



FIREFIGHTING BOOTS: A COMPARATIVE ANALYSIS OF THE PERCEPTIONS OF ELEMENTS FROM TWO PORTUGUESE FIRE DEPARTMENTS

^{1*} Anna Sophia Piacenza Moraes, ² Miguel Ângelo Carvalho, ³ Rachel Sager Boldt, ⁴ Fernando Batista Nunes Ferreira

^{1, 2, 3, 4} Departamento de Engenharia Têxtil, Universidade do Minho, Portugal

^{1*} E-mail: sophiapiacenza@gmail.com

ABSTRACT

Personal protective equipment is extremely relevant for protection against many occupational hazards that firefighters are often exposed to. The comfort of this equipment is directly related to the level of protection and operational performance. In order to evaluate and propose some improvements for the personal protective equipment used by Portuguese firefighters, a study is being conducted by the Center for Textile Science and Technology at the University of Minho, Portugal. As part of the data collection protocol, participants are interviewed and asked to complete a questionnaire so as to obtain their insights about the protective equipment used. The aim of this work is to present and compare the perceptions of members of two Portuguese fire departments about the protective footwear used when fighting urban and industrial fires. It is possible to conclude that although participants from both departments were satisfied with the protective footwear used, comfort can be ameliorated, especially regarding the weight and the sizing system.

KEYWORDS: Personal Protective Equipment. Urban and Industrial Fires. Comfort.

1. INTRODUÇÃO

Personal protective equipment (PPE) is considered the third line of defense for workers. Directive 89/656/EEC of the European Parliament emphasizes that, as a general rule, personal protective equipment (PPE) should only be used when there is no capacity to apply measures, methods, or processes of prevention inherent to the organization of work or through technical means of collective protection. However, in many work contexts, they are the only available resource to protect workers against various risks to which they are exposed. The occupation of firefighters is one such case.

Veiga (2019) points out that all activities of a firefighter involve risks that cannot be eliminated. PPE is intended to protect firefighters against physical, biological, and chemical risks present in various missions, directly dependent on the environment in which they are carried out, having very different characteristics. Therefore, PPE for the protection of firefighters varies according to the type of mission and the environments in which they are performed.

The role of fire departments for societies is absolutely crucial, being the first to be called to respond to a variety of situations. In Portugal, the mission of fire departments involves primarily: prevention and firefighting; rescue of populations in case of fires, floods, collapses, collisions, and, in general, in all accidents, disasters, or calamities; rescue of shipwrecked individuals and underwater searches; rescue and transport of accident victims and patients, including pre-hospital emergency care, within the integrated emergency medical system (Decree-Law No. 247/2007).

Within this framework, for urban and industrial firefighting (also called structural fires), the use of clothing (a set of jacket and pants or jumpsuit for trunk and limb protection) and other protective equipment is mandatory, such as gloves for hand and wrist protection; boots, for foot, ankle, and leg protection; cowl and helmet with visor for neck, face, and head protection (Castro and Abrantes, 2005).

1.1. BOTAS DE COMBATE A INCÊNDIOS URBANOS E INDUSTRIAIS

The risks to the feet, ankles, and legs in firefighting and other missions primarily include exposure to extreme temperatures from equipment, materials, and chemicals; exposure to cutting, piercing, or abrasive elements; handling or manipulation of heavy objects; contact with moving vehicles or objects; exposure to hot, wet, or slippery floors; and exposure to electric current or electrostatic charge.

For urban and industrial firefighting and other rescue activities, such as floods and rescues, boots must be used in accordance with the normative requirements established in the European standard EN 15090:2012. They should be made of leather, in black color, and may or may not have laces and closures. They must also necessarily include protective toe caps and puncture-resistant insoles, be resistant to oily substances and slipping, and exhibit heat-insulating properties. Depending on the type of mission, they should have anti-static and/or electrical insulation properties. Figure 1 illustrates two models of urban and industrial firefighting boots available in the Portuguese market.



