

ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Predisposing factors for frostbite – a ten-year retrospective study

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SUMMARY

Introduction/Objective Frostbite is a cold-induced injury of the tissue caused by the freezing of intra- and extracellular water, and characterized by thrombosis and ischemic necrosis. Although individual, socioeconomic, and environmental factors are all considered fundamental determinants of human health in general, their role in the occurrence of frostbite remains largely unknown. The aim of this study was to examine the associations among these factors and frostbite for patients in Belgrade, Serbia.

Methods We investigated a total of 24 patients that were hospitalized and treated for frostbites at the Clinic for Burns, Plastic, and Reconstructive surgery, Clinical Center of Serbia, 2008–2017.

Results The majority (88%) of the patients were male, 58% were long-term alcohol consumers, 46% were long-term smokers, and one patient was drug addict. Of the patients, 14 (58%) had no income and depended on government support, 10 (42%) were employed in physical labor or work on the field, and three (13%) of the patients were homeless. Of the 24 frostbite patients identified, deep frostbite accounted for 18 (75%), of whom 17 (70.8%) had an operative outcome. A majority of patients (42%) sustained frostbite when the temperature was in the range of -5–0°C on the date of occurrence.

Conclusion The results of our study showed that individual, social, and environmental factors were important determinants of frostbite. Our results will contribute to existing evidence for risk factors related to frostbite and will allow for comparisons across countries where these factors have been examined.

Keywords: frostbite; individual factors; socioeconomic factors; environmental factors

INTRODUCTION

Frostbite is a freezing cold thermal injury that occurs when tissues are exposed to temperatures below their freezing point, even above freezing temperature if exposure is prolonged [1]. Pathophysiology of frostbite can be divided into four overlapping pathologic phases: pre-freeze and freeze-thaw, which contribute to direct cellular injury, and vascular stasis and late ischemic phase, which can be described as the carriers of the indirect cellular injuries. The pre-freeze phase consists of vasoconstriction and ischemia. Ice crystal formation and cell disintegration are some of the hallmarks of the freeze-thaw phase. Rewarming leads to reperfusion, causing an inflammatory surge, vascular leak, thrombosis, and embolization that are characteristic of the freeze-thaw phase, but they also largely overlap with the vascular stasis stage. The late ischemic phase results from progressive tissue ischemia and infarction caused by a cascade of events including inflammation mediated by arachidonic acid [2–5].

In the past, frostbite was a leading cause of devastating casualties in wars. More than 10% of all American casualties were due to cold weather-related injuries in World War II and the Korean War. More than 15,000 amputations

for frostbite were performed by the German army alone on the Russian front in the winter of 1942 [6]. Recently, concern about frostbite has grown because it has become more widespread [7]. The prevalence of frostbite among the civilian population increased mostly owing to an increase in the number of homeless people, but also because of greater ease of air travel, participation in winter sports, and more ascents to high altitudes [7, 8, 9].

Predisposing factors for frostbite have been described in many large epidemiological studies conducted worldwide [10, 11, 12]. Studies conducted in United States, Norway, and Finland have linked frostbite to homelessness, improper clothing, atherosclerosis, wound infection, diabetes, smoking, and fatigue [13–16]. In Canada it was reported additional predisposing factors related to frostbite, such as alcohol consumption, smoking, psychiatric illness, vehicular failure, drug misuse, and homosexual intercourse [12, 17]. Recent studies have also provided evidence that prevalence is the highest between the ages of 30 and 49 [18, 19].

