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Ultrasonic biometry of the children eye

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Introduction

Accommodation significantly influences refractogenesis of the eye. It does not directly affect the growth of the eye, but it controls - stops or stimulates the eye growth process by changing the view formation distinctness in retina [1,2]. Defocusing of the view in the retina as one of the main factors, stimulating the eye axis lengthening has been indicated by other authors. Within the long period of work viewing the work object from a short distance the accommodation weakens, the view gets defocused in retina, i.e. becomes not distinct. It becomes as if "moved" behind retina, by this the growth of the eye anterior-posterior axis is preconditioned, i.e. myopization of the eye is taking place [3,4].

Experiments with concav and convex crystalline lenses within the accommodation period have indicated that when working at a short distance for a long time the accommodation starts to lag behind from the vision stimulus and hypertrophic view defocusing in retina is provoked [5]. With the repeating of the process the eye axis starts to lengthen. The influence of accommodation for the development of myopia has also been acknowledged by the experiments with plus crystalline lenses, which make the view more distinct in retina when working from a short distance diminishing the inadequacy between the retina photoreceptors and the distance of the view focus [2,6].

One of the methods enabling to objectively evaluate the changes in the human eyes taking place within the accommodation period is ultrasonic biometry.

The above method helps to make the influence of accommodation upon development and progress of myopia more precise [7,8,9,10,11,12]. Quite a number of works are assigned to that analysis of the above items, though the data given by different authors are different. D.J.Coleman [13] applying M type ultrasonography, enabling to evaluate the eye measurements according to the tissues structure have not determined the eye axis lengthening within the period of accommodation. While K.Storey and E.Rabie [14] present data about undoubted lengthening of eye axis in shortsighted eyes within accommodation process. R.D.Lepper and H.G.Trier [15] when researching eye changes while accommodating have determined the eye axis lengthening only in some cases, while in all the rest cases - reduced or unchanged length. H.M.Soriano [16], P.J.-T.Shum and co-authors [17] write about unchanged eye axis length during accommodation testing young shortsighted people (the age from 18 to 22) have determined a reliable eye axis lengthening within the period of accommodation.

Thus, the data about the results of eye biometric research within the period of accommodation are contradictory [8,18]. It may be explained by the fact that accommodation of different age people was investigated in different studies and most often with different ocular refraction.

The goal of our work is to evaluate the anatomic measurement of eye using precise ultrasonic biometry for 9-11 year old children with emmetropic refraction and their changes within the period of accommodation.

Materials and methods

The children (n=76) have been investigated (38 boys and 38 girls), the age of the children varying from 9 to 15 yrs.

The following items were being investigated: visual acuity to the distance and near accommodation reserves to distance, ocular refraction in cycloplegia (employing sol. Cyclogyli 1%) fundus of the eye employing direct ophthalmology method. The next day after cycloplegia children with both eyes normal emmetropy were investigated. The precise ultrasonic eye biometry was performed to them employing coordination equipment with fixed transducer (frequency 15 MHz) constructed in Biomedical Ultrasonic Engineering Laboratory of Kaunas University of Technology. Employing the fixed transducer the influence of the investigator's hand micromovements to the precision of measurement is avoided, which increases up to 0.1 mm (while measuring employing the usual A method the measurement precision equals to ±0.2 mm). The 0.25% tetracain solution is dropped into the patient's eye before the test. The following items were measured: the anterior chamber chamber depth, thickness of crystalline lens, vitreous body length, eye axis length and horizontal diameter, as the mono and binocularly caused accommodation hysteresis effects are similar [19], so the object was being fixed by one eye, while investigated by the other. First of all the right eye biometric investigations were performed, when the patient fixes his look to the distance (towards the Landolt optotype at the distance of 5 m, corresponding to 100% visual acuity).

The anatomic measurement of the right eye being evaluated according to ultrasonic curve, seen on A scanner screen (Fig. 1). After that the investigation of the same eye, fixing the Landolt optotype (corresponding to 100% vision from near) at the distance of 33 cm by the left eye is performed. Investigations of the left eye, fixing the look to the distance and to the near by the right eye were performed by us after 60 min, as the accommodation hysteresis disappears very slowly [7].

