ARMADILLO
MERINO

PERFORMANCE

THERMO-
REGULATION

This fact sheet covers the unique abilities of ZQ Merino fabric to stabilise body temperature

made from

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THERMO REGULATION

INTRODUCTION

The survival of living beings greatly depends on their capability to maintain a stable body temperature irrespective of the temperature of the surrounding environment. Body temperature depends on the heat produced minus the heat lost. Heat is lost by radiation, convection, and conduction, but the net loss by all three processes depends on a gradient between the body and the external environment.

Thermoregulation refers to the ability of an organism to maintain its body temperature within certain boundaries, even when the surrounding temperature is very different. The human body temperature is usually around 37.4°C. This process is one aspect of homeostasis: a dynamic state of stability between a human's internal environment and its external environment. In a steady-state situation, the heat produced by the body is balanced by the heat lost to the environment; however, both internal and external conditions can affect this, causing discomfort due to either being uncomfortably hot or cold.

There are two control systems for temperature regulation in endotherms (warm-blooded animals – like humans). The behavioural system involves conscious voluntary acts to adjust physical characteristics of the air-skin interface. An example of this would be moving out of the hot sun and into the shade to keep cool, or putting on a sweater to keep warm.

The physiological system also consists of involuntary responses of the body that generate or dissipate heat. Sweating is a large component of the physiological response to heat, with the main aim to cool the body through the process of evaporative cooling. Shivering is another involuntary physiological response to the other temperature extreme, seeking to warm the body through muscle spasms. Similarly, the muscles at the base of each hair (arrector pili) contract when the body is cold or scared, and in doing so, pulls the hair follicle in an upright position to assist in entrapping air next to the skin to provide warmth. The resultant dents created are called 'goose bumps'.

The integumentary system (the skin) is involved in a number of functions, which includes the very important role of regulating body temperature. The skin has nerve endings that will detect even minute or brief temperature changes, and the degree of coolness or warmth felt by the wearer will depend on well fabric conducts heat away from the skin. Heat has a natural tendency to move from warmer to cooler regions, and losses by the human body occur in a number of different ways:

- Radiation
- Conduction
- Convection
- Evaporative cooling

Radiation is the primary mechanism by which the body emits and absorbs heat, with up to half of body heat loss occurring through this means. Heat also transfers from the body to objects, via conduction, because the temperature of clothing fabrics is typically between that of the environment and that of the skin. Because warm air is lighter than cold air, it rises and is replaces by cooler air, with the resulting convection currents also carrying heat away from the body. Finally, evaporative cooling (of sweat) also allows the body to dissipate excess heat. Conduction and convection account for 15-20% of heat loss to the environment.

WHY THERMO-REGULATION IS IMPORTANT

Homeostasis refers to stability, balance or equilibrium. It is the body's attempt to maintain a constant internal environment. Maintaining a stable internal environment requires constant monitoring and adjustments as conditions change. This adjusting of physiological systems within the body is called homeostatic regulation.

Homeostatic regulation involves three parts of mechanisms: 1. The receptor, 2. The control centre and 3. The effector. The receptor receives information that something in the environment is changing. The control centre or integration centre then processes information received from the receptor, which then triggers the effector to respond to the commands of the control centre by either opposing or enhancing the stimulus. This is an ongoing process that continually works to restore and maintain homeostasis. For the process of regulating body temperature there are temperature receptors in the skin, which communicate information to the brain, which is the control centre, and the effectors are the blood vessels and sweat glands in the skin.

Thermo-regulation performance is critical in providing a comfortable environment to the body. Without this, the body can either, be subjected to heat or cold stress, which can, in turn impart serious health ramifications.

If the body is unable to maintain a normal temperature and it increases significantly above normal, a condition known as hyperthermia occurs. For humans, this occurs when the body is exposed to constant temperatures of approximately 55 °C (131 °F), and any prolonged exposure (longer than a few hours) at this temperature and up to around 75 °C (167 °F) death can occur. The opposite condition, when body temperature decreases below normal levels, is known as hypothermia.