Although individual, socioeconomic, and environmental factors are considered fundamental determinants of health in general, factors predisposing to frostbite are less well-known than previously thought [18]. Therefore,

Received • Примљено:

November 6, 2018

Revised • Ревизија:

April 9, 2019

Accepted • Прихваћено:

April 18, 2019

Online first: May 17, 2019

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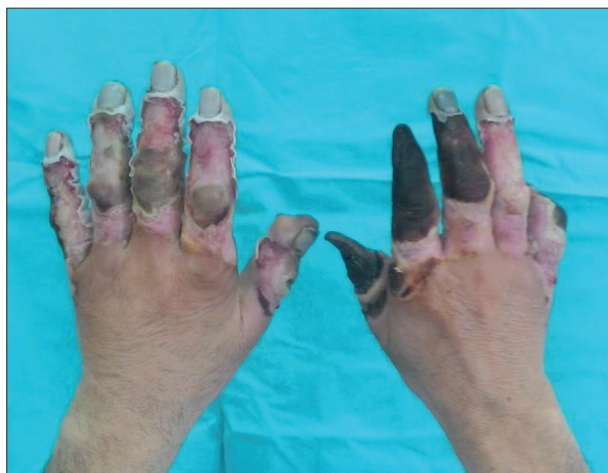


Figure 1. Frostbite of the hands



Figure 2. Frostbite of the feet

detailed studies are necessary to determine the predisposing factors influencing frostbite [10, 12, 18]. Therefore, we examined the associations among these factors and frostbite for patients in Belgrade, Serbia. Specifically, we surveyed records of the Clinic for Burns, Plastic, and Reconstructive Surgery, Clinical Center of Serbia for people admitted with frostbite in the period 2008–2017, and determined its association with individual, socioeconomic, and environmental factors. To the best of our knowledge, predisposing factors for frostbite have never been examined in any epidemiological study in Serbia.

METHODS

Study population

The study protocol was approved by the Ethics Committee of the Clinical Centre of Serbia, Belgrade, Serbia. The sample comprised all patients admitted to the Clinic for Burns, Plastic, and Reconstructive Surgery at the Clinical Center of Serbia during the period 2008–2017 with frostbite as primary or secondary diagnosis. A total of 24 patients were treated during the period of this study. The data were collected from the hospital discharge register. Each record contained information on the patient's sex, age, place of residence, employment, relationship status, primary or secondary diagnosis, habits such as smoking, alcoholism and drug abuse, date and place of occurrence of the injury, time between the injury and medical examination, and the length of the hospital stay. One patient was admitted two times for frostbite; only first admissions were included in this research.

Climatic data

To represent the temperatures at which frostbite had been sustained, we used the lowest daily temperature recorded by the closest weather station from the location of the injury on the day of frostbite. Mean daytime temperatures were classified in intervals $-20--15^{\circ}\text{C}$; $-15--10^{\circ}\text{C}$; $-10--5^{\circ}\text{C}$; $-5--0^{\circ}\text{C}$; and $0--5^{\circ}\text{C}$.

Statistics

We used descriptive statistics. This method simply described the basic features of the data.

RESULTS

Characteristics of the patients

A majority of the patients (88%) were male with the mean age of 49 years. The mean age of the female patients was 47 years. Frostbite was found to be most common (54%) in patients between 30 and 55 years of age. In 46% of the patients, frostbite was the only diagnosis, whereas 33% were also diagnosed with mental disease, 13% were diagnosed with cardiovascular disease, and 13% had other diagnoses such as diabetes mellitus, dementia, and hepatorenal syndrome. A total of 58% were long-term alcohol consumers, 46% were long-term smokers, and one patient (4.2%) was a drug addict (Table 1). Of the 24 frostbite patients identified, deep frostbite accounted for 18 (75%), of whom 17 (70.8%) had an operative outcome (Figure 1, Figure 2). Amputation occurred in 15 (62.5%) deep injuries and debridement in two (8.4%).

A majority of patients (46%) had no income and depended on government support. The percentage of patients employed was 29%, usually doing physical labor or farming. Seven patients lived alone, five with families, and four patients were homeless. In relation to the affected part of the body, 15 patients had frostbite on the feet, six on the hands, two on both the feet and the hands, and one patient had frostbite on the hands as well as other parts of the body such as ears and knees (Table 1). The average time between the injury and medical examination was 12 days. The average hospital stay was 36 days.

