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Change in ocular refraction after tropicamide cycloplegia in preschool children

Zmiana refrakcji oka po zastosowaniu tropikamidu u dzieci w wieku przedszkolnym

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Streszczenie: Cel: celem pracy jest ocena zmian refrakcji oka po zastosowaniu 1% tropikamidu oraz jego przydatności w diagnozowaniu wad refrakcji u dzieci w wieku przedszkolnym.
Materiał i metody: w badaniach wzięło udział 116 dzieci w wieku 5–6 lat (232 oczu). Wykonano obiektywne badanie refrakcji za pomocą autorefraktometru – bez cykloplegii i po cykloplegii 1% tropikamidem (2 x 1 kropla w odstępie 5 min).
Wyniki: podanie tropikamidu istotnie zmieniło sferyczny komponent wady refrakcji, zwiększając go o +0,78 D, pozostawiając natomiast bez zmiany komponent cylindryczny (zarówno moc i oś cylindra). Średnia wartość sferycznego komponentu wady refrakcji u dzieci w wieku 5–6 lat wyniosła +1,55 D, a komponentu cylindrycznego -0,51 D, oś 102°.
Wnioski: 1% tropikamid jest właściwym cykloplegikiem do stosowania u dzieci w wieku przedszkolnym. Wydaje się, że jego skuteczność w porażaniu akomodacji jest wystarczająca u pacjentów z tej grupy wiekowej, z wyłączeniem dzieci z dużą nadwzrocznością, anizometropią i zezem.

Słowa kluczowe: cykloplegia, dzieci, tropikamid, wada refrakcji, wiek przedszkolny.

Summary: Purpose: The aim of the study was to evaluate changes in ocular refraction after 1% tropicamide and its efficacy in diagnosing refractive errors in preschool children.
Material and methods: 116 children (232 eyes) at the age of 5 to 6 years participated in the study. An objective examination of refraction using autorefractor before and after 1% tropicamide cycloplegia (2 x 1 drop of the agent instilled 5 min apart) was performed in the study.
Results: After the instillation of tropicamide, the spherical component of the refractive error significantly increased by +0.78 D, while the cylindrical component (i.e. its power and axis) remained unaltered. In examining the refractive error, the mean value of the spherical component in children at the age of 5 to 6 years amounted to +1.55 D, in the cylindrical component mean value was -0.51 D, and the axis was 102°.
Conclusions: 1% Tropicamide appears an effective cycloplegic agent in preschool children, excluding children with high hyperopia, anisometropia, or strabismus.

Key words: children, cycloplegia, preschool children, refractive error, tropicamide.

Introduction

Cycloplegia seems useful in diagnosis of refractive errors in children since amplitude of accommodation as well as its dynamics in preschool age together make it difficult to identify refractive errors. Cycloplegic agents inhibit amplitude of accommodation, thus help to identify refractive errors, including latent hyperopia. Tropicamide (*tropicamidum*) is a cycloplegic agent commonly used in the clinical practice and research studies and it is applied more often than atropine or cyclopentolate. Tropicamide is characterized by the peak of action at 20–35 min after the first drop is instilled, after only 6 h the agent is no longer reliable (1), finally tropicamide does not cause any adverse effects (2,3). However, it is still questionable what effect tropicamide cycloplegia has on ciliary muscle, particularly on the amount of residual accommodation that remains after administering the cycloplegic agent. Unquestionably, when compared to atropine, tropicamide is not able to completely inhibit accommodation in children (4). Lovasik (5) observed that when a drop of 0.5% or 1% tropicamide is administered, 28–40% of accommodation is not paralyzed. In the studies by Milder (6), in patients aged below 9 years residual accommodation amounted to approximately 6.00 D. According to Gettes and Belmont (1), administering 2 drops of 1 % tropicamide causes stronger cycloplegic effect, however still it may leave 2.00 D of residual accommodation. Besides, its amount can vary according to the color of iris or race of the patient examined (5,7).

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Undoubtedly, information on the functioning of residual accommodation is important when choosing the right cycloplegic agent to be used, and low efficacy of tropicamide in that case does not imply that it is not useful in the diagnosis of refractive errors in children. Studies by Egashira et al. (8) showed that after administering tropicamide the mean refractive error increased by +0.77 D in children aged approximately 9 years. Mutti et al. (9) obtained similar results from their studies. In the group of children at the age of 6 to 12 years, tropicamide cycloplegia caused an increase in mean refractive error by +0.74 D. It is important to stress that after a child has a drop of tropicamide has been administered, the child may feel discomfort in eyes, i.e. burning eyes, which may cause problems when administering the second drop to the child's eye.

