

Microclimate Management

So much more than just airflow...

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Abstract

Low air loss surfaces were designed to help regulate the microclimate of the skin. Achieving the appropriate microclimate of skin—the optimum ranges of temperature and humidity—is a vital factor in the prevention and control of pressure ulcers. Because there are no recognized standards of performance in this area, Hill-Rom scientists have conducted a number of internal studies to determine an optimal performance range for their Advanced Microclimate™ Technology surfaces to achieve the desired microclimate management of skin. As a result, Hill-Rom, through a precise combination of airflow, air temperature and material technologies can effectively remove excess heat and moisture from a patient's skin to achieve a range of performance, which our studies suggest—between approximately 90 to 95.5 degrees F— provides comfort and enhanced therapeutic performance.

Introduction

According to the Institute of Healthcare Improvement (IHI), approximately 1.3 to 3 million people develop pressure ulcers annually in the United States. Resulting associated health care costs hover around \$8 billion,¹ and the human suffering knows no bounds.

Pressure ulcers can not only accelerate a patient's decline, but also cause an estimated 60,000 acute-care deaths from related complications. Pressure ulcers are high on the list of "never events" developed by the Centers for Medicare and Medicaid (CMS) and the National Quality Forum. These are serious, reportable errors that should not happen, but when they do occur, cause injury or death and result in increased treatment costs. The National Institute of Nursing Research reports that 73 percent of expenditures for pressure ulcer treatment are for nursing care.³

Although health care facilities have been focused on reducing pressure ulcers to alleviate suffering, avoiding pressure ulcers has assumed greater financial importance for hospitals and long-term care facilities since CMS announced that Medicare will not reimburse facilities for costs attributable to wounds acquired during in-patient stays. Additionally, the Joint Commission has made pressure ulcer prevention one of its National Patient Safety Goals for 2008.

Given these facts, the assessment and control of pressure ulcers are even more crucial to the financial stability of hospitals today. Data from a 2003 nationwide inpatient sample indicated that the rate of hospital stays related to pressure ulcers has increased 63 percent from 280,000 cases in 1993 to 455,000 cases in 2003.⁴

Evidenced-based practice guidelines, collaborative practice models, education, and outcomes measurement, are helping clinicians better manage chronic wound conditions in high-risk patient populations. As an adjunct to this effort, Hill-Rom, the leader among therapy surfaces, is moving to a new level of commitment in the prevention and treatment of patients with pressure ulcers through the technology of microclimate management.

Methodology

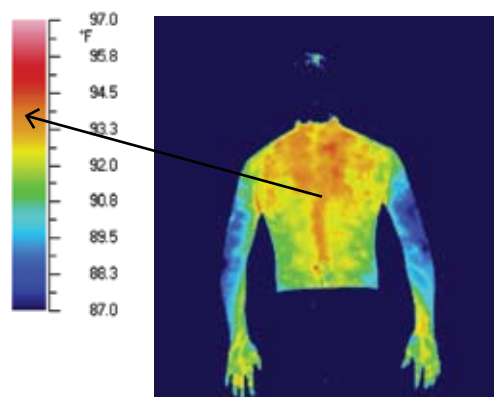
Causes of skin breakdown

A pressure ulcer is an injury to the skin and the underlying tissue. These wounds generally appear on the sacrum, hips, buttocks, heels, and other areas of the body that sustain pressure when a patient is lying in a bed, or sitting for long periods of time.

Although pressure generally is believed to be the primary external factor contributing to the development of pressure ulcers, shear, friction, heat and moisture also play significant roles. Pressure, shear and friction typically are classified as mechanical factors that contribute to skin breakdown. However, the levels of heat and moisture—more accurately humidity—are collectively known as skin microclimate. Establishing an optimal microclimate of the skin is a critical factor in deterring the formation of pressure ulcers.

Effect of microclimate on the skin

While skin temperature depends on a number of factors, the skin on the lower back under normal, open-air⁵ conditions typically ranges from 90 to 95 degrees F.



