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Ultrasonic biometry of pseudomyopic children eyes accommodation

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Introduction

Accommodation is the ability of eyes to change their focal distance in such a way that things being at different distances would form a distinct view in the retina. The aim of accommodation is to form a clear view in the retina from different distant objects by changing the refractive force of the optic system [1, 2, 6, 8].

Two factors have influence on the mechanism of accommodation:

a) physiological – contraction of ciliary muscle;

b) physical – elasticity of the lens.

When explaining the function of the eye accommodation widely accepted Helmholc theory, declared in 1909 has been still used. According to the classical theory when the eye accommodation ciliar muscle contracts releasing ties holding it, the lens acquires more convex form, its refracting force increases, prominence of the anterior surface of the lens increases too. When accommodation muscle relax, the lens returns to its "disaccommodation" condition, i.e. it becomes flat, its ties become tense [3, 4].

Investigation of accommodation problems enables to evaluate changes of the eye refraction, to carry out correction more exactly, to administer medicament or physical way of treatment for ciliar muscle [5]. Accommodation of the eye plays an important role in the development of the mechanism of myopia in the case of accommodation of the eye [6, 14].

A lot of scientists investigating the occurrence and mechanism of myopia pay the greatest attention to disorders of accommodation. Low ability of accommodation of the eye causes accommodation spasms, pseudomyopia, for that reason eyes tries to see the object from near distance and this is pathognomic sign of myopia [7]. The eye attempts to change its optical system to see the object which is closer without any accommodation strain. When the optical system is in formation the axis of the eye becomes longer and axial myopia develops [8].

Ultrasonic biometry as one of the objective research methods for evaluating refractogenesis process is widely used in children ophthalmology.

By measuring the thickness of the cornea, the depth of anterior chamber, the thickness of the lens, the length of eye axis and optico-anatomical elements interrelation it is possible to observe the speed of myopia progression and effectiveness of treatment measures in stopping this process [9].

In 1970 D. J. Coleman was the first to use the ultrasonic biometry method to investigate the eye accommodation and evaluate the changes in the size of optico-anatomical elements during accommodation. He did not notice marked changes in the length of eye axis while investigating this phenomenon. J. K. Storey [10] indicates an increase in the length of eye axis during accommodation to objects at near distances. L. F. Garner, G. Smith [11] point out that during accommodation the depth of an anterior chamber decreases while the lens thickness increases, but the length of eye axis does not undergo any changes. H. Bayramear, C. O. Cehi et al determined marked increase in the length of eye axis during accommodation [10]. D. O. Mutti, K. Zaudink, R. E. Fusano investigated parameters of children eye lens by the ultrasonic biometry method and determined that in children of 6-10 the thickness of lens decreased by 0.2 mm, i.e. the lens became thinner [12]. The authors indicate that after such "growth" of lens of these children later on the first signs of myopia occur after the age of 10.

According to the literary data different authors point out rather different changes in size of optical-anatomical elements during accommodation. Different authors studied different age groups of children whose eyes were of different refraction size. That's why we see that refraction process has not been fully studied and requires further investigation both in the age of children and adults.

The aim of our work has been to determine changes in optico-anatomical elements of eyes during accommodation using the precise ultrasonic biometry in children of 6-15 having pseudomyopia (accommodation spasm) and differences of these meanings after accommodation muscle was affected by a low frequency electromagnetic field.

Methods and materials

Research has been done on 56 children with pseudomyopia, their age being 6-15 years. The children of 6-10 were assigned to the first group (n=20), the children of 11-15 were in the second group (n=36).

In our work we have evaluated the following data: vision acuity to the distance, accommodation reserves to the distance, eye refraction during cyclophlegia (using Cyclogyli 0.1%).

In the case of pseudomyopia refraction fluctuated from +0.25 D to emetrophic.

Precise ultrasonic biometry was done by the ultrasonic measuring system which included:

a) coordinative equipment on which ultrasonic transducer of 15 kHz was fixed.

b) ultrasonic biometric apparatus working on A-regime. This equipment was constructed in the Biomedical Engineering Laboratory of Kaunas University of Technology. By using ultrasonic transducer fixing equipment it was possible to carry out precise ultrasonic biometry more exactly as this enabled to avoid researcher's hand micro-movements.