The aim of the present paper was to evaluate the change in ocular refraction after 1% tropicamide and its efficacy in diagnosing refractive errors in preschool children. Obviously, preschool age is the time when children start their education and correction of refractive error seems crucial in comfort of learning and acquiring new skills by children (10).

Material and methods

116 children (in total 232 eyes) at the age of 5 to 6 years from Poznań and Bydgoszcz participated in the study. Of the 116 subjects, 68 were girls and 48 were boys. All subjects had no constant or intermittent strabismus, nystagmus, eye pathologies, or neurological diseases. The parents were informed about all examination procedures to be performed and signed a written consent for the study. Primary eye examination (examination of visual acuity, accommodation and binocular vision), was carried out in kindergartens and primary schools in Poznań and Bydgoszcz. Next, the children underwent an ophthalmological examination at the Department of Optometry and Biology of Visual System in Poznań and at an ophthalmologist office in Bydgoszcz. The examination included, general review, medical and ocular history of the child, measurement of visual acuity, evaluation of the anterior segment, measurement of refractive error using autorefractor Tomey RC-4000 before and after tropicamide was administered, followed by evaluation of the fundus of the eye. 1 drop of cycloplegic agent was instilled to each eye twice, 5 min apart. The refractive examination was performed 25–30 min after first instillation. Examinations performed in the present study were part of a research project Estimating the risk for dyslexia in preschool children basing on examination of cerebral deficits – part 1 (pretest) No NN106 074634). All procedures in the study followed the tenets of Declaration of Helsinki (World Medical Association Declaration of Helsinki-Ethical Principles for Medical Research Involving Human Subjects, 2008) and were approved by The Commission Programme for Research on Ethics at University of Finance and Management in Warsaw.

Statistical analysis was performed using Statistica 7.1 – StatSoft®. In order to determine the statistical significance of the data, a student t-test for dependent samples was used. The results from refraction change are based on the spherical component (change in refractive errors) and the cylindrical one (change in astigmatism) of refractive error, measured with minus cylinder convention. All eyes (in total 232) were analyzed in the study with no division into left eye and the right one since, as the student t-test showed, there were no discrepancies in spherical power [$t(231) = -1.58$, $p = 0.117$], cylindrical power [$t(195) = 0.14$, $p = 0.886$] as well as in the axis of cylinder [$t(195) = -0.38$, $p = 0.704$] between right eye and the left one.

Results

Autorefractor examination before cycloplegia showed that the mean refractive error was +0.78 D (SD = 1.22 D). After cycloplegia, the mean refractive error increased by +0.78 D (SD = 0.82 D), which made the total refractive error equal to + 1.55 D (SD = 1.33). The Student t-test proved that tropicamide significantly changed the spherical component of the refractive error [$t(231) = -14.38$, $p = 0.000$]. 97% of examined eyes were hyperopic (sph > 0), 1% had no spherical component (sph = 0), and 2% were myopic (sph < 0). Figure 1 shows the refractive error distribution before and after cycloplegia.

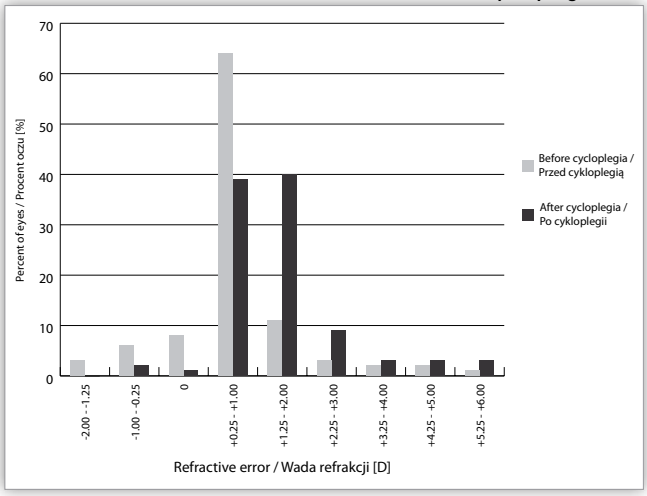

Fig. 1. Comparison of refractive error distribution before and after cycloplegia.

