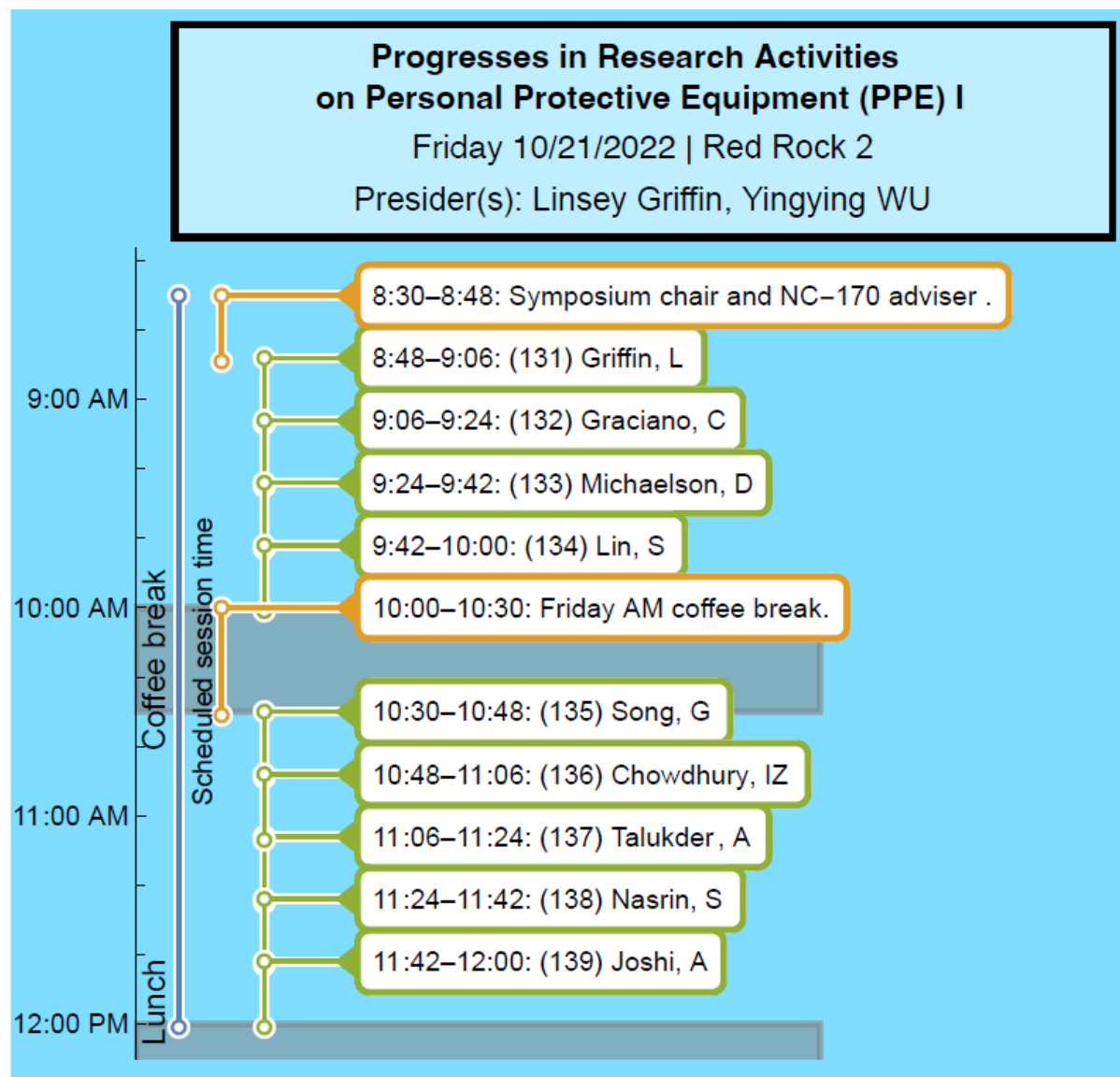


NC170: Annual Meeting in Las Vegas, NV
October 21, 2022

Chair: Chunhui Xiang
Chair Elect: Sumat Mandal
Secretary: Dawn Michaelson

Attendees: Gang Sun, Charles Freeman, Chunhui Xiang, Shu Hwa Lin, Yingying Wu, Elizabeth Bye, Sumat Mandal, Anugrah Shaw, Guowen Song, Dawn Michaelson, and Hang Liu

