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Research Article

Characterization of the Stress Profile in a Spanish Forest Firefighter's Workday

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Keywords

• HRV; PSS; Health; Ehealth; Firefighters; Technology

Abstract

Background: "A wildfire is a fire that spreads freely through vegetation with undesirable effects on vegetation. Predictions indicate that the effects of climate change will cause the rate of forest fires to increase by 50% by the end of 2100, and that these fires will become increasingly frequent in areas where they did not previously occur, such as in the Arctic. Spain accounts for almost 40 percent (39.39%) of the total number of hectares burned in 2022 in the European Union, with 236,575 of the 600,731 hectares burned, according to data from the European Commission's Copernicus European Fire Information System (EFFIS). The objectives of the present study were: a) to analyze the levels of stress present during a working day of forest firefighters when they did not carry out any firefighting operations and b) to analyze the level of agreement between the selected physiological and perceived stress assessment instruments.

Results: In general, the average total stress analyzed during a working day without an extinguishing operation shows low or very low stress balance (physiological stress) levels, closer to 0, and stress perception (psychological stress) levels also categorized as "low stress".

Conclusions: According to the results obtained, the level of physiological and self-perceived stress is moderate. The female gender is more stressed. The higher the age and experience, the lower the stress level. The study instruments used are valid for a quick and reliable measurement of stress levels.

INTRODUCTION

"A forest fire is a fire that spreads freely through vegetation with undesirable effects on the vegetation. A wildfire is distinguished from other types of fire by its wide spread, the speed with which it can spread from its place of origin, its potential to change direction unexpectedly, and its ability to overcome obstacles such as roads, rivers and firebreaks" [1].

Predictions indicate that the effects of climate change will cause the rate of forest fires to increase by 50% by the end of 2100, and that these fires will become increasingly frequent in areas where they did not previously occur, such as in the Arctic [2]. Spain accounts for almost 40 percent (39.39%) of the total number of hectares burned in 2022 in the European Union, with 236,575 of the 600,731 hectares burned, according to data from the European Commission's Copernicus European Fire Information System (EFFIS) [3].

The profession of forest firefighter, responsible for extinguishing forest fires, is characterized by its high seasonality (high personnel turnover year after year) and its high heterogeneity (age, training, experience and physical condition) [4]. In relation to the physical demands of forest firefighting work, a previous study carried out by Crespo-Ruiz et al., 2020 revealed a serious problem related to the high levels of body mass index that forest firefighters seem to have outside the summer season. This study identified, based on the body composition of 701 Spanish forest firefighters of both sexes, average body mass index (BMI) values of 24.85 in women and 27.83 in men, which represents a moderate-high risk of cardiovascular and metabolic disease according to the WHO [5].

It is important to point out at this point that the working conditions in which firefighting work is carried out (high temperatures, rocky areas, slopes, working with heavy tools, etc.) expose the body to very demanding work, both physically and psychologically, which can generate adverse psychological and behavioral reactions [6], for which they must be prepared both in the summer season with a high risk of fire and outside of it.

In the work context of the wildland firefighter, it is important to be able to measure and monitor stress levels with tools that are inexpensive, efficient and quick to apply. There are different tools to measure stress levels. On the one hand, there are those tools capable of quantifying physiological stress levels such as the measurement of cortisol levels, known as the stress hormone, through saliva [7], and the recording of heart rate variability (HRV), which is the time variation in milliseconds between the R and R intervals measured on an electrocardiogram, and demonstrates the interaction between the autonomic nervous system and the heart rate [8]. On the other hand, we can measure the level of psychological stress self-perceived by the professional during the working day through self-reported questionnaires [9], such as the 14-item Perceived Stress Scale (PSS) [10], or the question validated by the National Statistics Institute (INE): "Overall and

taking into account the conditions in which you carry out your work, indicate how you consider the level of stress in your job" from 1 to 7 items [11], which is more agile when incorporating into a recurrent monitoring of the level of perceived stress during the working day.

Compared to spot measurement of cortisol through saliva, HRV monitoring over a full working day has been validated in both performance training and occupational settings [7,12-16]. The widespread use of this tool has provided insight into how acute stress correlates with decreased HRV during sleep [17], and during the day [18], and has found a strong association between decreased HRV and work stress in different settings [12,15,19,20,21].

In relation to all this, it is important to know how forest firefighters manage their physical and psychological stress levels during the working day, both during and outside the summer period of maximum fire risk, in order to prepare personalized training plans to enable them to cope with their extinguishing tasks when a forest fire breaks out.

Based on the above, the objectives of the present study were: a) to analyze the levels of stress present during a working day in forest firefighters who did not carry out any firefighting operations and b) to analyze the level of agreement between the selected physiological and perceived stress assessment instruments.