During the examination the eye was anesthetized by 0.25% of tetracain solution. Having put the ultrasonic transducer to the eye the sight of another eye was directed to the object located at 5 m distance. Both eyes accommodate equally at the same time because of the effect of accommodation hysteresis [19].

In the ultrasonic curve on the A-scanner's screen the length of eye axis, the depth of the anterior chamber, the thickness of the lens, the length of the vitreous were measured.

Analogous measurements were carried out for the eye accommodating to the object located at 33 cm distance. After examining one eye because of slow accommodation hysteresis the examination of another one was done after 60 minutes.

Having examined 25 children for pseudomyopia treatment a low frequency electromagnetic field was used. 10 procedures, every lasting 15 minutes, were done for every child, the strength of the low frequency electromagnetic field was 1.2MT; an impulsive regime was used.

To estimate possibilities of the eye accommodation after treatment, measurements in size of optico-anatomical elements were carried out with the help of the precise ultrasonic biometry.

Results and discussions

Results are presented in the text as the mean and standard deviation (M±SD). Linear regression and correlation coefficients (*r*) according to Parson are used to analyze associations between variables. *p* values less than 0.05 were considered to be statistically significant.

In the first group, i.e. children of 6-10, pseudomyopic (accommodation spasm), vision acuity fluctuated from 0.3 to 0.9 according to Landolt ring opto-types table (Table 1).

Table 1**. Parameters of pseudomyopic eyes of children of 6 – 10.**

Parameter	Average	±95 per cent PI	Mediana	Min. Mean	Max. Mean
Visual acuity	0.56	0.49-0.62	0.50	0.3	0.9
Accommodation reserves to distance (d)	0.55	0.31-0.79	0	0	3
Axial length to the distance (mm)	23.58	23.40-23.75	23.65	22.6	24.4
Axial length to the nearness (mm)	23.58	23.40-23.75	23.5	22.6	24.4
Anterior chamber depth to the distance (mm)	2.89	2.83-2.94	2.90	2.7	3.2
Anterior chamber depth to the nearness (mm)	2.89	2.83-2.94	2.90	2.7	3.2
Difference of anterior chamber depth	0	0	0	0	0
Vitreous length to the distance (mm)	17.42	17.21-17.63	17.40	16.1	18.2
Vitreous length to the nearness (mm)	17.42	17.21-17.63	17.40	16.1	18.2
Difference of vitreous length	0	0	0	0	0
Lens thickness to distance (mm)	3.27	3.19-3.35	3.20	3	3.9
Lens thickness to nearness (mm)	3.27	3.19-3.35	3.20	3	3.9
Difference of lens thickness	0	0	0	0	0

Table 2**. Parameters of pseudomyopic eyes of children of 11-15.**

Parameter	Average	±95 per cent PI	Mediana	Min. Mean	Max. Mean
Visual acuity	0.65	0.59-0.69	0.60	0.3	1
Accommodation reserves to distance (D)	0.57	0.41-0.74	0	0	3
Axial length to the distance (mm)	23.94	23.78-24.09	24	22.4	25.1
Axial length to the nearness (mm)	23.94	23.78-24.09	24	22.4	25.1
Anterior chamber depth to the distance (mm)	2.84	2.81-2.87	2.90	2.5	3
Anterior chamber depth to the nearness (mm)	2.84	2.81-2.87	2.90	2.5	3
Difference of anterior chamber depth	0	0	0	0	0
Vitreous length to the distance (mm)	17.92	17.75-18.09	18	16.1	19.4
Vitreous length to the nearness (mm)	17.92	17.75-18.09	18	16.1	19.4
Difference of vitreous length	0	0	0	0	0
Lens thickness to distance (mm)	3.18	3.15-3.22	3.20	3	3.5
Lens thickness to nearness (mm)	3.18	3.15-3.22	3.20	3	3.5
Difference of lens thickness	0	0	0	0	0

