The relationship of the intensity of lens opacity with physical activity

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Key words: *lens opacity; physical activity; metabolic equivalents.*

Summary. *Objective. To study the character and the intensity of lens opacity and the visual acuity in cataract patients and controls and to determine the association of these indices with the subjects' physical activity.*

Material and methods. The lens opacity in 110 eyes of patients (n=110) aged 60.3±0.4 (mean±SEM) years admitted to the Clinic of Eye Diseases of Kaunas University of Medicine Hospital for cataract surgery and the lens opacity of 100 eyes of controls (n=50) aged 59.8±0.4 (mean±SEM) (p>0.05) years hospitalized in the Clinic of Skin and Venereal Diseases was evaluated according to the Lens Opacity Classification System, version III. Visual acuity was investigated using the Snellen chart. Physical activity in metabolic equivalent minutes per week (MET-minutes/week) was evaluated according to the International Physical Activity Questionnaire.

Results. The means of the intensity of lens opacity of patients with cataract were significantly higher, and the means of visual acuity and physical activity were significantly lower, compared to controls (p<0.01–0.001). For less active patients (<5900 MET-minutes/week) with the right eye examined, the odds ratio of cataract was by 7.00 (95% confidence interval 2.93–16.74, p<0.001) and for those with the left eye studied by 4.43 (95% confidence interval 1.97–9.98, p<0.001) times higher, compared to physically active (>5900 MET-minutes/week) patients. Physical activity was inversely correlated (r=–0.452, p<0.05) with the lens opacity in the cortex in physically active (>5900 MET-minutes/week) subjects with cataract who underwent the examination of the left eye.

Conclusion. The intensity of lens opacity and cataract are statistically significantly related to physical activity.

Introduction

Cataract is a common disease among the elderly. The prevalence of cataract increases in the fifth decade of human life (at the age of 41–50 years); in the eighth decade of life (at the age of 71–80 years), clinically manifested cataract is diagnosed in about one-half of people, and in the tenth decade (at the age of 91–100 years), cataract is diagnosed in every patient. Accordingly, the need for surgical operations due to cataract doubles with every decade, and every second person aged over 90 years needs surgery for cataract (1). On the other hand, surgical treatment and the application of new techniques are associated with increasing expenditures for medical services. All this encourages the researchers to determine factors that stimulate the development and progression of cataract. A close association of this condition with age suggests that its development, besides other known factors, such as smoking (2, 3), diabetes (4), reactive oxygen species (5, 6), nutritional peculiarities (7), the lack of antioxidants (8–10), etc., may also be influenced by the lack of physical activity.

It is known that physical inactivity evokes arterial hypertension, hypercholesterolemia, overweight, etc. (11), which are risk factors for diseases such as ischemic heart disease, diabetes mellitus, and hypertension. The aforementioned diseases are related to cataractogenesis (4, 12–15).

The aim of the study was to determine the character and the intensity of lens opacity and the visual acuity in cataract patients and controls and to determine the relationships of these indices with the physical activity of the studied subjects.

Patients and methods

The study was performed with the permission of the Ethical Committee of Kaunas University of Medicine (June 17, 2004, No. 6/2004).

The contingent of the study consisted of 110 patients aged 60.3±0.4 (mean±SEM) years, admitted to the Clinic of Eye Diseases of Kaunas University of Medicine Hospital for surgery for cataract, and 50