PREVIOUS OPTIONS

(LIMITATIONS OF OTHER FIBRES)

The properties of clothing materials critically influence the comfort and performance of the wearer. Synthetic textiles such as polypropylene and nylon have been commonly used as apparel systems to provide warmth to the wearer, usually by the mechanism of fabric thickness via either a surface pile and/or layering multiple garments. With these systems, it is usually the norm, that when the wearer feels hot, they remove a layer or undo a zip, or when they feel cold, a second layer is added. While, this will go some way to keeping the wearer comfortable, it is not an active thermo-regulation system that naturally provides the active response mechanism of managing the internal micro-climate without user intervention.

The effectiveness of textiles in providing thermal insulation largely depends on their ability to stabilise or trap layers of air around the body, since still air has a much greater resistance to conductive heat flow than any solid fibre substance (Benisek et al, 1987) (Table 1). The thicker the air layers, the greater the insulation, so materials which are thick and bulky (contain a high proportion by volume of air to fibre) are better insulators than thinner, flatter materials.

Table 1. Thermal conductivity of varying materials

Material:	Thermal conductivity:
Air	0.025
Aramid	0.130
Cotton	0.461
Polyester	0.141
Polypropylene	0.117
Viscose	0.289
Wool	0.193

With increasing relative humidity the thermal resistance of air is decreased significantly (Benisek et al, 1987) (Table 2), which will reduce the thermal insulation of textiles. Hydroscopic fibres (such as wool), maintain a lower relative humidity for a given set of conditions, thereby minimising this adverse effect compared to non-hydroscopic fibres such as polyester.

Table 2. Effect of relative humidity on thermal resistance

Relative humidity (%):	Thermal resistance (tog/cm)
0	4
65	3
100	1.5
Water	0.15

MERINO WOOL SOLUTION

Heat transmission or dispersal can be assessed by measuring fabric surface temperature (Figure 1). In a study by Pessenhofer et al. (1991), fabric surface temperatures were higher for wool indicating improved heat dispersal characteristics, while measures of retained heat were significantly lower for wool than for polypropylene.

When assessed subjectively, subjects involved in the investigation gave more positive responses to garment comfort questions with respect to wool than they did for polypropylene. Wool also exhibits favourable dynamic adaption to the flow of heat from the athlete to the environment. This is possibly due to the loading of the fibre with moisture from the massive generation of sweat that takes place following the commencement of high-load activity.

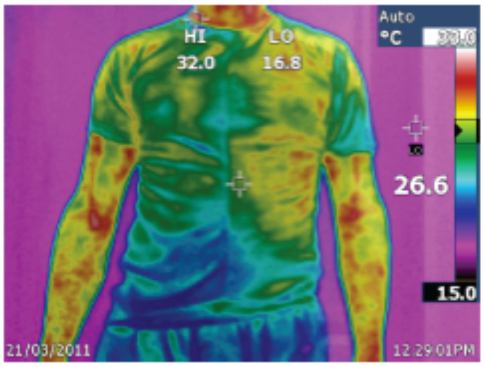

Figure 1. Infra-red image taken of athlete after 30 minutes of exercise wearing a garment of half Merino (RHS of image as viewed) and half polyester (LHS of image) – showing higher surface temperatures with the Merino half, indicative of more efficient heat release.

In addition to wool's moisture absorption properties, wool has an important differentiator in apparel usage in that an appreciable quantity of heat is also generated as water is absorbed into the fibre (Figure 2), and then lost again as the garment dries (Leeder,1984) – effectively warming and cooling the wearer when needed the most.

