Section IV: Discussion

Referring to the objectives, the goal of this project was to develop a mask that has high filtration rates towards pollutants, cost-effectiveness, and satisfactory breathability. The data presented that the designed mask had a greater mean filtration efficiency for all 3 PM sizes than the surgical mask. Since all p-values are below the 5% significance level, that means this test was statistically significant. Thus, proving that the designed mask had a higher filtration efficiency than the surgical mask. Although surgical masks are cost-effective, their detrimental breathability heavily outweighs this aspect. And the ones that can adequately balance breathability and comfort are highly expensive. However, the designed mask only cost about $20 - $23 to construct, proving its cost-effectiveness while being a proficient mask. With the addition of the exhalation valves, the mask was made more comfortable and breathable due to the organized distribution of oxygen and the repulsion of external threats like PM 2.5.

A contributing limitation in this project was the use of an electro-spinner. Originally, an electro-spinner was going to be used to develop a nanofibrous mesh to serve as a filter. However, after reaching out to multiple facilities, it seemed unlikely. The cost to use an electro-spinner was excruciatingly high, and the time and preparation needed would ultimately put this out of the scope of this project. To resolve this, it was decided to research pre-existing filters that inhibit electro-spun features to save time and money. Another limitation that the project faced was a light transmittance test. Instead of the particulate matter detection test, light transmittance was going to be implemented. However, it was tested that the light could not pick up the size and quantity of pollutants, so it ended up giving insufficient data. To resolve this, a Davis Instruments AirLink Air Quality Monitor was purchased and used in the above-mentioned particulate matter detection test.

In past studies, electro-spun membranes were used to test the air filtration mechanisms (Deng et al., 2022). The use of electro-spun nanofibers in this study fits into and has similar attributes as to the one of our studies. The Airinum Urban Air Mask filter contains electro-spun characteristics, helping it fit into Deng et al's study. This is also a similar study presented by Cimini et al in 2022, where they used electro-spun nanofibers for medical face masks. However, these studies did not incorporate exhalation valves unlike our study. They only incorporated the electro-spinning aspect but neglected the importance and benefits of exhalation valves. Additionally, to measure the quantity of particles in a certain environment, a high-tech light transmittance was performed (Nakai & Enoki, 2019).

Although our study previously attempted to conduct this test, the procedure was then switched to a detection test with an air quality sensor. Although the methods were different, the overall set-up was similar.

Future Research

There are many future avenues this project might undertake if there was more time. First, this project would heavily benefit personalization and customization. More specifically, the project would want customers to be able to adjust any part of the mask to their own suitable needs. For example, having adjustable ear straps would certainly impact and benefit the overall comfort of the user. The filter size having adaptability and adjusting suitable for the user would also benefit the comfort. Additionally, and important avenue this research would want to undertake is to apply the mask in a real-world application test. Preferably if time permitted, the study would have had volunteers test the mask and run a certain distance in them. This test would help determine if the runner’s pace was affected and if the mask’s experience was comfortable overall. Although the mask underwent a successful test, these future approaches would certainly enhance the mask in various ways.

Section V: Conclusion

The project’s objective was to design and develop a mask that had a high filtration rate for all different sizes of pollutants in the atmosphere. While creating this mask and the exhalation valves, an additional objective was to make it as cost-effective, comfortable, and breathable as possible. Through extensive research, a filter that most inhibited electro-spun qualities were the Airinum Urban Air Mask Filter, making it durable, breathable, and comfortable while filtering out the smallest of pollutants. Using OnShape and 3D-printing, the exhalation valves were modeled and designed. To test the filtration efficiency of the mask, a particulate matter detection test was performed. This test was able to quantify the amount of pollutant particles that penetrated through the mask. After 30 trials, the averages of the proportions of penetrated pollutants were calculated, giving the mask an overall filtration efficiency of 96.114%. Compared to the surgical and KN95’s efficiency of 95%, the designed mask showed a significant increase in filtration. Additionally, with the inclusion of exhalation valves, the breathability and comfort of the runner would increase in contrary to the surgical and KN95 masks, helping the pace and health of the runner be maintained. With the mechanisms of the designed mask, it has the potential to revolutionize the performance of recreational and professional runners by giving them an enhancing and healthy experience.