

Francisco Rebelo
Marcelo Soares *Editors*

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Editors

Francisco Rebelo
Faculdade de Arquitetura
Universidade de Lisboa
Lisbon, Portugal

Marcelo Soares
School of Design
Hunan University
Changsha, China

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A Gender Comparison of Portuguese Firefighters' Perceptions Concerning Personal Protective Equipment: Results from a Pilot Study

Anna S. P. Moraes¹(✉), Miguel A. F. Carvalho¹, Rachel S. Boldt¹,
Fernando B. N. Ferreira¹, Susan P. Ashdown², and Linsey Griffin³

¹ Department of Textile Engineering, University of Minho,
Campus Azurém, Guimarães, Portugal
sophiapiacenza@gmail.com

² Department of Textiles and Apparel, Cornell University, Ithaca, USA

³ Department of Design, Housing, and Apparel, University of Minnesota,
Minneapolis, USA

Abstract. Over the years, the nature of firefighting and the role of firefighters has evolved including a demographic change, with an increasing number of women in this profession. Recent studies have specifically addressed the particular needs of female firefighters. Ill-fitting turnout gear, protective gloves, and other personal protective equipment make female firefighters' tasks not only uncomfortable but also more difficult and dangerous. A pilot study comprising both male and female firefighters from a fire brigade located in the North of Portugal was conducted. The goal was to investigate the fit of the Portuguese firefighters' personal protective equipment, its level of adjustment to their anthropometrics and to identify areas that need improvement. This paper focuses on gender differences and presents the preliminary results regarding size selection and purchasing of protective clothing as well as the level of protection experienced among participants.

Keywords: Female firefighters · Fit and Size · Human Factors and Ergonomics · Protection level

1 Introduction

Over the years, the nature of firefighting and the role of firefighters has evolved [1, 2]. Though challenging, firefighting continues to be necessary and critical [3] and is considered one of the most dangerous, arduous, and physically demanding occupations [4–6]. Firefighters' personal protective equipment¹ has been designed to provide protection against multiple hazards [7] and has changed greatly from the equipment worn in the past [1]. Despite the advances in materials technology, many studies have shown several issues regarding the effective use of firefighters' personal protective equipment

¹ In general, includes a turnout gear (coat and pants), helmet, hood, gloves, boots, and a self-contained breathing apparatus.

(PPE), including issues with comfort, fit, sizing, mobility restriction, bulkiness as well as maintenance and cleaning aspects [4, 7].

Furthermore, we can highlight a demographic change in firefighting, with an increasing number of women in this profession. According to the National Fire Protection Association, the number of women serving as firefighters in the United States has increased over the years. Recent data report a total of 13,400 female career firefighters and 64,500 female volunteer firefighters² in the country [8]. In Portugal, it is possible to identify a similar trend. In 2018, 18.64% of Portuguese firefighters³ were women, with a total of 5,155 female firefighters [9].

This demographic change has been encouraging studies that specifically address the particular difficulties and needs of female firefighters. The fit of PPE appears in most of these studies as a common dissatisfaction among female participants. In a report on women in firefighting [11], “encountering problems with ill-fitting equipment” was evaluated with the highest rate of discrimination or harassment issues experienced. As stated by Boorady *et al.* [10], female firefighters commonly wear equipment designed and sized for men, in general, incorrectly sized and ill-fitted, affecting both job satisfaction and job performance. According to another study, ill-fitting PPE is a physical stressor for female firefighters [12]. Results of the Park & Langseth-Schmidt study [13] showed significantly lower survey ratings on overall satisfaction, perceived comfort, and performance of the turnout pants among women. Moreover, these issues are considered big threats to safety, increasing the risk of injury among female firefighters [14].

1.1 Portuguese Firefighters' PPE Study

In order to understand if the Portuguese firefighters' PPE is adjusted to their anthropometrics and determine areas needing improvement, an on-going study designated as *SizeFF Portugal – Anthropometric Study of Firefighters* is being developed by the 2C2T – Centre for Textile Science and Technology, in the Department of Textile Engineering at the University of Minho, in partnership with a U.S. study. In order to validate the study methods and tools as well as obtain the first insights from firefighters' experiences concerning their PPE, a pilot study was conducted in a fire brigade located in the North of Portugal. Preliminary results regarding fire gloves⁴, turnout coat and pants⁵, and fire boots⁶ were presented elsewhere. This paper presents

² Corresponding to 3.6% of total career firefighters and 9.4% of total volunteer firefighters.

³ Including both career and volunteer.

⁴ Moraes, A., Boldt, R., Carvalho, M., Ferreira, F. Portuguese firefighters' perceptions concerning protective gloves. In: Proceedings of AUTEK 2019 – 19th World Textile Conference. 11–19 June 2019, Ghent, Belgium (2019).