Infrared image of a 68" 150 lb. male in an open air environment

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Under these circumstances, both heat and moisture released by the skin are disbursed rapidly into the atmosphere and are the primary means that the body uses to cool itself. Additionally, this exposure to the atmosphere ensures that the microclimate at the skin surface is not appreciably different from the surrounding climate as a whole. These are the temperature and humidity conditions that the skin was designed to operate within normally.

When a person lies on a mattress, the free outflow of heat and moisture is blocked, causing both heat and moisture build up. This accumulation of heat also causes the skin on the back to warm. Research shows that even a small rise in the skin's natural temperature, in the lower back, for example, can cause a substantial increase in the local sweat rate from that patch of skin.⁵ The subsequent accumulation of moisture on the skin can exacerbate friction and shear forces, making it more susceptible to tearing.⁶

Wounds occur from unrelieved pressure that compresses blood vessels which provide the skin with nutrients and oxygen. When the skin is deprived of nutrients, tissue dies and a wound forms. Because warmer skin has been shown to require a greater supply of nutrients to survive, it is more vulnerable during periods of reduced blood flow.^{7,8}

This continual warming and wetting of skin creates an environment that differs markedly from the environment in which skin was designed to operate. Low air loss (LAL) mattress surfaces were developed 37 years ago⁹ to, in effect, re-connect this link with the atmosphere via a constant stream of environmental air to control temperature and moisture similarly to what is found naturally in our daily surroundings.

All LAL surfaces are not created equal

There are a number of design strategies employed with LAL surfaces to assist in the management of the microclimate, and, not surprisingly, there is a broad range in performance.

Heavy toppers made of foam, or other insulating materials may prevent the surface from doing an appropriate level of cooling. Inadequate air flow or air flow that is too warm may cause the same problem. Conversely, with a micro-vent type of LAL surface, excessive airflow on the skin may result in an excessive level of heat withdrawal and uncomfortably cool patients. Additionally, many LAL support systems fail to eliminate sufficient levels of moisture due to the above factors, or because the ticking materials do not allow for sufficient transmission of water vapor away from the skin.

Product performance standards are key

JAMA[®] published a randomized trial study for treatment of pressure ulcers in 1993⁹ which concluded that low air loss beds provide substantial improvement compared with foam mattresses in pressure ulcer healing. Although this therapy is found to be effective generally, performance standards have never been established by an independent group that are agreed upon by both the medical community and manufacturers alike.

The National Pressure Ulcer Advisory Panel (NPUAP) is coordinating the development of standardized protocols which will provide measurements for comparing and evaluating LAL surface support systems in the treatment of pressure wounds. However, as medical costs continue to increase and hospitals continue to search for the most effective and least costly methods for preventing pressure ulcers, standardized criteria, based on scientific evidence are necessary to assist clinicians in making informed decisions about the most appropriate LAL systems for patients.

Until now, no LAL manufacturer has been able to determine how a surface should perform to achieve an optimal microclimate of the skin—the physiological target temperature range that a body needs to maintain on a support surface to minimize the likelihood of skin breakdown.