Figure 1. Urban and Industrial Firefighting Boots (Guerra, 2005)

1.2. CONFORTO E NÍVEL DE SATISFAÇÃO DOS BOMBEIROS COM EPIS DE COMBATE A INCÊNDIOS

The comfort provided by personal protective equipment (PPE) has been increasingly discussed, considering its direct relationship with acceptance and usage (OSHA, 2004). PPE that is not compatible with the anthropometric characteristics of workers tends to be underutilized or not used at all.

The use of firefighting PPE requires firefighters to exert additional effort due to the weight, difficulty of movement, and, in some cases, reduced visibility (Guerra, 2005). Proper fitting of PPE is critical not only for protection but also for the operational performance of firefighters (Park and Hahn, 2014).

Experimental studies, such as Park et al. (2015a), indicate restrictions in the mobility of the lower body due to the use of PPE, particularly the impact of boots on ankle movement and the distal region of the foot sole. In another study, Park et al. (2015b) assessed the impact of PPE on gait patterns, compared different materials used in firefighting boots, and suggested the relevance of investigating the effect of boot fit on locomotion and perceived comfort.

Studies seeking to understand firefighters' perceptions regarding the use of their PPE have identified complaints, primarily related to comfort. Boorady et al. (2013) conducted focus group techniques and questionnaires with American firefighters. Participants mentioned excessive boot shaft height, hindering movement and boot fitting (Boorady et al., 2013). Also in the United States, using similar techniques, Park et al. (2014) obtained responses from 54 firefighters who rated support, lining, and flexibility as the worst characteristics of boots. Blisters on the feet and legs were also related to the consequences of bulky rubber boots, as well as a preference for leather boots (Park et al., 2014). An international study published by Lee et al. (2015) found that different materials are preferably used in boots in numerous countries, concluding that, overall, leather boots are preferred. Despite being heavier, stiffer, and having a poorer fit, rubber boots are more suitable for wet and less slippery areas in cold temperatures, such as during winter. Another study conducted by Nunes and Fontana (2012) with Brazilian firefighters mentioned the appearance of calluses due to boots and the difficulty regarding the available boot sizes.

In Portugal, the report "User Requirements - Fire Protection," published by the mobilizing project PPS4 2011/2012, highlighted the main problems with firefighting equipment according to Portuguese firefighters, based on an online survey. Of the 1,018 firefighters who responded to the questionnaire, about 90% of them pointed out "ease of movement" and "functionality" as "very important" characteristics in structural firefighting equipment. These two characteristics only ranked behind "thermal insulation," considered "very important" by

approximately 95% of respondents. General comfort was evaluated as the fourth "very important" characteristic, mentioned by more than 85% of respondents.

Regarding the satisfaction of Portuguese firefighters with PPE, more recently, through a questionnaire applied to 240 firefighters from 15 fire departments in the district of Bragança, Veiga (2019) concluded that the weight of boots affects the performance of professionals, with the impact considered lower only when compared to the open-circuit self-contained breathing apparatus (SCBA).

1.3. ESTUDO ANTROPOMÉTRICO DOS BOMBEIROS PORTUGUESES

Since 2017, a consortium of 12 universities in the United States has been conducting an anthropometric study called Size FF – Size Firefighter, with the primary goal of improving the current personal protective equipment (PPE) used by American firefighters. In 2018, in collaboration with this consortium, the Center for Science and Textile Technology (2C2T) at the University of Minho brought the study to Portugal, creating the Size FF Portugal study – Anthropometric Study of Portuguese Firefighters. The study involves data collection from fire departments in all districts of the country. In the initial phase, data were collected from about 100 firefighters from two different fire departments.

The aim of this article is to present a comparative analysis of the perceptions of Portuguese firefighters from these two departments regarding the level of satisfaction, usage experiences, and areas for improvement related to firefighting boots for urban and industrial firefighting.