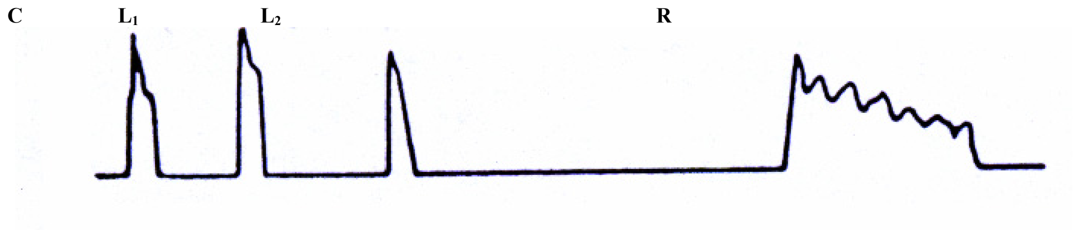


Fig. 1. **Scheme of A-echogram of the sagital (anterior-posterior) axis of the eye: C – reflection from cornea, C-L_1 – anterior chamber, L_1 – reflection from anterior surface of the lens, L_2 – reflection from posterior surface of the lens, L_1-L_2 – the lens, L_2-R – length of the vitreous, C-R – length of the eye axis**

Results are presented in the text as the mean and standard deviation (M±SD). Linear regression and correlation coefficients (r) according to Pearson were used to analyze associations between variables. The Mann-Whitney U test and χ^2 was used to compare mean values from two independent groups. A p values less than 0.05 was considered as statistically significant.

Results and discussion

Age average of the investigated children is 12,509±2,718 yrs (boys 11,836±2,623 yrs; girls 13,181±2,711 yrs). The 1st group consisted of 32 children of 9-10 years (age average 9,465±0,498 yrs).

The 2nd group - 44 children, 13-15 years (average age 14,722±0,808 yrs).

First of all we compared the anatomic measurement of eye of both age groups.

The children eyes ultrasonic biometry data of age groups are given in Table 1.

According to the Table 1 data, the anterior-posterior eye axis length, the horizontal diameter and vitreous body length of 9-10 years children are reliably smaller than the same measurements of the 13-15 years age group (p=0,000018; p=0,000037; p=0,002483) accordingly. The anterior chamber depth of the 2nd group children is slightly exceeding the same measurements among the 1st group children. While the child is growing the lens crystalline grows a bit flatter, though the difference between those parameters is not essential. When comparing the different eyes biometric investigation data within the group it has become clear that there are no essential difference between the right and left eyes measurements of both the 1st and the 2nd groups. There are no essential measurements difference between the boys' and girls' eyes, too.

Table 1. **Comparison of children eyes ultrasonic biometry data in age groups**

Eye measurements (mm)	I group	II group	p
Anterior-posterior eye axis length	23.238±0.474	23.673±0.0354	0.000018
Horizontal diameter of eye	23.188±0.42	23.595±0.385	0.000037
The ratio of the eye axis length and horizontal diameter	1.002±0.004	1.004±0.005	n.s.
Anterior chamber depth	3.888±0.555	3.902±0.62	n.s.
Lens crystalline thickness	2.925±0.154	2.907±0.117	n.s.
Length of vitreous body	16.425±0.651	16.859±0.554	0.002483

Table 2. **Children eyes ultrasonic biometry data within the period of accommodation in different age groups**

Eye measurements (mm)	To distance (5 m)	To near object (33 cm)	p
I group			
Anterior-posterior eye axis length	23.238±0.474	23.238±0.471	n.s.
Anterior chamber depth	3.888±0.555	3.822±0.553	0.018587
Lens crystalline thickness	2.925±0.155	3.19±0.189	0.0000001
Length of vitreous body	16.425±0.651	16.225±0.629	0.0000001
II group			
Anterior-posterior eye axis length	23.672±0.354	23.714±0.385	n.s.
Anterior chamber depth	3.902±0.62	3.745±0.748	0.000266
Lens crystalline thickness	2.907±0.117	3.268±0.141	0.0000001
Length of vitreous body	16.859±0.554	16.7±0.629	0.000058

We have evaluated the change of eye measurement within the period of accommodation (Table 2). The anterior chamber depth has reliably shortened within the accommodation period in both age groups (correspondingly 0,0666 ± 0,033; p = 0,018587 and 0,157±0,08; p=0,000266); and the length of vitreous body (0,2±0,022; p=0,0000001 and 0,159±0,075; p=0,000058). The lens crystalline has thickened significantly: 0,265±0,034; p=0,0000001 among the 1st group children and 0,361±0,024; p=0,0000001 among the 2nd group children. When accommodating the length of eye anterior-posterior axis has not changed among the 1st group children, the extension tendency of the anterior-posterior axis was observed among the 2nd group children, though it is statistically unreliable. To our opinion we failed to establish essential changes of anterior-posterior axis length during accommodation in the eyes of children with emmetropic refraction, because the external membrane of the eye - sclera - firm and elastic, thus a short-term accommodation tension does not cause a significant extension of axis. Mean while the elasticity of the eyes sclera of shortsighted is reduced so the probability of eye axis extension increases (especially in case of prolonged accommodation).

