometer in children aged 3 to 15 years old. *Clin Ophthalmol*.2009;3:429-31. Epub 2009 Aug 3

<sup>10</sup> American Academy of Ophthalmology. Refractive Errors in Children. July 25, 2014 <https://www.aao.org/eye-health/tips-prevention/children-refractive-errors>.

<sup>11</sup> Foster PJ & Jiang Y (2014). Epidemiology of myopia. *Eye*. 2014 Feb; 28 (2): 202-208.

<sup>12</sup> Fan DSP et al.Change in vision disorders among Hong Kong preschoolers in 10 years. *Clinical and Experimental Ophthalmology* 2011; 39: 398-403

Factors implicated in this rise in refractive errors include heredity, ethnicity, decreased outdoor activities and increased near work.

The problem can be addressed by performing proper refraction and prescribing optical correction as needed. However, refracting children can be challenging due to their inherent excessive accommodation and often poor or unreliable subjective response, resulting in an inaccurate determination of their refractive state. This issue can be resolved by conducting an objective refraction using cycloplegic agents.

## ACCOMMODATION

Accommodation is a process by which the eye changes optical power to maintain a clear image. It is a reflex that allows the eye to focus on objects at various distances. This process is being controlled by the ciliary muscles which change the shape of the lens when focusing. In the pediatric age group, the accommodative reflex is much stronger compared to adults. The young human eye can change focus from distance to near, up to as close as 6.5cm from the eye. This ability, however, declines with age<sup>13</sup>. This age-related decline decreases the amount of accommodation to less than 2 diopters by the time a person reaches 45-50 years old.<sup>14 15</sup> Cycloplegia is the state of the eye wherein the accommodative reflex is relaxed.

Inadequate cycloplegia is the presence of residual accommodation after instillation of cycloplegic agents. It can be detected by dynamic retinoscopy and near acuity measurement.<sup>16</sup>

## CYCLOPLEGIC REFRACTION

Cycloplegic refraction involves the instillation of pharmacologic (cycloplegic) agents prior to determining a person's refractive error. These cycloplegic agents prevent ciliary muscle contraction resulting in the temporary paralysis of accommodation. This way the full and accurate refractive error can be determined without the need of a subjective response from the child.

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<sup>13</sup> Chen AH; O' Leary DJ; Howell ER. Near Visual function in young children. *Ophthalmic Physiol Opt* 2000 May; 20(3): 185-198.

<sup>14</sup> Glasser A, Kaufman PL. Accommodation and Presbyopia. In: Kaufman PL, Alma A, eds. *Adler's Physiology of the Eye: Clinical Application*. 10th ed. St Louis: Mosby; 2003 167-233.

<sup>15</sup> Duane A: Studies in monocular and binocular accommodation with their clinical applications. *Am J Ophthalmol* 5:865,1922.

<sup>16</sup> Hunter, DG. Dynamic retinoscopy: the missing data. *Surv Ophthalmol*. 2001; 46 (3): 269-274.

Cycloplegic refraction is the gold standard for determining the full refractive error in the pediatric age group. Many studies have proven that the ciliary muscle tone remains high<sup>17</sup> in children, leading to significant differences in non-cycloplegic and cycloplegic refraction<sup>18</sup>. Studies have also shown that non-cycloplegic refraction would often lead to misclassification of refractive errors in a significant proportion of children<sup>19 20</sup>. Under-corrections and overcorrections are the errors committed when accommodation is not properly relaxed.<sup>21</sup>

Cycloplegic retinoscopy still remains to be the gold standard in measuring the refractive status of children. However, recent studies have shown that autorefractometry can be a suitable substitute for retinoscopy in children under cycloplegic conditions.<sup>22 23</sup>

## CYCLOPLEGIC AGENTS

Cycloplegic agents are muscarinic receptor blockers inhibiting ciliary muscle contraction. Efficacy of these drugs are cited in many studies<sup>24 25 26 27</sup>. These agents include the following:

1. Atropine sulfate

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<sup>17</sup> Fotedar R, Rochtchina E, Morgan I, Wang JJ, Mitchell P and Rose KA. Necessity of cycloplegia for assessing refractive error in 12 year old children: a population-based study. *Am J Ophthalmol*. 2007 Aug;144(2):307-9.