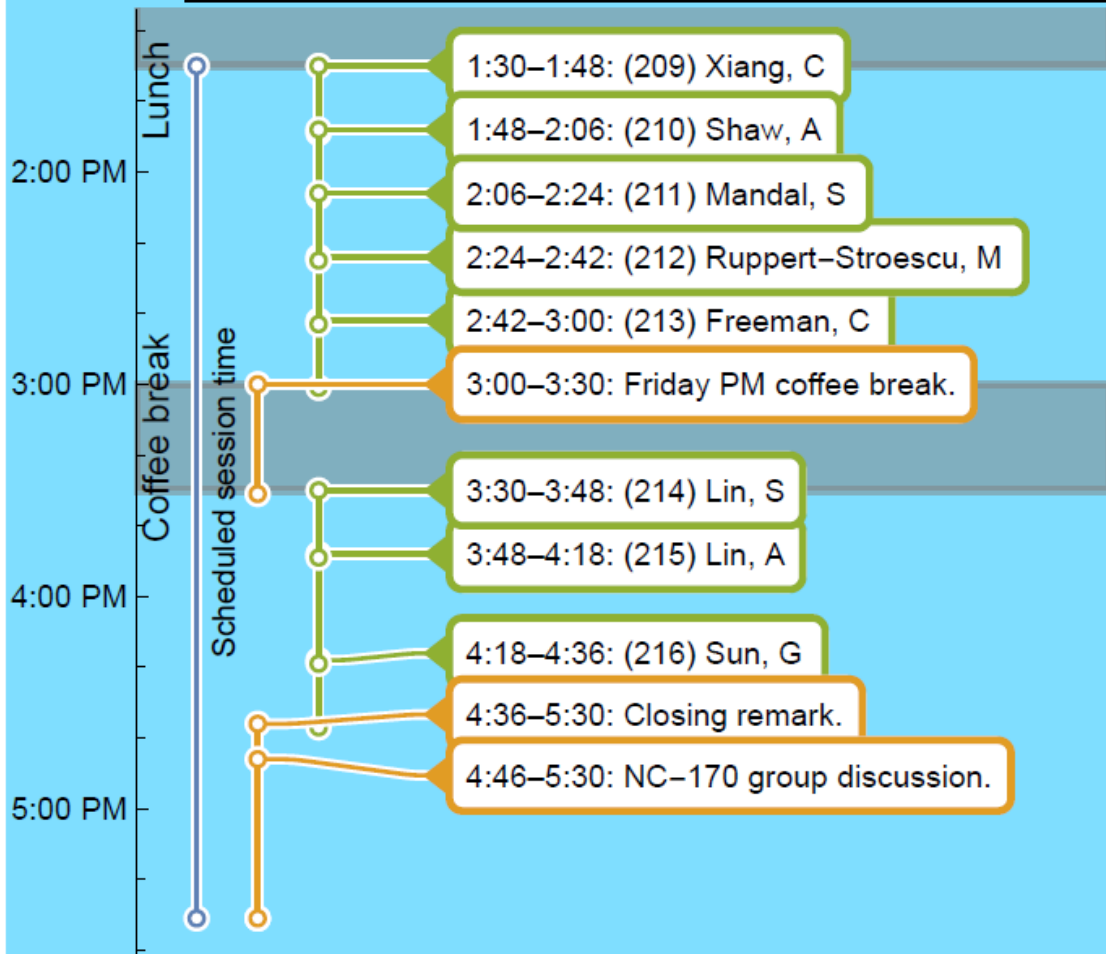
The annual meeting was held after the American Chemical Society, Western Regional Meeting, Progresses in Research Activities on Personal Protective Equipment (PPE) sessions in Las Vegas, NV. Presentations during this special topic session were mostly done by NC170 members and are shown below.



Progresses in Research Activities on Personal Protective Equipment (PPE) II

Friday 10/21/2022 | Red Rock 2

Presider(s): Guowen Song, Charles Freeman



Abstracts from Progresses in Research Activities on Personal Protective Equipment (PPE) sessions are eligible to be included in a book chapter. Gang Sun will be contacting presenters about the progression of the book after talking to the publisher.

2023 annual meeting date and location were discussed among the members in attendance. Gang Sun would like to pursue having the 2023 annual meeting at the AATCC conference on September 23, 2023. AATCC offers complimentary registration for presenters. Gang Sun will contact AATCC to see if a special session is an option. Annual meeting time needs to be scheduled for half of a day (4-hour minimum) so new proposal group work can be started.

NC170: Personal Protective Technologies for Current and Emerging Occupational and Environmental Hazards
Multistate Research Project: October 1, 2017 – September 30, 2022

Period of Report: **October 1, 2021 – September 30, 2022**

Impact Nugget

Colorado

CO (with collaborators OR, MN, KS, IA) - Firewomen experience fit challenges when selecting turnout coats and pants, leading to concerns about mobility and safety. This research builds an understanding of specific fit problems on the ability of firewomen to do their challenging work in a safe and stress-free manner. Interview and survey data collected for the manuscript pinpointed experiences with the PPE sizing processes that led to poor fit. The data also identified previously undocumented knowledge gaps between NFPA size standards, commercialized products, and processes used by manufacturers and firehouses to fit female practitioners. With effective fire industry partnerships and future research, women can experience fewer injuries, and improved comfort, and work performance with their PPE while establishing equality with their male counterparts.

Florida

Conducted nationwide three-dimensional body scanning on female firefighters in relation to the fit of their PPE to produce the largest female firefighter-specific anthropometric database to date. Evaluated auto-racing suits, a sustainable tent jacket for the homeless, and structural firefighter turnout suits on a state-of-the-art sweating thermal manikin.

Hawaii

The development of adopting VitaSigns for monitoring firefighters has resulted in the applications in the vest for firefighters and health care applications.

During the pandemic, Hawaii was experiencing the shortfall of resourcing materials and protective devices. Our goal was to provide instruction in such a way that all testing and construction could be done at home, allowing students to continue testing and making masks outside of school and opening the door for students and the community to teach others.

Kansas

During this reporting period, the K-State research group focused on the development of new firefighting Turnout coats and pants for firewomen. A new turnout coat and a new pair of turnout pants were designed and prototyped based on female firefighters' body shape. The new designs, upon validation and finalization, has great potentials for a new patent and commercialization, therefore benefiting the domestic female firefighters' onsite performance and safety to a great extent.

Maryland

Development of laboratory and field methods to measure decontamination and transfer of pesticide residues in garments worn by pesticide operators Methodology. The methodology can serve as baseline studies for future research.

Minnesota

MN has led the creation of six major 3D and 4D databases to aid in our understanding of the body-product relationship. We have collected data from over 1000 participants since 2016, utilizing hand-held, stationary, and 4D scanning systems. The landmarking, scanning, measurement, and analysis methods for each database were developed to improve the body-product relationship for specific wearable products.

MN developed a systematic process for improving the body-product relationship of mask fit. MN developed new facial anthropometry for predicting mask fit and the new measurements achieve 100% mask fit prediction accuracy for healthcare workers.

Over the last five years, MN and UO hand research has demonstrated a true need for detailed analysis of static and dynamic hand measurements. In 2019, the HDL team created a first of its kind large-scale 3D hand anthropometric database with over 800 hand scans. Exploring the application of new 3D hand data has been a top priority of the lab. We explored new technologies such as 3D simulation and digital prototyping which offer endless design opportunities for gloves and hand tools. The HDL anthropometric data and design research will inform functional glove and tool design for a range of fields and consumers.