Because of poor function of the accommodation muscle its accommodation reserves to the distance reached 0 - 3 diopters. By means of the ultrasonic biometry we wanted to investigate changes in the size of optico-anatomical elements taking place during accommodation. The average of the thickness of the main accommodation element, the lens, was 3.27 mm and during accommodation process the difference of its thickness wasn't observed. The changes in length of eye axis, the depth of the anterior chamber and in size of vitreous length were not observed too and their averages were 23.58 mm, 2.89 mm and 17.42 mm respectively. The obtained results showed and precise ultrasonic biometry confirmed that bad working-possibility of the eye accommodation muscle caused the occurrence of pseudomyopia.

Similar results were obtained in the second group, i.e. in children of 11-15 (Table 2). Their vision acuity reached 0.65 according to Landolt ring table. Accommodation reserves to the distance fluctuated from 0 to 3 diopters. The average of the length of eye axis in these children was 23.94 mm and it was a little longer than in the first group because the eyeball increases in the growing organism and its axis becomes longer. The thickness of the lens in this children group reached 3.18 mm and its was a little less than in the first one. This has confirmed the proposition made by other authors that during the growth of children the flattening of the lens is possible [13]. But during the process of accommodation no difference in the lens thickness has been noticed too what confirms poor working-capacity of the accommodation muscle. Averages of the depth of the anterior chamber and the length of the vitreous were 2.84 mm and 17.92 mm respectively. The length of the vitreous in this group was longer because of the increase in the eye length and flattening of its lens. This is the result of a natural eye growth process.

In order to eliminate accommodation spasm and restore the working possibility of the accommodation muscle the low frequency electromagnetic field was used in the treatment of 25 children with pseudomyopia. It induces a quasiphysiological effect improving blood circulation, causing relaxation of accommodation spasms.

One of the objective research methods – the precise ultrasonic biometry - was used to make the method of this treatment more objective, to show changes in optico-anatomical elements.

Vision acuity in children of 6-10 after procedures reached 0.8 according to the Landolt ring table (Table 3), accommodation reserves to the distance restored to 10.0 diopters. If there were no differences in lens thickness before the treatment during accommodation process, after the treatment its difference equalled to 0.19 mm. These observations showed that the lens took an active part in the accommodation process because of improvement in an accommodation muscle. Differences in the depth of the anterior chamber during accommodation were 0.12 mm and the difference in the vitreous length composed 0.08mm.

Table 3**. Parameters of pseudomyopic eyes before and after the treatment (6-10-year-olds).**

Parameter	Average	SD	Difference	*P* mean
Visual acuity before treatment	0.600	0.234		
Visual acuity after treatment	0.843	0.233	-0.243	<0.0001
Accommodation reserves to distance before treatment (D)	0.429	0.504		
Accommodation reserves to distance after treatment (D)	10.000	4.587	-10.571	<0.0001
Anterior chamber depth to distance before treatment (mm)	2.936	0.166		
Anterior chamber depth to distance after treatment (mm)	3.007	0.089	-0.071	<0.003
Anterior chamber depth to near before treatment (mm)	2.936	0.166		
Anterior chamber depth to near after treatment (mm)	2.886	0.158	0.050	<0.03
Differences of anterior chamber depth before treatment	0	0		
Differences of anterior chamber depth after treatment (mm)	0.121	0.088	-0.121	<0.0001
Lens thickness to distance before treatment (mm)	3.321	0.273		
Lens thickness to distance after treatment (mm)	3.129	0.395	0.193	<0.0001
Lens thickness to near before treatment (mm)	3.321	0.273		
Lens thickness to near after treatment (mm)	3.321	0.273	0.001	<0.0001
Differences of lens thickness before treatment (mm)	0	0		
Differences of lens thickness after treatment (mm)	0.193	0.141	-0.193	<0.0001
Vitreous length to distance before treatment (mm)	17.421	0.737		
Vitreous length to distance after treatment (mm)	17.543	0.804	-0.121	<0.0001
Vitreous length to near before treatment (mm)	17.421	0.737		
Vitreous length to near after treatment (mm)	17.471	0.764	-0.050	<0.03
Difference of vitreous before treatment (mm)	0	0		
Difference of vitreous after treatment (mm)	0.086	0.076	-0.086	<0.0001