Frostbite and temperature

A majority of patients (42%) sustained frostbite when the temperature was in the range of $-5--0^{\circ}\text{C}$ on the dates of

Table 1. Sex, age, employment, comorbidities, habits, and affected parts of the body

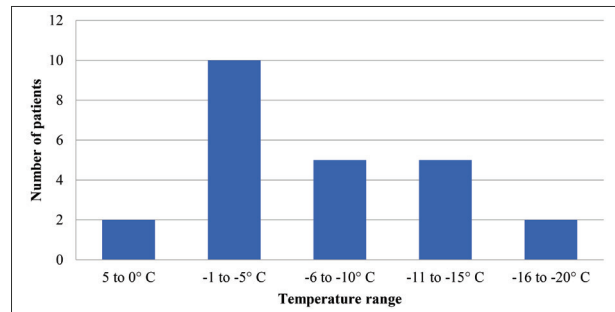
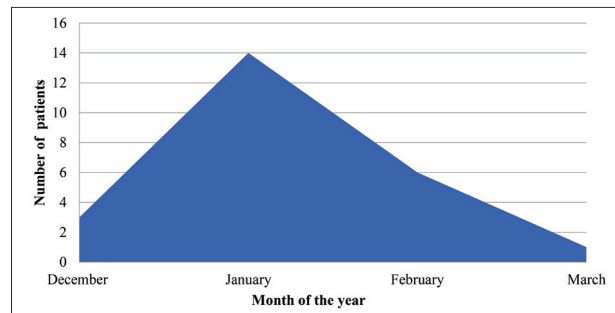
Sex	Number	Percent
Female	3	13%
Male	21	88%
Age		
18–30	2	8%
31–55	13	54%
55+	9	38%
Employment		
Employed	7	29%
Unemployed	11	46%
Retired	3	13%
Unknown	3	13%
Co-morbidities		
Cardiological	3	13%
Mental illness	8	33%
Neurological illness	3	13%
Habits		
Alcohol	14	58%
Cigarettes	11	46%
Drugs	1	4%
Affected part of the body		
Hand	6	25%
Feet	15	63%
Hands & Feet	2	8%
Hands, ears & knees	1	4%

occurrence of the injury (Figure 3). Figure 4 summarizes the climatic pattern and the number of cases per month. The number of patients was highest in January (58%), high in February (25%) and December (12%), and only one case (4%) was seen in March. No patients reported the presence of moisture or immersion of the exposed part of the body to the cold.

DISCUSSION

The results of the study extended work on examining the factors predisposing to frostbite by evaluating its association with individual, socioeconomic, and environmental factors. Our results were similar to those reported by others in some respects. In our study, the majority of patients abused alcohol, and the most severe cases of frostbite were among alcoholics. This is in line with the results obtained by Conway et al. [20], who noted that 27% of all frostbite victims in Alaska were alcoholics. Likewise, Fabian et al. [12] in a 10-year long retrospective study reported that among the top risk factors for frostbite was alcohol abuse.

Our results showed that 33% of the patients suffered from mental illness, generally mirroring previously findings by Kappes et al. [21], who concluded that next to alcohol abuse, mental disorders were the most significant determinants of extensive frostbite. Pinzur and Weaver [22] who found that patients suffering frostbite had significant discrepancies in the percentages of concomitant psychiatric diseases compared with what had been expected. Simi-

**Figure 3.** Injury occurrence according to temperature range**Figure 4.** Injury distribution by month

larly, recent studies have also shown that large numbers of patients with frostbite have psychiatric illnesses [10].

The study has also revealed that the majority of patients were between 30–55 years old. In contrast, previous research has shown that frostbite is most common among the elderly and young children [23]. Although this grouping seems intuitively correct, recent epidemiological studies have classified adults aged 30–49 years as the group at high risk of frostbite [18, 24]. Moreover, past research has indicated that males are more frequently affected by cold-induced injuries than females, which is also consistent with our results [10, 12, 18, 25, 26]. The incidents reported in these studies are strongly related to these findings, as males constituted a vast majority of subjects.

