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Physiology-Guided Classification of Primary Open Angle Glaucoma Eyes Based on Systolic Velocity Deviation: A Structural and Functional Analysis

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Abstract

Purpose : The multi-factorial nature of primary open angle glaucoma (POAG) adds to challenges related to both diagnosis and treatment. For instance, studies

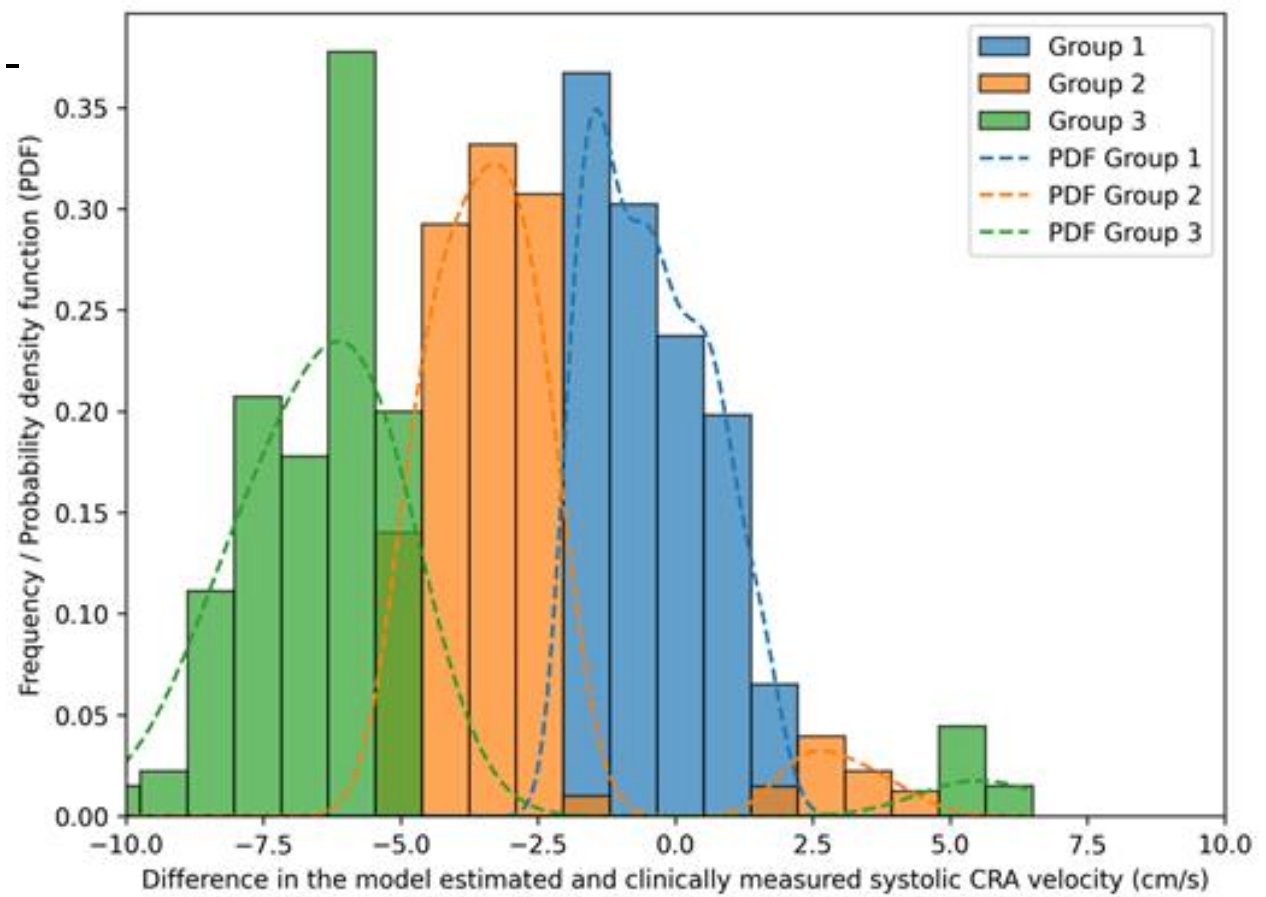
have failed to establish target values of factors such as intraocular pressure (IOP) and blood pressure (BP) that can be considered safe. Here, we leverage the peak systolic velocity (CRAsys) measured using color doppler imaging (CDI) in combination with a mathematical model based on physiological principles to characterize POAG eyes and identify those at a higher risk.

Methods : Over 900 POAG-diagnosed eyes from the Indianapolis Glaucoma Progression Study (IGPS) with measurements of CRAsys using CDI were taken. Using a mathematical model based on the physiology of healthy eyes, the individualized IOP, BP, and heart rate (HR) values were used as inputs to estimate the CRAsys that would be expected from a standard healthy eye. The values estimated by the model were then compared with CDI-measured values of CRAsys for each eye in IGPS. The eyes were then classified into three groups based on the difference between the model-estimated and the CDI-measured values [Fig.1]. Finally, clinically measured structural and functional markers were compared among these groups using a Kruskal-Wallis test.

Results : Table 1 shows the median values of the markers in all three groups as well as the results of the Kruskal-Wallis test. Group 1, Group 2, and Group 3 include eyes that deviated from the model-predicted standard healthy values by less than 2 cm/s, between 2 and 5 cm/s, and more than 5 cm/s, respectively. Among the three groups, eyes are Group 1 had the highest values for Retinal Nerve Fiber Layer (RNFL) thickness, lowest cup-to-disk (C/D) ratios, and the lowest mean deviation (MD) and patterned standard deviation (PSD). In contrast, Group 3 showed the worst structural and functional markers among the groups.

Conclusions : Using the values estimated by a physiology-based mathematical model on standard healthy eyes as a guideline to classify eyes, we were able to identify eyes that were significantly different both in terms of structure and visual function. This shows promise in establishing a more discernable characterization of eyes that are at higher risk for glaucoma.

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Distribution of the eyes in the three groups

Structural Markers				
RNFL thickness				
Markers	Group 1 (N = 336)	Group 2 (N = 454)	Group 3 (N = 137)	p-value
RNFL thickness superior	88.5	83.5	76	<0.01
RNFL thickness inferior	91	86	80	<0.01
RNFL thickness nasal	59	56	52	<0.01
RNFL thickness temporal	61	57	55	0.04
RNFL average	77	71	67	<0.01
C/D ratio				
Markers	Group 1 (N = 334)	Group 2 (N = 453)	Group 3 (N = 140)	p-value
C/D ratio (Area)	0.57	0.57	0.61	<0.01
C/D ratio (Horizontal)	0.77	0.78	0.82	<0.01
C/D ratio (Vertical)	0.73	0.73	0.76	0.03
Visual function Markers				
Markers	Group 1 (N = 360)	Group 2 (N = 476)	Group 3 (N = 158)	p-value
MD	-2.1	-2.42	-3.99	<0.01
PSD	2.31	2.61	4.59	<0.01

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Results from the statistical analysis on the three groups

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