Hyperglycemia

and

Refractive Error Fluctuation

[Senior Project]

Prepared by:

Gregory R. Morgan
Senior Intern

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Hyperglycemia and Refractive Error Fluctuation
A Prospective Study

Gregory R. Morgan

Abstract: Recent studies and popular theory indicate that with increasing blood sugar levels of diabetics, you will find an increase in myopia. Therefore, it is very common for diabetic patients to complain of fluctuating vision upon fluctuating sugar levels. This study is an attempt to determine if these changes are measurable clinically, and if they are in agreement with present theory.

Key Words: Diabetes Mellitus, hyperglycemia, blood glucose/blood sugar levels, myopia, hyperopia

INTRODUCTION

Diabetes Mellitus occurs because of lack of insulin or due to the presence of factors that oppose the action of insulin.[1] It is a leading cause of new blindness in the United States and afflicts approximately 14-15 million Americans.[2] The majority of diabetics have non-insulin dependent (Type II) diabetes as opposed to insulin dependent (Type I) diabetes. Whether Type I or Type II, the results is an increase in blood glucose concentration.

Diabetes is one of many systemic medical conditions that will affect the eye, and because the eye represents an end organ response system, all ocular structures may be affected.[2] The leading ocular complication is diabetic retinopathy which results from problems in the micro- and macro- vasculature of the retina due to hyperglycemia. Other ocular complications include cataract, glaucoma, and other slightly less significant factors. One of the less significant factors includes refractive error shifts. These refractive error shifts are caused by fluctuating blood glucose levels. Few studies have been performed in the past five years that determine whether these shifts are measurable. The following study is an attempt to do so through a small subject base at a prison hospital environment.

MATERIALS AND METHODS

The clinical background of eight patients in this study are shown in Table 1. The patients were all male and were under care at the Duane Waters Hospital Eye Clinic, which services inmates of the State Prison of Southern Michigan in Jackson, Michigan. Age ranges were from 33 to 53 years, five patients were of caucasian decent, three were African-American. Range of diabetes duration was from 2 months to 18 years. Four patients had Type II, and four had Type I diabetes mellitus. All patients complained of fluctuating vision. All patients had no outstanding ocular health history or abnormalities, with only one patient showing signs of diabetic retinopathy. Attempts were made not to exclude any diabetic patients that were seen, however, some factors such as patient non-compliance with the study and other serious eye disease did diminish the study sample.

Table 1: Clinical background of 8 diabetic cases

Subject #	Age	Race	DM Status	Duration of DM	Retinopathy Status	Therapy
1	33	W	IDDM	2 mos.	None	Insulin
2	33	A	IDDM	4 yrs.	None	Insulin
3	53	W	NIDDM	3 yrs.	None	Oral
4	48	A	IDDM	16 yrs.	Mod NPDR	Insulin
5	43	W	NIDDM	3 yrs.	None	Oral
6	46	A	IDDM	18 yrs.	None	Insulin
7	51	W	NIDDM	7 yrs.	None	Oral
8	42	W	NIDDM	1 yr.	None	Oral

DM = Diabetes Mellitus; W = White; A = African-American;
IDDM = Insulin Dependent Diabetes Mellitus; NIDDM = Non-Insulin Dependent Diabetes Mellitus; Mod NPDR = Moderate Non-Proliferative Diabetic Retinopathy

The study was composed of analyzing refractive error, best corrected visual acuities, and blood sugar levels at an initial visit and having each subject return about one month later to repeat these tests. Refractive error testing was started from retinoscopy or habitual spectacles and subjectively brought to best sphere. The cylinder and cylinder axis were then neutralized using the jackson cross-cylinder technique. Next, a binocular balance was determined using dissociated blur-balance. From there, a binocular best sphere was measured from just readable 20/20. This gave the final neutralization with visual acuity measured with standard Snellen charts up to 20/20. The patient was then immediately sent to the lab in the hospital for a non-fasting serum glucose check. Results of the glucose check were received a few days later.

RESULTS

Table 2 shows data gathered at the initial visit. Included in this table is the data that will be analyzed and compared to the same measurements at follow-up. Table 2 indicates each patient with right and left eyes separated, and gives the subjective refraction of each eye as well as best acuities that go along with this. Also included here are the serum glucose levels at the time of refraction.

Table 2: Initial visit - Examination findings

Subject #	Eye	Subjective Refraction	Visual Acuity	Serum Glucose Level (mg/dl)
1	OD OS	Pl. -.75 X 160 Pl. - 1.25 X 30	20/20 20/20	138
2	OD OS	-1.00 -.75 X 55 -.75 -.50 X 60	20/25 20/20	389
3	OD OS	-1.00 DS -1.25 DS	20/20 20/20	210
4	OD OS	-.75 - .50 X 32 -.75 -.75 X 26	20/20 20/20	525
5	OD OS	-4.75 -.25 X 133 -4.75 -.25 X 015	20/20 20/20	128
6	OD OS	+.50 - .75 X 70 +.50 -.50 X 115	20/20 20/20	328
7	OD OS	Pl. -.1.00 X 55 +.25 -.75 X 85	20/20 20/20	145
8	OD OS	-1.00 -.50 X 50 -.50 -.25 X 115	20/20 20/20	113
Average		**-0.98 DS -0.55 D cyl.**	**NA**	**247**

The follow-up data was compiled within a certain amount of time that is indicated in weeks in Table 3. Also listed are the same measurements that were included in Table 2 for comparison. An average of refractive spherical and cylindrical power as well as average glucose levels are also included in both tables. Results show that the sample study had just under one diopter of spherical power. Average glucose levels for initial and follow-up were around 240. Looking at the relationship of averaged glucose compared to averaged sphere and cylinder power, it is found that the higher (247) glucose level is only six units more than the follow-up (241). Comparing the sphere power of the higher glucose level (-0.98 DS) to the lower (-0.88 DS) one sees that the higher level has slightly more myopic correction. When looking at the astigmatic power of the higher level (-0.55 D) compared to the lower (-0.63 D) shows slightly less negative power. Cylinder axis was not clinically relevant, as minimal shift was noted. If one looks at the spherical equivalents of these, the higher level glucose shows a -1.26 diopter power with the lower at -1.20 diopters. Again, this shows more myopic correction with higher blood sugar levels. In final analysis of this data, not much can be concluded because all the numbers show very minimal differences, however, at a small scale one would deduct that overall negative power decreased upon decreased blood sugar levels.