3. MATERIAIS E MÉTODOS

The protocol established for the development of the Size FF Portugal study includes the collection of anthropometric data through direct and indirect measurements, the latter obtained through three-dimensional scanning. Additionally, it involves the administration of a questionnaire aimed at gathering participants' perceptions, identifying specific needs, assessing the level of satisfaction, and highlighting areas for improvement in relation to the Personal Protective Equipment (PPE) used. The questionnaire also seeks to obtain sociodemographic information from participants, details about the types of missions they are involved in, information about the fire department they serve, and insights into how the purchase and selection of PPE are carried out.

The questionnaire, originally developed by the American group, has been translated from English to Portuguese, aiming to maintain the questions as faithful as possible to the original. However, some questions have been adapted, especially those related to identification.

As Personal Protective Equipment (PPE) varies according to the types of missions performed, the decision was made to focus on the equipment used in urban and industrial firefighting. During the data collection, participants were verbally instructed to answer the questionnaire taking this model into account. The choice was based on the types of missions and the frequency of use of each type of equipment, with reference to the number of types of services provided by the fire departments, according to data from the Portuguese National Institute of Statistics, where the number of other fire incidents is approximately 6 times higher than firefighting in forested areas (INE, 2018). Additionally, these data should include other missions that do not involve firefighting but in which firefighters must use urban firefighting PPE, either in full or in part, such as vehicle extrications, statistically accounted for as "other services" (INE, 2018).

regarding the brands and models of the equipment, in order to adapt to what is offered in the Portuguese market.

The questionnaire, consisting of approximately 80 questions, is divided into 5 parts. The first includes questions for the sociodemographic characterization of the participants (gender, age, ethnicity, type of affiliation - professional or volunteer firefighter, years of experience as a firefighter, and types of missions they participate in) and the fire department they serve in (municipality and district, number of inhabitants, type of environment protected by the fire department). The second, third, and fifth parts include specific questions about the jacket, pants, and individual protective gloves, respectively. The fourth part, dedicated to protective boots, includes 16 questions divided into 4 topics: brand identification, model, size, and gender (3 questions); purchasing and selection process (4 questions); modifications made during use (1 question); and difficulties in adjusting specific regions of the boots (8 questions).

The online platform QualtricsXM was used for the development and administration of the questionnaire. Simultaneously, a semi-structured interview was conducted to clarify participants' doubts when necessary, as well as to include other questions that proved relevant throughout the study and were not initially included in the original questionnaire from the American study.

The questionnaires/interviews were applied individually, conducted by the responsible researcher. The interviews were recorded and later transcribed for analysis. The responses, stored on the QualtricsXM platform, were subsequently extracted for statistical analysis.

4. RESULTADOS E DISCUSSÃO

As mentioned, the results presented below highlight individual protective boots for urban and industrial firefighting. Initially, the sociodemographic data of the participants are presented, along with a brief characterization of the fire departments. Subsequently, the participants' perceptions regarding the fit in specific parts of the boots are presented. In the final section, other relevant aspects are discussed, either spontaneously reported by the participants or induced by the semi-structured interview.

4.1. INFORMAÇÕES SOCIODEMOGRÁFICAS

The first fire department from which data was collected is a volunteer fire department that protects a municipality with approximately 160,000 inhabitants. It has about 145 firefighters, with around 45 employed by the department (referred to as salaried) working an 8-hour daily shift. Salaried firefighters are also required to volunteer during weekend shifts and night shifts during the week. The remaining members of the department (approximately 100 individuals) work exclusively on a voluntary basis, with an 8-hour weekly shift at night on weekdays and a 12-hour shift on weekends, according to a schedule. From this point on, this fire department will be referred to as CB.01.V.

The second fire department where data was collected is a professional (sapador) type, composed exclusively of professional firefighters. Its 266 members protect a municipality with around 240,000 inhabitants. They are divided into 5 teams working in continuous shifts, with rotating 12-hour shifts. From this point on, this fire department will be referred to as CB.02.P.

