Insulated Spine Boards for Prehospital Trauma Care in a Cold Environment

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Abstract

Objectives: The aim of this study was to examine, during field conditions, what impact additional insulation on a spine board would have on thermoregulation.

Method: The study was conducted outdoors, under field conditions in February in the north of Sweden. The subjects, all wearing standardised clothing, were immobilised on uninsulated (n=10) or insulated spine boards (n=9). Tympanic temperature as well as the subjects' estimated sensation of cold and their estimated level of shivering were measured at five minute intervals during the trial. Statistical analysis of the data gathered for the first 55 minutes was performed.

Results: There were no differences between the two groups regarding reduction in body core temperature or cold discomfort. There was, however, a statistically significant increase in estimated shivering for the subjects placed on uninsulated spine boards.

Conclusion: Additional insulation on a spine board by the means of an insulation mat rendered a significantly reduced need for shivering in a cold environment. This is an effect that could be of great importance during protracted evacuations of injured, ill or otherwise compromised patients. In the light of these results we conclude that spine boards, as well as other materials used for prehospital transportation of patients in cold environments, should be well insulated. This is a measure that could be accomplished by such simple means as using an additional insulation mat.

Key words: Hypothermia, accidental hypothermia, body core temperature, shivering, thermoregulation, heat loss, cold exposure, ground chill, spine board.

Introduction

Accidental hypothermia is defined as an unintentional reduction of body core temperature to below 35° C (1, 2). When body core temperature declines below 37° C, thermoregulatory mechanisms are activated to counteract further cooling and to increase endogenous heat production. This is done by peripheral vasoconstriction and by autonomous and unsynchronised muscle contractions (shivering). Shivering and thereby effective thermoregulation peaks at about 35° C (mild hypothermia), and then gradually declines by further cooling. At body core temperatures below 32° C (moderate hypothermia) thermoregulation starts to fail and at body core temperatures below 28° C (severe hypothermia) it is almost non-existent.

Predisposing factors to hypothermia include old age, trauma, influence of drugs or alcohol, starvation states and certain endocrine-, neurological- and skin disorders (1). Hypothermia is a complicating factor in the treatment of trauma patients (3) and there is an increased mortality in hypothermic trauma patients compared to non-hypothermic trauma patients (4).

The annual incidence of accidental lethal hypothermia (ICD-10 X31) in Sweden (8.9 million inhabitants) is about 30-45 (5). For the most part, these lethal cases can be divided into two main groups. The largest group includes elderly, most of them chronic abusers under the influence of alcohol. The other group includes younger, sober persons having some kind of accident while performing outdoor sporting activities (6). Hypothermia is also one of the most common diagnoses among injuries in the wilderness. Out of 114 missions accomplished during 1989-1994 by the Reach and Treat Team, Mount Hood, Oregon, 15 patients were diagnosed with hypothermia, which made it the third most common diagnosis (7).

In the wilderness the first responder to attend to a cold victim is often another member of the same expedition or a mountain rescue team. Regardless of the level of education of the rescuer/rescuers or what medical equipment is at hand, the initial prehospital care should be focused on preventing further cooling (8). This can be achieved by simple means even during protracted evacuation and should be part of the trauma-protocol in non-urban-systems (9).

In a cold environment with direct contact to a cold surface, conduction can cause great heat loss (1). Accordingly, in order to prevent further cooling, actions should therefore be taken to insulate the cold victim from the underlying surface. An ordinary insulation mat is well suited for this purpose and in addition it is easy to use and to transport.

In the Swedish Mountain Rescue Service spine boards are used during the prehospital evacuation. The importance of insulating these spine boards with ordinary insulation mats to prevent hypothermia is currently discussed within the organisation. The object of this study was to examine, during field conditions, what impact additional insulation on a spine board would have on thermoregulation.

Material and methods

Nineteen healthy military conscripts from Jämtland Wing F4, volunteered as subjects in the study. The study protocol was approved by the Committee of Research and Ethics at Linköping University.

