# Ocular Scatter Index and Scheimpflug Imaging as a Measurement for Prediabetes: An Interdisciplinary Case Control Study

Alison Shuff[1], Brittany Martin[2], Madison Smith[3], George Asimellis[2]

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## Abstract

- Early diabetes is often undiagnosed due to most people not being screened for the disease until they reach the age of 39 years. Our area is considered the diabetes belt due to a combination of limited access to health care, obesity, and poor diabetic habits. A novel measurement, which can be included in the standard optometric primary care examination, provides association with early diabetes in the form of ocular scatter. Primary care providers may gain a new insight on early diabetes diagnosis and management.

## Hypothesis

- Elevated levels of ocular scatter may be seen with elevated hyperglycemia in early diabetes. Increased ocular scatter could be associated with the temporary increases in corneal and lenticular thickness and clarity. It appears that diabetes affects light scatter more than other possible predisposition.

## Purpose

- The purpose of this study is to use biometric and optical measurement tests on a range of patients to determine if the correlation between higher levels of ocular scatter and pre-diabetic/diabetic behavior exists in hopes of finding a new way to recognize and treat patients before Type II Diabetes has fully developed. Particularly, the study investigates possible association between blood glycose levels (HbA1c), forward ocular scatter measurements, and anterior chamber biometrics in individuals in the Appalachian region

## Methods

- The study enrolled 158 eyes from 79 individuals with a mean age of 26.6 years. The study was conducted among Appalachian residents, exclusively. Participants had no other ocular pathology, verified by a comprehensive eye examination at the KYCO clinic.
- HbA1c was measured using a portable test kit. It consisted of taking a small blood sample by using a small lancet to stick the finger. A drop of blood was collected, diluted and tested using the device. Results were given in 5 minutes.
- Two groups were formed, based on the threshold of HbA1c; affected group A (n = 58) was formed of individuals with HbA1c ≥ 5.0% (39 mmol/mol) which signifies prediabetic behavior as well as a non-affected group B (n = 62) of individuals with HbA1c < 5.0% which indicates healthy HbA1c levels.
- HbA1c was associated via linear regression with the following ocular indisposition measurements provided by the HD Analyzer/ Optical Quality Analysis System (OQAS Visiometrics, Terrassa Spain), based on double-pass aberrometry: Ocular Scatter Index (OSI), an objective measure of forward light scatter and aberrations, and digital break-up time, based on stability of the Strehl ratio of the three-dimensional point spread function (PSF).
- In addition, associations were sought with central corneal thickness, corneal density, anterior chamber depth, and lens thickness measured with the Pentacam HD (Oculus Optikgeräte, Wetzlar, Germany), which is a clinical Scheimpflug imaging device.

Authors have no commercial relationships relevant to the subject matter. All research was performed in accordance with institutional research policies at the University of Pikeville, Kentucky College of Optometry.

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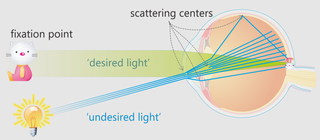
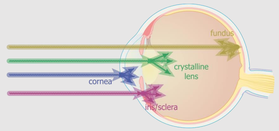
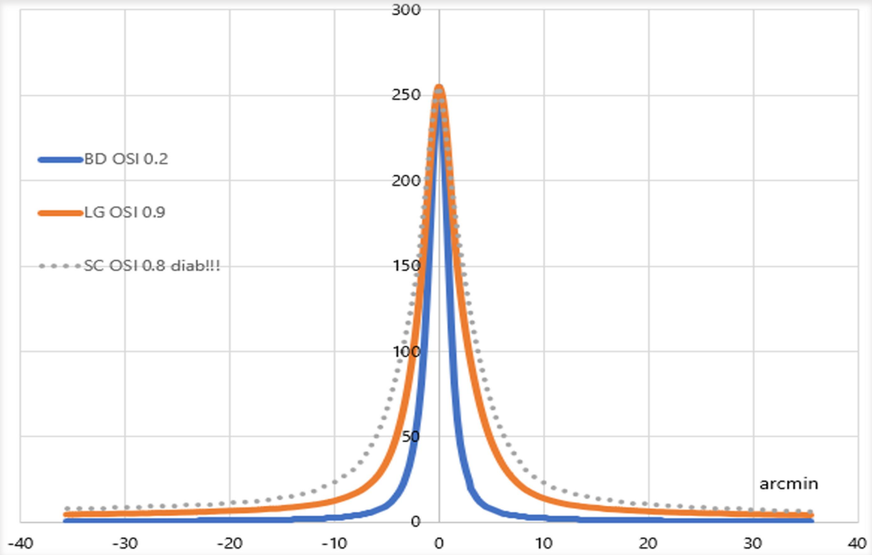
## Ocular Scatter