<sup>18</sup> Sanfilippo PG, Chu, BS, Biglault O, Kearns L, Boon MY, Young TL, Hammond CJ, Hewitt AW, Mackey DA. What is the appropriate age cut-off for cycloplegia in refraction?. *Acta Ophthalmol*. 2014 Sep;92(6):e458-62.

<sup>19</sup> Zhu D, Wang Y, Yang X, Yang D, Guo K, Guo Y, Jung X and Pan CW. Pre and post cycloplegic refraction in children and adolescents. *PLoS ONE*. 2016; 11(12): e0167628. Published online 2016 Dec 1. <https://doi.org/10.1371/journal.pone.0167628>.

<sup>20</sup> Hu YY, Wu JF, Lu TL, Wu H, Sun W, Wang XR, Bi HS, and Jonas JB. Effect of cycloplegia on the refractive status of children: the Shanding children eye study. *PLoS One*10(2):e0117482. Pub Feb 6,2015.<https://doi.org/10.1372/journal.pone.0117482>.

<sup>21</sup> Sankaridurg P, He X, Naduvilath T, Lv M, Ho A, Smith E 3rd, Erickson P, Zhu J, Zou H, Xu X. Comparison of noncycloplegic and cycloplegic autorefractometry in categorizing refractive error data in children. *Acta Ophthalmol*. 2017 Nov;95(7):e633-e640.

<sup>22</sup> Hashemi H, Khabazkhoob M, Asharlous A, Yekta A, Emamian MH, Fotouhi A. Overestimation of hyperopia with autorefractometry compared with retinoscopy under cycloplegia in school-age children. *Br J Ophthalmol*. 2018 Dec;102(12):1717-1722.

<sup>23</sup> Rotsos T, Grigoriou D, Kokkolaki A, Manios N. A comparison of manifest refractions, cycloplegic refractions and retinoscopy on the RMA-3000 autorefractometer in children aged 3 to 15 years old. *Clin Ophthalmol*.2009;3:429-31. Epub 2009 Aug 3.

<sup>24</sup> Celebi S, Ayhan U. Comparison of cyclopentolate and atropine in patients with refractive accommodative esotropia by means of retinoscopy, autorefractometry and biometric lens thickness. *Acta Ophthalmol Scand* 1999 Aug;77(4): 426-429.

<sup>25</sup> Rengstorff RH, Doughty CB. Mydriatic and cycloplegic drugs: a review of ocular and systemic complications. *Am J Optom Physiol Opt*. 1982 Feb;59(2):167-77.

<sup>26</sup> Robb RM, Petersen RA (1968) Cycloplegic refractions in children. *J Pediatr Ophthalmol* 5:110-114.

<sup>27</sup> Hiatt RL, Jerkins G (1983) Comparison of Atropine and Tropicamide in Esotropia. *Ann Ophthalmol* 15: 341-343.

2. Cyclopentolate hydrochloride (not FDA approved in the Philippines)
3. Homatropine hydrobromide (not available in the Philippines)
4. Tropicamide
5. Tropicamide - phenylephrine hydrochloride combination

These agents differ in the time and course of onset, recovery from cycloplegia and the depth of cycloplegia produced.<sup>28</sup>

Among these agents, atropine produces the most effective cycloplegia. Its peak effect is around 3 hours and it takes 8-14 days for its effect to completely wash off.

Cyclopentolate has a faster onset with a peak effect reaching 30-45 minutes. The effect washes out after 6-8 hours, making it more ideal for clinical use. Many studies have demonstrated that the cycloplegic effect of cyclopentolate is comparable to atropine.<sup>23,24</sup> There are, however, others that showed cyclopentolate is not enough in children 2-5 years of age, especially in hyperopic esotropic children with hyperopia greater than 2 diopters<sup>25</sup>.

Tropicamide is another alternative that is commonly used for cycloplegia. It is known for its rapid onset and cycloplegic effect of within 20-30 minutes after administration. Reports suggest that it is not as effective as cyclopentolate or atropine in inhibiting accommodation. It is still a useful cycloplegic agent for measuring low to moderate refractive errors. However, in infants and in patients with high hyperopia or strabismus, this is not recommended.<sup>29 30</sup> Residual accommodation from Tropicamide also varies with ethnicity.<sup>27</sup>

A combination of Tropicamide 0.5% and Phenylephrine Hydrochloride (PHCL) 0.5% for cycloplegic refraction has also been widely used for the past decades<sup>31 32</sup>. Phenylephrine does not significantly add to the cycloplegic effect of tropicamide but it contributes to the amount of mydriasis of the pupil and it reduces the depth of field, affecting patients'

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<sup>28</sup> Manny RE, Mohamed Hussein; Scheiman M, Kutz D, Neimann K, Zinzer K, The COMET Study Group. An effective cycloplegic agent for myopic children. *Investigative Ophthalmology and Visual Science* July 2001, Vol 42, 1728-1735.