While evaluating mathematically, the inter dependence (correlation coefficient) of the eye measurement was determined during the static refraction period and while accommodating to the nearness (33 cm) – dynamic refraction. A detailed analysis of the dependence of eye measurement is presented in Tables 3 and 4.

Table 3. **Eye measurements interrelation (during static refraction) – correlation coefficients**

Eye measurements (mm)	M±SD	r (X,Y)	p
Anterior-posterior eye axis length	23.489±0.46		
Anterior chamber depth	3.896±0.59	0.316	0.005494
Anterior-posterior eye axis length	23.489±0.46		
Length of vitreous body	16.676±0.63	0.483	0.00001
Anterior-posterior eye axis length	23.489±0.46		
Lens crystalline thickness	2.914±0.133	-0.248	0.031078
Anterior chamber depth	3.896±0.59		
Length of vitreous body	16.676±0.631	-0.656	0.0000001
Anterior chamber depth	3.896±0.59		
Lens crystalline thickness	2.914±0.133	-0.218	n.s.
Length of vitreous body	16.676±0.631		
Lens crystalline thickness	2.914±0.133	-0.185	n.s.

Table 4. **Eye measurements interrelation (during dynamic refraction) – correlation coefficients**

Eye measurements (mm)	M±SD	r (X,Y)	p
Anterior-posterior eye axis length	23.513±0.483		
Anterior chamber depth	3.778±0.59	0.327	0.003992
Anterior-posterior eye axis length	23.513±0.483		
Length of vitreous body	16.5±0.668	0.365	0.001182
Anterior-posterior eye axis length	23.513±0.483		
Lens crystalline thickness	3.235±0.166	0.125	n.s.
Anterior chamber depth	3.778±0.59		
Length of vitreous body	16.5±0.668	-0.73	0.0000001
Anterior chamber depth	3.778±0.59		
Lens crystalline thickness	3.235±0.166	-0.147	n.s.
Length of vitreous body	16.5±0.668		
Lens crystalline thickness	3.235±0.166	-0.011	n.s.

During static refraction a negative dependence between the anterior chamber depth and vitreous body length (r=-0,656) was firmly expressed; a direct dependence is expressed on the average between anterior-posterior eye axis length and anterior chamber depth as well as between anterior-posterior eye axis length and vitreous body length (correspondingly r=0,316 and r=0,483). A weak negative dependence is noticed between anterior-posterior eye axis length and the lens crystalline (r=-0,248). A negative dependence between anterior chamber length and vitreous body length is more firmly expressed while accommodating (r=-0,73). A direct dependence remains expressed on the average between anterior-posterior eye axis length and the anterior chamber depth with vitreous body length (r=0,327 and r=0,365). Mean while a positive dependence appears between anterior-posterior eye axis length and the lens crystalline (r=0,125) and it is statistically unreliable.

Differences between the correlation coefficients during static and dynamic refraction period and while accommodating are presented in Table 5.

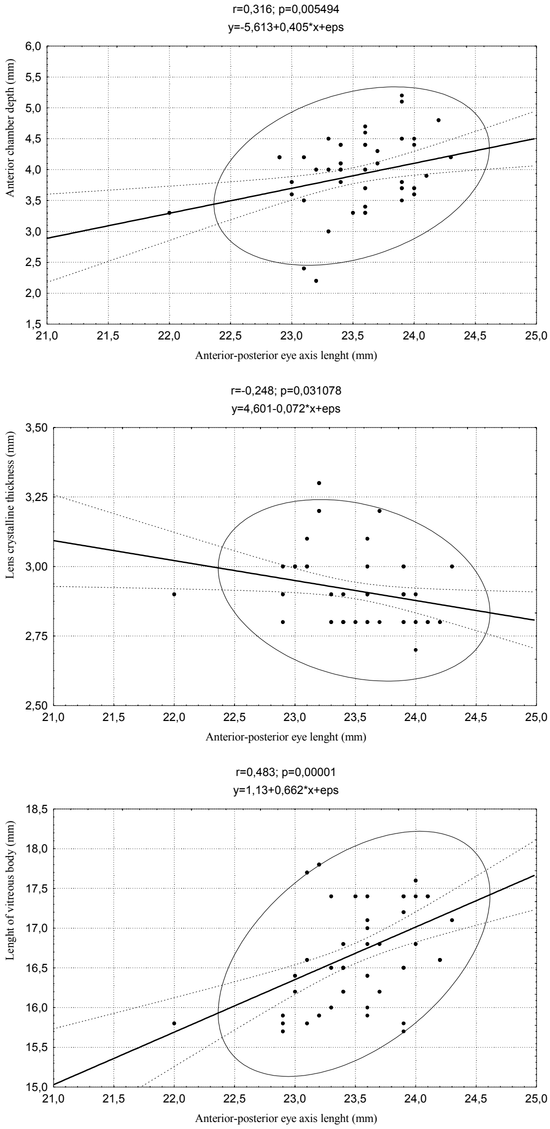
Statistically there is no significant difference among almost all inter dependence coefficients of eye measurement during static refraction and while accommodating. The exception is made by the difference of correlation coefficients between anterior-posterior eye axis length and thickness of lens crystalline it is statistically significant (p=0,20028).