Ocular scatter and its association with ocular anatomy.



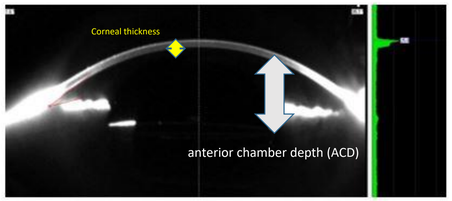

## Retinal Image Quality Metric: Point Spread Function (PSF)



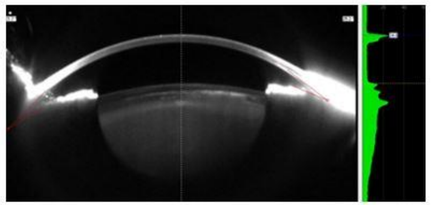

The gray-dotted line has actually a better OSI, indicating sharper vision. However, the PSF profile suggests worse vision (more expanded PSF) because of contribution of scatter.

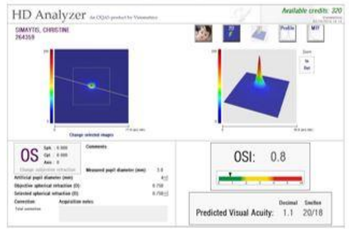
## Data Analysis (Pentacam and HD Analyzer)

The Pentacam instrument.

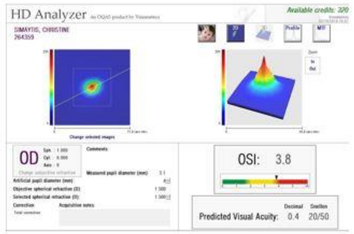



Measurements based on the Pentacam.






Measurements based on the HD Analyzer.




The HD Analyzer instrument.

Pentacam data investigate parameters in the anterior segment of the eye. Of those, we recorded central corneal thickness, (possible corneal swelling), anterior chamber depth (ADC), corneal densitometry, and lens densitometry.

HD Analyzer data investigate parameters pertaining the quality of the retinal image, as it is affected by ocular scatter. Of those, we recorded OSI (a metric of image quality, the lower the better), the shape of the Point Spread Function (PSF), measured by the 10% and the 50% width of the PSF, and Strehl ratio (the higher the better, values between 0.0 and 1.0), the shape of the Modulation Transfer Function (MTF), and Visual acuity, reported as logMAR.

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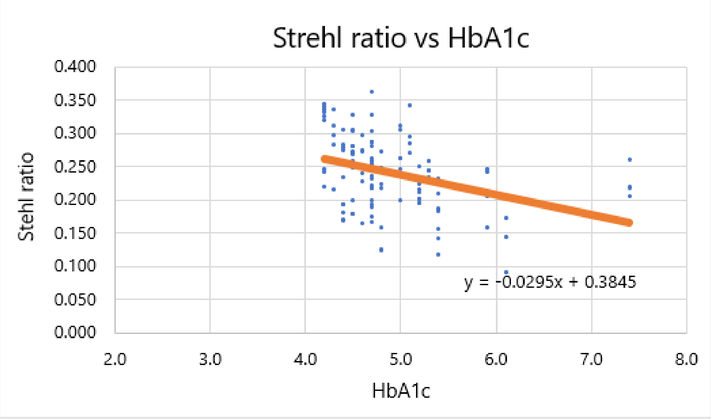
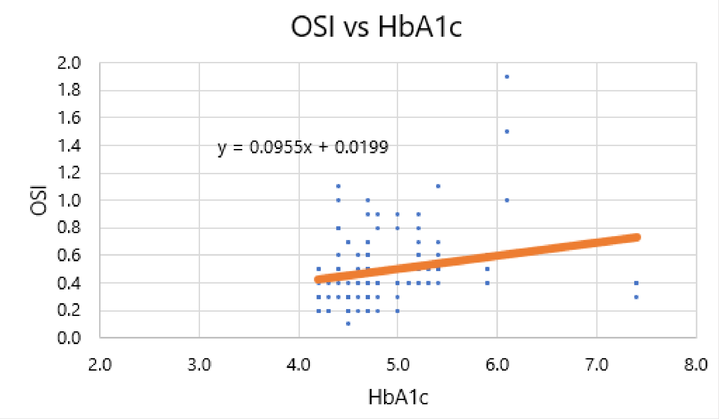
## Results