⁵ Moraes, A.S.P., Boldts, R.S., Ferreira, F.N., Carvalho, M.A.F., Ashdown, S.P. Assessment of Portuguese firefighters' needs: preliminary results of a pilot study. In: F. Rebelo and M.M. Soares (Eds). *Advances in Ergonomics in Design*. 721–732 (2020).

⁶ Moraes, A.S.P., Boldt, R.S., Carvalho, M.A., Ferreira, F.N., Ashdown, S.P., Griffin, L. Portuguese firefighters' boots: obtaining user input for an ergonomic redesign. *Journal of Textile Engineering & Fashion Technology*. 6(1), 1–7 (2020).

the preliminary results of gender differences concerning the purchasing, size selection, and protection level provided by turnout coats and pants as reported by the pilot study participants.

2 Material and Methods

For data collection, an online survey and an in-person semi-structured interview were administered. Participants were requested to answer the questions based on their perceptions and personal experience when selecting and wearing specific equipment for structural fires.

2.1 Online Survey

The survey was applied using an online platform⁷ and comprised 87 questions, divided into five parts. The first part included 11 socio-demographic questions including gender, age, race and ethnicity, firefighting status (type of commitment, experience, types of firefighting missions), and municipality identification questions (city and state, number of inhabitants, type of environment protected by the fire brigade). The following 4 parts included questions about specific personal protective items⁸ and focused on 4 topics: (i) brand, style, gender, and size identification; (ii) purchasing and selection process; (iii) equipment length of service, level of protection, injuries; and (iv) fit issues related to specific areas of personal protective items.

2.2 Semi-structured Interview

The semi-structured interview questions were initially formulated based on results from similar studies [2, 4, 10]. Throughout the pilot study, additional questions were included in the interview, as the participants shared their perceptions and mentioned other items or issues not previously considered.

2.3 Data Collection Protocol

After obtaining permission from the fire brigade's chief in command, all firefighters of the brigade were invited to participate. Once the consent of participants was obtained, a unique identifying number was assigned to each participant to protect privacy and maintain confidentiality.

A researcher was available throughout data collection to assist in filling out the survey, administer the interview questions, answer any questions participants may have had, as well as address additional questions when responses required further information and clarification.

⁷ Qualtrics Survey Platform.

⁸ Including turnout coat, turnout pants, fire boots, and fire gloves.

The survey/interviews were audio-recorded and further verbatim transcribed for the sake of data analysis accuracy. Data were collected from December 2018 to September 2019, and each interview/survey took approximately 40 min to be completed. Data were organized by classifying the most common issues and areas needing improvement identified by the participants.

3 Results and Discussion

Preliminary results of the pilot study are presented as follows. Gender differences regarding the purchasing process, difficulties in selecting the turnout coat and pants size, as well as the protection level experienced are discussed.

3.1 Demographic Information

The fire brigade comprises about 140 firefighters, including about 45 firefighters that are both career-volunteer⁹ personnel and about 95 only volunteer personnel. The brigade serves a medium-size municipality¹⁰, covering urban and suburban populations, as well as the wildland environment surrounding the city.

Forty-nine firefighters participated in the pilot study. Most participants were men, corresponding to 73.47% (n = 36), and 26.53% (n = 13) of the participants were women. Regarding their type of commitment, 26 male and 5 female participants were career-volunteer (63.27% in total), 9 male and 6 female participants were only volunteer firefighters (30.61% in total) and 2 female participants were trainees (4.08% in total). The assistant chief responsible for the brigade also participated in the study. The average age of the respondents was 40 among male participants and 30 among female participants. Firefighting experience was significantly different between gender, varying from 6.10 years for female participants to 18.69 years for male participants. Socio-demographic information is summarized in Table 1.

⁹ In Portugal, career firefighters commonly offer their services on a volunteer basis to their fire brigade in the hours that they are not regularly paid. Usually, they volunteer during night shifts and weekend shifts.

¹⁰ About 160,000 inhabitants.

Table 1. Participants socio-demographic information

	Total	Male	Female
# Participants	49 (100.00%)	36 (73.47%)	13 (26.53%)
Age (yrs)			
<i>Mean (SD)</i>	37.49 (10.23)	40.00 (10.13)	30.54 (6.94)
<i>Min – Max</i>	21–62	25–62	21–44
Experience (yrs)			
<i>Mean (SD)</i>	15.35 (11.28)	18.69 (10.86)	6.10 (6.28)
<i>Min – Max</i>	0.17 – 38	0.17 – 38	0.17 – 16
Type of commitment (#)			
<i>Career-volunteer</i>	31 (63.27%)	26 (72.22%)	5 (38.46%)
<i>Volunteer</i>	15 (30.61%)	9 (25.00%)	6 (46.15%)
<i>Trainee</i>	2 (4.08%)	0 (0.00%)	2 (15.39%)
<i>Other</i>	1 (2.04%)	1 (2.78%) ^a	0 (0.00%)

^aAssistant chief responsible for the brigade.