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controls aged 59.8±0.4 (mean±SEM) years ($p>0.05$), admitted to the Clinic of Skin and Venereal Diseases of Kaunas University of Medicine Hospital. In the case group, 71 subjects were males and 39 – females, and in the control group – 32 males and 18 females. Patients who, in addition to cataract, had myopia, glaucoma, pigmented retinitis, and systemic diseases (diabetes mellitus or diseases requiring treatment with steroid preparations), as well as those who had eye traumas or detached retina were excluded from the study, since the aforementioned causes could condition lens opacity. In all patients (110 eyes for surgical treatment) and controls (100 eyes), the studies of ophthalmologic indices (visual acuity, lens opacity, intraocular pressure, and fundus examination) were performed at the Clinic of Eye Diseases of Kaunas University of Medicine Hospital and the Department of Ophthalmology of the Institute for Biomedical Research. The examination of the anterior part of the eyes was performed using a slit lamp, and the examination of the fundus – using double aspheric fundus examination lens. Visual acuity in all subjects was determined using the Snellen chart, and subjective refraction was determined. Lens opacity was evaluated according to the Lens Opacity Classification System, version III (LOCS III) (16), using the lens opacity classification slide, *i.e.* the opacity was compared to the standard images on the slide placed on the screen of a negatoscope. The standards were six images of the lens for the evaluation of the intensity of the nuclear opacity (NO) and its color intensity (NC), five images for the evaluation of the cortical opacity (C), and five images for the evaluation of posterior subcapsular opacity (P). The lens was investigated after pharmacologic (1% Cyclogyl solution) mydriasis under a slit lamp. When illuminating the lens by a lateral slit, changes in the nucleus were determined. Opacity in the cortical layers and the posterior subcapsule was inspected under retroillumination. The intensity of the cataract was expressed in points on a decimal scale and described by the degree of maturity (16). The findings of the study were registered in a separate questionnaire. In addition to that, the questionnaire contained questions formulated according to the International Physical Activity Questionnaire (IPAQ), allowing for the evaluation of physical activity. The questionnaire is the most feasible instrument for measuring physical activity in large groups or populations. Many of the existing instruments are not comparable concerning the type of activities surveyed (*i.e.*, leisure-time activities only) and the format for data collection. The shorter version of IPAQ was used. The calculation of the total score for the short form requires the summation of the duration (in minutes) and the frequency (days) of walking and moderate-intensity and vigorous-intensity activities. Using the compendium of (17), an average metabolic equivalent (MET) score was derived for each type of activity. The following values were used for the analysis of IPAQ data:

Walking = 3.3 METs, Moderate physical activity = 4.0 METs, and Vigorous physical activity = 8.0 METs. Using these values, four continuous scores are defined:

Walking MET-minutes/week = 3.3 × walking minutes × walking days;

Moderate MET-minutes = 4.0 × moderate-intensity activity minutes × moderate-intensity activity days;

Vigorous MET-minutes/week = 8.0 × vigorous-intensity activity minutes × vigorous-intensity activity days;

Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores (18).

Statistical analysis. Statistical analysis of the data was performed using SPSS 13.1 (Statistical Package for Social Science) software package. The distribution of values of the studied indices was performed using Kolmogorov–Smirnov test. The values of the age of the examined subjects had normal distribution, and their statistical analysis was performed using Student's t-test. The values of the ophthalmologic and physical activity indices had non-normal distribution, and their statistical analysis was performed using nonparametric test for comparison of values. The differences between values of indices in the independent groups were determined using Mann–Whitney U test. The level of significance in the verification of statistical hypotheses was set at $p<0.05$. The correlation analysis of indices (non-normally distributed) was performed using Spearman's correlation coefficient.

Results

The mean values of the intensity of lens opacity (in the nucleus, the cortex, and the posterior subcapsule) and the mean intensity of the color of the nucleus (separately for the right and the left eyes) in the lenses of patients with cataract were significantly higher; the means of the values of visual acuity and physical activity were significantly lower, compared to controls ($p<0.01$–0.001) (Table 1). Methods of the statistical analysis of the data were used to determine the sensitivity and the specificity of the assessment of physical activity. In the studied groups, the physical activity scores of <5900 MET-minutes/week and >5900 MET-minutes/week (significantly differing,

