WHY YOUR GOLF CLOTHES PERFORM BETTER THAN YOU DO

Science leads to high-tech gear that works in the military, atop mountains and on the golf course

BY DAVID OWEN

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Gale-force winds and heavy rain struck Royal County Down during a stroke-play tournament in 1913. One player returned to the clubhouse "so benumbed with cold that the dressing room boy had to disrobe him," according to a later account.

A competitor named Henderson, hoping to avoid the same difficulty, borrowed a "waterproof kilt" from a friend named Combe (who had acquired it to wear over his trousers while hunting in wet weather). "Combe accompanied him to see how he fared," the account continues, "and was just in time to see the kilt suddenly ballooning upwards on his backswing, rendering Henderson momentarily airborne and giving a new and more literal meaning to the air shot."

Bad-weather golf clothing evolved slowly, at first, during subsequent decades, and for many years golfers in raingear looked like Audrey Hepburn flopping around in Gregory Peck's pajamas in "Roman Holiday." A major breakthrough occurred in 1969, when Robert W. Gore, an American engineer, stretched a heated rod of polytetrafluoroethylene—better known by the trade name Teflon—into the fabric we now call Gore-Tex. His invention contained millions of tiny air spaces, which were too small for liquid water to pass through but were large enough for water vapor—a property that's usually referred to as "breathability," although that term is misleading. (You'd suffocate if you had to breathe through your Gore-Tex golf jacket. But water vapor can migrate through it, toward the side on which the vapor concentration is lower.)

Variations on this bipolar relationship with moisture are among the critical features of virtually all modern sportswear, no matter what kind of weather it's intended for. The industry has been transformed by the introduction of materials and designs that, in one configuration or another, are intended to protect wearers not just from rain but from a steadily expanding list of environmental affronts, along the full range of survivable temperatures. (If you haven't bought golf clothes since the last time Tiger Woods won a major, brace yourself.) One consequence is that finding a decent selection of old-style all-cotton golf shirts can seem almost as difficult as getting a weekend tee time at Bethpage Black. But another is that, if you shop and dress wisely, you can play comfortably in more kinds of weather than you could have at any previous time in the history of the game, thereby effectively lengthening your golf season, by weeks if not months.

Apparel choices also affect performance. The tennis-player-turned-golfaholic Ivan Lendl, who won three consecutive U.S. Opens in the 1980s, made many nonnegotiable demands of Adidas, which supplied his clothing: The left shorts pocket had to be deeper than the right by a precise amount (to exactly hold two balls); there could be no elastic in the waistband, but also no belt; the shirttail had to be 30 centimeters (almost 12 inches) longer than normal, so that it couldn't come untucked. Lendl wasn't being a prima donna; he believed that if his clothes always felt exactly the way he wanted them to he'd have a competitive advantage, because he'd never have to think about them as he played. My current favorite rainsuit, by the Swedish company Galvin Green, would never be mistaken for a kilt or pajamas, and the pants feel so much like regular pants that on golf trips I've occasionally worn them to dinner. Recently, an executive at a major sportswear manufacturer told me, "Comfort seems like this soft, amorphous thing, but if you're comfortable you perform better, whether you're climbing Mount Everest or playing golf. It lets you focus on the task at hand."

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COLD-WEATHER WARNING: 'COTTON KILLS'

In the 1970s, the outdoor-gear company that today is called Patagonia began making sweaters for mountain climbers from a synthetic textile it had first noticed in the inventory of a defunct company that had sold fake fur. In the 1980s, it introduced underwear and other articles made from a different synthetic fabric, a treated polyester, which it called Capilene. The fibers in the new fabric had tiny grooves and a chemical coating, both of which helped to channel perspiration away from the wearer. Capilene clothing performed better in the mountains than any cotton equivalent because it didn't absorb sweat or melted snow and, therefore, didn't chill the wearer or freeze when temperatures got really cold. (Cotton's absorbency makes it great for diapers and golf towels but risky for winter clothing; hence the warning, among mountaineers, hunters, ice fishermen, snow golfers and other cold-season outdoorsmen, that "cotton kills.")

