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ARCTIC MILITARY CONFERENCE IN COLD WEATHER MEDICINE

Training videos to prevent cold weather injuries

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ABSTRACT

Cold weather injuries (CWIs) are a challenge during military training, exercises and operations in Arctic conditions. Soldier performance in these challenging conditions depends on protective equipment, knowledge, personal experience, routines, and leadership. Despite the Norwegian Armed Forces' goal of zero freezing cold injuries (FCIs), there has been a persistently high incidence of FCIs among the younger soldiers with an average of 120–150 new FCIs recorded each year. Therefore, an expert working group with representatives from medical, defence and research background was established in 2020. Their task was to develop a communication package to help prevent CWIs among military personnel. Training videos and an updated and improved official website were created with a focus on practical recommendations and advice to prevent CWIs and especially FCIs. Risks, prevention and symptoms of FCIs were emphasised. The main goal of the training videos was to supplement current teaching on guidance for CWI prevention in CWOs to prevent FCIs, but following the advice may prevent non-freezing cold injuries (NFCIs) and hypothermia. This informative paper describes the background, working methods and possible implications of the training videos, which may be a potential way forward to improve cold weather training and operations.

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Introduction

Managing the Arctic conditions better than an enemy can give operational advantages. However, cold weather operations (CWOs) present challenges in maintaining soldiers' health and performance [1], and thus also optimal operative capability. CWOs are in this informative paper defined as military operations taking place at ambient temperature below 4°C, but can otherwise involve a wide range of environmental conditions in terms of ambient temperature, wind, humidity, rain, snow and sunlight [2]. The physical strain due to high activity levels associated with working, walking or skiing in snow and difficult terrain, while dealing with heavy combat clothing and equipment also affects the soldiers thermal strain [3]. Together, the environmental conditions, the clothing, and the workload lead to a complex interaction of factors that decides the body's ability to maintain thermal balance during CWOs.

These conditions can be extremely challenging for NATO allies accustomed to warmer climates, but also remain a challenge even for those who normally train and operate in an Arctic environment. For the soldier, the key to successful CWOs is to maintain dexterity, tactile sensation, physical and cognitive performance, and to avoid cold weather injuries (CWIs). CWI is the common term for any type of injury that is sustained as a result of being exposed to cold, where the three most classic CWIs are hypothermia, non-freezing (NFCI) and freezing cold injuries (FCI) [1,4]. In Arctic environments, CWIs can occur all year round, in connection with military education, training and practice. Most of the military training, exercises and operations in Norway are, due to its geographical location, carried out in an Arctic environment, and CWIs are a challenge for many divisions in the Norwegian Armed Forces. In recent years, an average of 120–150 new FCIs have been recorded each year in the Norwegian Armed Forces [1]. This is a universal problem when operating in these environments. During winter service in the northern part of Scandinavia reported incident rates are around 2% per year [5,6], and during a joint Canadian/U.S. exercise in the High Arctic the incidence rate of FCIs was as high as 21% [7].

FCIs occurs when the temperature in the skin falls below the tissue's freezing point (–0.55°C) [1]. In contrast, NFCIs occur when fingers and feet are exposed to moisture and low temperatures for a long time, but the temperature is above the tissue's freezing point [1,8]. Most NFCIs occur in ambient temperatures between 0 and 15°C [1]. NFCIs and FCIs have negative implications for the Armed

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Forces operative capability. Previous NFCIs and FCIs can further reduce manual dexterity and the ability to carry out manual work and/or tasks requiring the use of fine motor skills when exposed to cold [9–11]. Furthermore, they can disturb the blood circulation, cause damage to the nerves, and give rise to a lifelong intolerance of cold and pain, not to mention the greater risk of re-injury in the same place. There is the additional risk that re-injury in the same place will be more serious the second time around [12]. Thus, NFCIs and FCIs can potentially reduce the sufferer's quality of life and adversely affect the person's career in the Armed Forces. Consequently, targeted measures are needed to prevent this type of cold injury.

