

The Effects of Cold

Until quite recently, there appeared to be a general lack of interest in South Africa about the effects that cold can have on the human body. To some degree this is understandable as excessive heat is perceived to be a greater danger. However, there are many situations, apart from working in cold and freezer stores, where hypothermia, or abnormally low body temperature, can easily occur.

Humans have an optimum “core body temperature” which ranges between 36.8°C and 37°C. Outside these limits, the human body will experience stress.

But, one must be careful with the term “core body temperature.” This will vary as the organs of the body operate at slightly different temperatures. It is clear, however, that when subjected to a cold environment, the trunk of the human body will unconsciously attempt to maintain a constant core or deep body temperature of around 37.3°C.

Lapdogs were popular in the days before electricity was to provide additional heat to their elderly owners

Begin quickly

The onset of hypothermia occurs when the core temperature drops below the minimum to maintain homeostasis in an individual. There is misunderstanding that it takes freezing temperatures of below 0°C to achieve this but it can happen at temperatures well above this point depending on the conditions, which include wind chill.

“Goose bumps”

To maintain temperature when exposed to an absence of heat, humans can produce more heat through shivering, physical exertion and metabolic activity. They can also minimise heat loss not only through increased insulation but also via vasoconstriction where the blood vessels narrow in the skin and subcutaneous fat acts as an insulator.

One mechanism to reduce heat loss is rudimentary, “goose bumps.” These are the body’s attempt to straighten our “furry coat” away from the body to improve insulation. However, unlike cats and dogs, our body hair mass is no longer sufficient to make much difference. Teeth chattering is really the spasms of the facial muscles working overtime to produce heat for the brain. These initial bodily reactions may actually be sufficient to increase the core temperature above 37°C for a short time, but the body’s energy reserves will be rapidly depleted. Shivering can increase the body’s metabolism by a factor of four!

Metabolic rate

The body has a number of temperature sensors which feed information to the hypothalamus in the brain. Where sensory information suggests that there is a general chilling of the body, then the hypothalamus raises the body’s metabolic rate. Raising the metabolic rate is like taking heavy exercise. The heart rate goes up, so does blood pressure, oxygen intake increases and heat is produced by muscle action.

There may also be certain chemical changes within the body to produce heat. If the feeling of cold is not addressed quickly, then vasoconstriction starts, which can be within minutes of entering a cold store. Vasoconstriction is where heat is preserved in the human trunk by reducing blood circulation to the peripheries ie, the hands and feet. Having a high surface to volume ratio, the hands and feet lose temperature quickly and the blood returning from them to the heart is relatively cold.



A full face balaclava which reduces the exposed skin to a minimum

Insulated hardhat for cold conditions together with insulated liner. The face can also be covered with a mask

Start to go blue

Cutting off circulation to these areas keeps the trunk warmer. In extreme cases, the hands and feet will start to go blue and become extremely painful as the blood circulation is reduced to about a third of the normal flow. As a total lack of circulation would be harmful to these extremities, vasodilation also occurs for short periods initially to allow sufficient blood back into these areas.

When this happens, a person's hands can suddenly feel warm. It has also been noticed that keeping the face warm can reduce vasoconstriction in the hands and feet. The wearing of balaclavas or insulated hard hats in cold stores is therefore advisable.

These are the body's attempt to straighten our "furry coat" away from the body to improve insulation

The hunting reaction

Vasoconstriction interspersed with periods of vasodilation at the extremities is known as the "hunting reaction" possibly because it was first noticed by hunters. The hunting reaction has been extensively studied and helps to prevent localised cold injury. It seems to operate via blood vessels called AVAs which are present in those parts of the human body most at risk of localised cold



Racking damage in a cold store

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injury such as the ears, nail beds, lips, cheeks and nose as well as the insides of the hands and feet. It also appears that certain genetic groups have a less effective "hunting reaction" than others although it can be improved through acclimatisation and the taking of vitamin C.

Africans, for example, have a relatively poor "hunting reaction" and are more prone to localised cold injury than Caucasians. For this reason, they need good protection when working in cold rooms.