<sup>29</sup> Egashira M, Kish LL, Twelker JD, Mutti DO, Zadnik K, Afams AJ. Comparison of cyclopentolate versus Tropicamide cycloplegia in Children. *Optom Vis Sci* 1993 Dec; 70 (12): 1019-26.

<sup>30</sup> Yazdani N, Sadeghi R. Comparison of cyclopentolate versus tropicamide cycloplegia: A systemic review and meta-analysis. *Journal of Optometry*. 2018 Jul-Sep;11(3):135-143.

<sup>31</sup> Hamasaki I, Hasebe S, Kimura S, Miyata M, Ohtsuki H. Cycloplegic effect of 0.5% tropicamide and 0.5% phenylephrine mixed eyedrops: objective assessment in Japanese schoolchildren with myopia. *Jpn J Ophthalmol*. 2007 Mar-April.

<sup>32</sup> Yoo SG, Cho MJ, Kim US, Baek SH. Cycloplegic refraction in hyperopic children: effectiveness of a 0.5% tropicamide and 0.5% phenylephrine addition to 1% cyclopentolate regimen. *Korean J Ophthal* 2017 Jun;31(3):249-256.

perception of blur<sup>33</sup>. Some authors claim that combined eyedrops are acceptable cycloplegic agents<sup>30</sup> However, this combination still has a weaker cycloplegic effect compared to the pure cyclopentolate regimen, especially for children under 5 years of age with high hyperopia and accommodative esotropia <sup>31</sup>

Below is a summary of important information on locally available cycloplegic agents that the healthcare provider must know before using these agents. Characteristics of the cycloplegic agents are also summarized in Table 1:

1. Atropine Sulfate 1%:

- Instilled in both eyes 2x a day for 3 days and the test is done on the 4th day
- Onset is 3-6 hours
- Duration of action is 10-14 days
- Side effects: fever, flushing, tachycardia, restlessness, speech fever, delirium, lid edema, redness of the eye <sup>34 35 36</sup>

2. Cyclopentolate Hydrochloride

- Preferred cycloplegic agent among Pediatric Ophthalmologists
- Comes in 0.5%, 1%, but only 1% concentration is available in the Philippines.
- Has a faster action and shorter duration of effect compared to Atropine
- Cycloplegia occurs in 45-90 minutes of instillation and duration of action lasts for 24-48 hours
- 2 drops of cyclopentolate 1%, 5 minutes apart provide considerable cycloplegia
- Side effects: burning sensation, allergic effect, lacrimation, disturbance of speech and restlessness, transient acute psychosis<sup>34 35 36 37 38</sup>
- Not FDA approved in the Philippines

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<sup>33</sup> Esteve-Taboada JJ, Del Aguila-Carrasco AJ, Berna-Molina P, Ferrer-Blasco T, Lopez-Gil N, Montes-Mico R. Effect of Phenylephrine on the Accommodative System. Journal of Ophthalmology Vol 2016, article ID 796813, 13 pages. <http://dx.doi.org/10.155/2016/7968918>

<sup>34</sup> Farhood QK. Cycloplegic Refraction in Children with Cyclopentolate versus Atropine. 3:239. Doi 10.4172/2155-9570.10000239. Published Aug 6, 2012.

<sup>35</sup> Mindel JS (1994) Cholinergic pharmacology. In: Tasman W, Jaeger EA, eds. Duane's Foundation of Clinical Ophthalmology, Vol3. Philadelphia: JB Lippincott 37.

<sup>36</sup> Wakayama A, Nishina S, Miki A, Utsumi T, Sigasawa J, Hayashi T, Sato M, Kimura A, Fujikadi T. Incidence of side effects of topical atropine sulfate and cyclopentolate Hydrochloride for cycloplegia in Japanese children: a multicenter study. Jpn J Ophthalmol 2018 Sep; 62 (5): 531-536 doi m10.1007/s10384-018-06 12-7. Pub 2018 Jul 25.

<sup>37</sup> Havener WH (1978) Ocular Pharmacology. 4th ed, p253. The C.V. Mosby Company, Saint Louis.