The main types of missions for both fire departments include extrications, pre-hospital emergencies, urban and industrial firefighting, and forest firefighting. However, forest firefighting is rarely within the competence of the professional fire department, as it is more directed towards incidents in urban environments.

Data collection took place at the facilities of both fire departments, with all their members invited to participate in the study. In the first department (CB.01.V), 49 firefighters

participated, including 13 females and 36 males. In the second department (CB.02.P), there were 32 firefighters, all male, as there were no women in their personnel. Table 2 presents the average ages, years of experience, and type of affiliation of the participants.

Table 2. Sociodemographic Data of Firefighters Participating in the Study

Fire Department	CB.01.V	CB.02.P
Number of participants	49	32
Age [years]		
<i>Mean (SD)</i>	37,49 (10,23)	33,44 (8,48)
<i>Min-Max</i>	21 – 62	23 – 51
Years of experience as a firefighter		
<i>Mean (SD)</i>	15,35 (11,28)	10,00 (7,69)
<i>Min-Max</i>	0,17 – 38	1 – 23
Type of affiliation [n (%)]		
<i>Professional</i>	-	32 (100%)
<i>Salaried and Volunteer</i>	31 (63,27%)	-
<i>Volunteer</i>	15 (30,61%)	-
<i>Intern</i>	2 (4,08%)	-
<i>Other *</i>	1 (2,04%)	-
Gender distribution [n (%)]		
<i>Male</i>	36 (73,47%)	32 (100%)
<i>Female</i>	13 (26,53%)	-

* Deputy Commander

5.1. PERCEPÇÕES SOBRE O AJUSTE DAS BOTAS DE COMBATE A INCÊNDIOS URBANOS

To assess the comfort of specific parts of the boots – handles, upper edge and lace region, calf and shin, toe cap, instep, arch, sole, and heel – the questionnaire includes an illustrative figure, followed by the same question for each: 'Please explain the fitting difficulty of the [specific part] of your individual protective boots.' For each of these questions, there are closed-response options based on the evaluated part of the boots (e.g., 'too loose,' 'too tight'...), a closed-response option 'I have no difficulty,' and an open-response option 'other (please explain).' The results of the responses from members of both departments are presented in Tables 3 and 4 and briefly described below.

Regarding the straps: they facilitate putting on the boots and this is the part where the differences between the two fire departments are most relevant. While the majority of participants (93.88%, n=46) from CB.01.V stated that they had no difficulty with the straps, 40.63% (n=13) of participants from CB.02.P chose the option 'other,' explaining that they do not use the straps to put on the boots or that the boots do not have straps. Regarding this question, we acknowledge the possibility of a distortion in the questionnaire administration, as while no participant in the first department mentioned not using the straps, in the second department, as one of the first participants reported not using the straps, the question began to be informally asked to participants. This aspect highlights the need to reformulate the question to clarify whether the absence of difficulties is related to the fact that the straps are not even used to put on the boots. Nevertheless, some participants emphasized the importance of the straps, as expressed by a male professional firefighter from CB.02.P when asked if he uses them and if the straps are good: 'I use them... it's great... it's the best thing... if they take that away from me, I don't think I can put on those boots.'"

Calf and shin: Regarding this part of the boots, participants from CB.01.V reported more difficulties than participants from CB.02.P. Regarding the calf, 14.29% (n=7) from CB.01.V and 9.38% (n=3) from CB.02.P chose 'other,' specifying that they are 'a little' or 'a bit' loose. The analysis of the responses identified a difficulty in interpreting the adjective 'too' used in the response options ('too tight,' 'too loose,' 'too long,' 'too short'...), directly translated from the questionnaire in English. This difficulty was also observed in questions about other specific parts of the boots."Parte superior do formulário

Toe cap: The part of the boots that shows more similarities in the responses of participants from both departments. The majority reported having no difficulty (87.76%, n=43 from CB.01.V and 87.50%, n=28 from CB.02.P). Three participants (6.12%) from CB.01.V and 1 participant (3.12%) from CB.02.P chose 'other' as their response. Among CB.01.V participants, one explained finding the toe cap 'a bit loose,' another mentioned that the difficulty lies in the size of the boots and the lack of standardization in numbering across different types of footwear and manufacturers. Other participants chose to respond 'other' and stated: 'it's great with two pairs of socks,' said a volunteer firefighter from CB.01.V, and 'I start to feel it on my toes if I walk for a long time with the boots,' emphasized a professional firefighter from CB.02.P."