Knowing the levels of physiological and perceived stress that forest firefighters experience during the working day without firefighting operations will allow us, for the first time, to create daily training plans that will prepare them optimally for a possible emergency exit, improving their reaction capacity and physical and psychological condition, especially outside the summer season with a high risk of forest fires. Likewise, finding a high level of agreement between instruments that require a higher economic and operational cost for the monitoring of HRV versus the use of self-reported questionnaires, which are cheaper and more accessible, could improve the periodic and recurrent evaluation of the stress levels of forest firefighters, which could significantly improve the number of scientific studies focused on improving the working conditions and reducing the risks of forest firefighters in both summer and non-summer seasons.

DATA AND METHODS

Design

The study design was descriptive-comparative. A total of 211 forest firefighters were assessed over a 24-hour period, 87.98% of whom were male and 12.01% of whom were female. All subjects wore the Firstbeat Bodyguard 2.0 device for 24 hours and answered the INE stress question from the National Health Survey. The research was approved by the Research Ethics Committee of the Área Sanitaria Integrada de Talavera de la Reina, Toledo, Spain (Code CElm: 22/18) and all the rules stipulated in the Declaration of Helsinki on the ethical use of volunteers were complied with. The confidentiality of participants' data was maintained at all times in accordance with the requirements of the General Data Protection Regulation (GDPR) (EU) 2016/679. The data collection lasted 5 weeks. Two weeks for each of the different forest fire brigade bases in the Castilla-La Mancha region.

Participants

The response to physiological and self-perceived stress during a working day outside the summer season and without firefighting intervention was analyzed in a sample of 211 forest firefighters, age 44.33±9.37 years, height 1.70 ± 0.75 m, weight 78.03 ± 14.15 kg assigned to the province of Castilla La Mancha (Spain). All subjects participated voluntarily, were healthy and had at least one year of professional experience. Those with severe cardiac disease, nervous system disease, very high blood pressure (≥180 / 100 mmHg), type 1 or 2 diabetes with autonomic neuropathy, severe neurological disease, fever or other acute illness, as well as BMI>40 were excluded [20]. All participants signed an informed consent form before participating in the study.

Interventions

First, participants were called 10 minutes before the start of the working day to answer the INE question in the National Health Survey. Once they answered the question, the operation and placement of the device was explained to them. Once the operation was explained, the device was found to start recording data. Subsequently, data logging was carried out for 48 hours. This register was fragmented into 8 working hours. These 8 working hours will be those of the analysis.

The outcome measures obtained were balance stress (SB) in a working day without any exit and/or emergency and self-perceived stress. Physiological stress was determined by cardiac variability (HRV) recorded on a non-invasive Firstbeat Bodyguard 2.0 device (Firstbeat Technologies Ltd., Jyväskylä, Finland). Data were recorded using Firstbeat Analysis Server software (version 6.3, Firstbeat Technologies Ltd.), which includes artefact detection and correction for irregular ectopic beats and signal noise. If the trend of the result is towards -1, physiologically the individual's body is considered to be more stressed, whereas if the result trends towards +1, physiologically the individual's body is considered to be more relaxed. Self-perceived stress was determined by the question: Overall and taking into account the conditions under which you perform your job, please indicate how you consider the level of stress in your job on a scale from 1 (not at all stressful) to 7 (very stressful) [11].

Data were recorded in an Excel 2018 database. Results were exported and processed in SPSS Statistics v23.0 (Armonk, NY, USA).

Statistical methods

Statistical analyses were performed using SPSS Statistics v23.0 (Armonk, NY, USA). In order to characterize the stress profile of a working day, descriptive statistics were used. These data are presented as mean ± standard deviation (SD). To assess whether there are differences in the stress profile by gender, age or province, a three-factor ANOVA was performed. In order to assess the level of agreement between the two measurement instruments, a correlation between the two instruments was carried out.

RESULTS

The overall physiological stress level according to the device is -0.19 ± 0.57. By provinces the level of general physiological stress and self-perceived stress are shown in Table 1.

In general, the average total stress analyzed during a working day without an extinguishing operation shows low or very low stress balance (physiological stress) levels, closer to 0, and stress perception (psychological stress) levels also categorized as "low stress". If we analyze stress levels by gender and age, in relation to stress balance, men aged 36 to 45 (-0.53) and women aged 26 to 35 (-0.52), have the highest stress balance values, much closer to -1. This means that their bodies tend to be more stressed. We found no significant differences with respect to other age groups ($p<0.05$).

In relation to perceived stress, men aged 36-45 years and women aged 56-65 years have the highest perceived stress.