At the beginning of the COVID-19 pandemic when traditional N95 respirators were in short supply in the United States, MN led an interdisciplinary team of experts in the development of new mask designs that use repurposed filtration media and commercially available components. Filtration efficiency test results showed that the filtration media can be used for high quality facemasks and quantitative fit testing demonstrated that the new mask designs could be viable alternatives to traditional N95 respirators. In fact, our research demonstrated that the MNmask fit performance was superior to several N95 respirators currently on the market. MN created a process for quickly manufacturing the mask designs, and manufacturing viability was tested by utilizing an unskilled workforce to create 6000 masks over 10 days during the pandemic. This research has continued to produce a far-reaching body of knowledge around mask design, face anthropometry and mask fit prediction, mask usability, and differences in mask fit for occupational and general use.

By integrating a systems approach to design, MN research has advanced our understanding and discovery of the body-product relationship, interdisciplinary mask design research, systematic causes of sizing, fit, and safety challenges with turnout gear, organizational and systems influence on the hospital gown. MN research expands the design process for human and global systems to address product inequities and industry shortcomings.

New York

Conducted nationwide three-dimensional scanning on female/male firefighters' feet in relation to the fit and comfort of their fire boots to improve sizing systems of fire boots. Developed wearable respiration and gait monitoring system by engineering stretchable fiber-optic sensors. Also developed new design, testing method and material structure to improve comfort, fit and filtration of cloth facemasks. Developed convertible jackets made of post-use tent for thermal protection for homeless. Developed methods to evaluate virtual PPE coverall fit on animated body scans. Developed methods to evaluate the fit of facemasks by using virtual prototypes.

Oklahoma

Oklahoma State University (OK State) mainly focused on developing a Textile and Apparel Science Laboratory (TASL). The purpose of this laboratory will be to analyze the protective and comfort performance of textile materials through bench-/full-scale equipment and modeling.

Oregon

The University of Oregon has been actively participating on the NC-170 project with scanning/anthropometric research, data analysis, paper writing and conference presentations.

Washington

The development of side-by-side wet-spun conductive fibers has opened up a new technology paradigm to manufacture unspinnable polymers into fibers. The strain and chemical sensors fabricated from the side-by-side conductive fibers have great potential applications in smart wearables.

New Facilities and Equipment

Oklahoma

- OK State installed and calibrated Kawabata Evaluation System, which is a series of equipment to objectively measure the mechanical properties in order to evaluate the sensorial comfort performance of fabric materials.
- OK State installed Thermal Protective Performance (TPP) Tester, Moisture Management Tester (MMT), Dry Rate (DR) Tester, and a new 3D body Scanning Equipment to evaluate the thermal protective and thermo-physiological comfort performance of the fabric materials.
- OK State installed Bioburden tester to evaluate the biological contamination on textile materials.

Oregon

- Artec 3D scanner
- Creality 3D printer
- SizeStream scanner
- Anthropometer

Florida

- New three-dimensional stationary Size Stream body scanner
- Renovations to Textile Testing Laboratory for commercial washer, dryer, and new launderometer.

Unique Project-Related Findings

Colorado

Recent activities related to this project include identifying firewomen's specific fit problems with their turnout coats and pants. These activities build an understanding of specific fit problems on the ability of firewomen to do their challenging work in a safe and stress-free manner.

WA - We have furthered our understanding of the various factors that affect the properties of side-by-side fibers. Among the factors, solution viscoelasticity difference between the two solutions plays an important role.

Florida

Current sizing standards for female firefighter PPE are not relevant to the current female firefighter population in terms of anthropometrics for both the structural and wildland fire service. A recycled tent jacket adequately insulates and provides shelter for the homeless population while reducing textile waste. The first manikin total heat loss (THL) value was established for auto-racing suits (to the authors' knowledge). An air gap ease study related to the fit of structural firefighting PPE indicates increasing ease above industry standards has detrimental effects in relation to firefighter physiological comfort.

Hawaii

HI continued the work ECG on personal use and wearable sensors for monitoring health care;

Kansas

The researchers found research focusing on fit issues amongst firefighters, particularly firewomen is limited. They also found the most of the existing brands in the current market do not use separate patterns for men and women. The novel functional designs of female specific turnout coats and pants design proposed and developed by the KS research team were tested to be in favor by female firefighters, though some minor improvements are needed.

New York

Fire boots are mostly optimized for male firefighters, even though the percentage of female firefighters has increased. A majority of female firefighters wear male fire boots due to a lack of support from both the market and fire departments, which causes an improper fit of the boots with negative impacts on their walking and safety on unfavorable fireground. This study compared the foot morphology of 74 female and 22 male firefighters through 3D scanning and analyzed foot measurements from the Size USA dataset. The analysis focused on the foot measurements in foot length between 9.5–10.75", and each measurement was normalized by foot length. T-test showed a significant difference in foot width between the female and male firefighters, and in foot width, lateral/medial ankle height, and foot girth between the sexes in the Size USA. The findings address that male fire boots can't offer an ideal fit for female firefighters.

Cloth face masks help control the spread of respiratory viruses but have not been optimized for effectiveness and reusability after repeated cleaning. Guidance specifically for cloth face coverings has recently been developed in response to Covid-19 (AATCC M14-2020 and ASTM F3502 2021). A few studies have compared types of cloth or cloth facemasks and other studies have demonstrated the effectiveness of several methods to decontaminate fabrics of bacteria and viruses, but none to date have investigated the impact of decontamination on the filtration efficiency (FE) and air permeability (AP). This study characterized a broad range of fabric types (3 knit, 7 woven, and 3 nonwoven) before and after 40 decontamination cycles by home laundry, microwave steam, or dishwasher. AP was quantified following ASTM D737, and FE was assessed using NaCl aerosol in a simulated breathing system. While most fabrics

maintained or improved their FE after 40 decontamination cycles, the AP of many fabrics decreased due to detergent buildup, fiber breakage, and structure changes. Tightly woven cotton fabrics had unacceptable AP and FE performance. Knit and nonwoven structures had the best balance of properties, and although they are not recommended for use in single-layer masks, they have potential use in multilayer masks.

