COMPARISON OF FACEMASK CHARACTERISTICS WITH USER ASSESSMENT OF COMFORT

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Background

According to the Occupational Safety and Health Administration (OSHA), an estimated five million workers are required to wear respirators in over one million workplaces in the United States.[1]

Occupational respiratory diseases are strongly correlated with exposure to causative agents. Wearing a filtering facepiece respirator (FFR) has the potential to reduce worker exposure to concentrations below recommended exposure limits. However, respirator discomfort is associated with low respirator use across many industries.[2,3]

According to NIOSH, more than 20 million workers are potentially exposed to occupational agents that are capable of causing chronic obstructive pulmonary disease (COPD) and asthma.

Approximately 28% of adult asthma cases can potentially be attributed to workplace conditions.[4] Existing asthma may worsen due to occupational exposures. NIOSH also estimates that occupational asthma costs approximately $400 million each year in the United States.

Objectives

1. Evaluate the physical properties of N95 FFRs associated with comfort.

2. Determine the strength of association between N95 FFR physical properties and user perception of comfort.

Methods

3M 8210 3M 8511 Dentec AD2N95A Moldex 2200 Honeywell 4200 Dentec AD4N95 RZ Mask- F2 filter Moldex 2300 Moldex 4200 3M Aura 9210+

Evaluation of physical properties of ten N95 FFRs:

Pressure drop:
- Pressure drop was measured using a pressure column.
- Three samples from each FFR were cut and placed under the column at four flow rates, for minute each.
- Trials were performed at 0.6, 1.6, 2.6, 3.6 L/min.

Temperature:
- Temperature measurements were taken by placing a thermistor inside of a 3M 8210 and 3M 8511 FFR, which were worn for one minute each.
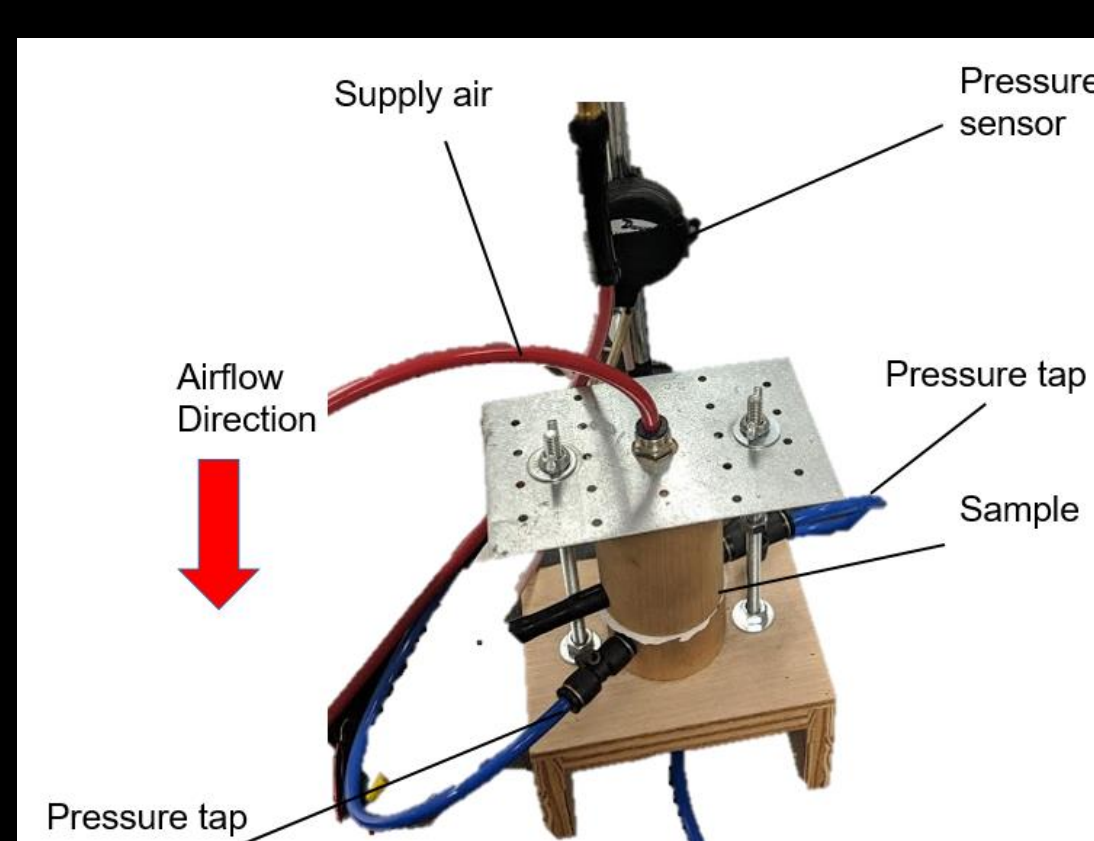
Water vapor transmission:
- Measured using a Twing-Albert EZ cup (ASTM E96).
- A sealed box with constant airflow of 10 L/min was used during one hour trials.
- The difference in sample apparatus pre- and post- weights were subtracted to determine how much water passed through the FFR sample.