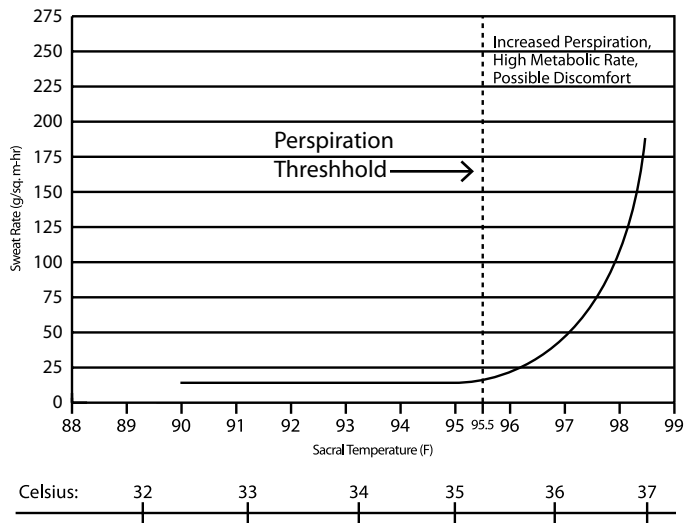
Determining the microclimate of skin

Just as Hill-Rom is a leader in the development of multiple measures for evaluating surface performance, company scientists conducting internal studies recently defined the range of performance that appears to be optimal with respect to skin health. These studies suggest that this optimal range is a matter of restoring the conditions that the skin was designed to operate in as opposed to subjecting it to circumstances that occur when skin is flush against a mattress surface for long periods of time. Thus, Hill-Rom scientists now are able to specify and design within a range of performance that allows patients to remain comfortable while excess heat and moisture are reduced to help achieve the desired therapeutic outcome.

Defining an optimal range for performance

Low air loss surfaces were developed to help regulate the microclimate of the skin. Controlling the heat and moisture levels of the skin surface, known as skin microclimate management, play significant roles in the prevention and control of pressure ulcers in the following two ways: Prolonged, high levels of moisture weaken the skin, making it susceptible to the damaging effects of pressure and shear forces. This condition, known as maceration, causes skin to soften, turn white and, if the surface tears, become prone to infection from bacteria or fungi. The skin especially may begin to break down in the areas subjected to mechanical forces such as the heavily-loaded, weight-bearing bony prominences.

A second, critical effect is caused by accumulation of heat which causes the skin to warm excessively. When a patch of skin is warmed beyond a specific level, sometimes referred to as the perspiration threshold—above approximately 35 degrees C, or 95.5 degrees F—local perspiration in that region increases markedly. The rate that this perspiration passes through a surface determines the amount of moisture accumulation.



Low Back Skin Temperature vs. Local Perspiration Rate^{10,11}

Warm skin requires a greater supply of blood-borne nutrients. When there is unrelieved, external pressure or shear forces on warm skin, blood flow is reduced. If the skin is deprived of oxygen and nutrients for too long, tissue dies and a pressure ulcer forms. Cooling skin slightly has been shown to exert a protective effect, reducing the likelihood of skin breakdown when exposed to external forces.^{7,8}

The right combination of factors

There are a myriad of ways to achieve cooling of skin, or the evaporation of moisture through various surface construction decisions. However, Hill-Rom, based on the best available evidence and using advanced thermal testing equipment, has achieved what we believe to be the desired microclimate management of the skin through a formula which includes a precise combination of airflow, air temperature, and material technologies to effectively remove excess heat and moisture from a patient’s skin. In addition, the surface ticking acts like a specialty barrier and helps to prevent penetration of fluids, bacteria and other pathogen ingress, creating a safer and more comfortable advanced thermal technology surface for patients.

Thus, it is by using Advanced Microclimate™ Technology that the “sweet spot” between all the variables is achieved—optimal heat and moisture withdrawal, the desired cooling effect and the management of tissue breakdown.

Maintaining skin at this targeted temperature range—approximately 90 to 95.5 degrees F—also ensures patient comfort and fosters better therapeutic performance.

As more research is compiled, temperature ranges may need to be modified for different target populations. Examples include patients who are exceedingly inactive, the elderly, or those suffering from strokes or spinal cord injuries.

It’s so much more than air flow

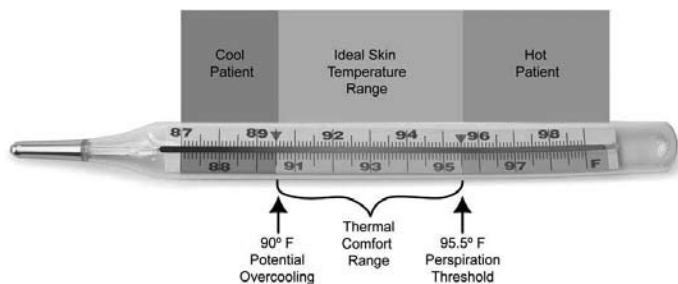
A number of internal studies have been conducted and dozens of scientific articles reviewed to determine what we believe to be the optimal therapeutic and comfort range for removing heat and moisture from LAL surfaces. When LAL surfaces are discussed, it often is thought that optimum performance is based only on the rate of airflow that the surface provides, but what is crucial is maintaining just the right amount of heat and moisture withdrawal to arrive at a desired balance to maintain comfort and yet cool the skin to prevent tissue breakdown.