Another study on cloth facemasks concentrates on optimizing aerosol capture and air permeability through fabric selection. Material choices were evaluated in two modes: Flat Filter (FF) and Head Form (HF). FF isolates material factors while HF simulates the performance of the constructed masks on a 3D printed child head form. In FF mode, higher filtration efficiency correlated to lower air permeability in both reusable commercial and experimental face masks regardless of fiber contents, fabric structures, and number of layers. Our prototype face mask developed in design exploration successfully captured $37\pm 12\%$ of $0.3\ \mu\text{m}$, $87\pm 3\%$ of $0.5\ \mu\text{m}$, and $87\pm 2\%$ of $1.0\ \mu\text{m}$ particles while maintaining good air permeability, moisture capture, and aerosolized salt capture in HF mode. Sealing masks to minimize outward leakage reduced particle capture up to 64%. Particle leakage data captured at the eye level of the head form illuminated the synergy between mask design, material choice, and fit.

Our study on the fit evaluation of digital coveralls applied a novel procedure for fit analysis. We analyzed the fit of coveralls in different poses, and evaluated the interaction between the body and garment as well as assessed the movement of ease during body movement by using a single A-pose body scan. Using virtual coveralls not only helped eliminate the process of superimposing minimally clothed and clothed bodies but also increased the accuracy of alignment. The findings from the objective measurements showed that measurements taken from the digital coveralls detected significant differences across the three different poses. The seams that were located on the digital coveralls were visible, which further helped evaluate the alignment of the coverall on body landmarks and take objective measurements. The process also helped better observe how garment ease was moving and how this affected the virtual fit.

Oklahoma

There is a requirement to include the computation modeling techniques (e.g., Artificial Neural Network, Computational Fluid Dynamics) in this field to conveniently, accurately, and economically evaluate and predict the protective and comfort performance of textiles and clothing. There is a requirement evaluate the dry rate and moisture management properties of the fabrics used in oilfield workers' clothing.

Oregon

Research continues to demonstrate there are needs to resize, fit and design PPE for women and minorities, and there are clear ways of addressing those challenges through new legislation, follow-up studies and partnerships with governing agencies and manufacturers.

Accomplishment Summaries

Objective 1

With collaborators, CO developed a manuscript from data were collected from manufacturer-provided web communications regarding sizing and fit, user surveys ($n = 74$), and 1:1 interviews ($n = 31$) with U.S. female firefighters. This manuscript specifically addresses

sizing and fitting process challenges experienced by female firefighter's. COLLABORATORS: MO, CO, MN, IA, KS, OR, GA (Brenau)

OK Partially developed TASL at OSU to evaluate the protective and comfort performance of fabrics.

NY - The study on firefighters' feet by sex and weight-bearing identified dynamic change in foot morphology that impacts comfort, fit and mobility. This data can be used to improve sizing system of fireboots for female and male firefighters.

Decontamination studies on materials used in cloth face masks quantified the impact of laundering, dishwasher cycles or microwave steam on the filtration efficiency and breathability of a range of woven, nonwoven and knit fabrics. Tightly woven cotton fabrics had unacceptably low breathability as measured by air permeability. Knit and nonwoven fabrics had the best balance of breathability and particle capture and could be suitable as layers in multilayer face masks. None of the materials tested were effective at capturing virus sized particles (0.3 μm) as a single layer filter. (Objective 1).

Objective 2

CO is currently processing body scans of female firefighters to extract body measurements. Collaborators developed the protocol for placing landmarks in the digital scan for the lower body. CO worked with KS to develop a parallel protocol for land marking the upper body. These data are landmarked and nearly ready to send off to collaborators at KS and FSU to extract measurements, develop the measurement sheet, and analyze the data.

NY - The study on facemasks developed and assessed new designs, material structure, size/fit assessment guidelines, and new realistic methods of evaluating filtration and comfort. The study on coveralls evaluated the fit of digital coveralls in static and animated poses created by 3D body scans of 35 men and women (Objectives 2 and 3).

Objective 3

WA - Met with Anugrah Shaw to discuss Washington State University's involvement in the project. Polled contacts across the U.S. and found a program that provided information regarding categorizing hand-held applications for a global operator exposure database.

MA - Develop/revise and implement research-based performance guidelines and standards for items and systems of personal protective equipment and protective clothing. Participated in Project Group for revision of the spray test used in ISO 27065. Principal Investigator, as the Convenor of ISO/TC94/SC13/WG3 on chemical protective clothing is actively involved in the revision of other PPE standards.

Objective 4

WA has developed cotton and polyacrylonitrile (PAN) based conductive fibers with intrinsically conductive polymers and fabricated both strain and chemical sensors. The sensing effects have been evaluated and the results showed promising applications for smart wearables.

MN developed a systematic process for improving the body-product relationship of mask fit. MN developed new facial anthropometry for predicting mask fit and the new measurements achieve 100% mask fit prediction accuracy for healthcare workers.

Over the last five years, MN and UO hand research has demonstrated a true need for detailed analysis of static and dynamic hand measurements. MN and UO team created a first of

its kind large-scale 3D hand anthropometric database with over 800 hand scans. Exploring the application of new 3D hand data has been a top priority of the lab. We explored new technologies such as 3D simulation and digital prototyping which offer endless design opportunities for gloves and hand tools. The MN and UO anthropometric data and design research will inform functional glove and tool design for a range of fields and consumers.