This energy release is referred to as 'heat of sorption' and occurs in all fibres to some extent, but is particularly pronounced in wool. The extent to which the processes of absorption and desorption occur is governed by the relative humidity of the surrounding environment and existing moisture content of the fibre. The higher the ambient humidity, the greater the absorption f water (Leeder 1984). The reason Merino gives of heat when it absorbs water as liquid or vapour relates to:

- Water vapour condensing within the fibre (releasing its latent heat of condensation)
- Water disrupting existing bonding networks and structure within the fibre, forming new chemical bonds (with associated energy release)

Put simply, addition of a polar molecule like water alters the internal chemistry of Merino to release energy as heat. Conversely, removing water (eg. By drying) requires the opposite – an input of energy.

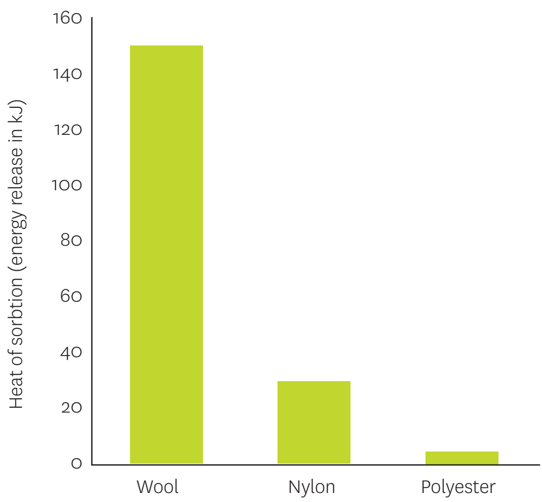

Figure 2. Heat of sorption of wool and other synthetic fibres (Collie and Johnson, 1998)

Furthermore, a study (Laing et al 2007) comparing physiological responses of athletes exercising while wearing single layers of merino, polyester or 50/50 Merino/polyester activewear (237+/- 16g/m2), under hot and cold conditions, revealed the following statistically significant differences:

- A longer time to onset of sweating whilst wearing Merino single jersey fabric (Figure 3)
- Lower heart rate during resting and walking whilst wearing Merino in hot conditions
- Greater heat content of the body when wearing polyester interlock fabric (under both hot and cold conditions)· Evaporative cooling
- Greater stability of skin temperature under Merino fabric
- Greater stability in core temperature whilst running, walking and resting in Merino (hot and cold conditions).

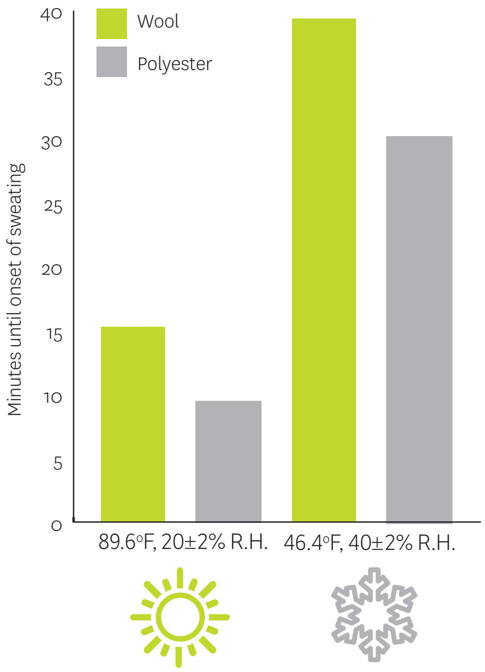

Figure 3. Time to onset of sweating when exercising and Wearing Merino vs polyester base layer product

SUMMARY

The chemical structure of Merino fibre means that it has the ability to gain and release heat depending on the external and internal environment – thus buffering wearers against environmental changes – properties that are not shared by synthetic fibres such as nylon and polyester.

As it absorbs moisture, Merino fibre releases a small, but perceptible amount of heat. In an apparel or hosiery application, this prevents the wearer from chilling in wet, cool conditions. In hot conditions the reverse effect occurs, affording a natural means of buffering the body's microclimate.

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