Cold diuresis

Once vasoconstriction begins, the body has to make further adjustments as there is now more blood in the body trunk than was previously the case. This increases blood pressure. Although reduced blood temperature will reduce blood volume somewhat by itself, it is insufficient and the renal system starts to remove plasma from the blood. The rate of plasma removal depends on posture, and will be greater for someone who is seated, such as a reach-truck driver, than it will be for someone who is standing upright. This process is called cold diuresis.

The kidneys are put under stress resulting not only in increased levels of urination but also in the loss of chlorides from the body. It was originally thought that increased urination was due to the body not having to perspire at cold temperatures. However, this is incorrect as perspiration and moisture loss from the respiratory tract still occur at low temperatures as any cold store worker knows. It appears that the process of cold diuresis is regulated by hormones excreted by the pituitary gland.

Mental confusion

Superficial cooling can increase vigilance and brain activity. However, in the first stages of hypothermia, down to a core temperature of 35 C, brain activity will decrease. People become confused which can make their situation worse. Even small variations of brain temperature can cause confusion as also happens with a mild fever.

There is some argument that this mental confusion in cold conditions can be partly caused by a lack of oxygen, or anoxia. This is one reason why physical stock counts in freezer stores can be inaccurate. It also accounts for some of the damage to equipment in this type of warehouse.

Shivering

Shivering generally starts after the onset of vasoconstriction although the initial muscle tension may not be noticeable. Shivering is the body's way of creating heat and is caused by muscle action. There are two major types of shivering: normal shivering and deep shivering. Deep shivering is the body's last method for creating heat which is very frightening for anyone who has experienced it. It normally does not happen until the rectal temperature has begun to fall. The body's muscles contract in violent spasms which are uncontrollable. This uses up the remaining energy reserves and, thereafter, the body trunk continues to cool until the heart stops beating at a temperature of around 29°C.

When the core temperature is lower, there is no detectable heartbeat and the need for oxygen is reduced. Death however, is not inevitable and people have been resuscitated from core temperatures of as low as 13°C.

Resuscitation

Assuming that the person is removed from the cold environment in time, care must be taken in the resuscitation process. This is because moderate heating, will cause vasodilation on the body surface which is colder than the core. Relatively cold blood will then return to the heart increasing the risk of heart failure.

Understanding insulation

There are several kinds of heat loss. Body tissues conduct heat outwards from the core, and more importantly there is convection of heat via the blood. Finally 20% of human cooling occurs through evaporation where there is a heat exchange between the water vapour and the colder external air. Of this 20%, two thirds is caused by perspiration and one third by water vapour exhaled from the respiratory tract.

Even at cold temperatures, the body continues to exhale water vapour, and to perspire when excess heat is being produced via work and also when the person is under mental stress. In the latter situation, perspiration is largely confined to the



Lewis Pugh finishing his swim at the North Pole palms and soles of the feet.

A thermal break

In the absence of fires, shelter and other forms of external heating, a human must rely on the insulation provided by his or her own body and clothes.

The thermal insulation of clothing is proportional

It also appears that certain genetic groups have a less effective "hunting reaction" than others

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A Siberian Husky can survive comfortably at sub zero temperatures due mainly to his insulated coat, and his metabolism which will only start producing additional heat at around -10°C

to the amount of dead air that has been trapped. There are now several types of insulation which have been developed to trap air efficiently in lightweight garments. If the dead air space is thicker than about 25mms, then air currents can develop within the insulation greatly reducing its ability to stop the movement of heat.

Mental confusion in cold conditions can be partly caused by a lack of oxygen, or anoxia

The outside fabric layer must be windproof to prevent the ingress of cold air. Curved surfaces like glove fingers increase surface area and can, in certain instances, reduce the level of insulation. This is one reason why it is difficult to keep fingers warm.

Perspiration

Finally perspiration, although uncomfortable, does not necessarily destroy the thermal insulation of clothing unless it compresses the structure of the insulating fabric thus preventing it from trapping air.

Working in cold climates makes the body produce more heat. Indeed the weight and bulk of the insulated clothing itself raises the metabolic rate. It is therefore quite possible for those working hard in cold stores to overheat inside insulated clothing. As far as possible, the clothing must effectively insulate a person when they are standing still.