***Table 1.* Comparison of the ophthalmological indices and physical activity between examined groups**

Indices	Groups	n_1	mean±SEM_1	n_2	mean±SEM_2
NO	1	52	4.57±0.25*	58	4.51±0.21*
NO	2	50	2.09±0.05	50	2.10±0.06
NC	1	52	4.54±0.25*	58	4.50±0.21*
NC	2	50	2.09±0.06	50	2.05±0.06
C	1	52	3.91±0.22*	58	3.44±0.22*
C	2	50	1.03±0.21	50	0.79±0.12
P	1	52	3.10±0.28*	58	3.25±0.24*
P	2	50	0.79±0.17	50	0.52±0.09
Visus	1	52	0.10±0.02*	58	0.12±0.02*
Visus	2	50	0.93±0.03	50	0.95±0.03
PA	1	52	4242±421*	58	5409±586**
PA	2	50	7258±489	50	7262±492

Group 1 – patients with cataract; Group 2 – controls. NO – opacity of nucleus; NC – color of nucleus; C – opacity of cortex; P – posterior subcapsular opacity; PA – physical activity; Visus – visual acuity.
* $p<0.001$; ** $p<0.01$ group 1 *vs.* group 2.

Physical activity is expressed in metabolic equivalent minutes per week. n_1 and mean±SEM_1 are for the right eye, n_2 and mean±SEM_2 – for the left eye. Ophthalmological indices NO, NC, C, and P were evaluated according to the Lens Opacity Classification System, version III.

$p<0.001$) were found in different numbers of subjects. For instance, in the control group, only in 15 (27.8%) subjects with the right eye examined and in 15 (28.3%) with the left eye examined, the physical activity scores were <5900 MET-minutes/week, whereas in the case group these numbers were 39 (72.2%) and 38 (71.7%) subjects with the right and the left eye studied, respectively. The scores of >5900 MET-minutes/week were found in 35 (72.9%) control subjects with the right eye examined, in 35 (63.6%) controls with the left eye investigated, in 13 (27.1%) case subjects with the right eye studied, and in 20 (36.4%) case subjects with the left eye investigated. Using these data, we determined a statistically significant association bet-

***Table 2.* Association of the physical activity with cataract of the right eye**

Physical activity	Groups				OR	95% CI	p
	cataract		control				
	n	%	n	%			
>5900 MET-minutes/week	13	27.1	35	72.9			
<5900 MET-minutes/week	39	72.2	15	27.8	7.00	2.93–16.74	<0.001

MET-minutes/week – metabolic equivalent minutes per week; OR – odds ratio; CI – confidence interval; PA – physical activity. Chi-square test – 20.7.

***Table 3.* Association of the physical activity with cataract of the left eye**

Physical activity	Groups				OR	95% CI	p
	cataract		control				
	n	%	n	%			
>5900 MET-minutes/week	20	36.4	35	63.6			
<5900 MET-minutes/week	38	71.7	15	28.3	4.43	1.97–9.98	<0.001

Abbreviations are the same as in Table 2. Chi-square test –13.6.

Table 4. **Changes in ophthalmological indices of the right and left eyes depending on physical activity**

Indices	Groups of PA	n_1	mean±SEM_1	n_2	mean±SEM_2
NO	<5900 MET-minutes/week	54	3.98±0.26*	53	3.82±0.22***
NO	>5900 MET-minutes/week	48	2.66±0.19	55	2.98±0.22
NC	<5900 MET-minutes/week	54	3.99±0.26*	53	3.83±0.22***
NC	>5900 MET-minutes/week	48	2.59±0.19	55	2.92±0.22
C	<5900 MET-minutes/week	54	3.11±0.29**	53	2.56±0.25****
C	>5900 MET-minutes/week	48	1.81±0.25	55	1.89±0.26
P	<5900 MET-minutes/week	54	2.50±0.29***	53	2.30±0.26****
P	>5900 MET-minutes/week	48	1.35±0.24	55	1.69±0.26
Visus	<5900 MET-minutes/week	54	0.32±0.05*	53	0.35±0.06***
Visus	>5900 MET-minutes/week	48	0.72±0.06	55	0.66±0.06