<sup>38</sup> Khurana AK, Ahluwalia BK, Rajan C, Vohra AK. Acute psychosis associated with topical cyclopentolate hydrochloride. Am J Ophthalmol. 1988 Jan 15;105(1):91.

### 3. Tropicamide

- A widely used cycloplegic agent when atropine and cyclopentolate are not available. It is also used as a mydriatic agent.
- Available in 0.5% and 1% solution
- Cycloplegia occurs in 30 minutes
- Duration of action is up to 2-6 hours
- Side effects: blurring of vision, photophobia, eye irritation, dry mouth, skin rash and stomach upset

### 4. Tropicamide - Phenylephrine Hydrochloride combination

- It is a mydriatic agent that also has cycloplegic effects
- 1 drop 2 or 3 times every 3-5 minutes
- Duration of action: 2-6 hours
- Cycloplegia occurs in 30 mins
- Side effects: hypersensitivity, tachycardia, flushing, hypertension, gastrointestinal symptoms

**Table 1: Cycloplegic agents in children<sup>39</sup>**

	Cycloplegic Effect		
AGENT	Maximum (min)	Recovery time	Side effects
Tropicamide	30	2-6 h	Blurring of vision photophobia
Tropicamide - phenylephrine combination	30	2 - 6 h	Hypersensitivity Tachycardia Flushing Hypertension GI Symptoms
Cyclopentolate	25-75	6-24 h	Psychosis, seizure
Homatropine	30-40	1-3 h	Ataxia

<sup>39</sup> Wright KW, Spiegel PH (2003) Pediatric Ophthalmology and Strabismus. 2nd ed Section II chapter 3 Practical aspects of pediatric ophthalmology Chapter 3: Pediatric eye examination pp65-66



Atropine	60-180	3-12 days	Flushing tachycardia, fever, delirium
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*Modified table taken from Pediatric Ophthalmology and Strabismus by Wright KW, Spiegel PH*

## Why is Cycloplegic Refraction Necessary for Children with Visual Impairment?

Cycloplegic refraction is the preferred method of determining refractive errors in children. It can identify the “true” refractive power of the eye, especially in children with strabismus and/or amblyopia.

In patients with limited cooperation, such as infants and toddlers, it allows the eye healthcare provider to determine the refractive error without the need for a subjective response on visual acuity. Alternatively, it can be used for suspected malingering patients to rule out refractive and/ or organic causes of blurred vision. In addition to obtaining the refraction, the eye healthcare provider is able to perform a dilated comprehensive eye examination in the same sitting, to rule out other ocular problems.

Cycloplegic refraction can also detect accommodative spasm and is useful in managing children with asthenopic symptoms.

## CONCLUSION

Cycloplegic refraction is highly recommended for determining the refractive errors in children because of the strong accommodative reflex in this age group. It is essential in diagnosing accurate refractive errors thereby avoiding significant misclassifications in this population.

The younger the patient, the greater the amplitude of accommodation. Because of powerful accommodation and their limited level of cooperation, it is difficult for the examiner to determine the correct refractive error in infants, toddlers and young children since subjective refraction alone will not be as accurate.

As the child reaches early adulthood, the accommodative amplitude becomes less and non-cycloplegic methods may be used. However, cycloplegic refraction is still recommended when necessary, such as in some pathologic cases, so that the true refractive state of the eye can be determined.

## RECOMMENDATIONS FOR CARE

We recommend that cycloplegic refraction should be the preferred method of refracting young children found to have abnormal visual acuity on screening. It is important for the healthcare providers administering cycloplegic agents to be aware of the potential adverse effects of these drugs and be able to manage them appropriately when they occur. In cases wherein an eye care practitioner who is qualified and capable of performing this procedure is not available, a careful non-cycloplegic subjective refraction may be performed, provided that the child can cooperate with subjective testing.

If the visual acuity of a child less than 5 years old cannot be corrected to 20/30, or the visual acuity of a child 5 years old or older cannot be corrected to 20/20 by means of subjective refraction, the child should be referred to an ophthalmologist for a comprehensive eye examination. Likewise, if a young child cannot cooperate with subjective refraction, he/ she should be referred to an ophthalmologist for a prompt comprehensive eye examination. In addition, those with inadequate cycloplegia from tropicamide or tropicamide-phenylephrine eye drops need to be referred to an ophthalmologist for cycloplegia using atropine sulfate or cyclopentolate.