KS - The work done by KS group has been centered on objective 1 & 2. The KS group investigated factors that impact the selection, use, care and maintenance of firefighting turnout coats and pants. Three-dimensional body scans of female firefighters were analyzed to understand female fighters' body shape and size. Female firefighters' concerns and needs of PPEs were also studied using surveys and interviews. A market analysis was also performed to understand the gap between user's expectations/needs and what are available in the market. Besides, new designs of turnout coats and pants were developed based on the KS group's research, and found to be of great potential for benefitting fire women.

NY - The study on wearable respiration and gait-monitoring systems can be further developed and commercialized for remote/real-time monitoring of health conditions for first responders, and vulnerable population including children and elderly citizens. (Objective 4) The study on convertible design of survival jackets made of post-use tent offers thermal protection for homeless with minimal alteration of post-use tent. (Objective 4)

OR - The University of Oregon has been actively collaborating with other NC-170 universities (Minnesota, Cornell, Florida State, Iowa State, Kansas State and Colorado State) to analyze qualitative and quantitative data and develop peer review papers to disseminate research related to female firefighter PPE (boots, gloves, coats, and pants). University of Oregon has specifically researched footwear traction characteristics for aging users indoors and outdoors, evaluated if human perception through touch can correlate with effusivity, and developed methods to landmark, measure and analyze 3D body scans with machine learning.

HI continued the work ECG on personal use and wearable sensors for monitoring health care.

FL - The study on female firefighter anthropometrics met objective one to investigate factors that impact the selection and use of protective clothing for an underserved workplace population (female firefighters). All other projects met objective two to assess and improve the performance of PPE and protective clothing for first responders, racing athletes, and vulnerable populations.

Published Written Works

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- Galada, A. & Baytar, F., Developing a prediction model for crotch length measurement to improve bifurcated garment fit and enable mass customization (In Press). *International Journal of Clothing Science and Technology*
- Goodge, K., Maher, M., Du Puis, J., Park, H., Baytar, F., & Frey, M. (In Press). Cloth Face Mask Fit and Functionality for Children 4-6 Years Old – Part II: Materials, *Fashion and Textiles*.
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Scientific and Outreach Presentations

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- Baytar, F. & Vuruskan, A. (2021, November 3-6). *Dynamic body models and garments for apparel product development: A conceptual model*. 2021 International Textile and Apparel Association Virtual Conference.
- Baytar, F., Kim, Y., Maher, M. & Zong, W. (2021, November 3-6). *Preferences of dress design elements for mass customization targeting women in the U.S.* 2021 International Textile and Apparel Association Virtual Conference.

- Baytar, F., Kim, Y., Maher, M., Galada, A. & Devine, C. (2021, November 3-6). *Examining crotch lengths at the trochanterion plane by using 3D body scanning to suggest considerations for improving sizing of absorbent underwear panels and pads*. 2021 International Textile and Apparel Association Virtual Conference.
- Baytar, F., Maher, M. & Galada, A. (2022). Evaluating Fit by Using Animated Body Scan Avatars and Digital Coveralls. *3DBODY.TECH Conference & Expo*. [Online presentation]. Lugano, Switzerland.
- Carvalho, M., Boldt, R., Ferreira, F., Ashdown, S., Griffin, L., & Moraes, A.S. (2022). Portuguese female firefighters anthropometrics: preliminary results. Presented at *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022) and the Affiliated Conferences*, New York, NY. July 2022.
- Chowdhury, I. Z., Mandal, S., Boorady, L. M., Agnew, R. J. Real-time Investigation of the Temperature Profile of Moist Thermal Protective Textiles. *Fiber Society Spring Conference*, Leuven, Belgium, May 30-June 1, 2022.
- Chowdhury, I. Z., Mandal, S., Boorady, L. M., Agnew, R. J. Sweat drying performance of PPE fabric materials used in high-risk sectors. *American Chemical Society Western Regional Meeting, Las Vegas, USA*, October 19-22, 2022.
- Du Puis, J. L., Goodge, K., Forstenhausler, L., Maher, M., Baytar, F., Frey M., & Park, H. (2021). Cloth Face Mask Fit and Functionality for Children 4-6 years Old. *2021 Annual Conference of ITAA (International Textile and Apparel Association)*, Baltimore, MD. (Oral presentation)
- Goodge, K., & Baytar, F. (2022). Talking Heads: 3D Head Scanning to Assess the Dynamic Fit of Facemasks. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.
- Goodge, K., & Frey, M. W., (2021, November). Cloth Face Coverings: Effect of Decontamination Method on Fabric Performance [Conference Presentation]. *American Association of Textile Chemists and Colorists Textile Discovery Summit*, Durham, NC, United States.(oral presentation)
- Goodge, K., Greene, R., Frey, M.W., (2022, May). Air Permeability and Filtration of Multilayer Fabric Systems for Use in Cloth Face Masks [Conference Keynote Presentation]. *The Fiber Society Conference*, Leuven, Belgium.
- Goodge, K., Lin, A., Xiao, R., & Park, H. (2022). Evaluating the Extended Comfort of Multilayer Face Coverings. *2022 International Conference on Clothing and Textiles*, Seoul, Korea.
- Graciano, C. & Wu, Y. *Protecting Women Who Protect Us: Designing & Creating Female Firefighting Personal Protective Equipment*. Poster presentation at Kansas State University Undergraduate Research Showcase in April 20-22, 2022. Poster presentation at the College of Health and Human Sciences Research, Scholarly and Creative Activities, and Design (RSCAD) Forum, Kansas State University Undergraduate Research, April 13-14, 2022. Best Creative Display Poster Award.
- Griffin, L., Savateev, E. ^G, Seifert, E. ^G, & Yu, M. ^G (2022). Functional Anthropometric Differences of the lower body for aging women based on body shape and size. Presented at *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022) and the Affiliated Conferences*, New York, NY. July 2022.
- Griffin, L., Yu, M. ^G, Cloet, A. ^G, Arnold, S., Carlson, N., & Durfee, W. (2022). Mask design implications based on mask fit and performance across different age groups (presentation)