Table 3. Responses from participants of both fire departments for the parts: straps, calf and shin, toe cap.

	Long		Short		Loose		Narrow		No difficulty		Other	
	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P
Regarding the straps												
n	0	0	1	1	0	0	1	0	46	18	1	13
%	0	0	2,04	3,13	0	0	2,04	0	93,88	56,25	2,04	40,63
Calf and shin												
n	1	0	0	0	2	3	2	0	37	26	7	3
%	2,04	0	0	0	4,08	9,38	4,08	0	75,51	81,25	14,29	9,38
Toe cap												
n	-	-	0	0	3	2	0	1	43	28	3	1
%	-	-	0	0	6,12	6,25	0	3,13	87,76	87,5	6,12	3,12

Upper edge: The majority of participants from both fire departments (71.43%, n=35 for CB.01.V and 71.88%, n=23 for CB.02.P) reported having no difficulty with the upper edge of the boots. However, 9 participants from CB.01.V chose 'other' as their response. Among these, among female firefighters, 2 mentioned that the boots are 'a bit wide,' 1 mentioned them being 'a bit tight,' and another mentioned that the boots hurt the skin, so she wears a high sock above the upper edge of the boots. The responses from male participants in the same department were similar, with 2 of them mentioning that the edges are a bit loose and 3 mentioning skin irritation. The 'other' responses from the 3 participants from CB.02.P are quite similar. The firefighters' verbalizations illustrate their perceptions:"

Now it bothers because they are old, but when they are new, they have that sponge that is comfortable. I can already see the sponge on mine... it starts to bother. I wear a sock like a soccer player, so it's not rubbing the skin with the boot, there's already the sock to prevent it from rubbing, burning... (male, volunteer, CB.01.V).

There's something there... if a person doesn't have a high sock, the upper part, when sweating, with the uniform, starts to turn red on the leg muscle, starts to rub. The pants are on the outside, start rubbing on the leg muscle, then it can even get inflamed if we don't have a sock to protect (male, salaried and volunteer, CB.01.V).

It's... it was that part I was talking about... it's a bit loose, and there's friction on the calves... it's also more because of that. If you're wearing a high sock, you don't notice it as much... sometimes, if you're running a bit... when I wear normal socks, I know that... [laughs] if it's going to last a bit... that part is going to suffer... on the top of the boot (male, professional, CB.02.P).

Instep: The responses from participants from CB.02.P were more varied than those from participants from CB.01.V regarding the instep. For 4 participants (12.5%), the boots are very tight in this area, for 1 participant (3.125%), it is very loose, and for 1 (3.125%) participant, it is very narrow. Among the 2 participants from the same fire department who chose 'other' as their response, one stated, 'they are a bit tight in the ankle area, in the joint,' and the other mentioned the strategy used when receiving the boots:"

When they were new, it was such a situation because I... I only wore them on the night shift... because, on the night shift, we have the convenience that when there's duty, there's duty, and when there's no duty, we can go rest, right? [laughs] So, we take off the boots... and during the day, I had to wear them all day... and I started using them little by little, until they molded to the body... to the foot (male, professional, CB.02.P).