Qualitative evaluation of six N95 FFRs:
- A qualitative survey was used to evaluate FFR comfort based on three questions related to (1) overall fit against the face, (2) temperature, and (3) ease of breathing using a scale from one to six (N=50).
- FFRs were worn for two minutes each with a one minute break in between FFR trials.
- A final question asked which of the first three questions was most important in terms of discomfort.
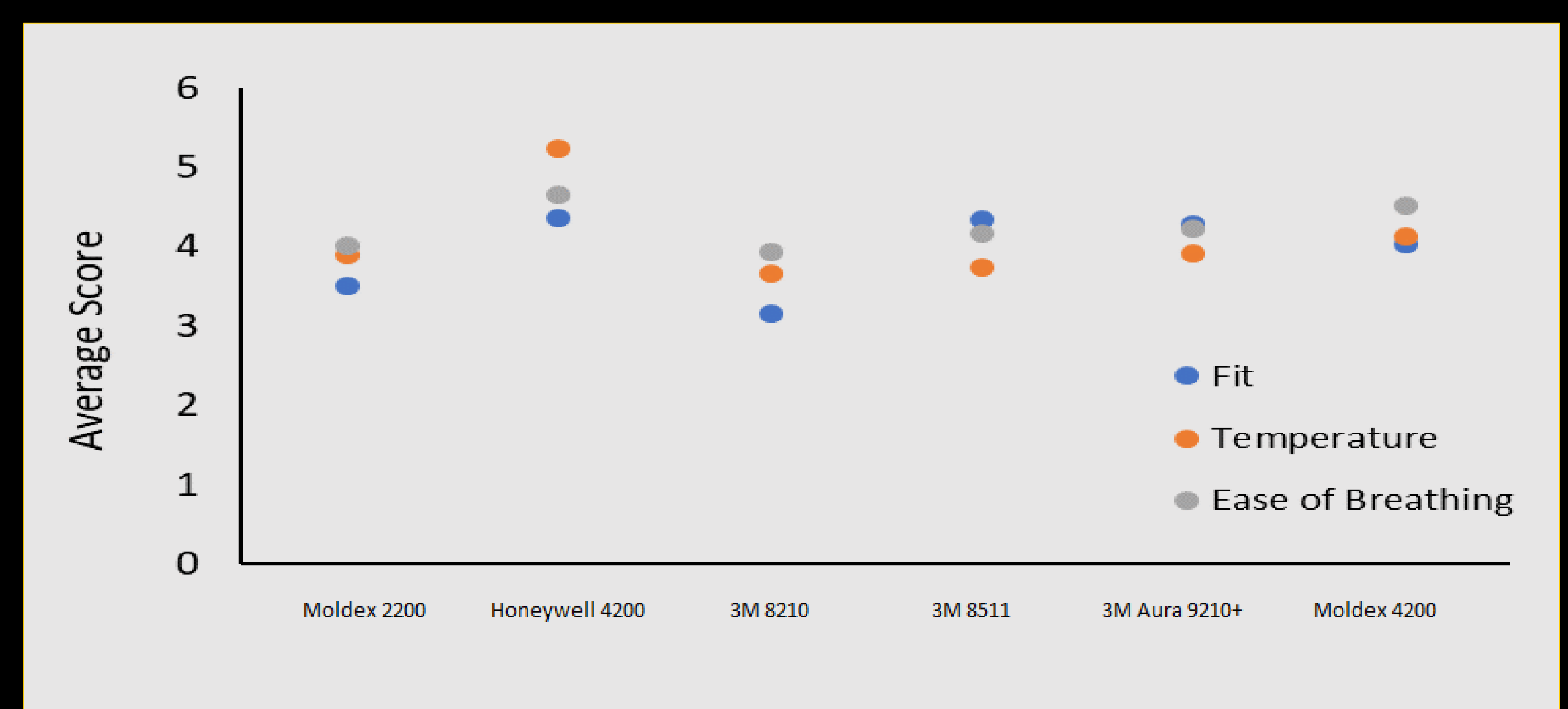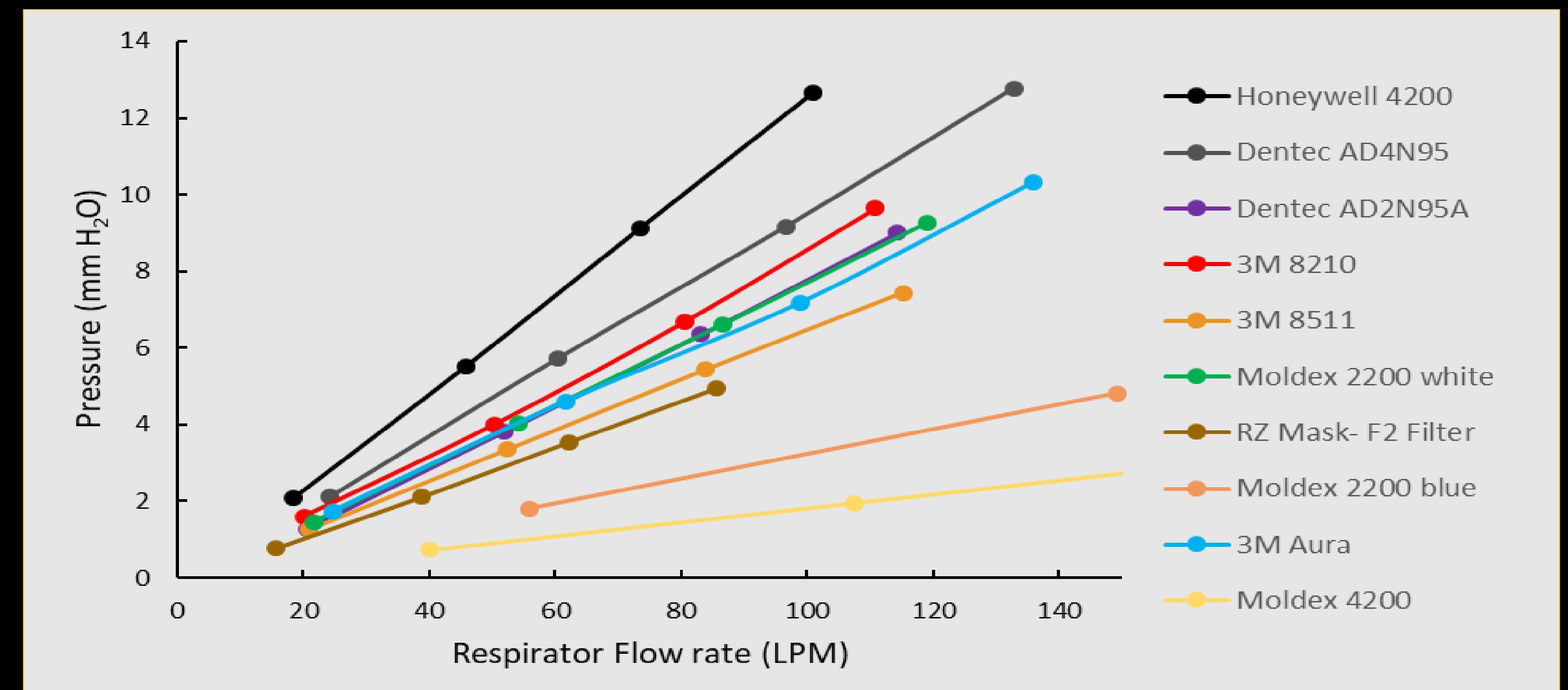
Experimental Setup