Furthermore, the results showed that the majority of patients had no income and depended on government support. This finding strongly correlated with many previous studies that have linked frostbite to poverty [22]. For example, according to Pinzur and Weaver [22], the frostbite observed in urban areas in the United States typically occurred among the poor and homeless. Finally, in our study, all patients had frostbite on the feet and hands. These results are consistent with studies that revealed almost unanimous evidence that these anatomical areas were most at risk of sustaining frostbite [10, 27, 28]. The feet and hands are considered sites for 90% of frostbite-related injuries, with the feet the most commonly affected [10].

Our results also showed that frostbite occurrence (42%) was highest at temperatures -5–0°C. However, Juopperi et al. [18] noted in their study in Finland that the incidence of frostbite increased at temperatures below -15°C in Helsinki. It is possible that as the average temperature in Serbia in winter are higher than those in Finland, Serbians may

not be aware of the effects of cold weather, consequently they do not dress adequately, so they may be less qualified at protecting themselves. Inadequate clothing has previously been confirmed as a risk factor for acquiring frostbite in many studies [29].

Certain limitations of our results should be considered. First, the study sample was a consecutive series of patients attending only one clinic in Belgrade during the observed period. The findings obtained in such settings cannot be easily generalized. Second, we collected data from a small number of patients that had been hospitalized, and did not analyze data for patients from outpatient departments who had small or superficial frostbite. But even in Finland, where temperatures are very low in winter Koljonen et al. [30] noted that cases of hospitalization for frostbite were rare. Future work should include both hospitalized patients and those in outpatient departments from all clinics for burns, and plastic and reconstructive surgeries in Serbia. Notwithstanding these limitations, the results of our study showed that many factors determined frostbite in Serbia.

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CONCLUSION

This study was added to work that examined individual, social, and environmental factors influencing frostbite. Our data indicated that these factors were important determinants of frostbite. This was noteworthy for several reasons. First, our results contributed to existing evidence for risk factors related to frostbite. Second, the results of our study will allow for comparisons across countries where these factors have been examined. Further, it will help us better understand the issue and allow for greater awareness of frostbite, especially among the public in Serbia and, hopefully, will help prevent future cases. Finally, and more broadly, the factors related to frostbite that were examined provides researchers with additional tools for capturing the evolution of, as well as differences and similarities among, these factors at the global level.

Conflict of interest: None declared.

Фактори који утичу на настанак смрзотина – десетогодишња ретроспективна студија

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САЖЕТАК

Увод/Циљ Смрзотине су повреде настале смрзавањем интраћелијске и екстраћелијске течности које доводи до тромбозе и исхемијске некрозе. Иако се лични, социоекономски фактори, као и фактори средине сматрају важним детерминантама људског здравља генерално, њихов утицај на смрзотине у великој мери је још увек непознат.

Циљ ове студије био је да се испита утицај ових фактора на настанак смрзотина у Београду (Србија).

Метод У овој студији је учествовало укупно 24 болесника хоспитализована и лечена на Клиници за опекотине, пластичну и реконструктивну хирургију Клиничког центра Србије, у периоду између 2008. и 2017. године.

Резултати Већина болесника (88%) били су мушкарци, 58% болесника били су дугогодишњи алкохоличари, 46% болесника били су дугогодишњи пушачи и један болесник је био зависник од дроге. Четрнаест (58%) болесника није

имало приходе и зависило је од подршке државе, 10 (42%) болесника су били физички или пољопривредни радници и три (13%) болесника су била бескућници. Од 24 испитивана болесника дубоке смрзотине је имало 18 (75%) њих, од којих је 17 (70,8%) оперисано. Највећи број болесника (42%) задобио је смрзотине када је температура ваздуха била између -5°C и 0°C.

Закључак Резултати нашег истраживања показали су да индивидуални фактори, социјални фактори, као и фактори средине представљају важне детерминанте код настанка смрзотина. Наши резултати допринеће постојећим доказима о факторима ризика који се односе на смрзотине и омогућиће поређења у земљама у којима су ови фактори испитивани.

Кључне речи: смрзотине; лични фактори; социоекономски фактори; фактори средине