Investigating the Physiological Effects of Nasal Cycling using Computational Models

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BACKGROUND

- Nasal cycling is a natural phenomenon in which asymmetrical increases in blood flow in the inferior turbinate and septum cause alterations in airflow.
- Though purpose of nasal cycling remains unclear, some theories suggests that the more patent airway optimizes heating and humidification of inhaled air, and the more occluded airway enhances pathogen trapping
- *Objective*: To investigate the functionality of nasal cycling using computational fluid dynamic (CFD) simulations of airflow and heat transfer utilize multiple subjects at a single time point in time.

SUBJECTS

- Three-dimensional reconstructions of nasal passages were created from CT scans of 26 subjects with normal anatomy.
- Each patient was categorized based on degree of nasal cycling as mid-cycle, mild or extreme cycling, and the more congested nasal passage was noted.
- For each subject Gender, Age, Race, Weight, and NOSE Score were recorded and there was no significant different between study groups.
  - Ages of participants ranged from 18-81 years with 9 males and 15 females.

Airflow and Heat Flux Simulations

- Airway reconstructed using CT images followed by ICEM-CFD™.
- Simulations were performed for the mid cycling, mild cycling, and extreme cycling groups for both unilateral and bilateral passages.
- CFD simulations of nasal airflow and heat transfer were performed to target 15L/min inspiratory flowrate.

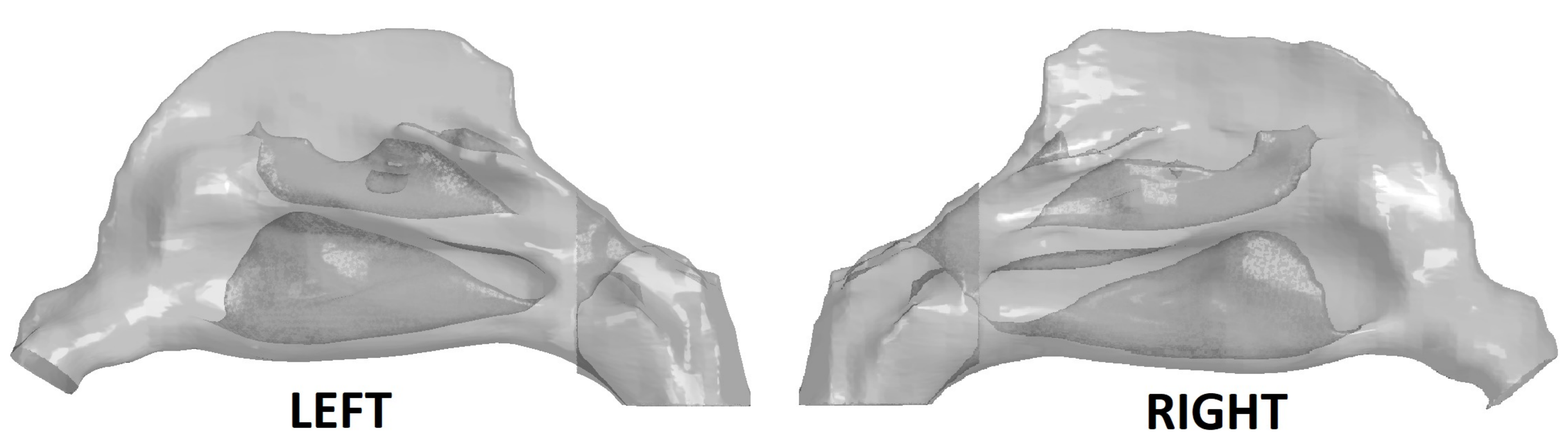

Figure 1: 3D Reconstruction of Nasal Airway from CT images.

RESULTS

- Airflow:
  - In the less congested unilateral nasal passage, extreme cycling had the greatest airflow (mean: mid-cycle 8.92L/min, mild 9.09L/min, extreme 10.6L/min, p=0.03).
  - The opposite was true in the more congested passage with these subjects having the lowest airflow (mean: mid-cycle 6.09L/min, mild 5.91L/min, extreme 4.42L/min, p=0.03).
- Heat flux:
  - Average mucosal heat flux in the more congested airway declined with increasing nasal cycling state (mean: mid-cycle 151.8W/m2, mild 139.4W/m2, extreme 111.8W/m2, p=0.01).
  - Bilateral average mucosal heat flux was greatest in subjects experiencing mild cycling, albeit it was not statistically significant from the other cycling states (p=0.06).
- Nasal airway resistance and wall shear stress were unremarkable among cycling groups either unilaterally or bilaterally.