Physiological adaptation to cold is limited, so the most powerful form of human thermoregulation is behavioural, such as changing one's posture, seeking shelter or warmth, and wearing clothing suited for the environment and the activity. However, good routines and proper use of combat clothing and soldier equipment in the cold requires both knowledge and experience. Moisture, wind and low temperature combined with low physical activity present challenges [3]. Moisture is particularly problematic in the cold, increasing the risk of CWIs. The high conductivity of water causes high cooling rate of the body when wearing wet clothing in the cold. The moisture can come from the environment and from the body. Wearing too much clothing, increasing work intensity, or changing activity can induce heat stress even in the cold [13]. For a lightly clad person, the most effective way of losing heat is through evaporation of water through sweating. However, sweating in cold weather combat clothing produces a hot and humid microclimate next to the skin, which causes sweat accumulation in the clothing without a corresponding loss of body heat through evaporation. Thus, while combat winter clothing protects the wearer from heat loss, it can also lead to thermal problems, especially in non-steady-state conditions (e.g. transitioning from marching with heavy load to low-level activities or rest). Therefore, situations involving varying work intensity in the cold require active regulation of the clothing. This is easier said than done in most practical situations, and requires knowledge, personal experience, routines, good leadership, and a continuous focus on teaching and training [2].

In cold environments, whole-body cooling can occur despite the wearing of cold weather combat clothing and soldiers' personal equipment. Hands, feet and parts of the face [14] are especially vulnerable to local cooling [15–17]. To prevent heat loss from the body, the circulation of warm blood to the skin and extremities is decreased by reducing the diameter of the blood vessels (vasoconstriction), thereby decreasing the skin temperature. In addition, the insulation of hand and footgear is also often inadequate, further reducing the hand and foot temperature. There is a temperature-induced degradation of manual performance at a finger skin temperature below 12–20°C [18] or hand temperature below 15°C [19]. Hence, loss of manual function occurs long before FCI [9]. Reduced manual dexterity can lead to loss of basic skills critical for soldiers in both training and battle, such as zipping, lacing boots, raising a tent, and handling weapons [20]. In addition to vasoconstriction and inadequate insulation, handling weapons and other metal equipment with high conductivity makes the hands susceptible to FCIs. Protecting the hands from heat loss while not losing manual dexterity due to bulky materials of gloves/mittens is a puzzle not yet solved. However, good preventive measures include always keeping a protective layer between skin and metal objects, and to always practice handling equipment while wearing mittens, but this requires knowledge, training and adherence.

Even though the risk of CWIs can be high during CWOs in the Arctic, the Arctic environment is not necessarily a barrier to performing physical activity [2] as "*Man in the cold is not necessarily a cold man*" [21]. Ensuring optimal operative capability in the cold and avoiding CWIs requires knowledge, implementation of best practices, and CWO training and experience. Expert training and personal experience in how to use cold weather combat clothing and personal soldier equipment is essential to maintain performance and health during training and operations in the cold [17,22]. In addition, good leadership is crucial, and soldiers must be encouraged to alert superiors of emerging problems to prevent a situation from worsening, as things quickly goes from bad to worse in the Arctic.

Despite the Norwegian Armed Forces' goal of zero FCIs, there has been a persistently high incidence of FCIs among the younger soldiers. Therefore, there was a need to reduce these cases, in addition to help to better prepare allied forces training in Norway.

This informative paper aims to communicate to allies a potential way to improve cold weather training and operations, and the training videos can be a starting point for preparations for future multi-national training or exercises.

Materials and methods

To help prevent FCIs in the Norwegian Armed Forces, and allies training in Norway, a working group was established

in 2020 with the task of developing a communication package to prevent CWIs among military personnel. The working group's first aim was to give an overview of the recommendations and advice for preventing peripheral CWIs based on research and best practices. The second aim was to decide how the knowledge should be communicated in order for it to be implemented in practice. The third aim was to discuss any gaps between the scientific literature and best practices. The group consisted of experts from the Norwegian Armed Forces Joint Medical Services, the Norwegian School of Winter Warfare, His Majesty the King's Guard and the Norwegian Air Force's Specialist School, as well as the civilian research institute SINTEF and the Norwegian Defence Research Establishment (FFI). SINTEF is Norway's largest research institute and they have years of experience from research of petroleum workers in the Arctic. Therefore, an expert on work physiology in extreme cold environments from SINTEF was included in the working group to share expertise and scientific knowledge from the civilian sector. The working group operated for 2.5 years, and held two official meetings per year. The working group started its work by going through existing advice, guidelines and teaching material used by the Norwegian Armed Forces to assess its quality and look for shortcomings.