Results

Figure 1. Top graph illustrates the average pressure drop measurements from samples of ten different FFR types performed at four different flow rates. Data was corrected for differences in surface area between the N95 FFRs. Bottom graph illustrates the distribution of survey responses for question one, two, and three across six different N95 FFRs.

Brand	Water vapor transmission (g)	Surface Area (cm^2)	Total weight (g)	Pressure drop at 3.6 LPM (mm H$_2$O)
3M 8210	0.24	174.71	9.79	9.63
3M 8511	0.22	181.82	14.39	7.44
Dentec AD2N95A	0.31	180.35	10.46	9.01
Dentec AD4N95	0.28	209.42	10.25	12.77
RZ Mask- F2 filter	-	134.95	46.55	4.93
Moldex 2300	0.33	177.13	22.12	10.54
Moldex 2200	0.32	187.84	16.7	9.27
Honeywell 4200	0.38	159.39	109.41	12.66
3M Aura 9210+	0.23	214.37	9.47	10.33
Moldex 4200	0.26	313.87	14.78	4.55

	Temperature (°C)	Difference (°C)
3M 8210 (no exhalation valve)	27.86	0.59
3M 8511 (exhalation valve)	27.27	

Figure 2. Top table illustrates physical properties of ten N95 FFRs. Bottom table illustrates temperature differences between two N95 FFR's.

Statistical Analyses:
Kruskal Wallis test: P< 0.05

- Spearman correlation = 0.2 between pressure drop and ease of breathing score
- Spearman correlation = 0.6 for water vapor transmission and temperature
  - *Neither spearman correlation coefficient was statistically significant

Conclusion

- Material properties varied between FFR types. However, the extent to which participants could discern these differences were questionable under the testing conditions.
- Fit was found to be most important characteristic contributing to discomfort.

Future Work

- Evaluate new respirator designs and properties
- Determine the influence that use duration and work intensity have on comfort.

Acknowledgements & References

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4. NIOSH. National Occupational Research Agenda 1996 [Available from:https://www.cdc.gov/niosh/docs/96115/diseas.html