Footbed: Participants from both fire departments have different perceptions regarding the footbed. While in CB.01.V the responses were quite varied (8.16%, n=4 answered 'very hard'; 2.04%, n=1 answered 'very soft'; 4.08%, n=2 answered 'very wide'), in CB.02.P, 37.50% (n=12) of participants responded as 'very hard.' Still, for CB.01.V, among those who chose 'other' as their response (8.16%, n=4), 1 participant stated that they are 'a bit wide,' another mentioned they are 'slightly wide, uses two pairs of socks,' and a female firefighter said they are 'a bit wide.' Another participant, who also chose this response, suggested that 'it would be interesting to have insoles with another type of material more resistant to sweating.' Regarding the question, it is worth emphasizing that the feet were mentioned by respondents from Project PPS4 (2011/2012) as the second zone of the body – the first is the face – where heat is felt most intensely, considered very important by more than 35% of participants. Similar results regarding this aspect were obtained by Veiga (2019).

Arch: Pointed out as very loose, the arch part of the insoles does not provide good internal support, according to 14.29% (n=7) of participants from CB.01.V and 9.38% (n=3) of participants from CB.02.P. Conversely, 1 participant (2.04%) from CB.01.V considered it very tight (having excessive internal height support). However, the majority of participants from both fire departments reported having no difficulty in this part of the boots (81.63%, n=40 from CB.01.V and 90.63%, n=29 from CB.02.P). From CB.01.V, 1 participant (2.04%) chose 'other,' stating that the boot 'does not follow the curve of the arch of the foot' (male, salaried and volunteer, CB.01.V)."

Table 3. Responses from participants from both fire departments for the parts: upper edge, instep, footbed, arch, heels.

	Tight/Strong support (arch)/Hard (footbed)		Loose/No support (arch)/Very soft (footbed)		Narrow		Wide (instep/footbed)/Poor fit with pants (upper edge)		No difficulty		Other	
	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P	CB.01.V	CB.02.P
Upper edge												
n	3	0	2	6	-	-	0	0	35	23	9	3

%	6,12	0	4,08	18,75	-	-	0	0	71,43	71,88	18,37	9,38
Instep												
n	0	4	2	1	0	1	1	0	46	24	0	2
%	0	12,5	4,08	3,13	0	3,13	2,04	0	93,88	75,00	0	6,25
Footbed												
n	4	12	1	0	0	1	2	0	38	18	4	1
%	8,16	37,5	2,04	0	0	3,13	4,08	0	77,55	56,25	8,16	3,13
Arch												
n	1	0	7	3	-	-	-	-	40	29	1	0
%	2,04	0	14,3	9,38	-	-	-	-	81,63	90,63	2,04	0
Heel												
n	0	3	6	3	-	-	-	-	41	21	2	5
%	0	9,38	12,2	9,38	-	-	-	-	83,68	65,62	4,08	15,63

Heel: For CB.02.P participants, the heel portion of the boots was considered to have a poorer fit compared to CB.01.V participants. For 83.68% (n=41) of CB.01.V participants, the heel posed no difficulty. A smaller percentage (65.62%, n=21) of CB.02.P participants responded similarly. Among CB.02.P participants, 3 (9.38%) reported "too tight," another 3 (9.38%) reported "too loose," and 5 (15.63%) responded with "other," with heel tightness being highlighted by the majority, especially when new, as illustrated by the testimonials below:

They cause a lot of blisters... (male, professional, CB.02.P).

Initially, it always hurts until you adapt. Today, I no longer come with red feet... (male, professional, CB.02.P).

It's tough... after a few minutes, it starts grinding on the heel... (male, professional, CB.02.P).

It's tough, and there's a part that causes discomfort. I've had blisters on my heels... with water and heat, just a slight friction is enough (male, professional, CB.02.P).

The 2 participants (4.08%) from CB.01.V, who also responded with "other," express similar opinions:

In the heel, if I wear thin socks and there's a lot of space, it will rub... if I wear socks that fill the space, it doesn't rub, and there isn't as much friction (male, volunteer, CB.01.V).

Yeah... it hurts. After a long time, it starts to hurt. After prolonged use, as they say here, it still doesn't have a bed, meaning it's not softened [laughs] (male, employed and volunteer, CB.01.V).