- only). Presented at *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022) and the Affiliated Conferences*, New York, NY. July 2022.
- Hillaire, J. & Baytar, F, (2022). All 3D Garment Design and Development Processes for 3D Weaving. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.
- Jo, J. & Baytar, F, (2022). Generative Pants Pattern Making for Optimized Fit in Mass Customization. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.
- Jo, J., & Park, H. (2022). Machine Embroidery Enclosure for Stretchable Fiber Optic Respiration Sensor. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.
- Jo, J., Zhang, Z., Griffin, L., Sokolowski, S., McQuerry, M., & Park, H. (November 2021). Differences in foot measurement between female and male firefighters. *2021 International Textile and Apparel Association Conference*. [virtual due to COVID]
- Jo, J., Zhang, Z., Griffin, L., Sokolowski, S., McQuerry, M., & Park, H. (November 2021). Differences in foot measurement between female and male firefighters. *2021 International Textile and Apparel Association Conference*. [virtual due to COVID]
- Kim, Y. & Baytar, F. (2021, November 3-6). *Compressive sportswear for strength training of consumers in the U.S.: Wear experience comparisons between men and women*. 2021 International Textile and Apparel Association Virtual Conference.
- Lin, S., & Robison, E. (2021). Exploring mask design process for the COVID-19 Pandemic, *International Textile and Apparel Association International Virtual Annual Conference*.
- Lin, S., & Robison, E. (2021). Mask instruction for the COVID-19 Pandemic: Testing, evaluation & construction plus community sharing; *International Textile and Apparel Association International Virtual Annual Conference*.
- Maher, M. & Baytar, F, (2022). Associations between Body Measurements, Age, and BMI to Determine Female Body Asymmetry. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.
- Maher, M., Goodge, K., Du Puis, J. L., Fey, M., Park, H., & Baytar, F. (2022). Cloth Face Mask Fit and Function for Children: Sizing and Fit Analysis. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*, Denver, CO.
- Mandal, S., Batcheller, J., Song, G., & Grover, I. B. Modeling of hot water immersion and compression performance of fabrics used in firefighters' clothing. *Fiber Society Spring Conference*, Leuven, Belgium, May 30-June 1, 2022.
- Mandal, S., Chowdhury, I. Z., Boorady, L. M., Agnew, R. J. Real-time investigation of the temperature profile of moist thermal protective textiles. *American Chemical Society Western Regional Meeting, Las Vegas, USA, October 19-22, 2022*.
- Mandal, S., Chowdhury, I. Z., Song, G., Agnew, R. J. Evaluation of thermal protective performance of single-layered fabrics used in high-risk sector workers' protective clothing. *International Textile and Apparel Association (ITAA) Annual Conference*, Colorado, USA, October 26-29, 2022.
- Mandal, S., Song, G., Chowdhury, I. Z. Characterizing steam protective performance of fabric materials. *4th Virtual Congress on Materials Science and Engineering*, Mar. 28-31, 2022.
- Mazumder, N., Mandal, S., Agnew, R. J., Petrova, A., Boorady, L. M., & Song, G. Characterizing the tensile strength of the fabrics materials under radiant heat exposure.

- Materials 2022- 3rd International Conference on Materials Science & Engineering*, Boston, MA, USA, April 18-20, 2022.
- McQuerry, M. & Dodson, A. (February 2022). Physiological comfort of first responders when wearing a novel zinc ion face covering for COVID-19 prevention. *University of Florida Clinical and Translational Science Institute 2022 COVID-19 Research Symposium*. [virtual due to COVID]
- McQuerry, M. & Kwon, C. (2022). Investigation of design, comfort, and mobility issues for female firefighter personal protective clothing. *National Fire Protection Association, Fire Protection Research Foundation, Technical Panel*. (presented virtually).
- McQuerry, M. & Kwon, C. (2022). The future of women's gear: a comparison of NFPA 1971 and 1977 sizing standards to U.S. female firefighter anthropometrics. *National Fire Protection Association, Fire Protection Research Foundation, 2022 Webinar Series*. (virtual webinar).
- McQuerry, M. (2022). Equitable Sizing Standards for Female Firefighter PPE. *Centers for Disease Control (CDC), National Institute for Occupational Safety and Health (NIOSH), National Personal Protective Technology Laboratory (NPPTL), Equitable Personal Protective Equipment (PPE) Protections Workshop*. Invited Presenter/Panelist, (virtual).
- McQuerry, M. (November 2021). Assessment of a novel antimicrobial zinc ion fiber for COVID-19 prevention in nonwoven face coverings for thermal comfort impacts in healthcare settings. *2021 International Textile and Apparel Association Conference*.
- Nasrin, S., Mandal, S., Boorady, L. M., Petrova, A., & Agnew, R. J. Characterizing the effect of fabric properties on drying performance in sportswear. *International Textile and Apparel Association (ITAA) Annual Conference*, Colorado, USA, October 26-29, 2022.
- Nasrin, S., Mandal, S., Petrova, A., Boorady, L. M., & Agnew, R. J. Analysing the effects of fabric properties on drying performance in sportswear. *Fiber Society Spring Conference*, Leuven, Belgium, May 30-June 1, 2022.
- Nasrin, S., Mandal, S., Petrova, A., Boorady, L. M., Agnew, R. J. Investigation of fabric properties on drying performance of knitted sportswear fabrics. *American Chemical Society Western Regional Meeting, Las Vegas, USA, October 19-22, 2022*.
- Norris, H., & Park, H. (2022). Reflective Material as Thermal Control in Cycling Jerseys. *2022 Annual Conference of ITAA (International Textile and Apparel Association)*, Denver, CO.
- Riedy, R. & McQuerry, M. (accepted for presentation October 2022). Analyzing the heat loss of motorsports racing suits. *International Textile and Apparel Association Conference*. Denver, CO.
- Shu-hwa, L., Boorady, L. M., Mandal, S. Evaluation of thermal protective performance of single-layered fabrics used in high-risk sector workers' protective clothing. *American Chemical Society Western Regional Meeting, Las Vegas, USA, October 19-22, 2022*.
- Sokolowski, S. & Karolidis, E. (2022, September). Development of Thermal Effusivity + Human Perception Thermal Spectrums for the Sports Apparel Industry. *CTherm Virtual Presentation*, September 28, 2022.
- Sokolowski, S. L. & Mark, S. (2022, May). Always Searching for the Best Fit for Everyone with Top Product Designer, Dr. Susan Sokolowski.
<https://open.spotify.com/episode/5vDvIglCTX9gj0RtrwtoDn>