Ryc. 1. Porównanie rozkładu występowania wad refrakcji przed cykloplegią i po niej.

Besides, as shown in Figure 2, changes in spherical component after cycloplegia were analyzed for different ranges of refractive errors.

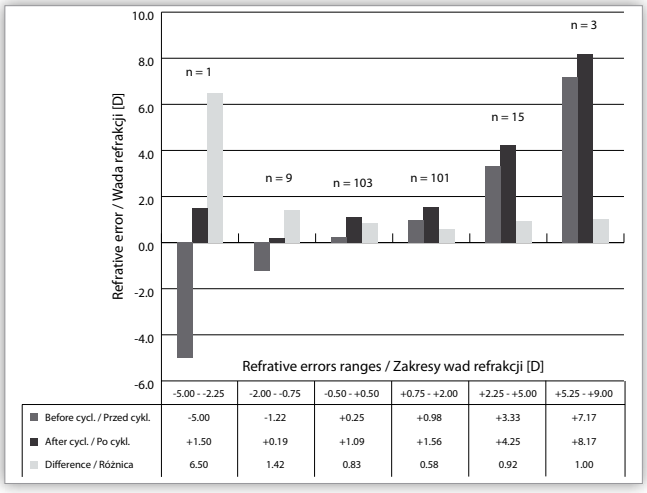

Fig. 2. Changes in cycloplegic refraction for different ranges of refractive errors.

Ryc. 2. Zmiana wartości refrakcji po cykloplegii dla różnych zakresów wad refrakcji.

In children with higher refractive error, tropicamide occurred more effective than in children with lower refractive error. Particularly, it can be observed in results before cycloplegia for the group of myopics with < -0.75 D.

The analysis of astigmatism showed that cylindrical power did not respond to tropicamide: before cycloplegia the power was -0.54 D (SD = 0.67 D), and after cycloplegia it was equal to -0.51 D (SD = 0.57 D) [t(195) = -1.17, p = 0.243]. The power of cylindrical axis also stayed unaltered: before cycloplegia the power was 103° (SD = 60°), and after cycloplegia it was equal to 102° (SD = 63°) (against-the-rule astigmatism) [t(195) = 0.21, p = 0.83]. Of all patients examined, 22% of the eyes had astigmatism > 0.50 D, and 12% had astigmatism > 1.00 D. Figure 3 shows mean power of spherical and cylindrical component before and after cycloplegia.

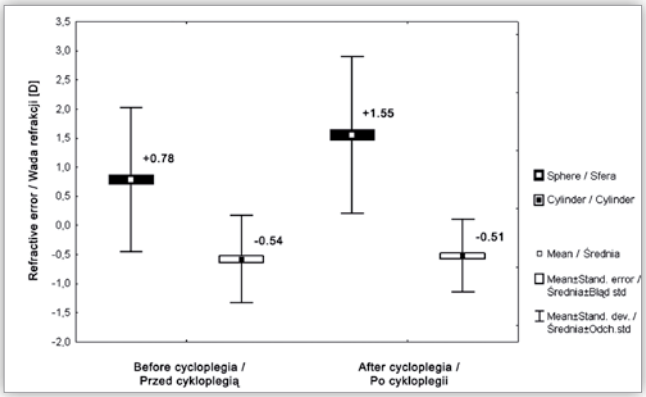

Fig. 3. Mean power of spherical and cylindrical component before and after cycloplegia.

Ryc. 3. Średnia wartość mocy komponentów sferycznego i cylindrycznego przed cykloplegią i po niej.

Discussion

The studies reported here showed the effect of 1% tropicamide cycloplegia on preschool children, thus the obtained results may be useful in evaluating the efficacy of the cycloplegic agent in diagnosing refractive errors in that age group. Tropicamide, among other cycloplegic agents, was chosen because of its common use both in clinical and scientific research. Its peak cycloplegic action appears at 20–35 min after the first instillation and cycloplegia or mydriasis elapses after only 6 h (1). Moreover, tropicamide does not cause any adverse effects, when compared to other cycloplegic agents (2,3). In the light of recent studies, tropicamide occurs a very effective cycloplegic agent, which seems contradictory to a common view which claims that tropicamide is unable to completely annihilate residual accommodation. Manny et al. (7) claimed that subjective residual accommodation (measured with the push-up or first blur test), mainly examined by Milder (6) and Lovasik (5), is overestimated in relation to objective residual accommodation measured with refractor, considered as most reliable in evaluating residual accommmodation. In turn, other research on children (7,8) proved that when compared to 3.27 D residual accommodation measured with the push-up test, residual accommodation after tropicamide is not more than 0.71 D when autorefractor is used.