In the 1990s, a former Uni-

THIS PAGE
Nike Hyper Adapt Jacket, $100. **Patagonia** Merino 3 Zip Neck, $125. **Under Armour** HeatGear Sonic Compression Leggings, $40. **Adidas** adiZero One shoes, $180. **FootJoy** StaSof glove, $24.

OPENING PAGES
FootJoy DryJoys Tour XP Rain Shirt, $250, Base Layer Crew Shirt, $58, RainGrip Gloves, $22. **Galvin Green** August Gore-Tex Paclite pant, $410.

versity of Maryland football player named Kevin Plank applied the same concept to sportswear intended for the opposite temperature extreme. He sold shirts made from a different treated-polyester fabric, which, like Capilene, "wicked" sweat from skin and caused it to spread out over a broader surface, so that it could evaporate more rapidly—in this case, with the goal of leaving the wearer cooler as well as drier, because as sweat turns to vapor it carries heat with it. (This is why perspiring cools us off.) Plank called his shirts and his company Under Armour.

To anyone who's old enough to remember sliding off leather couches in double-knit pants, the resurrection of polyester as a luxury clothing item has probably come as a shock. But the polyester in high-quality modern sports clothing is different from the polyester in the white three-piece suit that John Travolta wore in "Saturday Night Fever." Textile manufacturers have been able to create synthetic materials that approach or improve on many of the desirable characteristics of natural materials, while overcoming some of their drawbacks. And in recent years they've found ways to modify natural fibers, too, so that, for example, you can now buy treated-wool garments that do things that might astonish sheep.

At Under Armour, whose headquarters are in a steadily expanding complex of buildings on the Baltimore waterfront, most of the product development and testing occurs in a facility called the Innovation Lab, which not even employees are allowed to enter without authorization. The lab has 3-D printers for rapid-prototyping things like redesigned shoe insoles; an array of fancy sewing machines, for quickly assembling experimental garments; and an air-locked room filled with devices that do things like rub fabric samples together under varying amounts of pressure to imitate the abrasive power of defensive linemen's thighs. There's also a high-ceilinged, black-curtained enclosure that looks like a hotel health club but is actually a testing space, in which technicians can use a variety of cameras, sensors and motion-capture devices to study athletes as they try possible new products.

"We can put golfers in one shirt and have them take a hundred swings," Kevin M. Haley, the company's senior vice president of innovation, told me. "And then we can put them in another shirt and have them take a hundred swings, and we can capture,

to a tenth of a degree, every bend in every limb in all the different planes they're operating in." Haley and his staff track changes in skin temperature with dime-size stick-on monitors, use infrared cameras to identify hot spots, and measure perspiration. And if they find that the placement of a seam on a prototype shirt is interfering with a golfer's backswing, they can rip it apart and try again.

LESSONS FROM THE INUIT ON HOW TO SURVIVE

Before the Norwegian explorer Roald Amundsen made his successful trek to the South Pole and back, in 1910-'12, he spent two years living among the Inuit, in northern Canada. He studied how they dressed, and the lessons he learned help to explain why he and his men survived their expedition to the bottom of the world but his rival Robert Scott and his men did not. Many of the same lessons can be applied to golfers who play in adverse conditions. George Havenith, a professor of environmental physiology and ergonomics at Loughborough University, in England, told me that Amundsen and Scott wore multiple layers—still the recommended clothing scheme for cold-weather activities of all kinds—but that Amundsen chose and managed his layers better.

"The sealskins and reindeer hides that Amundsen's men wore would develop hoarfrost on the inside, where the moisture from their bodies would condense and freeze," he said. "But they would then remove the skins and shake them out, getting rid of the moisture."

