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Physiology-enhanced data analytics to evaluate the effect of altitude on intraocular pressure

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Abstract

Purpose : While it is known that altitude affects intraocular pressure (IOP), the underlying mechanisms remain unclear. Mean arterial pressure (MAP) and osmotic pressure difference (OPD) are considered important factors governing the IOP change with altitude. Herein we use a novel physiology-enhanced approach to analyze data from the Mont Blanc Study (MBS) (Bruttini et al. 2020), with the goal of assessing the relative roles of MAP and OPD on IOP.

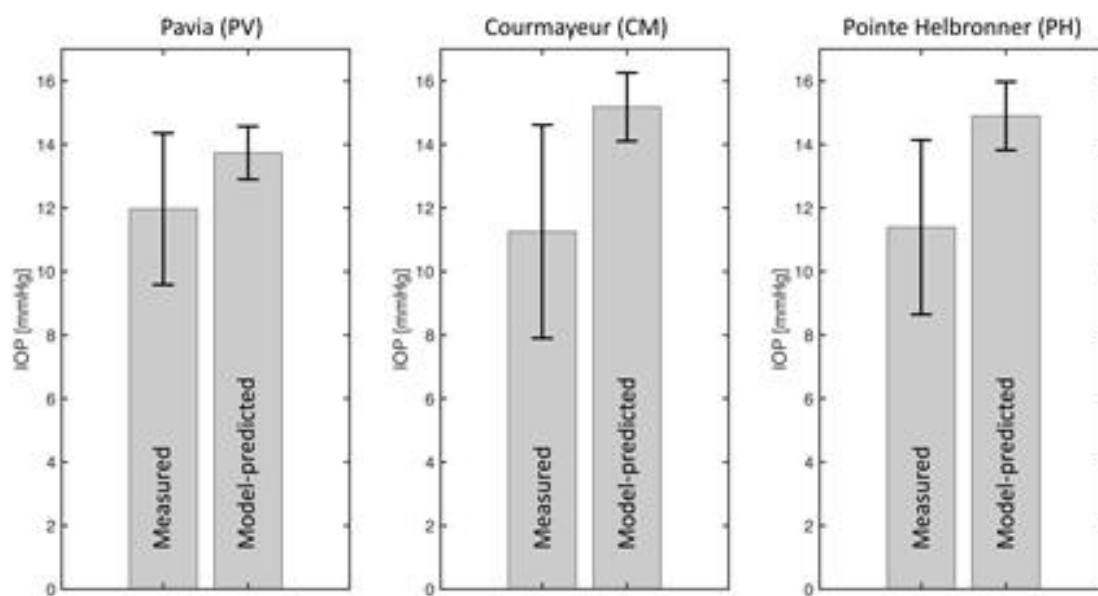
Methods : In MBS, IOP and MAP were measured in 33 healthy volunteers at 77 m above sea level (a.s.l.) (Pavia, PV, Italy), at 1,300 m a.s.l. (Courmayeur, CM, Italy) and 3,466 m a.s.l. (Pointe Helbronner, PH, Mont Blanc Mountain, Italy), in addition to other systemic factors. A validated mathematical model for aqueous humor (AH) circulation (Szopos et al 2016) was used to analyze the MBS data. In the model, IOP is predicted as the result of the balance between AH production and drainage, with MAP and OPD included as parameters regulating AH production.

Results : A first analysis is conducted using measured MAP as an individualized model input to predict the corresponding IOP and compare it with IOP measured at different altitudes (PV, CM, PH). Fig.1 shows that changes in MAP are not sufficient to explain the measured IOP differences, since the measured IOP decreases with altitude while the model-predicted IOP increases. A second analysis is conducted by using the measured MAP and IOP as an individualized model inputs and estimates the OPD that would be

necessary to have AH flow balance at different altitudes (PV, CM, PH). Fig. 2 shows that changes in OPD, in conjunction with MAP, capture the decreasing trend of IOP with altitude as observed in MBS.

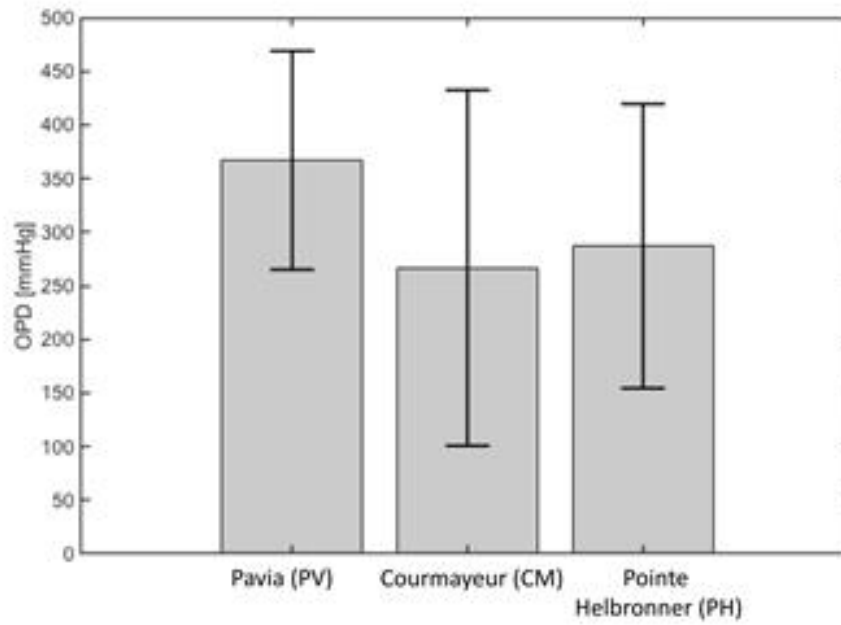
Conclusions : Physiology-enhanced data analytics based on mathematical modeling suggests OPD plays an important role in regulating IOP with changes in altitude. Modeling factors that are conjectured to be relevant such as OPD may provide insights into parameters that cannot be measured directly. Future model analytics will include the effect of temperature and central corneal thickness for enhanced specificity.

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Comparison between measured and model-predicted IOP based on individualized MAP.



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Model-predicted OPD based on individualized MAP and IOP inputs.

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