3.2 Purchasing

When asked if the turnout gear was specifically purchased for an individual, the responses of female participants were significantly different from their male counterparts. Twenty-six male participants (72.22%) answered that their turnout coat was specifically purchased for them and only 2 female participants (15.38%) answered the same. Responses of turnout pants were similar as 27 (75.00%) of the male participants answered that their turnout pants were specifically purchased for them and only 1 (7.69%) female participant answered affirmatively.

Although the fire brigade has been progressively investing in specifically tailored turnout gear¹¹, career firefighters have priority over volunteers, as they use their equipment more frequently. Usually, volunteer personnel is provided with turnout gear already used by former firefighters.

3.3 Size Selection

Correct sizing is particularly important in protective clothing, as the performance of the clothing depends on the correct fit [15]. When participants were asked if they experienced any difficulties in selecting their turnout coat size, 46.15% (n = 6) of female respondents answered «yes» while only 16.67% (n = 6) of male participants answered the question affirmatively. Difficulties experienced in selecting their turnout pants size were similar. Female participants' responses were significantly different than male responses, as 61.54% (n = 8) of female participants expressed difficulties in selecting their turnout pants, while only 16.67% (n = 6) of male answered «yes».

¹¹ For this, the manufacturer provides a sample set of sizes and adjust to their individual measurements. According to the study participants, modifications were usually made on the coat sleeve length and on the pants leg length.

Difficulties mentioned by female participants in selecting their turnout gear were similar for both the coats and pants, including the fit, sizing system, and the availability of sizes in the brigade. Examples of difficulties mentioned are illustrated in Table 2.

Table 2. Female participants difficulties in selecting the turnout gear size (type of commitment)

SIZING	COAT	“the smaller size was too small, and the size above was too big [for me]” (volunteer)	
	PANTS	“the size above was too big and the smaller size didn’t fit on the hips” (volunteer) “I was in doubt between L and XL” (volunteer)	
FIT	COAT	“the S fits great on the armhole, but it is too tight on the hips” (career-volunteer) “I believe that, as they are Unisex, sometimes they fit on the arms but don’t fit on the torso... other times, they fit on the torso, but not on the arms” (career-volunteer)	
	PANTS	“[turnout pants] are a bit bulky” (volunteer) “it’s the same as the coat... if they fit in one region, they don’t fit in another” (career-volunteer)	
AVAILABILITY	COAT	“there is a lack of available sizes [in the brigade]” (volunteer) “I’ve got the available size [in the station]... you know... but it should be a M” (volunteer) “I haven’t picked it [the size]... I’ve got the smallest size available at that time” (career-volunteer)	
		PANTS	“there were not many sizes [available]” (trainee) “I haven’t chosen the size... they were just assigned [to me]” (career-volunteer) “they just provided me those [pants]” (career-volunteer)

As recommended by Shuster [12], the availability of PPE in sizes that fit women can remediate the problems faced by female firefighters. However, a more adequate sizing system remains a challenge. As male and female anthropometrics are sufficiently different, turnout gear needs to be designed differently [11].

3.4 Protection Level

Concerning the protection level, responses from female participants were slightly different from male participants. According to 69.23% (n = 9) of the female respondents, they feel «very protected» by their turnout coat and according to 30.77% (n = 4) of female participants they feel «somewhat protected». Male participants answered as follows for their turnout coat: 77.78% (n = 28) feel «very protected», 19.44% (n = 7) feel «somewhat protected» and 2.78% (n = 1) feel «very little protection».

A higher perception of protection level with turnout pants was also expressed among male participants (very protected: 80.56%, $n = 29$; somewhat protected: 16.67%, $n = 6$; very little protection: 2.78%, $n = 1$). Female participants expressed a lower evaluation concerning perceived protection of turnout pants: 61.54% ($n = 8$) answered that they feel «very protected» and 38.46% ($n = 5$) answered that they feel «somewhat protected».

These results are in accordance with the Hollerbach *et al.* study [14] that identified issues with ill-fitting gear as one of the biggest threats to safety for female firefighters.

4 Final Considerations

The level of protection is an important feature to consider when selecting personal protective equipment. In the case of firefighting, comfort is also of paramount relevance. According to recent studies, female firefighters are more subjected to ill-fitting PPE, usually designed for male anthropometrics. The preliminary results presented in this paper corroborate such findings, as female participants expressed more difficulties in selecting their protective clothing than male participants. The availability of sizes and the sizing system was also discussed. In addition, the level of protection experienced was also evaluated as being lower by the female participants. Although the number of participants was modest, the findings of this pilot study provided valuable insights to better understand the main issues experienced by the Portuguese female firefighters regarding their PPE.

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