Scientists at Hill-Rom are not only working to establish performance recommendations for microclimate management, but also have pioneered the use of materials that move with patients to minimize shear and friction. This user-centric approach to microclimate management also takes into account the needs and challenges faced by today’s caregivers and their patients. Hill-Rom is helping to meet these challenges through its quantifying research on advanced thermal technology surfaces and the therapeutic effect of microclimate management on pressure ulcers.

Conclusion

Ascertaining the appropriate microclimate of the skin is a critical factor in the treatment and control of pressure ulcers. From published findings in combination with Hill-Rom’s internal studies, a logical target zone of optimal therapeutic performance for skin has been established. Hill-Rom used these findings as a baseline for its Advanced Microclimate™ Technology and determined how this technology can be best optimized to help prevent skin breakdown.

Studies suggest that if the skin, when in contact with a surface, is maintained at a temperature between approximately 90 to 95.5 degrees F, moisture production by the skin is significantly reduced in the vast majority of patients, thus diminishing the likelihood of maceration. Equally significant, this moderate cooling takes advantage of the protective effect provided by the skin’s reduced need for nutrients while a temperature range is maintained that, according to these studies, should be comfortable for the vast majority of patients.



Endnotes

- 1 Kuhn BA, Coulter SJ. Balancing the pressure ulcer cost and quality equation. *Nursing Economics*. 1992; 10(5):353-359.
- 2 Ferguson, M., Cook, A., Rimmasch, H., Bender, S., Voss, A., "Pressure Ulcer Management," *MedSurg Nursing*, Aug. 2000.
- 3 National Institutes of Health, National Institute of Nursing Research, Significant Item in the House, Senate, and Conference Appropriations Committee Reports, FY 2001, House Appropriations Committee Report Language (H. Rpt. 106-645).
- 4 Russo CA, Elixhauser A., "Hospitalizations Related to Pressure Sores, 2003," *HCUP Statistical Brief #3*, April 2006.
- 5 Nadel, E., Bullard, R., and Stolwijk, J., Importance of Skin Temperature in the Regulation of Sweating. *J. Appl. Physiol.* 1971;31(1): 0-87.
- 6 Lachenbruch, C., Barnett, R., McGowan, E., Stacy, R., and Salters, B. A Method for the Measurement of Frictional Forces Between Live Human Skin and Common Hospital Materials. *Proceedings of the 14th Annual Clinical Symposium on Wound Care*, 1999. No. 38.
- 7 Kokate, JY, Leland, KJ, Held, AM, Hansen, GL, Kveen, GI, Johnson, BA, et al. "Temperature-Modulated Pressure Ulcers: A Porcine Model." *Arch. Phys Med Rehabil.* 1995;76:666-673.
- 8 Iazzio, P., "Temperature Modulation of Pressure Ulcer Formation: Using a Swine Model. *Medscape Today*, (from WebMD): *Wounds*. Volume 18, posted Sept. 2004.
- 9 Farrell, B.A., Osterwell, D., and Christenson, P., Dept. of Medicine, UCLA School of Medicine, *JAMA*®, "A randomized trial of low air loss bed for treatment of pressure ulcers."
- 10 Williamson, R., Lachenbruch C., and Pilz, B. (2007). *Sweat Accumulation Testing*. Hill-Rom Test Request #T20070572.
- 11 Lachenbruch, C. (2003). *A Study of Skin Temperature vs. Sweat Rate in the Mattress Environment*. Property of Hill-Rom.

About the Author

Dr. Charlie Lachenbruch is a biomedical engineer who specializes in the field of product performance testing. A Hill-Rom employee for 12 years, he currently is the Therapy Research and Development Lead for surfaces. Prior to this, he was an independent consultant and worked in hospital and laboratory settings. Lachenbruch holds a bachelor's degree in engineering from Johns Hopkins University, a master's in physiology from the University of North Texas and a doctorate in biomedical engineering from the University of Texas.

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