To get an overview of the current recommendations and advice for preventing peripheral CWIs, some professional presentations about general cold physiology, and military education and soldiers training in CWO were held at the first working meetings. The aim was for all members to gain a common understanding of existing knowledge, and what is already being done to prevent CWIs in both the Armed Forces and civilian worker life. The representative from the Norwegian School of Winter Warfare described how the Norwegian Armed Forces educates and prepares soldiers for winter service in soldier training. The representative from SINTEF informed about work done towards civilian working life where extensive international work has been carried out to ensure the health, environment and safety of workers in the petroleum industry. This has resulted in ISO standardised recommendations for the prevention of CWIs [23]. In addition, discursive work was done to align different perspectives represented in research vs. practice and in medicine vs. the military. This was done to ensure that the advice was communicated professionally, correctly, in an understandable way for the soldiers, and that all representatives agreed upon the advices in the communication package.

After a review of existing experience- and research-based knowledge, it was decided that the Norwegian Armed Forces' Handbook for winter service [24] should be used as the professional basis for the information package. Furthermore, this information was both quality assured by the Norwegian Armed Forces professional authorities, and in line with newer research and ISO standardised recommendations given for the prevention of CWIs in the civilian labour force.

The working group assessed that the high incidence of CWIs in the Norwegian Armed Forces indicates that available information on CWIs does not always reach the individual soldier. Therefore, it was decided that the communication package should be adapted directly to military personnel, in particular to clarify the value of preventing CWIs. The working group considered young soldiers in or on their way into basic service, as well as young officers as the most important target groups. Previous studies have shown that young soldiers are the most susceptible to FCIs [1,5,6].

It was agreed to 1) improve the Norwegian Armed Forces' website on CWIs in the communication package, with advice and information better adapted to the Norwegian Armed Forces personnel and 2) develop animated information videos for the dissemination of the most important information, and shed light on CWIs from different perspectives to clarify risks, prevention and symptoms. Further, the webpage should also function as a place to gather all information on the subject for military commanders and instructors, and a place to go to for professional updates prior to education and courses.

It was decided to produce both Norwegian and English language versions of the videos so that the message could also be conveyed directly to allied soldiers before training in Norway. In order to develop the website and produce videos, the working group enlisted the support and involvement from the Norwegian Armed Forces Media Centre and an advertising agency for the practical work with website development and video production.

Training videos

The main results from this work is the official "Cold weather injuries – and their prevention" website (https://www.forsvaret.no/soldater-og-ansatte/soldat/kaldvaersskader-forebygging) and the tutorial videos. A "Long version" of the video was made in both Norwegian and English (https://youtu.be/c5UulfTdp0c), along with separate ones on "Risks" (https://youtu.be/LN9h7c0sL1w), "Prevention" (https://youtu.be/oPXm8sLBtWY) and "Symptoms" (https://youtu.be/kutOvGDhgs4). The videos use footage from real CWOs to show the hazards and set the context (Figure 1), while animations were used to get the advice across to the viewer (Figures 2 and 3).

Before making the videos and the website, the working group prepared a summary list of the information it considered most important to communicate (Table 1).

The summary was based upon more comprehensive lists of advice for suitable clothing (Table 2), risks (Table 3), and sleep and nutrition (Table 4). To provide the rationale and broader context for some of the advice, a number of statements were also included in the videos and on the website, e.g.:

> Use mesh underwear closest to the body to trap air, then one or more layers of wool. As the outer layer you should have windproof garments. The air between the layers then heats up and acts as a heat insulator.

> Frostbite can occur sooner than you think. Listen to your body. If in doubt - tell an officer.

> Dehydration (a low amount of water in the body) increases the risk of local cold weather injury, partly because the ability to regulate body temperature decreases.