When they are working, the clothing should allow a sufficient loss of heat to more or less balance what is being produced. Additional heat produced with hard work can be almost three times what is produced by the body at rest. While it is advisable for people working in cold temperatures to work methodically so as to keep additional heat generation to a minimum, sweating will occur and the clothing must be able to "wick" the dampness away from the body while retaining it within the clothing.

A Clo unit?

The clo unit was defined in 1941 to help military commanders understand what type of clothing soldiers required in different climatic conditions. One clo unit represents the insulating value of a man's underclothes and lightweight suit which allows him to be comfortable when he is sitting in an office with an ambient temperature of approximately 21°C, an airflow of 10cms/sec and an air humidity of less than 50%.

The number of clo units required by a cold store worker at an air temperature of -20°C depends on the amount of heat his body is generating. Without a heated cab, a reach-truck driver whose metabolism is at rest will require about six clo of insulation whereas a picker engaged in heavy work will only need two clo. When specifying cold store protective equipment, managers should not look only at price but consider the clo value of the clothing and match it to the prevailing conditions in the store.

Medical implications

There are several problems that arise when people work in cold stores. First off, people who



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are not correctly equipped will quickly become uncomfortable and unproductive. Allowing them to warm up for ten minutes in every hour does not provide a solution as this moderate heating only serves to further drive down core temperatures, in effect making the worker less productive when he goes back into the cold store than he was when he came out. As already mentioned, mental activity will quickly decrease, increasing the chance of accidents and mistakes.

Workers will also be prone to catching colds and flu as the human immune system can be somewhat suppressed and any bronchial infections can become worse when working in cold stores. Apart from colds and flu, there are other long term health risks which can affect those who work in cold stores especially if they are not properly protected. These risks will vary depending on age, fitness and underlying health problems. It must also be stressed here that there has been no research done in South Africa, as far as we can tell, on long-term health problems associated with working in cold stores and it is an area where research is required.

In the UK, a report was commissioned by Birdseye Walls in the late 1970's. This report resulted in substantial improvements to cold store protective clothing and the way in which it is used. Today one is simply not allowed to enter a cold store in the UK without proper protection.

Dietary changes

People's diets can change when they are exposed to cold temperatures regularly. First of all they will eat more, although with acclimatisation, intake levels may reduce. There will also be a tendency to eat a greater percentage of fat. Indeed, in some tests conducted in the Arctic, a craving for fat was noticed. The consumption of carbohydrates, although not as effective as fat, is also likely to increase and can sometimes be noticed in high levels of sugar consumption, especially as this is the quickest way to get an increase in body heat. A high protein diet does not seem to be effective for those working in the cold.

When dietary changes are considered from a health perspective, there are several aspects that should be borne in mind. Increasing the intake of fat will tend to raise the level of 'bad' cholesterol. Increased consumption of sugars may increase the risk of type 2 diabetes. In a South African cold-store medical screening done in the early 1990's unusually high levels of hypertension and diabetes were found among the employees of one facility.

Whether this was due to the cold temperatures was not proven as they may simply have been the result of common eating habits. But the high incidence of these medical conditions among cold-store personnel was somewhat suspicious.

Thermal shock

However, it is not only the cold temperatures themselves that can put a workers' health at risk. The long-term danger of moving from ambient temperatures of up to plus 35°C to those as low as minus 25°C almost instantaneously are frequently overlooked. The shock to the system from this sudden temperature change can only be imagined. Cold-store personnel can make this

transition many times a day. Proper clothing and the presence of airlocks reduces the intensity of this thermal shock.

It is also known that the risk of heart attacks rises as the ambient temperature falls. In France, tests showed that a 10°C drop in temperature increased the risk of heart attacks in males by 13% and in the US the rate of heart attacks in the winter months is over 50% higher than for the summer months. These figures were compiled from general statistics. If one looks at the possible added dangers that come from working in cold stores, ie, thermal shock and possible dietary changes, then it is likely that the incidence of heart problems will be higher among cold-store workers than among the normal working population.

