PORTUGUESE FIREFIGHTERS' PERCEPTIONS CONCERNING PROTECTIVE GLOVES

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ABSTRACT

In firefighting, gloves continue to be an important item of personal protective equipment and must provide adequate hand protection while allowing firefighters to conduct operations. However, studies have shown that enhanced thermal protection entails greater bulkiness, leading to discomfort and limited dexterity, and sizing systems may not be the most appropriate. An ongoing study on firefighters' personal protective equipment in Portugal has found similar results. This paper presents some of the participants' perceptions regarding their gloves, including finger length, difficulty in putting on and removing when gloves are wet, dexterity issues, and styles/sizes available in the brigade.

Key Words: Firefighting, fire gloves, protection level, fit issues

1. INTRODUCTION

Upper extremities consistently appear as the most common body region of nonfatal occupational injuries and hand injuries figure as the largest subsection. In firefighting, burns and other injuries to the hand, though lessened over the years, still represent a significant proportion of all fireground injuries [1] [2].

Personal protective equipment – PPE, is considered the main protection for firefighters working in hazardous environments without any other type of protection available [3]. Still, gloves remain an important PPE item to protect firefighters and must adequately fit their multifaceted dimensions and shapes of their hands, and provide them with protection from sharp objects, fluids, flame, and heat [4].

Firefighting gloves use the same principles of layering materials that are applied to turnout gear, usually employing a functional three-layer construction comprised of an outer shell, a moisture barrier (or barrier layer), and a separate or combined thermal lining [1]. Outer shell materials are usually leather (including cowhide, elk hide, pigskin, goat skin, and other special leathers) or textile (mainly technical synthetic materials, like Kevlar® polyamide) while barrier materials are made of Polytetrafluoroethylene (PTFE) or Polyurethane. Thermal liners are commonly constructed of knit materials, which can be a flame-resistant Modacrylic material or Kevlar/Nomex® knit materials.

Despite the development of special materials for firefighting personal protection equipment, the lack of comfort and fit of protective gloves continues to be a common complaint among firefighters. Nonetheless, Dianat *et al.* [5] highlight the fact that the primary concern when designing protective gloves has been hand protection rather than hand performance. Recent studies [6] [7] have shown that enhanced thermal protection entails greater bulkiness, leading to discomfort and limited dexterity. Furthermore, the Hsiao *et al.* [4] study found that the

American standard for structural firefighting glove-sizing (*NFPA 1971 Standard on protective ensemble for structural firefighting and proximity firefighting, 2013 edition*) underrepresents firefighter hand size range and variations of shape.

Aiming to evaluate the Portuguese firefighters' PPE, a study designated as *SizeFF Portugal – Anthropometric Study of Firefighters* is being developed by 2C2T - Centre for Textile Science and Technology, in the Department of Textile Engineering at the University of Minho in partnership with the US *Size FF* Project. In order to obtain the first insights from firefighters' experiences in wearing their turnout ensemble and other protective equipment, a pilot study was conducted in a fire brigade located in the North of Portugal. This paper presents the first qualitative results related to their fire gloves.

2. MATERIALS AND METHODS

After obtaining the permission from the fire brigade's chief in command, all firefighters were invited to participate. For data collection, both an online survey and an in-person semi-structured interview were administered. The online survey was comprised of 83 questions, divided into five parts, including questions about: sociodemographic information, turnout coat, turnout pants, fire boots, and fire gloves. The interview was followed by additional questions, in order to obtain clarification or encourage more detail to supplement participants' initial responses to the survey.

This combined data collection method was chosen for the in-depth information that can be obtained as participants describe their perceptions and experiences of wearing their current equipment. Interviews/surveys were audio recorded and further transcribed for the sake of data analysis accuracy. Data was collected in December 2018 and January 2019, and each interview/survey took approximately 40 minutes.

3. RESULTS AND DISCUSSION

3.1 Demographic Information

The fire brigade serves a medium size municipality (about 160,000 inhabitants) including urban and suburban populations, as well as the surrounding wildland environment. The brigade comprises of 38 firefighters, including both career and volunteer personnel and only volunteer personnel. Sixteen firefighters participated in the pilot study, including only volunteer firefighters (25%, n=4) and both career and volunteer firefighters (75.00%, n=12). Most participants were male, corresponding to 87.5% (n=14), while 12.5% (n=2) of the participants were female. The average age of the respondents was 37 years (ranging from 21 to 61 years; SD=11), and the average years of firefighting experience was 17 for male participants (ranging from 4 to 33 years; SD=10), and 0.75 year for female respondents. Concerning the dominant hand, most participants were right-handed (93.75%, n=15), and only one participant (6.25%, n=1) was left-handed.