Analyzing the results we obtain no significant differences between the balance stress variables and gender and age. We also found no significant differences between stress perception with age and province. This indicates that the level of stress (neither physiological nor perceived) would not be conditioned by age, gender or location. We would only have a significant relationship between perceived stress and sex (0.05), where women perceive a higher level of stress, and between physiological stress and location (<.001), where Albacete has higher stress (Table 2).

Likewise, when we studied the level of concordance between the two instruments, no correlation was found that could validate the use of one or the other indistinctly to be able to reliably know the level of stress that the forest firefighter presents during the working day.

DISCUSSION

The main objective of the present study was to analyze the stress response during a working day in a sample of forest firefighters who did not carry out any firefighting operations outside the summer season.

In this sense, average levels of stress balance (physiological stress) are shown to be low or very low, closer to 0, and levels of stress perception (perceived stress) are also categorized as "low stress". Previous studies have shown that during forest firefighting operations, due to their characteristics and the holography of the terrain in which they occur, the levels of physiological and self-perceived stress of forest firefighters during the working day increase exponentially, requiring a high level of physical and mental demand on the part of the professional during emergencies, which leads to high levels of anxiety and stress [22]. The study by Osorio et al. (2013), describes the profession of forest firefighter as a profession with moderate and high levels of stress [23], a categorization that would not correspond to the performance of this profession in non-summer seasons according to the findings of the present study.

The study by Romero et al. (2018), indicates that the level of stress of the forest firefighter depends on the accumulated work experience, with those professionals who have less experience as firefighters perceiving greater stress [24]. In our study the mean age of the sample was 44.33 ± 9.37 years, men aged 36 to 45 years (-0.53), and women aged between 26 and 35 years (-0.52), are those who presented a higher value of stress balance, much closer to -1 in terms of physiological stress and 36 to 45 years in men and 56 to 65 years in women in terms of perceived stress, corresponding to the younger age groups in the profession. Thus, we find that the younger they are, the higher the stress levels.

Our main objective in the study was to analyze the levels of stress present during a working day of forest firefighters when they did not carry out any firefighting operations, with the complementary aim of being able to contribute an original study that would provide valuable information on the physiological and psychological response of the professional outside the summer season with a view to improving their physical preparation plans. As has been observed in previous studies, the high body mass indexes present in forest firefighters outside the summer season pose a high metabolic and cardiorespiratory risk for the

Table 1: Overall physiological and perceived stress by province and gender.

	Gender	Toledo	Cuenca	Albacete	Guadalajara	Ciudad Real
Stress Balance (-1 a + 1)	Total	-0.29 ± 0.63	-0.23 ± 0.57	-0.34 ± 0.41	0.45 ± 0.23	-0.26 ± 0.54
	Man	-0.28 ± 0.64	-0.22 ± 0.58	-0.34 ± 0.42	0.45 ± 0.19	-0.28 ± 0.55
	Woman	-0.37 ± 0.52	-0.28 ± 0.57	-0.43 ± 0.12	0.47 ± 0.40	-0.10 ± 0.26
Stress perception (1-7)	Total	3.85 ± 1.78	4.17 ± 1.38	3.74 ±1.71	3.75 ± 1.18	3.72 ± 1.45
	Man	3.72 ± 1.78	4.23 ± 1.33	3.69 ± 1.75	3.70 ± 1.17	3.58 ± 1.49
	Woman	5 ± 1.10	4.14 ± 1.57	4.50 ± 0.71	4 ± 1.22	4.40 ± 0.55

*p<0,05

Table 2: Anova gender, age and province.

		Main effects ANOVA (F,p) (Age)			Main effects ANOVA (F,p) (Sex)			Main effects ANOVA (F,p) (Province)		
	Mean SD	F	p	n2p	F	p	n2p	F	p	n2p
Stress balance	-.193±.578	1.25	0.292	0.018	0.189	0.664	0.001	11.4	<.001	0.182
Stress perception	3.81±1.537	1.37	0.252	0.02	3.88	0.05	0.018	0.822	0.513	0.016

professional, which may be aggravated in firefighting operations, exposed to extreme external conditions, posing an additional risk to the fire both for the professional and for the firefighters accompanying him [5].

In this regard, the exponential increase in the rate of forest fires worldwide [3], highlights the importance of maintaining physical fitness to meet the occupational requirements of the profession, from physical exertion and shift work, to sleep disruption and witnessing potentially traumatic events. Failure to prepare for and mitigate these occupational demands with an appropriate lead time prior to the high fire risk season can have lasting implications for overall performance, as well as health and well-being [25]. With regard to the design of specific physical preparation plans for forest firefighters, our results show no significant differences between the variables of balance stress and perception stress with respect to age, sex, or the location where the job is performed. This could facilitate the creation of standard training plans individualized to the starting physical condition of each subject, in which the physical trainer can take as a starting point the general physical exercise recommendations of reference institutions such as the World Health Organization [26], and progress them according to reference manuals such as that of Cepeda, F. (2017) [27].