5.2. OUTROS ASPECTOS RELEVANTES: PESO E TAMANHO DAS BOTAS

As factors compromising the comfort of firefighters in carrying out their activities, the weight and volume of firefighting Personal Protective Equipment (PPE) are considered. Although not included in the original questionnaire applied to both fire departments, the weight of the boots was a subject of discussion among several participants and, therefore, included in the interview script. Regarding this aspect, some considerations are illustrative:

Everything is great! The only thing is that after many hours with them on, they start to feel heavy... (male, employed and volunteer, CB.01.V).

That's very heavy... I think the worst part is the weight of the boots because of the steel toe. After some time, it starts to weigh (female, volunteer, CB.01.V).

Oh, yes, they're quite heavy, aren't they? But I think in terms of weight, it shouldn't be much different from the ones I had before; it's probably about the same. The equipment itself is heavy, isn't it? So with everything, with ARICA, fully equipped, facial piece... there you go, the more, how can I say, the more protection a person has, the harder it is to work, you know? (male, professional, CB.02.P).

Such perceptions align with the findings of other studies. According to Veiga (2019), among the features that should be modified in urban firefighting boots, weight is considered the most relevant. The PPS4 Partnership report (2011/2012) also highlights the excessive weight of boots, along with limited thermal insulation and impermeability, presenting, as described, a "low ergonomic index."

However, it's essential to consider that boots are generally worn for short periods. Urban and industrial firefighting missions are often quick, especially when compared to those in wildland firefighting. Many CB.01.V participants reported that, in the case of wildland firefighting boots, the impact of weight is even more relevant to discomfort. It's worth noting that urban firefighting boots are used for more extended periods during training and formations.

Another aspect noted during the questionnaire application was the use of two pairs of socks or higher socks, described by some participants as "soccer player style." This strategy was reported by several firefighters, especially among CB.01.V participants, to prevent friction, especially on the calves and heels. It was identified that this strategy is also used by many participants to adjust the boot size, either because they don't have the correct size available in the fire department (in the case of CB.01.V) or because they choose a larger size for easier donning and doffing of the boots (reported by several participants). This underscores the need for improvement in the numbering system used by manufacturers. It's important that the sizing system also accounts for the ankle and calf regions, which significantly impact boot comfort.

7. CONCLUSÕES

This article compared the perceptions of members from two Portuguese fire departments regarding boots for urban and industrial firefighting. Overall, participants expressed satisfaction with the boots. When comparing perceptions of specific parts of the boots, volunteer firefighters reported less difficulty in 5 of the assessed areas – straps, toe cap, instep, sole, and heel. The other 3 parts assessed – upper edge, calf, and arch – presented less difficulty for professional firefighters.

It is concluded that there are areas for improvement in terms of comfort and fit of urban firefighting boots available in the Portuguese market. The weight of the boots was spontaneously mentioned by several participants from both departments. Additionally, there was observed difficulty with manufactured sizes, not always adjusted or compatible with the anthropometric measurements of feet, ankles, and calves, directly affecting the comfort of the boots. The strategy of using two pairs of socks or higher socks reflects this need.

These aspects highlight the relevance of the Size FF Portugal study, which aims, among other objectives, to develop sizing systems that better address the anthropometric dimensions of Portuguese firefighters. In this way, Personal Protective Equipment (PPE) will be more effectively adapted, providing comfort, ultimately contributing to the performance of professionals who are crucial to society.

At this stage of the study, it was possible to obtain relevant information and a better understanding of the reality of firefighters in Portugal. Additionally, questions not included in the original questionnaire were added, and the language was revised to improve the questionnaire's comprehension.

8. AGRADECIMENTOS

We thank the Center for Textile Science and Technology (2C2T) at the University of Minho. This study is funded with FEDER funds from the Operational Program for Competitiveness (COMPETE) POCI-01-0145-FEDER-007136, with national funds from the Portuguese Foundation for Science and Technology (FCT), under project UID/CTM/000264, by the Fund for Support to Victims of the Pedrógão Fires, and by ICC/Lavoro. We also express gratitude to the United States North Central Multistate Research Project (NC-170) for their support in the development of the study.