Abbreviations are the same as in Table 1. Indices of group <5900 MET-minutes/week *vs.* group >5900 MET-minutes/week.
* $p<0.001$; ** $p<0.01$; *** $p<0.05$; **** $p=0.051$.

ween physical activity and cataract (Tables 2 and 3). Odds ratio of cataract for less active patients (<5900 MET-minutes/week) with the right eye examined was by 7.00 (95% CI 2.93–16.74, $p<0.001$) and for those with the left eye studied by 4.43 (95% CI 1.97–9.98, $p<0.001$) times higher, compared to physically active (>5900 MET-minutes/week) patients. In addition to that, if the physical activity score was <5900 MET-minutes/week, statistical differences of the mean values of ophthalmological indices between the respective values, compared to cases when the physical activity score was >5900 MET-minutes/week, for the right eye were more expressed than for the left eye (Table 4). Physical activity inversely correlated ($r=-0.452$, $p<0.05$, $n=20$) with the lens opacity in the cortex of physically active (>5900 MET-minutes/week) subjects with cataract who underwent the examination of the left eye. There was a tendency for correlation ($r=-0.526$, $p=0.065$, $n=13$) between physical activity and color intensity of the nucleus of the lens in active (>5900 MET-minutes/week) patients with the right eyes studied.

Discussion

The findings showed an increase in the intensity of lens opacity and a decrease in visual acuity in case of a decrease in physical activity (Table 1). When the lens opacity increases, changes in the quality of the image projected on the retina occur due to the scatter and absorption of the visible light waves <450 nm (19). The sources that scatter and absorb the light may be conditioned by a number of causes. These causes may be oxidative stress (the increase in the amount of free radicals in the organism) (5, 6), osmotic changes (20), changes in the structure of crystallins (21), the accumulation of Ca ions in the lens (22, 23), increased compactness of fibers (24), etc. Physical inactivity evokes arterial hypertension, hypercholesterolemia, overweight, etc. (11) and at that time may induce the formation of the active forms of oxygen. This is also confirmed by our experimental findings (25). In cases of prolonged (48 days) hypodynamics, additional feeding of rabbits with zinc as an essential component of superoxide dismutase, a free radical scavenging enzyme and a component of repair enzymes of nucleic acids (26), protects vascular endothelium (25), microfilaments (27), and the retinal vascular cells of the eye (28) from damage. Thus, one of the causes of an intensive increase in lens opacity in our patients could have been a rise in the amount of free radicals resulting from decreased physical activity. In addition to that, low physical activity stimulating the formation of the active forms of oxygen may also cause damage to cell membranes. An increase in the membrane permeability results in changes in the ion (Na^+/K^+) ratio in cells and a decrease in the activity of membrane enzymes, including Na^+-K^+-ATPase, which stimulates the accumulation of the interstitial substratum in cells, *i.e.* the formation of vacuoles. According to our data (24), in case of hypodynamics, microscopic examination of the cortical layer cells of lenses showed extensive cellular vacuolization, and many vacuoles were found to be located close to the nucleus of fiber cells. According to the literature data, increased osmotic pressure in the periphery of the lens results in the formation of vacuoles that extend to the anterior layers of the lens and stimulate the progression of turbidity in all layers, especially in the nucleus, and also causes changes in the proteins of the lens (20). The importance of proteins (crystallins) conditioning the transparency of the lens and their role in the pathogenesis of cataract are confirmed by data showing that the destruction of this protein gene accelerates the process of the decrease in lens transparency (29). The lens remains transparent as long as the short-range order of crystallin proteins does not break down and as long as proteins remain in their native or soluble form (21). Changes in crystallin structure stimulate an increase in crystallin aggregation and a decrease in its solubility, which becomes the cause of light scatter. In cells of cortical layer of the lens, low-high-density material may be considered to be the light-scattering center, which may be formed of aggregated lens proteins and calcium in case of a 48-day hypodynamics (24). Our findings in this research showed that increased physical activity might have an opposite effect on the intensity of lens opacity. This is shown by an inverse correlation ($r=-0.452$, $p<0.05$) between physical activity and the intensity of the lens opacity in the cortex of physically active (>5900 MET-minutes/week) subjects with cataract. According to literature data (22), increased intracellular Ca^{2+} induces cortical opacification in the human lens as well. Disturbances in calcium homeostasis are associated with various forms of cataract; *e.g.*, Ca^{2+}-mediated disintegrative globulization of fiber cells may be responsible for the formation of light-scattering centers during cataractogenesis (23).