Mathematical analysis of inter dependence of eye measurement allows stating that the longer anterior-posterior eye axis length the deeper anterior chamber and the bigger vitreous body length. The lens crystalline has the tendency to become flat.

Correlation coefficients while looking to distance and near objects (while accommodating) are expressed by regression trends Fig. 2, 3 and 4, which indicate at hypothetical dependence relations of various eye measurements.

Table 5. **Eye measurements interrelation - differences of correlation coefficients during static and dynamic refraction**

Eye measurements (mm)	Static		Dynamic		Difference r^1 and r^2	p
	M±SD	r^1	M±SD	r^2		
Anterior-posterior eye axis length	23.489±0.46		23.513±0.483			
Anterior chamber depth	3.896±0.59	0.316	3.778±0.59	0.327	0.011	n.s.
Anterior-posterior eye axis length	23.489±0.46		23.513±0.483			
Length of vitreous body	16.676±0.63	0.483	16.5±0.668	0.365	0.118	n.s.
Anterior-posterior eye axis length	23.489±0.46		23.513±0.483			
Lens crystalline thickness	2.914±0.133	-0.248	3.235±0.166	0.125	0.373	0.0028
Anterior chamber depth	3.896±0.59		3.778±0.59			
Length of vitreous body	16.676±0.631	-0.656	16.5±0.668	-0.73	0.074	n.s.
Anterior chamber depth	3.896±0.59		3.778±0.59			
Lens crystalline thickness	2.914±0.133	-0.218	3.235±0.166	-0.147	0.071	n.s.
Length of vitreous body	16.676±0.631		16.5±0.668			
Lens crystalline thickness	2.914±0.133	-0.185	3.235±0.166	-0.011	0.174	n.s.



Note: ellipse – confidence interval (coefficient – 0.95), confidence bands (level – 0.95)

Fig. 1. **Regression trends of some eye measurement interrelation factors (during static refraction)**