The idea being that it is easier to follow instructions if you know the reasons for them. In addition, short statements were used to emphasise the most important information, e.g.:

> If you master the cold, it becomes an ally. Dress according to the weather and activity.

> And finally: Listen to your body. If you are in doubt, there is no doubt: Inform an officer

For the website, relevant questions were highlighted and answered, e.g.:

> Question – "Can you get used to the cold?"

> Answer – "Yes, mentally. However, the cold is dangerous, even if your tolerance increases. With increased mental tolerance, you can expose yourself to a greater risk of frostbite because you can feel able to endure more than you actually do".

> Question – "Does some people feel cold more often than others?"

Figure 1. Screenshots from the video "Risks".

Figure 2. Screenshots from the video "Prevention".

> Answer – "Yes. There are large individual differences, and it varies particularly with body size and body composition."

Overall, the communication package including the updated website and the animated videos were made to increase the knowledge and knowhow for maintaining performance and avoiding CWIs, especially FCIs during CWOs. For the videos, the language was kept simple and communicated with a clear officer voice, only the most important advice was given, and the videos incorporated some background knowledge.

Discussion

The purpose of the communication package was to improve cold weather training in the Norwegian Armed

Figure 3. Screenshot from the video "Symptoms".

Table 1. Summary of key points for communication.

Take care of yourself, your partner, and your fellow soldier
• It is important to report when you or your fellow soldier are cold and/or wet
Correct use of clothing and equipment
• Use shoes that are too big, preferably 1–2 sizes
• Use overboots
• Change to dry socks when resting
• Always use a protective layer between skin and metal
• Use mittens rather than gloves
• Change clothing according to activity
Basic physiology
• Cold hands and feet pose a risk of injury and loss of function
• Sweating in cold environments poses a risk of injury
• Understanding the danger signals
• Eat and sleep whenever possible
• Intake of proper nutrition

Forces and allies. This informative paper is a way to communicate to allies that the training videos can be a starting point for preparing CWO in a future multi-national training or exercises to prevent CWIs, including dressing appropriately for the conditions and having good routines for taking care of their bodies, equipment and fellow soldiers. The effect of the training videos on FCIs occurrence have yet to be evaluated, and can perhaps be evaluated in a future multi-national cold weather training event.

Table 2. How to dress properly in the cold.

General
• Adjust clothing according to activity level and climate
• Use several thin layers of clothing rather than few and thick
• Work wet, rest dry
• Repair or change damaged clothes
• Cover head, neck, hands and feet from wind and precipitation
Head, neck and face
• Headwear should cover forehead, ears, neck and partly the jaw and chin
• Use balaclava and full face mask
• Use the hood
• Turn the face from the wind when possible
• Use googles
Feet
• Use shoes that are too big, preferably 1–2 sizes
• Use thick inner soles in boots and/or in overboots
• Use overboots when needed
Hands
• Always use a protective layer between skin and metal (e.g. weapons)
• Mittens are warmer than gloves
• Practise wearing gloves/mittens during practical tasks

Table 3. Risk of injury.

Danger signals
• Reduced manual dexterity
• Pain in hands and feet
• Red skin, swelling, tingling and numbness
• White spots (and blisters) on nose, cheeks, ears and fingers
Risk factors
• Low ambient temperature
• Wind
• Precipitation
• Sudden weather changes
• Long term cold exposure, especially combined with precipitation/water
• Not sufficient clothing
• Damaged clothing
• Not changing to dry clothes at rest
• Wet foot and hand garments with low insulation
• Dehydration
• Sleep deprivation
• Snuff or smoking (nicotine)
When the damage has occurred
• Notify a commander if you suspect injury on yourself or others
• Prevent deterioration by seeking shelter or covering exposed skin
• Use skin on skin, e.g. hands/feet on someone else's stomach or your own hands under the armpits, but do not rub or massage the damaged skin.
• Note that previous damage increases risk of new injury

The working group created an overview of practical recommendations and advice to prevent CWIs and FCIs in particular, based on best practice and scientific knowledge. As previous studies have shown that soldiers in or on their way into basic military training are the most exposed to FCIs [1], they and young officers were identified as the primary audience of the advices. It was determined that the best way to

Table 4. Advice on nutrition and sleep.