Table 3: Follow-up visit - Examination findings

Subject #	Weeks from Initial	Eye	Subjective Refraction	Visual Acuity	Serum Glucose level (mg/dl)
1	6	OD OS	Pl. -1.25 X 162 Pl. -1.25 X 29	20/20 20/20	97
2	7	OD OS	-1.00 -1.00 X 65 -.75 -.75 X 60	20/20 20/20	530
3	5	OD DS	-1.50 DS -1.50 DS	20/20 20/20	203
4	5	OD OS	-1.00 -.75 X 27 -1.00 -.75 X 23	20/20 20/20	499
5	6	OD OS	-4.50 DS -4.50 -.25 X 10	20/20 20/20	89
6	5	OD OS	+1.00 -.75 X 70 +1.25 -.75 X 115	20/20 20/20	286
7	6	OD OS	Pl. -1.00 X 58 Pl. -1.00 X 87	20/20 20/20	126
8	6	OD DS	-.25 -.50 X 52 -.25 DS	20/20 20/20	97
Average		**-0.88 DS -0.63 D. cyl.**		**NA**	**241**

Another view of this data is to compare each individual's eyes with their difference in spherical power and cylindrical power going from higher to lower sugar levels. This data is compiled in Table 4. The total difference in sugar as well as sphere and cylinder are then totalled and averaged at the bottom. As shown in this table, the average change in glucose levels is about 21 mg/dl, with an average shift going from higher level to lower showing a +0.09 diopter sphere change and minimal cylinder change. As in the previous analysis from Table 2 and 3 this comparison shows a minimal overall change and again it can be determined that negative power decreased with decreased blood sugar. If one was to take a ratio of the average blood sugar change in decreasing levels to the diopter sphere change you would need a decrease in negative power. This ratio is most likely exaggerated due to the small population and many other factors that might not point us to any definite conclusions.

DISCUSSION

It has long been known that hyperglycemia causes shifts in refractive error and diabetics will often complain of frequent episodes of blurred vision. Upon literature search for information on whether or not these episodes can be measured, it was found not to be documented well in the past 5-6 years. It had been believed in the past that increasing blood sugar levels caused increased hyperopia.[3,4,5,6,7] Some of the studies on this subject looked at flattening of the lens curvature upon increased blood sugar. There was also thought that the osmotic forces inside the lens were balanced by high glucose levels in the aqueous humor, causing fluctuation in refractive index of the lens, thus inducing hyperopia.

Table 4: Individual blood glucose differences with associated refractive error differences

Subject # / Eye	Blood Sugar High -> Low	Sphere Power Change High Sugar -> Low (DS)	Cylinder Power High Sugar -> Low (D cyl)
1 OD OS	138 - 97 = 41	0 0	-.50 0
2 OD OS	530 - 389 = 141	0 0	+.25 +.25
3 OD OS	210 - 203 = 7	-.50 -.25	0 0
4 OD OS	525 - 499 = 26	-.25 -.25	-.25 0
5 OD OS	128 - 89 = 39	+.25 +.25	+.25 0
6 OD OS	328 - 286 = 42	+.50 +.75	0 -.25
7 OD OS	145 - 126 = 19	0 -.25	0 -.25
8 OD OS	113 - 97 = 16	+.75 +.25	0 +.25
Total Diff.	**331**	**+1.25**	**-0.25**
Average	**20.69**	**+0.09**	**-0.02**

The latest of the studies on the thought of hyperopia with hyperglycemia was found in 1988. Though few studies were found after this time, the literature and everything this writer has learned point to the contrary, in which myopia is associated with hyperglycemia.[1,2] Most theories here relate to an increase in refractive index in the crystalline lens due to the changing osmotic flow between the aqueous humor and the layers of the lens.[1,2,8,9] This flow of water into the lens also causes a swelling of the lens, thus increasing lens curvature and focus of light more in front of the retina = myopia.[2] All the aforementioned theories of lens swelling and increased refractive index relate to the aldose reductase-catalyzed synthesis of sorbitol in the lens, which is involved in the production of early cataracts in diabetics. In actuality, the refractive error shifts are probably just an early manifestation of this cataract formation.[2]

The main objective of this study was to see if a small subject group would show measurable relationships of refractive error variations to glucose changes, and to determine whether this information would show tendencies in agreement with the latest theories. The results of the testing did show, on a very small scale, an increase in myopic power upon increasing blood sugar. However, with such a small sample and such small differences in the figures, it would be unwise to take this study as definite proof of the various theories. All things considered, other factors would need to be considered to bring any true validity to a study of this nature. A large sample, including corneal curvature measurements and more accurate acuity measurements may have been useful. Also, manipulating the blood sugar of the patients by varying the amount of sugar intake before testing may be helpful. In conclusion, this study was performed on too small a subject group to determine any definite proof that the refractive error fluctuations are measurable, or to prove that the latest theories on increased myopia with increased blood sugar are correct.

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