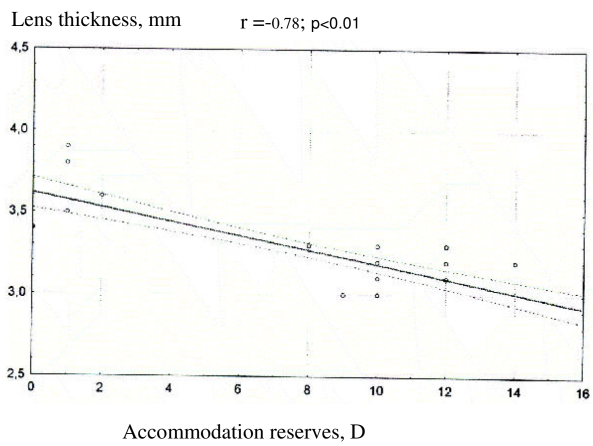
Differences in the size of eye optico-anatomical elements in children of 11-15 on accommodation after the treatment by a low frequency electromagnetic field were noticed. Their vision acuity after treatment reached 0.8 according to the Landolt ring table (Table 4) and the reserves of accommodation to the distance were restored up to 11.5 diopters (Table 4).

Table 4. **Parameters of pseudomyopic eyes before and after the treatment (2nd age group).**

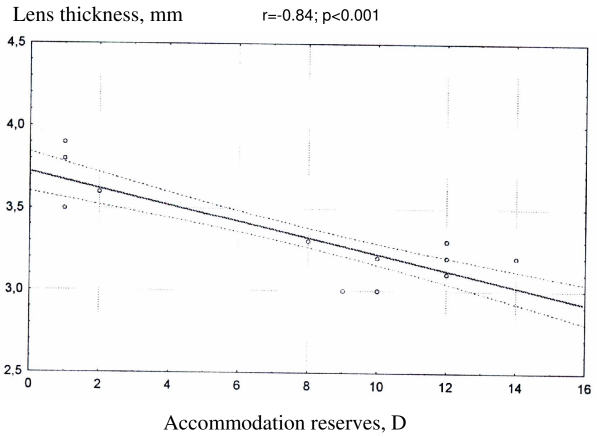
Parameter	Average	SD	Difference	*P* mean
Visual acuity before treatment	0.709	0.237		
Visual acuity after treatment	0.855	0.237	-0.146	<0.0001
Accommodation reserves to distance before treatment (D)	0.364	0.492		
Accommodation reserves to distance after treatment (D)	11.546	3.985	-11.182	<0.0001
Anterior chamber depth to distance before treatment (mm)	2.918	0.105		
Anterior chamber depth to distance after treatment (mm)	3.027	0.088	-0.109	<0.0001
Anterior chamber depth to near before treatment (mm)	2.918	0.105		
Anterior chamber depth to near after treatment (mm)	2.891	0.119	0.027	<0.05
Differences of anterior chamber depth before treatment	0	0		
Differences of anterior chamber depth after treatment (mm)	0.136	0.079	-0.136	<0.0001
Lens thickness to distance before treatment (mm)	3.182	0.162		
Lens thickness to distance after treatment (mm)	2.973	0.223	0.209	<0.0001
Lens thickness to near before treatment (mm)	3.182	0.162		
Lens thickness to near after treatment (mm)	3.200	0.145	-0.018	<0.04
Differences of lens thickness before treatment (mm)	0	0		
Differences of lens thickness after treatment (mm)	0.227	0.099	-0.227	<0.0001
Vitreous length to distance before treatment (mm)	17.818	0.815		
Vitreous length to distance after treatment (mm)	17.918	0.812	-0.100	<0.0003
Vitreous length to near before treatment (mm)	17.818	0.815		
Vitreous length to near after treatment (mm)	17.827	0.815	-0.009	NS
Difference of vitreous before treatment (mm)	0	0		
Difference of vitreous after treatment (mm)	0.091	0.092	-0.091	<0.0002

The lens was found to be thinner in disaccommodation condition after the treatment than it was before the treatment, due to that during accommodation the difference of lens thickness reached to 0.22 mm. That showed a good working-capacity of the accommodation muscle. Differences in the depth of the anterior chamber were found to be 0.13 mm and the difference in the length of the vitreous was 0.09 mm, respectively.