By contrast, Scott and his men wore mainly cotton and wool. Wool is a good insulator, and its fibers are able to absorb and isolate moisture inside themselves, up to a third of their weight. (This is why wool keeps you warm when it's wet; in addition, the water-absorption process gives off a small amount of heat.) But as wool captures moisture it becomes heavier, and in very cold conditions the sequestered moisture eventually freezes. And, even if it doesn't freeze, wet wool takes far longer to dry than synthetics do. This is why you can sometimes put on a polyester golf shirt right out of the washing machine, but a wet wool sweater can feel sodden for days.

High-tech golf clothing made from synthetic textiles is far more permeable to water vapor than Amundsen's reindeer skins were, but the hoarfrost example still applies—and for hot-weather clothing, too. No matter how "breathable" a fabric is, direct ventilation can be critical, for the same reasons that opening a window or turning on an exhaust fan will clear a bathroom of shower steam faster than waiting for the vapor to migrate through the skin of the house (or condense on the walls and drip down to the floor). Havenith told me, "The first study I ever did was of permeable rainwear on bicyclists. When we measured the amount of water in the clothing and underclothing, we found quite a big difference between the breathable and non-breathable ones. But no matter what the cyclists were wearing they still got soaked." In other words, the difference was measurable in the lab but not detectable by the lab rats—a common outcome.

Permeability works best when exertion and relative humidity are both moderate; if either level becomes extreme, even high-tech fabrics need help, because tiny membrane openings can't keep up.

Eric Schindler, who is the director of men's golf apparel for Nike, told me that his company's designers have added "standing ventilation" to some Nike golf clothing,

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for just that reason. "At Doral, where it was fairly humid, Tiger wore a polo that contained mesh fabric and perforations, to enable any type of wind or breeze to get inside the garment and accelerate the cooling," he said. "If you look at Tiger's entire line, you'll see that maybe 90 percent of it has ventilation built into it, because he has a really high metabolism, and even when he's just standing there he's running hot." (Other manufacturers have incorporated similar features.) All of the shirts in Nike's Tiger Woods Apparel collection have small laser-cut holes in the collar, to improve air flow on the back of the neck. Direct ventilation is especially important when humidity is high, because moist air on the outside of a garment impedes wicking and vapor transfer, and, as a garment becomes saturated with sweat, its permeability falls further. Wearers can help by unbuttoning, unzipping and untucking (where allowed)—and by moving around, because movement creates a "bellows effect" in garments that are loose enough to flap.

Another lesson that Amundsen took from the Inuit involved timing. Most of us dress for golf based on the conditions when our round begins—and if it's cold we tend to stay bundled up until we feel uncomfortably warm. (On my home course, there's a steep slope on the fourth fairway that I think of as Sweater Hill, because climbing it is a workout and golfers often pause at the top to remove their sweater or jacket.) "But the Inuit didn't wait till they were hot," Havenith told me. "They adjusted their clothing just before their exertion level changed—almost slightly too early. The advantage of doing that is that they avoided moisture accumulation in their clothing."

Cold-weather golfers can profitably follow the Inuit example by assiduously taking things off and putting them back on, in anticipation of changing conditions. Evan Daniel, an apparel designer at Patagonia, told me, "I'm a really aggressive layer-er and un-layer-er when I'm backcountry skiing or doing almost anything else outside. It might seem inefficient to change that much, but it makes me comfortable the whole time."

The lightness of modern golf clothing makes it possible to carry a full selection of layers, even if you're serving as your own caddie. I have a Uniqlo down vest that I keep in my golf bag all winter (in a Ziploc bag with the air squeezed out). It's so compact and weighs so little—less than four golf balls—that last year I forgot to put it back in

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my closet until more than a month after warm weather had returned.