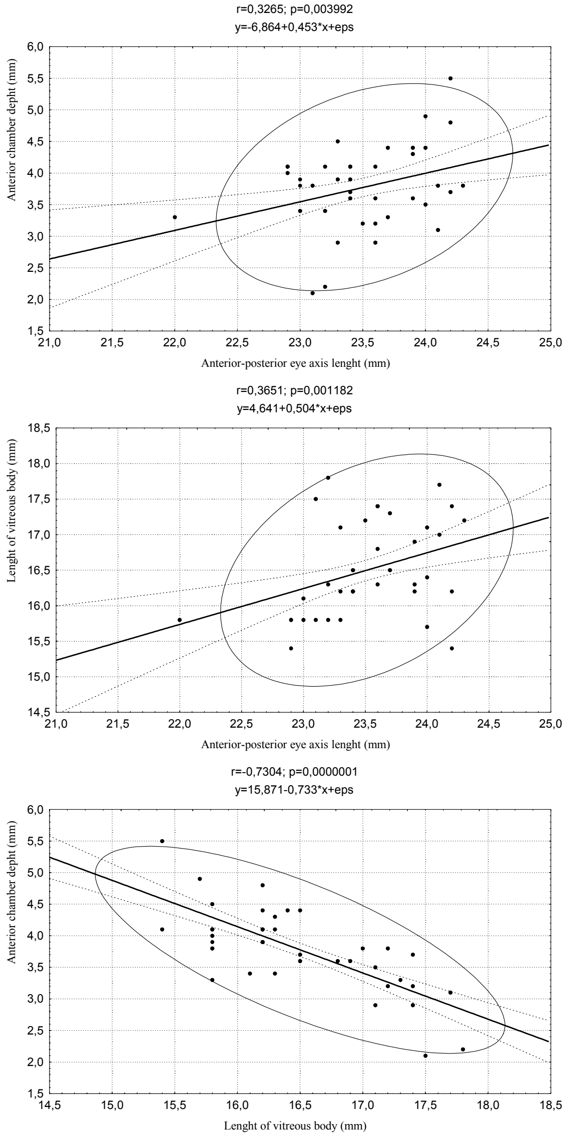
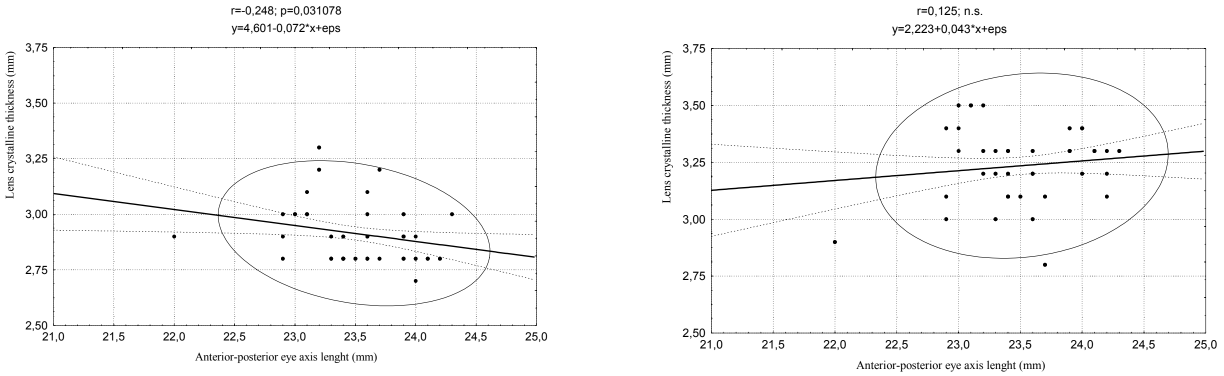


Fig. 2. **Regression trends of some eye measurement interrelation factors (during dynamic refraction)**



Note: ellipse – confidence interval (coefficient – 0.95), confidence bands (level – 0.95)

Fig. 3. **The comparison of crystalline lens thickness and anterior-posterior eye axis length; static (to the left) and dynamic (to the right)**

Conclusions

1. According to the data of ultrasonographic biometry, anterior-posterior eye axis length, horizontal diameter and vitreous body length differ reliably for children of the age 9-10 years and 13-16 years. Mentioned eye measurements are significantly bigger in the eyes of children belonging to the 2nd group. Differences between anterior chamber depth and the thickness of the lens crystalline are not significant in different age groups.
2. During accommodation (while fixing the look at the distance of 33 cm) the thickness of lens crystalline significantly increases, while the anterior chamber depth and vitreous body depth diminishes ($p<0.05$ in all cases).
3. Statistically reliable anterior-posterior eye axis lengthening was not determined during the accommodation period in the eyes of children with emmetropic refraction.
4. While evaluating mathematically, a direct dependence is expressed on the average level between anterior-posterior eye axis length and the anterior chamber as well as between anterior-posterior eye axis length and vitreous body length, which remains during accommodation, too.
5. Looking at the distance, there is a weak negative dependence between the anterior-posterior eye axis length and the crystalline lens, which becomes positive while accommodating, but statistically unreliable.

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Vaikų akių ultragarsiniai biometriniai tyrimai

Reziumė

Straipsnyje pateikiami 9-15 metų vaikų (n=76) su emetropine akies refrakcija akies obuolio precizinio ultragarsinio biometrinio tyrimo duomenys ir jų pokyčiai akomodacijos metu. I-os grupės vaikų (amžius 9-10 metų) akies ašies ilgis, horizontalus diametras ir stiklakūnio ilgis statistiškai reikšmingai mažesni už tuos pačius matmenis tarp II-os grupės vaikų (13-15 metų). Vaikui augant, kiek pagilėja priekinė kamera ir suplokštėja lęšiukas, bet skirtumas tarp šių dydžių amžiaus grupėse neesminis. Akomodacijos metu (pervedant žvilgsnį iš 5 m į 33 cm atstumą), priekinės kameros gylis ir stiklakūnio ilgis statistiškai reikšmingai sutrumpėja; lęšiuko storis patikimai padidėja. Statistiškai reikšmingų priekinės-užpakalinės akies ašies ilgio pokyčių akomodacijos metu nenustatėme.

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