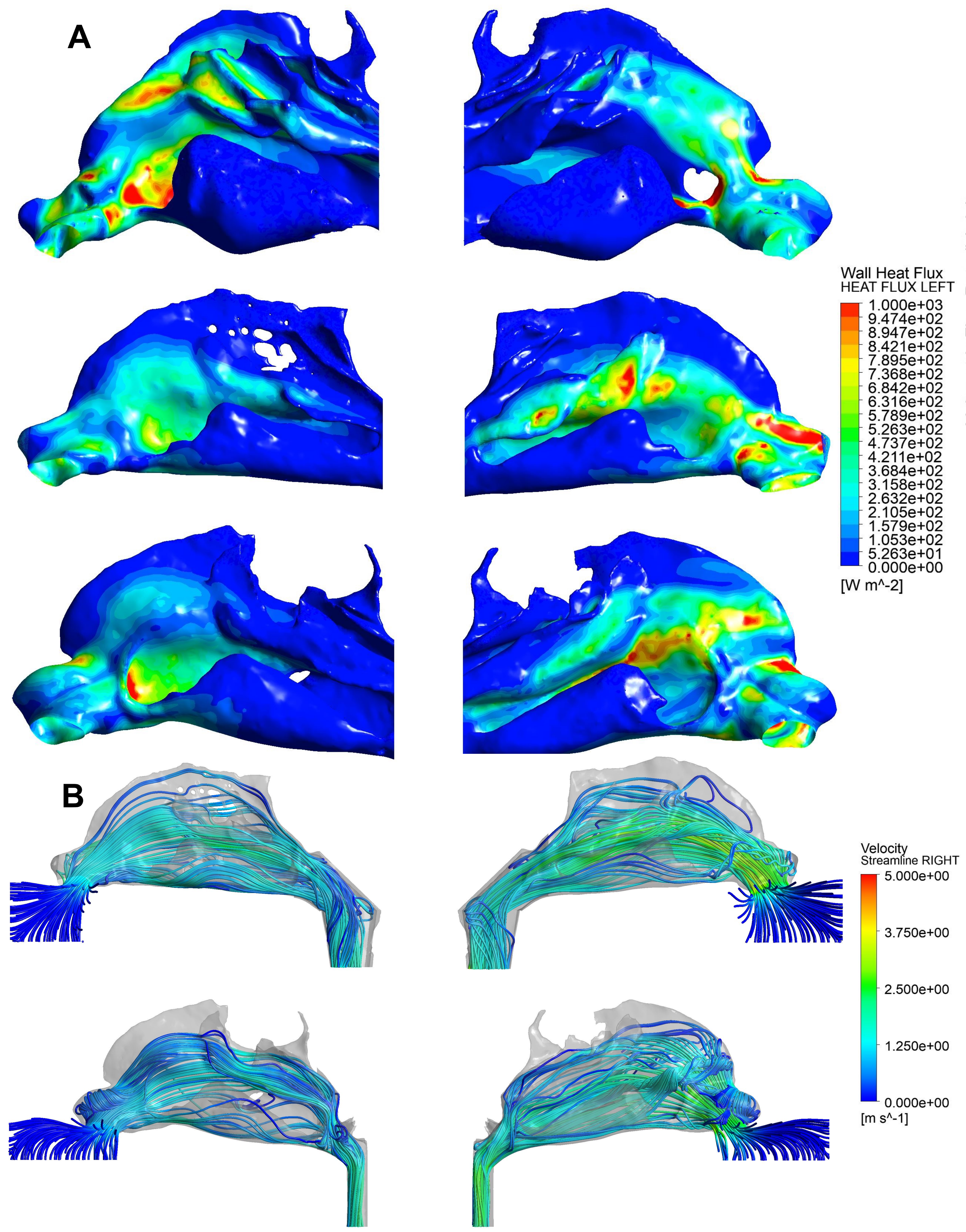

Figure 2: (A) Wall heat flux in the left and right airway in the Mid cycle (Top), Mild cycling (Middle), and Extreme cycling (Bottom) groups. (B) Airflow Velocity in the left and right airway in the Mild cycling (Middle) and Extreme cycling (Bottom) groups.