3.2 Gloves and other PPE items

In general, participants expressed satisfaction with their PPE. However, among all the PPE items included in the survey (turnout coat, turnout pants, gloves and fire boots) gloves were

cited as the most problematic among participants. More than half of the participants (62.5%, n=10) responded that they had experienced fit issues when wearing their fire gloves, instead of 37.5% (n=6) who had not experienced any fit issue. These results corroborate with similar studies [6] [7] [8], with glove issues being one of the predominant complaints among firefighters.

3.3 Glove size

All participants (100%, n=16) responded to have selected the size of the fire gloves by themselves. However, when asked how the glove size was selected, 75% (n=12) responded that it was selected from options previously available in the station, while 18.75% (n=3) responded to have tried on various styles/sizes brought to the station by a manufacturer.

When asked about difficulties experienced when selecting the fire glove size, 75% (n=12) replied not having had any difficulty, while 25% (n=4) replied having experienced difficulties. The difficulties mentioned by the participants were mainly related to sizing (fingers too long when compared to the palm of the hand), a trade-off between fit and dexterity, and glove flexibility (hard to put on). Also, one participant mentioned the coat sleeve-glove interface, as described here:

> *"First, I tried them on without the fire coat, and afterwards I changed them for a bigger size because of the attached knit gauntlet"(male/volunteer).*

When asked about experiencing any fit issue with the fire gloves, one participant responded:

> *"Well… yes…the size S is too tight… in fact, it is not too tight, it is narrow… but in the end I don't have dexterity when working with them… I can move in the size S but it is like having your hands tied, you know what I mean? There should be something between the S and M sizes, to be like… perfect" (male/both career and volunteer).*

3.4 Protection Level

Concerning the protection level, 87.5% (n=14) of the participants responded feeling protected by their fire gloves, and 12.5% (n=2) responded not feeling protected. One participant reported it in the following manner:

> *"[the gloves] don't provide great safety… they hamper operations" (male/both career and volunteer).*

A similar situation is described by one participant of the Boorady *et al.* study [6]. Another participant responded not feeling protected by the glove, as mentioned here:

> *"in this case I don´t feel [protected], because after getting wet the heat passes right through them" (male/both career and volunteer).*

As described by Park *et al.* [7], a quick heat transfer in the wet gloves, as compared to dry gloves, increases the risk of burn injury.

3.5 Putting on and removing

Similarly to the Boorady *et al.* [6] results, many participants indicated having issues related to putting on and removing their gloves. This is because the liner tends to turn inside out when removing the gloves, especially when the gloves are wet. One participant mentioned:

> *"when I pull the glove off the lining comes out, especially when the gloves are wet… if the liner comes out, after that, putting it back on is really hard… the finger tips should be sewn…"(male/both career and volunteer).*

The same situation was described by a participant of the Park *et al.* [7] study. According to the authors, this seemed to render firefighters hesitant to take off their wet gloves, despite thermal discomfort, loss of grip, and increased risk of burn injury. According to Stull & Stull [1], the development of means to retain the liner inside the shell is a classic problem in the design of gloves, and common solutions, such as tabs or adhesives applied at the fingertips, create bulk and reduce tactility, which can be a problem when firefighters must use radios and certain tools that require a certain sense of touch.

3.6 Fire Glove fit issues

Figure 1 shows the participants' responses to fit issues in specific parts of their fire gloves. In general, the thumb and fingers were similarly evaluated by the participants, despite the little finger, which was cited as the most problematic finger.

The main fit issue that was pointed out was glove flexibility, followed by finger length ("too long" according to 2 respondents) and finger width ("too wide" according to 1 respondent). For another respondent the glove's fingers are "a bit wide and a bit long" (included as "other"). Similar results were found in the Park *et al.* [6] study, with the excessive length of glove fingers appearing as a commonly reported issue.

The palm of the glove was cited as too big/wide by 3 participants (18.75%), and not flexible enough by another 3 participants (18.75%). For one participant (6.25%), the palm of the glove is too narrow, and for another participant only a bit narrow (6.25% - other). One participant also responded that the palm is too long (6.25%). For 43.75% (n=7) the palm of the hand does not present any fit issue.

Concerning the back of the glove, the results were slightly better, cited as being too wide/big by one participant (6.25%), as too narrow by another participant (6.25%), and as a bit narrow by another participant (6.25% - other). Only one participant responded feeling the back of the glove as not flexible enough. Fourteen (75%) participants expressed no fit issue related to the back of the glove.