Nutrition
• Avoid dehydration and energy deficiency
• Use the breaks well – eat and drink whenever possible
• Consume all the food/drink distributed
• Eat more than you think is necessary
Sleep
• Comfortable sleep requires proper equipment
• Sleep whenever possible

distribute the knowledge to the target group was to make tutorial videos, along with updating and improving the official "Cold weather injuries – and their prevention" website. Further, much of the current best practice is based upon practical knowledge, years of experience, and basic thermal physiology. There is a lack of scientific knowledge on several topics.

Having soldiers that thrive and cope in the cold gives an operational advantage, and is dependent on solider equipment, knowledge, personal experience, routines, and leadership. Today's soldiers in basic training in Norway are expected to acquire a lot of knowledge on a huge variety of topics, and the time to practice is limited. In addition, many recruits these days come with little experience from outdoor life. This places great demands on the information they receive ahead of the physical exercises. Therefore, the working group wanted to make a supplement to today's teaching materials about the prevention of CWIs, especially FCI.

Metrics show that videos, rather than text, lead to higher engagement in social media. This pivot from text to video has also occurred in domains and sectors outside of social media, especially in the field of learning. However, there is still a debate about whether video-based learning can improve retention and engagement. Nevertheless, it is safe to say that video will continue to be a part of our education in the future. One can also combine the power of video, the nuance of text, and the ability to focus the reader's attention on key themes or points. By adding voice-over and text to the visuals of the video, you may reach out to more students, as some may prefer video-based learning and others may prefer text or auditory learning. Accordingly, the Norwegian Armed Forces and NATO allies [25] have started to include more basic e-learning. Since the target group consisted of young adults that are used to searching for and receiving information in video format, the animated videos were considered the best option for communicating a lot of content and text. The experience of the Norwegian Armed Forces Media Centre was that when the aim is to convey academic messages, or the videos are intended to be used for teaching, animated videos have a better effect than real videos with actors. This is because an animation gives less focus on the visuals, and more focus on the actual message. Furthermore, it is possible to include lists, points, text and voice-over in such films, which helps to reinforce and clarify the message.

It was not always easy to decide which advice should be given in the videos because the environmental conditions, clothing, equipment and workload lead to a complex interplay of factors that can affect the soldier's operational capability. In addition, there will always be large individual differences in physiological and subjective responses under the same conditions. Therefore, some of the advice given is relatively general. An example of a general advice is adjusting clothing according to activity level and climate. This is important advice that does not give specific guidance on what type of clothing is suitable for different activity levels and environmental conditions. One must have more specific background knowledge and use that knowledge actively to know what type of clothing is suitable. There are also ongoing studies investigating the potential for using models as cold weather management decision tools. Although many models have been available for over two decades, validation studies have been limited [3].

Some of the advice given in the videos is very specific and applies to all operations in the cold. One example is wearing roomy shoes with thick soles. Changing clothing during the exercises can be difficult enough, and changing the protection on the feet is extra challenging. Therefore, preparation and good advice from the start are essential for keeping the feet warm and avoiding FCIs. Other specific advice provided in the videos is intended to be used in a specific context. For example, wearing different headgear like a hood will be very dependent on activity and weather conditions. A hood is a part of the clothing that is easy to forget, and the advice was given so that the soldiers would more easily remember to wear it during, for example, windy conditions. To know the correct clothing for different combinations of environments and activities, one is dependent on practical experience in addition to expert advices before and during training.