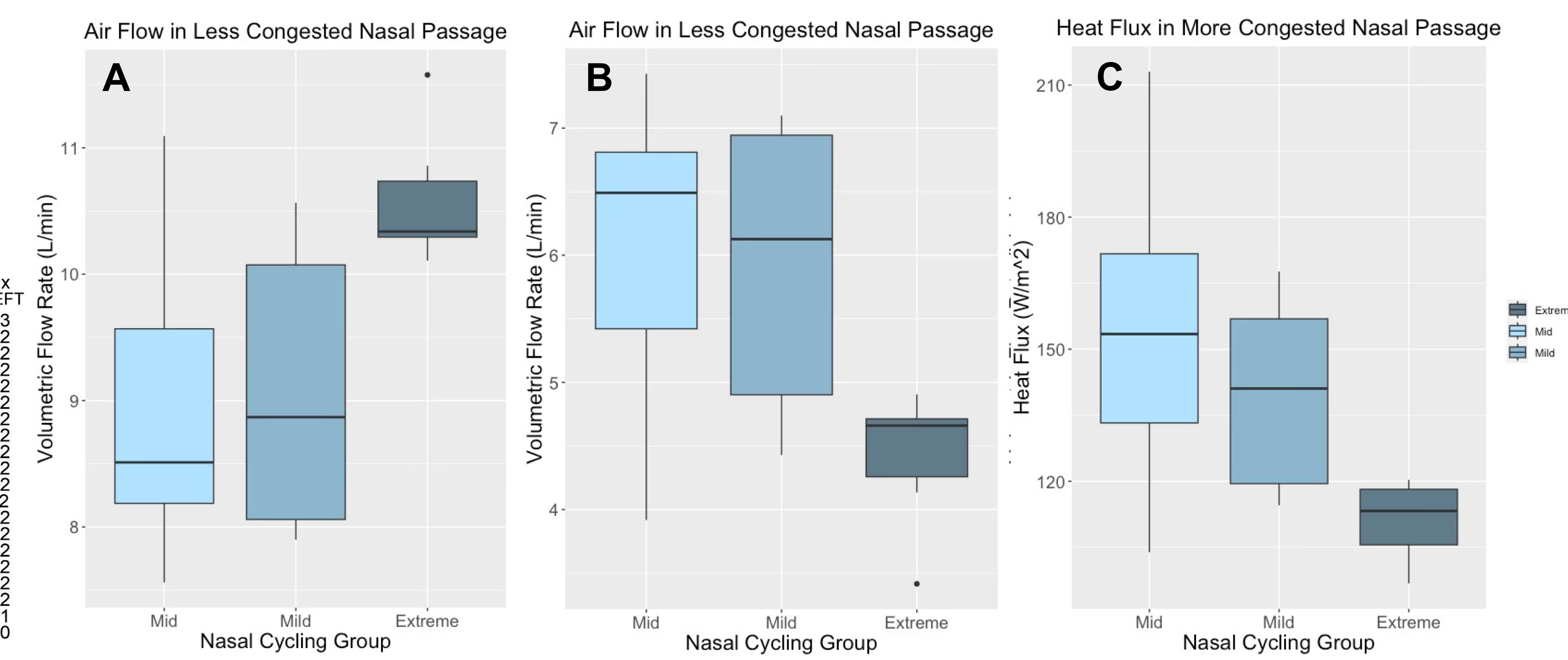

Figure 3: Boxplots comparing airflow in the less congested nasal passage (A), airflow in the more congested nasal passage (B), and heat flux in the more congested nasal passage (C).

CONCLUSIONS

- There are significant changes in heat flux of the more congested nasal passage as the nasal cycling state increases from mid-cycling compared to extreme cycling.
- This finding is consistent with the theory that the function of nasal cycling includes optimizing the heat of inhaled air.
- Further investigation will be needed to assess nasal cycling effects for pathogen trapping using CFD.

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