The study was carried out during four days in February in Östersund in the north of Sweden. The subjects were randomized either to be placed on spine boards with no additional insulation (n=10) or to be placed on identical spine boards fitted with an insulation mat as additional insulation (n=9). The spine board selected for the study is made of a 5 mm thick shell of fibreglass reinforced plastic and a 20 mm thick core of polyurethane (Glasfiberprodukter, Trehörningsjö, Sweden) and that is the spine board most commonly used in the Swedish Mountain Rescue Service. The insulation mat used by the Swedish Armed Forces was added to this spine board as the additional insulation. It is made out of closed cell polyethylene with a thickness of 15 mm (Fagerdala World Foams, Fagerdala, Sweden). Thermal conductivity (W/mK) of the included materials are: polyethylene between 0,036 and 0,058, polyurethane between 0,016 and 0,036 and fibre glass around 0,070 (10,11). Factors that affect these values are e.g.: temperature, density of the material and orientation of chain segments (10). Both insulation mats and spine boards were placed outdoors in ambient temperature for about two hours prior to the start of the trials.

Each day two or three subjects from each group participated. Air temperature and wind speed conditions at the time of the trials were: day 1: -4 °C, 2-3 m/s, day 2: -12 °C, 1-2 m/s, day 3: -16 °C, 0 m/s, day 4: -14 °C, 0 m/s. The subjects were all between 19 and 21 years old, height (mean ± SD) 178 ± 8 cm and weight 71 ± 9 kg. During the twenty-four hour period preceding the exposure to cold subjects avoided alcohol and they all had eight hours of rest during the night. The diet was not modified but they all had three equivalent meals during the day.

Trials began at approximately 7 pm each day. The subjects all wore minimal standardized clothing (underpants, long-sleeved undershirt, light wind jacket and light wind trousers and also two pairs of socks and mittens to minimize the risk of local cold injuries). Tympanic thermometers for continuous measuring were applied indoors. After ten minutes at rest an initial temperature was registered. Then the subjects were placed outdoors, either on a spine board with an insulation mat or on a spine board without any additional insulation. Tympanic temperatures as well as the subjects' estimated sensation of cold according to the Cold Discomfort Scale (CDS) and their estimated level of shivering according to the Estimated Shivering Scale (ESS) were measured at five minute intervals.

The Cold Discomfort Scale (CDS) is a visual analogue scale where a person estimates his sensation of cold for the entire body, not specifically for different parts of the body, providing values of 1 to 10, where 1 means "*feeling no cold*" and where 10 means "*unbearable feeling of cold*". The Estimated Shivering Scale (ESS) is a similar kind of scale where a person estimates his level of shivering, this time providing values of 0 to 10, where 0 means "*no shivering*" and 10 means "*vigorous shivering*".

Body core temperature was registered with a tympanic thermometer (Gilbert Metraux Electronique, Switzerland). Tympanic temperature has been shown to correlate well with oesophageal temperature (12), which is the most accurate non-invasive method of measuring body core temperature (1). The temperature-sensing accuracy of the thermometer is ± 0.1 °C and it is provided with an insulation cap that protects it from the influence of wind and ambient temperature. Six thermometers were used randomly in the two groups during the study.

The limit of cooling was set to a reduction of body core temperature of 1.5 °C or an estimation of 10 on the Cold Discomfort Scale. The subjects were also free to terminate at any time they wanted. A relative limit of cooling was chosen to take into account the individual difference in initial body core temperature. When the limit of cooling was reached the subjects were taken care of and insulated with either woollen blankets or rescue bags with a subsequent indoor recovery.

Statistical methods

Any differences in mean body core temperature between the two groups were determined by analysis of variance with a paired Student's T-test whereas any differences in estimated shivering and cold discomfort were determined by analysis of variance with a Mann-Whitney U-test. Statistically significant differences were accepted at $p<0.05$. After 55 minutes, three of the subjects were forced to terminate the trial due to the termination criteria stated and the sample was then reduced from 19 to 16 subjects. Therefore we also chose to terminate the statistical analysis at this point of time.