- Sokolowski, S. L. & Searcy, J. A. (2021, October). 3D Scanning + Machine Learning to Improve Human Performance. *University of Oregon Wu Tsai Alliance Virtual Presentation*, October 15th, 2021.
- Sokolowski, S. L. & Zou. (2021, November). Workflow Analysis to Understand Ease of Importing, Stitching and Dressing Existing N95 Mask Patterns with Current 3D Apparel Modeling Software Programs for Sizing and Fit. *International Textile and Apparel Association Virtual Conference Presentation*, November 3-6, 2021.
- Sokolowski, S. L. (2021, November). Where Anthropometry + Product Design + Data Science Merge to Improve Human Performance. *Third Annual Oregon Bioengineering Symposium Presentation*, Oregon Health and Science University, Portland, Oregon, November 12, 2021
- Sokolowski, S. L. (2021, November). Where anthropometry + Runner Experiences + Machine Learning Merge to Improve Human Performance. *Wu Tsai Alliance Virtual Presentation*, November 2nd, 2021.
- Sokolowski, S. L. (2022, June). Science + Product Design: How Research Can Help Inform Better Performing Products. *University of Oregon Research Compliance Services (RCS) Virtual Presentation*, June 7, 2022.
- Sokolowski, S. L., & Bettencourt, C. (2022, July). Understanding Footwear Traction Performance to Reduce the Risk of Outdoor Falls and Improve Mobility for the Aging Population. *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022)*, Manhattan, New York, July 28, 2022.
- Sokolowski, S. L., Searcy, J. A., Calabrese, D., and Zou, Y. (2021, October). Exemplar 3D Faces and N95 Pleated Mask Measurement Comparison by Sex and Race. *12th International Conference and Exhibition on 3D Body Scanning and Processing Technologies Paper Presentation*, Lugano, Switzerland, October 19-20, 2021.
- Sokolowski, S. L., Zou, Y. & Searcy, J., (2021, November). Workflow Analysis to Understand Ease of Preparation and Importation of 3D Exemplar Head Scan Data to 3D Modeling Software Programs for N95 Mask Sizing and Fit, *International Textile and Apparel Association Annual Virtual Conference Presentation*, November 3-6, 2021.
- Sokolowski, S., Marks, M., Park, H., Griffin, L., & McQuerry, M., (July 2022). Visual, volumetric and anthropometric measurements comparisons between boot interior and 3D foot scans to improve firefighters safety. *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022)*. Manhattan, New York.
- Sokolowski, S., Park, H., Griffin, L., & McQuerry, M. & Tuttle, J. (2022, July). Visual, volumetric, and anthropometric measurements comparisons between boot interior and 3D foot scans to improve firefighters safety. *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022)*, Manhattan, New York, July 28, 2022.
- Sokolowski, S.L., Karolidis, E., Hakimian, A., Ackermann, S. (2022, February). Measuring Cool Touch of Key Sports Performance Apparel T-Shirt Materials Using a Modified Transient Plane Source (MTPS) Sensor to Inform Future Technology Development. *The Minerals, Metals & Materials Conference*, Anaheim, California, February 27–March 3, 2022.
- Yang, Y. & Baytar, F. (2022). An Improved "Team Mental Model" as an Assessment Tool for Group Decision-making during Fit Sessions, *2022 Annual Conference of ITAA (International Textile and Apparel Association)*. Denver, CO.

Yu, M. ^G & *Griffin, L. (2022). Evaluation of face anthropometry for mask design. Presented at *13th International Conference on Applied Human Factors and Ergonomics (AHFE 2022) and the Affiliated Conferences*, New York, NY. July 2022.

Zong, W., Elangovan, T., McQuerry, M., Poley-Bogan M., Simonson, N., & Park, H. (accepted for presentation October 2022). Recycled tent converted to a survival jacket for homeless people. *International Textile and Apparel Association Conference*. Denver, CO.

Funds Leveraged

CAREER: Processing Intrinsically Conductive Polymers for Fibers via Side-by-Side Spinning”, NSF, 3/2022 – 2/2027; PI: Liu, H.

Carter, Heather, & Sumit Mandal, Living well through cotton, Cotton Incorporated, USA, \$29,930, 2022

Cockpit Monitoring of Pilot Muscle Tension, Heart Rate and Respiration, PIs: Organic Robotics Corp. Inc. & Park, H., Source of Funds: US Air Force, Amount Funded: \$749,914 (Award to Park: \$225,006), Period: April 2022 – March 2023

Development of protective coveralls for female farmworkers to use before, during, and after pregnancy, PI: Baytar, F, Source of Funds: National Institute of Food and Agriculture, USDA, Amount Funded: \$90,000.

