Assessment of a novel antimicrobial zinc ion fiber for COVID-19 prevention in nonwoven face coverings for thermal comfort impacts in healthcare settings

Meredith McQuerry, Ph.D. & Reannan Riedy, Florida State University

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Introduction: COVID-19 has made "PPE" a household name for the general population in the United States and beyond. The CDC released guidelines in 2020 recommending the use of face coverings to help slow the spread of COVID-19 (Centers for Disease Control and Prevention, 2020). These guidelines include suggestions for selecting, wearing, making, and washing masks. Per the CDC's recommendations, masks should fit snugly but comfortably against the side of the face, be secured with ties or ear loops, include multiple layers of fabric, and allow for breathing without restriction (Centers for Disease Control and Prevention, 2020). Ensuring proper fit, comfort, and breathability helps promote proper mask usage by the end user and reduces the likelihood of users touching their face or mask. The majority of the CDC's guidelines pertain to either protection or comfort. From the protection side, a novel, proprietary antimicrobial fiber technology with embedded zinc ions within the polymer matrix has demonstrated deactivation of bacteria, fungi, and viruses including SARs-CoV-2 (Beninate, 2020; Britton, 2021). Due to the use of zinc, there is no leaching or unwanted yellowing of the material as is common with the use of silver for most antimicrobial applications. The zinc ion fiber allows face coverings to remain odor and mildew resistant while fighting against common bacteria and viruses such as COVID-19, potentially reducing the burdensome health effects of wearing N95 masks or respirators (Powell, Kim, & Roberge, 2017). The thermal comfort of this material, and many other face masks, however, is often not considered and unknown (Way, Smith, Agostini, & Mitchell, 2020; Yao, Wang, Ye, Zhang, & Peng, 2019). Given the long-term wear of such face coverings, by healthcare workers and the general population, it is important the potential adoption of such a new material is assessed for its impact on wearer comfort.

Research Purpose and Method: Based on the need to assess a novel textile material for such an important end use, this study compared the thermal comfort (perceived comfort, breathability, temperature sensation, and fit) of a commercially available nonwoven surgical mask to a similar mask made of the proprietary zinc ion fiber through a human wear study. Two nonwoven face masks were assessed in a wear trial: 1) a novel zinc ion multi-layer nonwoven mask and 2) a commercially available multi-layer nonwoven mask. Ten healthy, full-time, career, male (n=9) and female (n=1) firefighters (age: 34.5 ± 4.8 years, height: 1.77 ± 0.08m, weight: 90.8 ± 18kg) were recruited to participate in this study. Prior to obtaining informed consent, all study procedures and potential risks were explained to participants verbally per Institutional Review Board (IRB) requirements. Dependent variables collected include perceived ease of mask fit, overall mask comfort, perceived facial comfort, breathability, and facial temperature sensations. Table 1 describes the ratings collected, scales used to perform the measurements, and the sampling time of the data set. Each participant performed two treadmill exercise test sessions separated by at least 24-48 hours. The order in which the participants wore each mask (zinc ion

versus control) was randomized. Proper orientation of the face masks (facing outward with pleats folded down) was ensured prior to beginning each test session. Participants then entered the environmental chamber set at 72°F and 50%RH where they sat for 5 minutes to acclimate to the environment while wearing the face mask. Participants then proceeded to begin the treadmill exercise, simulating medical task metabolic rates ("Compendium of Physical Activities," 2011) including sitting at a nurse's station, conducting in-room patient care while standing, pushing a patient in a wheelchair, and walking throughout the work place. Individual two sample T-tests, assuming equal variances, were performed at all test intervals for all five perception ratings.

Table 1. Perception ratings, rating scales, and sampling times.

Perception Rating	Rating Scale	Sample Time*
Perceived Ease of Mask Fit Rating (EMF)	Adapted (International Standards Organization, 2001)	PE & PSR
Overall Perceived Mask Comfort Rating (OMC)	Adapted (International Standards Organization, 1995)	PE & PSR
Perceived Facial Comfort Rating (FC)	Adapted from ISO 10551, 2001	PE, MTS 1-6, PSR
Perceived Breathability Rating (BRE)	Modified (Borg, 1982)	PE, MTS 1-6, PSR
Perceived Facial Temperature Rating (FTS)	Modified ISO 10551, 1995	PE, MTS 1-6, PSR

*PE = pre-exercise; immediately before the start of the exercise protocol but after the acclimation period; MTS = immediately post the medical task simulation exercise; PSR = post seated rest period.