Asthma

People suffering from asthma experience problems when they breathe in cold dry air as it narrows the airways by thickening the mucous lin-

Africans, for example, have a relatively poor "hunting reaction" and are more prone to localised cold injury than Caucasians



Salopette worn with a full jacket. This arrangement gives double insulation to the body trunk



Cold store worker using bubble wrap to keep his feet warm



Chilblains are not confined to the fingers and toes. The nose, ears and face can also be affected

ing which makes breathing more difficult. This problem can be partially solved by covering the nose and mouth with a scarf or by wearing a face mask. However, cold-store conditions are not favourable to asthmatics.

Joint pain including arthritis

Those suffering from arthritis also need to take

added care as exposure to cold temperatures tends to exacerbate joint pain. This is why those whose work includes kneeling on cold-store floors at operating temperatures should have insulated pads on their knees. A study has shown that cold-store workers have more complaints regarding joint pain than those working at ambient temperatures. This has been attributed to the fact that the temperature of the synovial fluid which surrounds the joints decreases in the cold increasing the risk of joint damage.

Raynaud's disease

A lack of proper protection can also increase the chances of Raynaud's disease which seems to be caused by working at low temperatures with inadequate protection. The hands and feet are subjected periodically to spasmodic episodes of vasoconstriction which are far more intense than the body's normal reaction to the cold.

Why many sailors died after being rescued from the North Atlantic during the Second World War

Immersion foot and chilblains

Immersion foot is caused when the feet are exposed to cold temperatures for long periods in damp conditions. Chilblains are a milder form of immersion foot. The temperatures do not have to be below freezing and perspiration alone is quite sufficient to cause the condition.

Common signs of immersion foot include a swollen waxy appearance. The feet feel cold and walking is difficult with complaints like "it feels like walking on cotton wool". This is followed by periods when the feet are gorged with blood becoming red, hot and very painful. Immersion foot, like Raynaud's disease, seems to have its basis in damage to both the nervous and vascular system and can persist for considerable periods.

The best way to prevent immersion foot is by keeping the feet dry, normally achieved by changing socks more than once a day. Immersion foot does not appear to be common in South African cold stores but fungal infections are. Changing into dry clean socks more than once a day should also prevent this.

Many are not aware that cold-store floors are extremely cold and that proper cold store boots are essential to reduce heat loss from the feet.

Renal stress

As has already been noted, the body removes plasma from the blood when it experiences cold, a condition known as cold diuresis. This places stress on the kidneys. While we have no direct evidence that this can damage the renal system, we understand that renal failure can accompany

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heat stroke. As cold diuresis is caused by low rather than high temperatures, we feel that it should also be avoided if at all possible especially as it also results in dehydration.

Frostbite

Frostbite should not occur among cold store workers as they do not spend enough time at low temperatures to actually freeze body tissue. However if people are working in cold stores with the evaporator fans running, then the wind chill factor can negatively affect exposed skin, especially on the face. For example, in a room running at minus 25°C an air flow of 10kms per hour will reduce the effective temperature to minus 33°C. This temperature level can cause frostbite on exposed skin in just over 30 minutes.

People have been resuscitated from core temperatures of as low as 13°C

There have also been cases of frostbite recorded among fishermen who have handled frozen tuna in the holds of sea-going fishing vessels. Frostbite needs to be distinguished from injuries caused when exposed skin comes into contact with cold steel or concrete. Hands can acclimatise to this sort of situation within reason by reducing of water

present in the outer layers of skin, but care must still be taken. Ironically, the lack of sensitivity in cold hands can also prevent a person from feeling how hot an object is, resulting in burns.

Conclusion

Working in cold conditions affects the human body in a number of ways, and places it under stress. Worker productivity in South African cold stores is low when compared to the US or Europe. Productivity could be more than doubled if employee comfort was taken seriously and properly-designed protective wear worn. There is also little interest in exploring what the possible long term health risks may be of working in these conditions. To improve productivity as well as to manage the risks attached to working in cold store conditions, the wearing of properly-designed cold-store clothing is absolutely essential.



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