9. REFERÊNCIAS

- Boorady, L.M., Barker, J., Lee, Y.A. et al., 2013. “Exploration of firefighter turnout gear Part 1: Identifying male firefighter user needs”. *Journal of Textile and Apparel, Technology and Management*, Vol. 8(1).
- Castro, C.F. e Abrantes, J.M.B., 2005. *Combate a incêndios urbanos e industriais (vol. X)*. Escola Nacional de Bombeiros, Sintra, 2ª edição.
- Decreto-Lei nº 247/2007. (27 de junho de 2007). *Diário da República* nº 122/2007, Série I, Ministério da Administração Interna. Lisboa. 20 Set 2020 < <https://data.dre.pt/eli/dec-lei/247/2007/06/27/p/dre/pt/html>>.

Directiva 89/656/CEE. (30 de novembro de 1989). Relativa às prescrições mínimas de segurança e de saúde para a utilização pelos trabalhadores de equipamentos de protecção individual no trabalho. 5 Out. 2020 <<https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:31989L0656&from=PT>>.

EN 15090 (2012). Norma Europeia. Footwear for firefighters. Instituto Português da Qualidade.

Guerra, A.M., 2005. Segurança e protecção individual (vol. VIII). Escola Nacional de Bombeiros, Sintra, 2ª edição.

INE (Instituto Nacional de Estatística), 2018. Serviços Prestados (Nº) pelos corpos de bombeiros por Localização Geográfica (NUTS-2013) e Tipo de Serviço Prestado. 1 Out 2020<https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008230&contexto=bd&selTab=tab2>

Lee, J., Park, J., Park, H. et al. (2015). “What do firefighters desire from the next generation of personal protective equipment? Outcomes from an international survey”. *Industrial Health*, Vol. 53 (5), p. 434-444.

Nunes, D.A. e Fontana, R.T., 2012. “Condições de trabalho e fatores de risco da atividade realizada pelo bombeiro”. *Ciência Cuidado e Saúde*, Vol. 11(4), p. 721-729.

OSHA (Occupational Safety and Health Administration), 2004. Personal Protective Equipment. Booklet OSHA 3151-12R. 09 Out 2020 <<http://www.osha.gov/Publications/osha3151.pdf>>

Parceria PPS4 – Projeto Mobilizador Power Textiles 21 (2011/2012). Relatório Requisitos do utilizador – Protecção ao fogo. 20 Set 2020 <http://www.prociv.pt/bk/BOMBEIROS/CB/Documents/Relatorio%20requisitos%20utilizador_pps4%20prote%C3%A7%C3%A3o%20fogo.pdf>

Park, H. e Hahn, K.H.Y., 2014. “Perception of firefighters’ turnout ensemble and level of satisfaction by body movement”. *International Journal of Fashion Design, Technology and Education*, Vol.7(2), p.85-95.

Park, H., Park, J., Lin, S. et al., 2014. “Assessment of Firefighters’ needs for personal protective equipment”. *Fashion and Textiles*, Vol. 1, p. 01-13.

Park, H., Trejo, H., Miles, M. et al., 2015a. "Impact of firefighter gear on lower body range of motion". *International Journal of Clothing Science and Technology*, Vol. 27(2), p.315-334.

Park, H., Kim, S., Morris, K. et al., 2015b. “Effect of firefighters' personal protective equipment on gait”. *Applied Ergonomics*, Vol. 48, p.42-48.

Veiga, V.I.R., 2019. Condições de satisfação com o uso de equipamento de protecção individual (EPI) no combate a incêndios urbanos e florestais por bombeiros no distrito de Bragança. Dissertação de mestrado. Instituto Politécnico de Bragança, Bragança.