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Perception of Firefighters' Turnout Ensemble and Level of Satisfaction by Body Movement

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Firefighting is a dangerous occupation involving numerous intense physical activities in hazardous environmental conditions (Coca, Williams, Roberge, & Powell, 2010). Considering that the personal protective equipment (PPE) is the main protection for firefighters working in hazardous environments without any other type of protection available, wearing properly fitting PPE is critical not only to firefighters' safety but also to their occupational performance. Furthermore, a review of the literature identified an increase in the number of female firefighters in the USA; increased from 3% in 2006 to 4.5% in 2012 (U.S. Bureau of Labor Statistics, 2006, 2012). Considering the gradually growing female population in the fire service, it is important to understand the differences in perception related to the performance of women's gear, as well as further needs for improvement between male and female protective gear. This information may be used to improve the design of PPE systems in a way that considers the different anatomical and physical characteristics of male and female firefighters. Therefore, the purpose of this study is to investigate the perception of firefighters' turnout ensembles and the level of satisfaction during each body movement in job related tasks using a large sample. The type of commitment (career vs. volunteer) and gender-specific fit issues were examined by exploring user input and perceptions and using a questionnaire that included open-ended questions, which allowed for both quantitative and qualitative analysis.

First, an interview with five firefighters at a fire department in the eastern part of the USA about firefighters' job-related body motions that affect their interaction with the turnout gear was conducted to develop questionnaire. The job-related motions identified were categorized into five types of activity: walking, bending, reaching overhead, carrying equipment, and extreme limb movement. Extreme limb movement included stair climbing, ladder operation, crawling, and duck walking, in which firefighters crouch low but with their knees off the floor. The ensuing surveys were created using the online survey website, Qualtrics.com, and revised to improve the clarity and validity of the questions after a pilot test with five firefighters from the same fire department. The questions for the final online survey included 22 questions about demographic information (age, gender, ethnicity, height, and weight), commitment to fire service (years of experience and type of commitment; volunteer vs. career), perceived importance of the fit of the turnout ensemble, and satisfaction with the turnout ensemble in major job-related body movements on a 5-point Likert scale (1 = very dissatisfied; 5 = very satisfied). A figure indicating 14 aspects of the turnout ensemble was presented to the participants with the questions so that they could point out the areas of discomfort and restriction. In addition, each question with a text entry about the fit satisfaction of each area of the turnout ensemble allowed

respondents to comment on their perceived reason for discomfort or dissatisfaction. Finally, suggestions for design improvements were solicited from respondents in open-ended questions.

A total of 516 firefighters completed the survey. Overall, approximately 40% of the participants were male and 60% were female. Approximately 85% of the respondents were Caucasian American. The average age of the male respondents was 44.5 years ( $SD = 11.0$ ) and the female respondent was 39.2 years ( $SD = 9.2$ ). One way ANOVA statistical analysis discovered significant gender differences in firefighters' perception of the fit and functionality of the turnout ensemble in multiple areas in relation to job-related tasks. Overall, both male and female firefighters indicated the lowest satisfaction with the turnout coat while moving actively, as compared to simple walking. Female participants had a significantly lower satisfaction score than males with the fit and functionality in all 14 areas of the turnout coat (coat length, chest, sleeve length, armhole, sleeve fit, shoulder, neckline, coat pockets, pants length, leg fit, crotch, hip, waist, and cargo pockets). Common fit issues such as a stiff or oversized neckline and inappropriate location of knee pads, too low and bulky crotch, tightness in the lower pants leg, and inaccessibility of pockets that affect male and female firefighters are addressed. Volunteer firefighters showed relatively lower satisfaction with their turnout ensemble than career firefighters in shoulder fit ( $F = 4.744$ ;  $p = .03$ ), sleeve length ( $F = 8.634$ ;  $p = .004$ ), armhole ( $F = 5.742$ ;  $p = .017$ ), and pants length ( $F = 5.569$ ;  $p = .019$ ) during extreme limb movements. Firefighters' responses to open-ended questions about 'constructive user input for improved fire gear design' identified their perceptions about (1) the need for custom-fitted turnout ensembles and (2) the need for changes in design for female firefighters.

The findings of the current study suggest that female firefighters' lower satisfaction with their turnout ensemble compared to that of their male colleagues may be attributed to the use of turnout ensembles designed for the male body. This male-centered design approach produces a typical ill-fitting turnout ensemble for female firefighters, with an oversized neckline and shoulders, a coat length that is too long, sleeves that are too long and wide, and a tight fit at the chest and hips. A lower level of fit satisfaction in volunteer firefighters than in career firefighters may be attributed to limited access/availability of the resources or the supply system that volunteer firefighters have. This study also suggests that designers need to consider anthropometric data and human factors to provide improved sizing and fit of firefighters' turnout ensembles. Further specific suggestions for design improvements are discussed in the conclusion.

#### References:

- Coca, A., Williams, W. J., Roberge, R. J., & Powell, J. B. (2010). Effects of fire fighter protective ensembles on mobility and performance. *Applied Ergonomics*, 41(4), 636–641.
- U.S. Bureau of Labor Statistics. (2006 & 2012). Occupational outlook handbook. Retrieved from <http://www.bls.gov>