Likewise, it is worth highlighting the absence in the literature to date of previous studies such as the present one that measure the levels of physiological and self-perceived stress in forest firefighters during a working day without firefighting operations. Due to the original characteristics of this study in terms of the number of forest firefighters analyzed with HRV monitoring technology, the operational difficulty overcome to obtain the evaluation of professionals from different geographical areas, age and sex, and the timing of the data collection outside the summer operation. The results can contribute as a basis for future lines of research to better categorize the physical and mental demands that the profession of forest firefighter requires throughout the year.

However, as key limitations of the study to be improved in future research, it would be recommended to include among the variables to be analyzed the number of days without previous firefighting intervention, the years of experience as a forest firefighter and to include a longitudinal study that can monitor with tools suitable for high heat and sweat conditions, the monitoring of HRV during a firefighting operation.

CONCLUSIONS

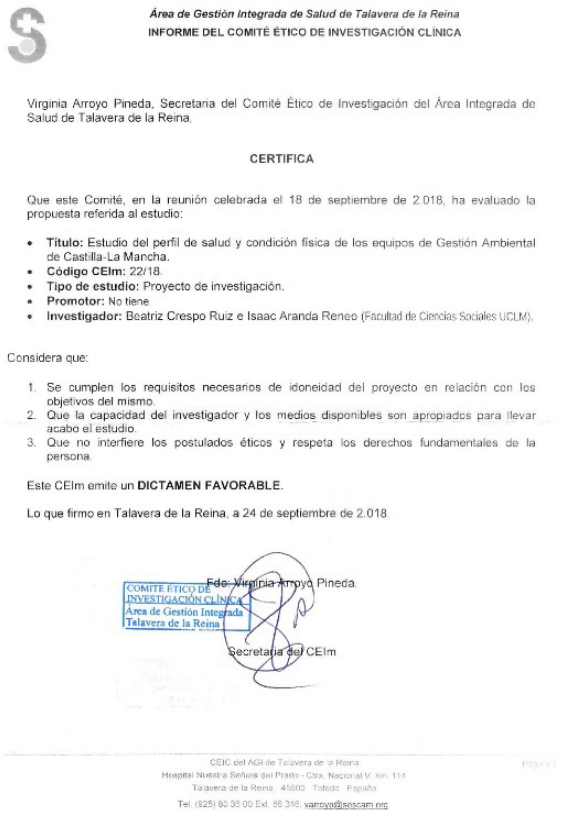
According to the results obtained, the level of physiological and self-perceived stress is moderate. Women are more stressed. The older and more experienced the stress level decreases.

The survey instruments used are valid for quick and reliable measurement of stress levels.

However, studies of longer duration and with more variables are needed to see if the trend continues or if stress levels may be due to other factors not studied in this research.

DECLARATIONS

Ethical Approval



Área de Gestión Integrada de Salud de Talavera de la Reina
INFORME DEL COMITÉ ÉTICO DE INVESTIGACIÓN CLÍNICA

Virginia Arroyo Pineda, Secretaria del Comité Ético de Investigación del Área Integrada de Salud de Talavera de la Reina.

CERTIFICA

Que este Comité, en la reunión celebrada el 18 de septiembre de 2.018, ha evaluado la propuesta referida al estudio:

- **Título:** Estudio del perfil de salud y condición física de los equipos de Gestión Ambiental de Castilla-La Mancha.
- **Código CEIm:** 22/18.
- **Tipo de estudio:** Proyecto de investigación.
- **Promotor:** No tiene.
- **Investigador:** Beatriz Crespo Ruiz e Isaac Aranda Reneo (Facultad de Ciencias Sociales UCLM).

Considera que:

1. Se cumplen los requisitos necesarios de idoneidad del proyecto en relación con los objetivos del mismo.
2. Que la capacidad del investigador y los medios disponibles son apropiados para llevar acabo el estudio.
3. Que no interfiere los postulados éticos y respeta los derechos fundamentales de la persona.

Este CEIm emite un **DICTAMEN FAVORABLE**.

Lo que firmo en Talavera de la Reina, a 24 de septiembre de 2.018

COMITÉ ÉTICO DE INVESTIGACIÓN CLÍNICA
Área de Gestión Integrada
Talavera de la Reina

Fdo: Virginia Arroyo Pineda

Secretaria del CEIm

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Authors' Contributions

The authors' contributions are as follows:

Paula Esteban-García: Data collection & Research design and review.

Shai Rivas-Galan: Data collection & Research design and review.

Beatriz Crespo-Ruiz: Data collection & Research design and review.

Availability of Data and Material

The data are available in an anonymised form.

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