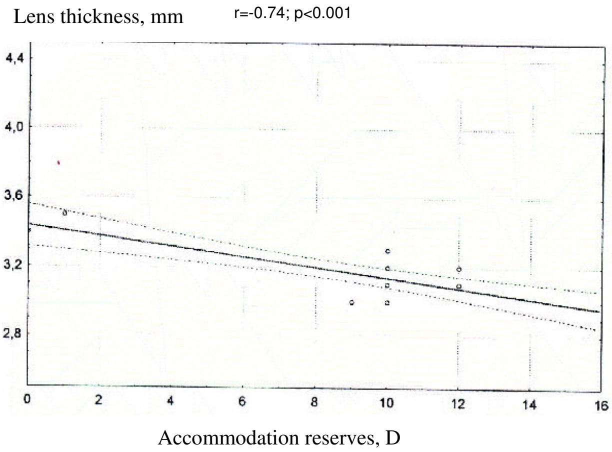
The marked correlation was established between the thickness of the lens before treatment and accommodation reserves after treatment in case of pseudomyopia when making an influence by a low frequency electromagnetic field (Fig.1). In the general group the correlation coefficient was r = - 0.78. The fact enables to state that accommodation reserves will be the more after a treatment the less the lens is before treatment. This could be explained in the following: when a “thinner” lens manifests less accommodation spasm by using a low frequency electromagnetic field it is possible to eliminate accommodation spasm and make the lens to take a more active part in an accommodation process.



a) All cases;



b) 6-10 years old;



c) 11-15 years old;

Fig. 1 **Interrelation between lens thickness and accommodation reserves of pseudomyopic children eyes (a,b,c).**

Conclusions

1. No changes in the size of the eye optical anatomical elements were found in an accommodation process for children with accommodation spasm (pseudomyopia) diagnosed by data of the precise ultrasonic biometry.

2. After the treatment by a low frequency electromagnetic field for children of 6-10 years old accommodation reserves have restored. The difference in lens thickness in accommodation process was 0.19±0.14 mm and in children of 11-15 years old it was 0.22±0.9 mm ($p<0.001$).

3. In the group of pseudomyopia the marked correlation between the thickness of the lens before treatment by a low frequency electromagnetic field and reserves of the eye accommodation after the treatment (r= - 0.78) was established.

4. The ultrasonic biometry is an effective method in evaluating the activity of the eye accommodation apparatus, the possibilities of the eye accommodation and the effectiveness of the method of treatment to improve the accommodation function.

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Ultragarsinės biometrijos naudojimas akių akomodacijai pseudomiopijos atveju įvertinti

Reziumė

Aptariami 6–15 metų vaikų (n=56), kuriems nustatyta netikroji trumparegystė (pseudomiopija), akies optinių-anatominių elementų dydžiai ir jų pasikeitimas akomodacijos metu (perkeliant žvilgsnį iš 5 m į 33 cm atstumą). 1-oje vaikų grupėje (amžius nuo 6 iki 10 metų, n=20) ir 2-oje vaikų grupėje (amžius nuo 11 iki 15 metų, n=36) priekinės kameros gylio, lęšiuko storio ar stiklakūnio ilgio skirtumo akomoduojant nepastebėta. Po gydymo žemojo dažnio elektromagnetiniu lauku akies optinių-anatominių elementų dydis pasikeitė, ypač lęšiuko ekskursijose ($p<0.001$). Nustatyta, kad netikrosios trumparegystės atveju būna didelė koreliacija tarp lęšiuko storio ir akies akomodacijos rezervų (r= –0.78).

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