Results

Prior to immobilization on the spine board there were no significant differences in initial body core temperature between the two groups. Subjects placed on the insulated spine board had an initial body core temperature (mean ± SEM) of 37.0 ± 0.1 ºC (n=9) whereas subjects placed on the uninsulated spine board had an initial body core temperature of 36.8 ± 0.1º C (n=10). The subjects estimated sensation of cold discomfort according to the Cold Discomfort Scale (CDS) were at that time 1 ± 0 (median ± interquartile range). Their estimated level of shivering according to the Estimated Shivering Scale (ESS) were at the same time 0 ± 0 (median ± interquartile range).

Mean body core temperature in both groups decreased almost identically after immobilization on the spine boards (figure 1). Fifty-five minutes after immobilisation, mean body core temperature of the subjects placed on insulated spine boards had decreased 0.6 ± 0.1 ºC. Mean body core temperature of the subjects placed on uninsulated spine boards decreased 0.5 ± 0.1 ºC during the same period of time. At no time during the trial were there any significant differences between the two groups regarding changes in mean body core temperature.

The subjects estimated sensation of cold discomfort increased almost identically to end-point values of 7 ± 1 in both groups (figure 2). There was no significant difference between the two groups regarding estimated cold discomfort.

Estimation of shivering on the other hand diverged between the two groups (figure 3). After 35 minutes of exposure to the cold environment, the subjects immobilised on uninsulated spine boards showed a significantly higher degree of estimated shivering. This diversity enhanced even further during the trial and continued to be significant right up to the termination of the analysis after 55 minutes. The subjects placed on insulated spine boards estimated their shivering as 4 ± 1 whereas the subjects placed on uninsulated spine boards estimated their shivering as 8 ± 1 at that point of time.

Discussion

After immobilization in a cold environment on an insulated or uninsulated spine board respectively, there were no differences between the two groups of subjects regarding reduction in body core temperature or cold discomfort. However, the subjects placed on uninsulated spine boards showed a statistically significant increase in their estimated shivering.

In a cold environment and with direct contact to a cold surface, conduction can cause great heat loss (1) and one could, therefore, predict a higher rate of heat loss if precautions for insulating from the underlying surface are not taken. We consider the fact that the subjects placed on uninsulated spine boards did not show a greater decrease in body core temperature or a higher degree of estimated cold discomfort compared to the subjects placed on insulated spine boards being due to a compensatory increase in endogenous heat production in the form of shivering. This increased shivering of the subjects placed on uninsulated spine boards was easily observed during the trial and the following statistical analysis revealed a significantly higher degree of estimated shivering. It should be emphasized that although the spine boards are constructed out of an insulating material the additional insulation in the form of an insulation mat rendered this considerable effect on thermoregulation.

The importance of insulating a person from cold surfaces is well known, but to the authors knowledge this is the first clinical study that has investigated the impact of an additional insulation, in the form of an insulation mat, on a spine board with regards to effects on body core temperature, estimated cold discomfort and estimated shivering.

Efficient thermoregulation presupposes the ability of increasing endogenous heat production by means of shivering. A reduction of this ability, as is seen in i.e. traumatised patients, could be fatal in a situation where the individual is exposed to a cold environment (1). Shivering further leads to increased oxygen consumption and would therefore result in an adverse stress on the organ systems, which could be overwhelming for an already compromised patient. Already during the first hour of immobilisation, we saw a significantly increased degree of shivering in subjects placed on uninsulated spine boards. This strengthens the arguments for an early prehospital protection of the patient from the cold underlying surface by means of using well insulated stretchers, spine boards or vacuum mattresses. This is a measure that would be of particular importance during protracted evacuation where an extended period of time is needed before the patient can be transferred to a warm environment. Measures for insulating from ground chill should of course be accompanied by covering the patient with blankets or the use of rescue bags to prevent heat loss by convection, radiation or evaporation as well.