The wrist was also cited as "too narrow" by 2 participants (12.5%), as "a bit narrow" by one participant (6.25% - other), and as "too long" by 2 other participants (12.5%). Eleven participants (68.75%) affirmed not experiencing any fit issue related to the wrist, and mentioned the benefit of the adjusting strap.

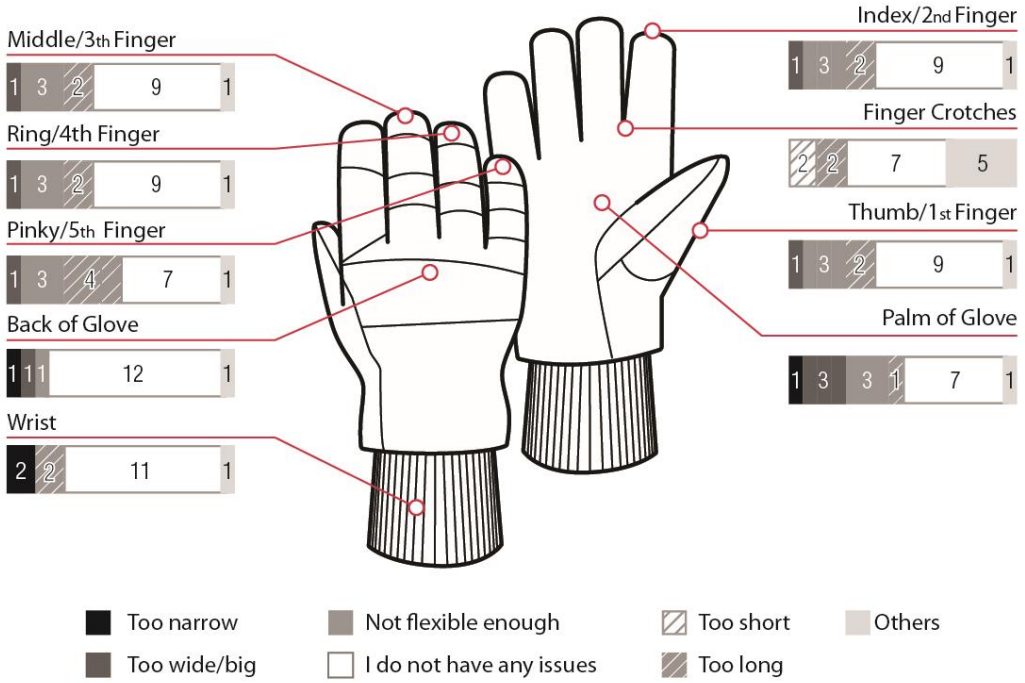

Figure 1. Glove fit issues

3.7 Dexterity issues

Dexterity while wearing the gloves was cited as problematic by many participants. According to one participant, the gloves are not flexible due to the multiple layers, compromising tactility and dexterity. However, the dexterity should also be considered as directly related to the type of operation being performed.

Specific glove styles for different types of firefighting are available on the market, but only one glove style is provided by the fire brigade. Many participants reported having bought other glove styles for specific operations, like vehicle extrication, in which a finer grip is of paramount importance. When asked about the need for a high level of tactility and dexterity, one participant simply stated:

> *" [when I go to perform extrication] I take other gloves… but I've bought them… just because of this… because you need tactility… [with the gloves provided by the brigade] it's impossible… we need to have better touch… and to not lose tactility I bought these gloves specifically for extrication… when we have a call, I take both" (male/both career and volunteer).*

In some cases, firefighters may rely on gloves that are thinner and more comfortable, but not in compliance with firefighting requirements. This was exemplified by a situation described by a female participant, in which it was reported that agricultural gloves were bought to be used for vehicle extrication training.

4. FINAL CONSIDERATIONS

Firefighting is one of the most dangerous occupations in which hand protection is of paramount importance. Protective fire gloves must provide adequate hand protection while allowing firefighters to effectively conduct essential firefighting operations. However, comfort and fit of protection gloves remains a common complaint among firefighters. The study presented here, with 16 male and female participants from a fire brigade located in the North of Portugal, found similar results, with gloves being principal in participants' comments.

The data collected allowed a better understanding of issues encountered and explored the firefighters' perceptions in using protective gloves in greater detail. The main issues identified by the participants included the sizing system, finger length, difficulty in putting on and removing the gloves when they are wet, dexterity issues, and not enough styles/sizes available in the brigade. Findings from this study provide qualitative insights to further recommend improvements for redesigning Portuguese firefighters' gloves.

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