The amount of residual accommodation can be thus analyzed in the following way. If it is assumed that tropicamide causes 2.00 D of residual accommodation, then it will show no refractive error in children with hyperopia 2.00 D. Preschool children are the age group which shows hyperopia at this amount, ranging from +1.50 D to +2.25 D (11). The result from the mean refractive error for +1.55 D (SD = 1.33) obtained in the present paper appears to be similar to the findings of other researchers (8,11,12). Based on previous studies (8,9), the mean maximum residual accommodation may be expected to be not more than 0.75 D in children after cycloplegia. Since the aim of the present paper is to examine the change in ocular refraction after tropicamide cycloplegia only, we did not elaborate on residual accommodation more thoroughly. Thus, further research is necessary to evaluate residual accommodation after cycloplegic agent.

It is important to realize that tropicamide may not be able to cause full cycloplegia in children with a higher refractive error, which may in result lessen the possibility of identifying anisometropia. Weakley (13) indicates that there is a higher risk of amblyopia in children with different refractive errors at about 1.00 D in each eye. High anisometropia makes it more probable for amblyopia to occur. In the incidence of anisometropia and strabismus, atropine is recommended as one of stronger cycloplegic agents (14). The other method for examining anisometropia is retinoscopy with ocular correction prescribed on the basis of refraction after tropicamide cycloplegia. This method based on mobility of fundus reflexes and their brightness, can easily identify anisometropia. If both reflexes are of similar brightness and mobility, we can assume that there is no anisometropy in that case (14).

In the present study, instillation of 2 x 1 drop of tropicamide at 5 min apart caused an increase in ocular refraction by +0.78 D in children, as a result the total refraction reached +1.55 D. Mutty (9), Egashira et al. (8), Twelker and Mutty (15) obtained similar results from their studies on tropicamide (an increase respectively by +0.74 D, +0.77 D, +0.89 D). As it can be seen in Figure 1, the distribution of refractive errors shifted toward hyperopia. The studies also proved that tropicamide had a stronger effect on children with a higher refractive error, compared to those with a lower refractive error, which can be particularly observed in children with refraction < -0.75 D before cycloplegia. Strong accommodation in preschool children together with children's mental condition and psychological accommodation may cause problems in identifying refractive errors, which may lead to diagnosis of physiological hyperopia as myopia. Before cycloplegia, approximately 17% of examined eyes were myopic, whereas, after cycloplegia was applied only 3% of the eyes were myopic. Similarly, Bannon (16) emphasized that, when compared to adult group, children showed higher hyperopia (or lower myopia) after administering cycloplegic agents.

Most subjects examined in the present study (80%) showed the refractive error in the range of +0.25 to +2.00 D. In long-term studies, Hirsch (17) assumed that when a 5–6 years old child has hyperopia ranging from +0.50 to +1.25 D, the child is expected to be emmetropic after he or she reaches 13–14 years of age. These findings bring hope for the future since, according to the above assumptions, children will probably be emmetropic or slightly myopic.

It is important to stress that the mean power and axis of astigmatism did not respond much to tropicamide. Thus, cycloplegia

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seems optional in a correct diagnosis of the value and cylindrical axis in astigmatism. However, our findings remain slightly contradictory to the research by Twelker and Mutty (15) (significant change by -0.49 D), and Mutty et al. (9) (change by -0.21 D).

To conclude, despite some criticism and controversy, tropicamide cycloplegia appears to be effective in preschool children. Its peak of action, duration, and no adverse effects make tropicamide a useful cycloplegic agent, especially when other agents are not available. However, it is important to realize that tropicamide cycloplegia should not be administered to children with strabismus, anisometropia, or high refractive errors. Preschool children are the age group in which correct diagnosis of refractive errors may be crucial for their future life and condition of their visual system, moreover, that age seems a critical period for appropriate management in children with high refractive errors, anisometropia, or strabismus.

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