Result and Discussion: The findings of this study indicate the control and zinc ion masks performed similarly for all subjective assessments (Table 2). Both masks either had the same, or similar ratings for the majority of the measured subjective perceptions. There were slight differences between the two masks at certain intervals, with the largest difference of 0.6 found at the beginning of the protocol for OMC and FTS, as well as after 20 mins for FTS. The novel zinc ion mask was rated as slightly cooler in the beginning of the trial (at 0.8 versus 1.3), until 35 minutes into the protocol. The differences in facial temperature were most prominent before exercise began and after 20 minutes. For FC, the maximum rating throughout the protocol for both masks were 1.6, meaning "*slightly uncomfortable to uncomfortable*." The control mask, however, reached a rating of 1.6 just 35 minutes into the protocol whereas the zinc ion mask did not reach a rating of slight discomfort until the very end of the exercise (50 minutes). This indicates the zinc ion mask is comfortable for a longer period of time compared to the control mask. Both masks were rated as easy to breathe in, indicating they both meet the CDC guidelines for breathability. Overall, the lack of significant and meaningful differences between the control mask and the novel zinc ion mask regarding subjective comfort remain important findings. These results indicate that in addition to superior protection capabilities, the zinc ion mask provides at least as much comfort as another mask on the market today, and in some cases, increases comfort for longer periods of time.

Table 2. Overall average perception ratings for the 60 minute protocol for each mask.

Perception Rating	Average Rating	
	Control Mask	Zinc Ion Mask
Ease of Fit	2.1	2.1
Overall Perceived Comfort	0.5	0.7
Facial Comfort	1.3	1.2
Breathability	10.3	10.3
Facial Temperature Sensation	2	1.8

References

Beninate, R. (2020). Cantonment based manufacturing company invents virus-killing mask. Retrieved July 14, 2020, from https://weartv.com/news/local/cantonment-based-manufacturing-company-invents-virus-killing-mask

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, *14*(5), 377–381. Retrieved from http://www.hsph.harvard.edu/nutritionsource/borg-scale/

Britton, N. (2021). Ascend Files First FDA 510(k) Submission Based on Acteev™ Technology. Retrieved January 7, 2020, from https://www.businesswire.com/news/home/20200630005878/en/Ascend-Files-First-FDA-510-k-Submission-Based-on-Acteev™-Technology

Centers for Disease Control and Prevention. (2020). Use of Masks to Help Slow the Spread of COVID-19. Retrieved April 7, 2020, from https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/diy-cloth-face-coverings.html

Compendium of Physical Activities. (2011). Retrieved January 1, 2015, from https://sites.google.com/site/compendiumofphysicalactivities/Activity-Categories/occupation

International Standards Organization. (1995). ISO 10551: 1995 Ergonomics of the thermal environment: Assessment of the influence of the thermal environment using subjective judgement scales. ISO.

International Standards Organization. (2001). ISO 10551: 2001 Ergonomics of the thermal environment: Assessment of the influence of the thermal environment using subjective judgement scales. ISO.

Powell, J. B., Kim, J. H., & Roberge, R. J. (2017). Powered air-purifying respirator use in healthcare: Effects on thermal sensations and comfort. *Journal of Occupational and Environmental Hygiene*, *14*(12), 947–954. https://doi.org/10.1080/15459624.2017.1358817

Way, H., Smith, P. B., Agostini, G., & Mitchell, J. C. (2020). A scoping review of surgical masks and N95 filtering facepiece respirators: learning from the past to guide the future of dentistry. *2Safety Science*, *131*. https://doi.org/10.1016/j.ssci.2020.104920

Yao, B. guo, Wang, Y. xiao, Ye, X. yu, Zhang, F., & Peng, Y. liang. (2019). Impact of structural features on dynamic breathing resistance of healthcare face mask. *Science of the Total Environment*, *689*, 743–753. https://doi.org/10.1016/j.scitotenv.2019.06.463