Spine boards are today in common use for spinal immobilization of trauma patients by emergency medical services worldwide. Although well suited and recommended for this purpose some adverse effects from prolonged immobilization has been pointed out, e.g. patient discomfort and the risk of developing decubitus ulcers (13). Adding extra padding to a spine board has been shown to significantly improve patient comfort without compromising c-spine immobilization (14). In addition to the insulating effect, the insulation mat will therefore, also be likely to have this beneficial effect.

As the study was carried out in a field environment in order to resemble as much of realistic conditions as possible, the study is enclosed with the limitation that the ambient conditions regarding temperature and wind speed were not quite identical during the four days of the study. Another limitation to the study is that visual analogue scales for estimating cold discomfort and shivering are not yet fully scientifically evaluated. For a more accurate value of thermogenesis, oxygen consumption as well as muscular activity could be monitored as a complement.

Conclusion

An additional insulation on a spine board by the means of an insulation mat rendered a significantly reduced need for shivering in a cold environment. This is an effect that could be of great importance during protracted evacuation of injured, ill or otherwise compromised patients. In the light of these results we conclude that spine boards, as well as other materials used for prehospital transportation of patients in cold environments, should be well insulated. This is a measure that could be accomplished by such simple means as using an insulation mat.

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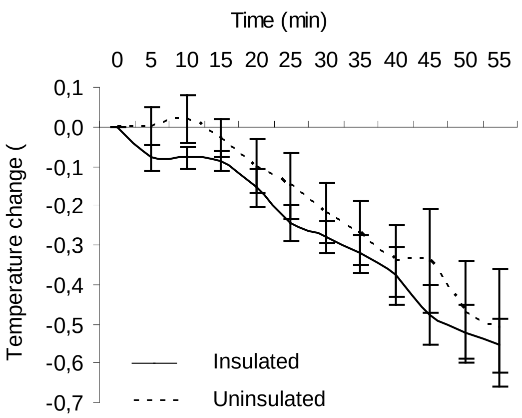

Figure 1. Change in body core temperature on insulated (n=9) and uninsulated (n=10) spine boards. Mean and SEM.

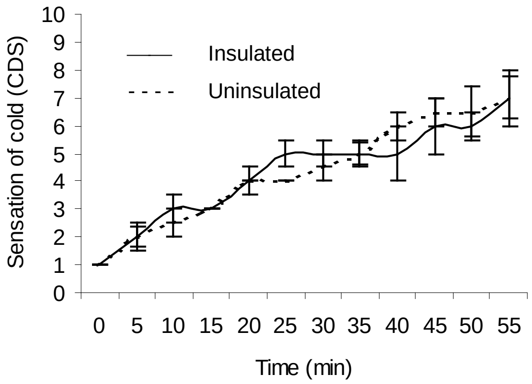

Figure 2. Estimated sensation of cold according to the CDS-scale (where *1= feeling no cold* and *10= unbearable feeling of cold*) on insulated (n=9) and uninsulated (n=10) spine boards. Median and interquartile range.

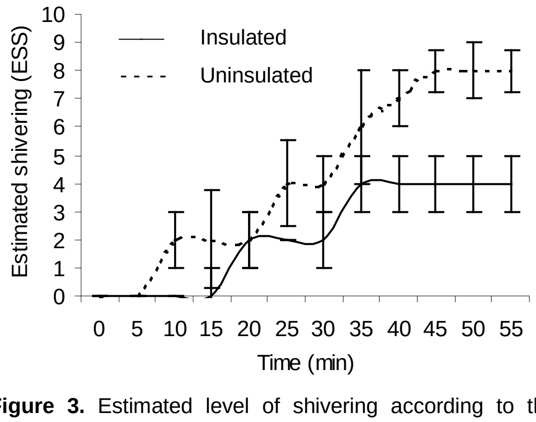

Figure 3. Estimated level of shivering according to the ESS-scale (where *0= no shivering* and *10= vigorous shivering*) on insulated (n=9) and uninsulated (n=10) spine boards. Median and interquartile range.