| | Biometrics | | | Pentacam Data | | |
|---|---|---|---|---|---|---|
| | BMI [Kgr/m$^2$] | HbA1c [%] | | Cornea Thickness [µm] | Cornea Density | Lens Density |
| Average | 26.59 | 4.87 | | 534.98 | 21.52 | 14.63 |
| Stdev | ±6.27 | ±0.58 | | ±70.99 | ±4.96 | ±5.44 |
| Max | 54.41 | 7.40 | | 628.00 | 42.30 | 44.30 |
| Min | 17.93 | 4.00 | | 105.00 | 15.50 | 8.80 |

| | HD Analyzer Data | | | | | | |
|---|---|---|---|---|---|---|---|
| | OSI | MTF cutoff [c/degree] | Strehl ratio | Width at 50 % [arcmin] | Width at 10% [arcmin] | Visual Acuity [logMAR] | Depth of Focus [D] |
| Average | 0.49 | 42.18 | 0.24 | 3.21 | 9.70 | -0.13 | 1.04 |
| Stdev | ±0.27 | ±8.48 | ±0.05 | ±0.82 | ±3.08 | ±0.10 | ±0.69 |
| Max | 1.90 | 55.22 | 0.36 | 5.68 | 23.55 | 0.22 | 3.25 |
| Min | 0.10 | 17.62 | 0.09 | 2.09 | 5.51 | -0.26 | 0.25 |

Correlations were identified between diabetic biometric data (HbA1c) and ocular measurements such as PSF, Strehl ratio and OSI. Individuals with increased HbA1c data had more expanded PSF profile, suggesting presence of scatter. Strehl ratio has a negative correlation with HbA1c: the higher the HbA1c, the worse the Strehl ratio (which is expressed with increased measure). OSI has a positive correlation with HbA1c: the higher the HbA1c, the higher the OSI (which is suggests increased scatter).



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## Discussion

Prevention of diabetes and diabetes-related complications through treatment and disease self-management is paramount in changing this deadly and costly course and demands continued innovation in health programs and services and new partnerships among health professionals. Diabetic patients can benefit from early detection, since effective intervention is available. In addition, distinct geographic patterns of severe vision loss (SVL) prevalence were found in the United States, 77.3% of counties in the top SVL prevalence quartile (≥4.2%) were located in the South. SVL was significantly correlated with poverty (r = 0.5), 437 counties were in the top quartiles for both SVL and poverty, and 83.1% of those counties were located in southern states. Currently, ophthalmic complications from diabetes are not adequately screened, especially within the primary care setting, and further quality improvement measures may improve adherence to recommended screening protocols.

However, there are limited data and research databases at local levels, where interventions and policy decisions to reduce the burden of vision loss and eliminate disparities are often developed and implemented [34]. A search in the peer-review literature reveals only four publications that studied the prevalence of diabetes in the following Southern States: South Carolina, North Carolina, Alabama, and West Virginia. A factor that presents additional challenges to addressing the increasing problem of the prevalence of diabetes in rural Appalachia is in differences in perceived healthy lifestyle habits and a general acceptance of a higher average body weight. Factors contributing to this is the relative isolation of many of these communities.

## Conclusions

This study establishes benchmark data for ocular biometry and scatter among Appalachian population. It lays the foundation for a diabetic-targeted population analysis of scatter levels.

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