Conclusions

Thus, lens opacity has many causes that are related to physical activity as well. This is shown by the findings of the correlation analysis and the odds ratio for cataract. For instance, physical activity inversely correlated ($r=-0.452$, $p<0.05$) with the lens opacity in the cortex of physically active (>5900 MET-minutes/week) subjects with cataract who underwent the examination of the left eye. The odds ratio of cataract for less active patients (<5900 MET-minutes/week) with the right eyes examined was by 7.00 (95% confidence interval 2.93–16.74, $p<0.001$) and for those with left eyes examined by 4.43 (95% confidence interval 1.97–9.98, $p<0.001$) times higher, compared to physically active (>5900 MET-minutes/week) patients.

Lęšiuko drumstėjimo intensyvumo ryšys su žmogaus fiziniu aktyvumu

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Raktažodžiai: lęšiuko drumstėjimas, fizinis aktyvumas, metaboliniai ekvivalentai.

Santrauka. *Tyrimo tikslas.* Nustatyti lęšiuko drumstėjimo pobūdį, intensyvumą bei regėjimo aštrumą sergantiesiems katarakta ir kontroliniams asmenims, taip pat šių rodiklių ryšį su tiriamųjų fiziniu aktyvumu.

Medžiaga ir metodai. Oftalmologiniai tyrimai atlikti Kauno medicinos universiteto klinikų Akių ligų klinikoje. Tirti sirgusieji katarakta (n=110), kurių amžiaus vidurkis 60,3±0,4 metų, kontrolinės grupės tiriamieji (n=50) gydyti Kauno medicinos universiteto klinikų Odos ir venerinių ligų klinikoje (amžiaus vidurkis – 59,8±0,4 metų). Lęšiuko drumstėjimas įvertintas remiantis LOCS III (angl. *Lens Opacity Classification System III*) klasifikacija. Regėjimo aštrumas ištirtas naudojant Snelleno lentelę. Tiriamojo fizinis aktyvumas metabolinio ekvivalento (MET)-minutėmis per savaitę nustatytas remiantis Tarptautiniu fizinio aktyvumo klausimynu.

Rezultatai. Sergančiųjų katarakta lęšiukų drumstėjimo intensyvumo vidurkiai buvo statistiškai reikšmingai didesni, o regėjimo aštrumo ir fizinio aktyvumo vidurkiai mažesni nei kontrolinės grupės tiriamųjų ($p<0,01$–$0,001$). Fiziškai mažiau aktyvių tiriamųjų (<5900 MET-minutės per savaitę) kataraktos šansų santykis dešinės akies buvo 7,00 (95 proc. pasikliautinasis intervalas 2,93–16,74, $p<0,001$), kairės akies – 4,43 (95 proc. pasikliautinasis intervalas 1,97–9,98, $p<0,001$) kartų didesnis negu fiziškai aktyvių tiriamųjų (>5900 MET-minutės per savaitę). Fiziškai aktyvių (>5900 MET-minutės per savaitę) tiriamųjų žievinių lęšiuko drumsčių intensyvumas kairėje akyje atvirkščiai koreliavo ($r=-0,452$, $p<0,05$) su jų fiziniu aktyvumu.

Išvada. Akies lęšiuko drumstėjimo intensyvumas ir katarakta yra statistiškai reikšmingai susiję su fiziniu aktyvumu.

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