There are some physiological challenges during operations in the cold that you cannot completely avoid, even by both dressing and behaving according to best practices. In particular, cold-induced vasoconstriction and sweating can, both by itself and by influencing other factors, lead to challenges in keeping a proper heat balance and maintaining manual performance. Vasoconstriction is something that is hard to control. It is a powerful mechanism that controls heat transfer. Sometimes vasoconstriction can be unnecessary from a total body heat perspective in conditions where for example the core temperature is high due to physical exercise. This means that it is possible to get NFCI or FCI even with high core temperature. In addition, there are large individual differences in responses to cold, and it has been shown that young army conscripts have a large variability in the rewarming ability of the hands after mild cold provocation [26]. To complicate matters, it is shown that if thermal comfort is to be maintained and sweating in the clothes is to be avoided when performing physical work in the cold, the extremities will often be somewhat cooled [27]. Therefore, soldiers should adjust the hand protection according to knowledge, experience, and their own preferences. In addition, they are encouraged to practise wearing gloves/mittens during practical tasks. That is because FCIs depend mainly on changes in peripheral blood flow and associated decrease in skin temperature [28] which in some conditions can occur rapidly. Especially in extreme weather conditions (temperatures below the freezing point, high wind speed and humidity) and when touching e.g. metal surfaces, FCIs can occur quickly and therefore measures to ensure adequate protection needs to be taken in advance. By practising wearing gloves/mittens during practical tasks, they avoid exposing the skin to direct contact with metal, snow and water. In addition, this reduces the risk that the mittens will be blown away or lost, become wet from the surface they are put on, or full of snow on the inside. Simple habits such as these can further reduce the risk of NFCIs and FCIs.

Another physiological induced challenge in the cold is sweating. The soldiers need to be aware that the risk of hypothermia increases if the clothing gets wet from either sweating, precipitation, or wading through water (or a combination of these), especially when combined with low-level activities or rest. Preventive measures from becoming wet involves regulating the intensity of activity, regulating clothing items and clothing layers, and ventilation of the clothing. Nevertheless, it is impossible to completely avoid getting wet during military operations. Thus, especially in long lasting CWOs, it is necessary to carry a set of dry clothing to change into, and if clothing items are restricted, to "work wet, rest dry".

Most of the current best practices are based upon practical knowledge, years of experience, and basic thermal physiology, and scientific knowledge is lacking on several topics. For example, whether dehydrated persons are at increased risk of FCIs is controversial. Gaining further scientific knowledge is difficult, however, being dehydrated affects both physical and cognitive performance and can thereby affect the soldier. The lack of scientific knowledge is partly due to ethical considerations, time- and cost consuming studies, the lack of robust, wireless wearable sensor applications with long battery life for monitoring in extreme environments, and volunteered soldiers to participate in controlled research studies in their otherwise so tight schedule. However, the advice given in the videos are considered good for preventing CWIs during CWOs from a medical, military and research point of view. It is too soon to tell whether the information provided by the website and the videos has resulted in fewer CWIs in the Norwegian Armed Forces, as the material is currently under implementation. The performance of the new teaching material will be evaluated in the future after implementation and when new data on CWIs are available.

Military relevance

The training videos may be used by allies to be better prepared for future CWOs, and can be translated as needed to better reach out to the allied soldiers. The videos have so far been translated to into Ukrainian. The videos are currently used as a supplement to today's teaching in the Norwegian Armed Forces and are included in the digital material sent to new students at the Norwegian School of Winter Warfare. Soldiers, course participants and instructors at the Winter Warfare School are actively informed about where they can find the films and everyone is asked to watch them. The films are also shared with allies on the NATO Centre of Excellence Cold Weather Operations (COE CWO) website (https://www.forsvaret.no/en/organisation/centre-of-excellence-cold-weather-operations). The animated videos will eventually also be shown on screens in the garrison in the military camp. It is anticipated that the soldiers' increased knowledge of practical prevention of CWIs will help to reduce the incidence of injuries during CWOs, and will also keep the soldiers confident and comfortable in the cold, further enhancing the operative capability.

Conclusion

A communication package with training videos in Norwegian and English and an updated and improved official website were developed to guide the soldiers in or about to enter basic military training, young officers, and allied personnel before participating in CWOs. The videos provide a summarised presentation of the information every soldier and officer should know when operating in cold weather conditions. The intension is to help them to be prepared before CWOs, dress appropriately for the conditions, and have good routines to take care of their bodies, equipment and fellow soldiers. The training content consists of clear and understandable advice that should be possible to remember and carry out in a military setting. The content aims to prevent FCIs, but following the advice will also prevent NFCIs and hypothermia. The content supplements current teaching as guidance for CWI prevention and can be used during mission planning for armed forces operating in the Arctic.

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