Footwear Enhanced for All-Threats, PIs: Jeffrey Stull, International Personnel Protection, & Park, H., Gait-Monitoring Fiber Optic Shoe Insole, PI: Park, H. & Jo, J., Source of Funds: Cornell Technology for Licensing IGNITE Research Acceleration, Amount Funded: \$25,000, Period: September, 2021 – August, 2022

Graciano, C. & Wu, Y. Protecting Women Who Protect Us: Designing & Creating Female Firefighting Personal Protective Equipment. Undergraduate Research Award from *the Office of Undergraduate Research & Creative Inquiry*, Kansas State University, Manhattan, KS, United States. \$500.

Griffin, L. (2022-2025) 3D Anthropometric Head Assessment and Respirator Design. *Agriculture Experiment Station, College of Design, University of Minnesota*. Supports partial salary and graduate research assistant each year. AES awards are awarded through a competitive process within the College of Design following a proposal review of a peer committee and external reviewers. Equivalent Amount: \$120,000.

Griffin, L. (2022-2023) Dynamic 3D Hand Anthropometry and Assessment for Manufacturing Spaces. *Toyota Motor Corporation*. Amount: \$108,764.

Griffin, L. (2022-2023). Pilot Study to Develop Customized Pediatric Respiratory Masks. *Imagine Fund, University of MN*. Amount: \$5,000 + match by the department for 25% graduate assistant.

Griffin, L. (2022-2024) Co-Principal & Design Systems and Circular Economies Research. *Kusske Design Initiative, College of Design, University of Minnesota Foundation*. Supports partial salary, summer research, and graduate research assistants each year. KDI co-principal awards are faculty awards given through a competitive process in the College of Design following a proposal review by the Senior Leadership Group. Equivalent Amount: \$200,000.

Griffin, L., Durfee, W., Hillmyer, M., Franklin, R., Pui, D., & Arnold, S. (2020-2022). MNmask: A Novel Method for Respirator Alternatives, *Office of Discovery and Translation, University of Minnesota*. \$50,000.

Griffin, L., Durfee, W., Hillmyer, M., Franklin, R., Pui, D., & Arnold, S. (2020-2022), MNmask: A Novel Method for Respirator Alternatives, *University of MN Foundation: Cummins International*. \$50,000.

Hallinan, D., McQuerry, M., & Dickens, T. (2021). Acquisition of a versatile thermal conductivity measurement instrument. *Equipment and Infrastructure Enhancement Grant, Florida State University*. (\$51,939).

Hebert, Paulette & Sumit Mandal, Textile & Environment: Light, Surface & Air, OSU College of Human Sciences Technology Seed Funding, \$8,832, 2022

McQuerry, M. (2021) Acquisition of Textile Testing Equipment and Lab Renovations. *Florida State University, Office of the Provost*. (\$80,000).

McQuerry, M. (PI) & Kwon, C. (Co-PI). (9/18/2019-9/17/2021). Investigation of design, comfort, and mobility issues for female firefighter personal protective clothing. *Department of Homeland Security (DHS), Federal Emergency Management Agency (FEMA), FY 2018 Assistance to Firefighters Grant Program*. (\$403,632).

McQuerry, M. (PI) & Ormsbee, M. (Co-PI). (02/2018-12/2022). Physiological comfort assessment of a novel lightweight turnout composite. *Fire-Dex Firefighter Research Grant Program*. RF02919. (\$149,964).

McQuerry, M., Schofield, S., & Ormsbee, M. (01/2019-07/2022). Development of a new turnout suit design for reduced heat stress and physiological strain. *Fire-Dex Firefighter Research Grant Program*. RF03023. (\$145,723).

Okronipa, Harriet & Sumit Mandal, Funding Application to Purchase PrismGraphPad, OSU College of Human Sciences Technology Seed Funding, \$3,774, 2022

Ridgway, J. and McQuerry, M. (2021). Body scanning technology: a changing retail environment calls for innovative approaches to product development and in-store experiences. *Student Technology Fees Grant, Florida State University*. (\$28,350).

Smart Firegear Development Research with STEM Education Outreach Component for 4H groups, PIs: Park, H & Fran Kozen, Source of Funds: National Institute of Food and Agriculture,

USDA, Amount Funded: \$156,966 (Park's portion: \$89,500), Period: October, 2022 – September, 2025

Sumit Mandal, Article Processing Charge (APC) for characterizing the tensile Strength of the fabric materials used in firefighters' protective clothing under radiant heat exposure, MDPI Publisher, Switzerland, \$2,338, (In-Kind) 2022

Sumit Mandal, Article Processing Charge (APC) for characterizing steam penetration through thermal protective fabric materials, MDPI Publisher, Switzerland, \$1,062, (In-Kind), 2022

Sumit Mandal, Evaluation of the Efficacy of Ozone Treatment on Firefighter Turnout Gear for the Decontamination of Polycyclic Aromatic Hydrocarbons (PAH) – Phase 1, Small Scale Testing, Sani Sport/Sani DefenX, \$15,690, 2022

Sumit Mandal, (Collaborators: Dr. Paulette Hebert, Dr. Adriana Petrova), Predicting the Apparent Color of Carpets under Different Light Sources, OSU Humanities, Arts, and Design (HAD) Research Grants, USA, \$10,000, 2022

Sumit Mandal, Dr. Paulette Hebert, Dr. Semra Peksoz (2022) Funding Application to Purchase Fabric Air Permeability Testing Equipment, OSU College of Human Sciences Technology Seed Funding, \$16,659

Sumit Mandal, Funding Application for NFPA Certified Fire-Resistant Fabrics, MSA Globe, USA \$22,000 (in-kind), 2022

University of Oregon Faculty Grant, Data Science Seed Fund, University of Oregon, Wu Tsai Alliance, Innovation Hub Award

Wu, Y. (PI), Anthropometric Study of Firefighters: Male and Female Full Body, Hands, and Feet., 2018-2027, *National Institute of Food and Agriculture*, \$7,500 -10,000 per year.