PROTECTING SOLDIERS AND GIRL SCOUTS

No one is more concerned about the functionality and portability of their clothing than the people I recently heard described as "the ultimate athletes": soldiers. A modern American infantryman can be required to wear and carry more than a hundred pounds of gear while performing in daunting climatic conditions, and under the most psychologically stressful circumstances imaginable. As a consequence, the Defense Department tests clothing and other gear with tremendous care. Its main facility is the Natick Soldier Systems Center, in suburban Boston. The base belongs to the Army, but it serves the other branches, too. John D. Harlow, a former soldier who runs the center's public affairs office, told me, "If soldiers wear it, eat it, sleep under it, or have it dropped on them, it's researched and developed here." Most of what was worn by the Navy SEALs who got Osama bin Laden passed through Natick first.

Not long ago, Harlow gave me a tour. Our first stop was the Doriot Climatic Chambers, two huge wind tunnels that the Army uses to simulate unpleasant weather of all kinds. Operators can lower the temperature in the "arctic" chamber to -70°F and raise it in the "tropic" one to 165°F. They can set the relative humidity anywhere from 10 to 90 percent, and by specifying latitude and longitude they can reproduce solar conditions anywhere in the world. Each tunnel has two built-in programmable treadmills, and each treadmill can handle five soldiers at a time. They can make rain fall from the ceiling at a rate of up to four inches an hour, and they can generate sustained winds of 40 miles per hour. "Girl Scout troops visit a couple of times a year," Sarah Welch, a retired Army medic who now works at the facility, told me. "We jack the wind up to 30 mph, and there are braids and pigtails everywhere."

Sportswear manufacturers follow the Army's clothing research closely, and they can rent the chambers for studies of their own. (The ceilings in both wind tunnels are high enough for full swings with a driver.) The influences work in both directions. In the clothing-design department at Natick, I saw an "Innovation Board," on which a designer had pinned an advertisement for a golf shirt in Nike's Tiger Woods collection. Woods, like many golfers, has often fussed with his shirtsleeves before swinging, to push them out of the way, and Nike, in the hope of making such adjustments unnecessary, has reconfigured the shoulder and back seams on some of its shirts. Annette LaFleur, team leader of Natick's Design, Pattern and Prototype Team, told me, "We haven't done anything with it yet, but we all thought it was interesting, and that maybe a soldier could benefit from it, too. We think about seam placement a lot."

Optimized fit is a recurring theme in the design of high-performance clothing of all kinds, both military and civilian. George Havenith, the Loughborough professor who studied Amundsen and Scott, also studied the clothing worn by the English mountaineer George Mallory at the time of his death, on Mount Everest, in 1924. He told me that Mallory was probably dressed inadequately for the weather he faced at the end, but that in many ways his clothing was innovative. Like Scott, he wore multiple layers of wool, but he also wore several intermediate layers of silk, which acted almost like lubricants. "That gives you a big advantage," Havenith said, "because when there's less friction there's less energy consumption." Almost all the synthetic fabrics tend to work like this—and that can be especially important for golf swings, in which turning and flexibility are critical.

The slipperiest golf clothes I own are my two compression shirts: one made by Under Armour and one made by a company called IntelliSkin. Tight, stretchy clothes that squeeze your body are said to have numerous athletic benefits, including improving your posture, making you cooler, making you warmer, helping your muscles recover faster after exertion, and enabling you (in the case of IntelliSkin) to become a "Full Time Human." Harry Vardon once said that every golfer should play in a jacket and suspenders, to keep the swing compact, and both my compression shirts feel something like that. I wonder also whether they might not reduce the risk of gagging over three-foot putts, in the same way that a gently compressive vest called the ThunderShirt is said to relieve anxieties in nervous dogs and cats. Still, wearing super-tight clothing requires a certain firmness of purpose, even if no one else can see it. In theory, a compression garment should make you look thinner, but the first time I glimpsed myself in a mirror in profile I thought, *I really need to start ordering salads instead of fries with my bacon cheeseburgers.*

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ARMY ADVANCES (AND CONSTRAINTS)

In a conference room at Natick, I saw the Army's new Gen III Extreme Cold Weather Clothing System, which was developed there. The system includes an assortment of wicking base layers, insulating middle layers and impermeable outer shells—a basic approach familiar to anyone who spends time outdoors in the winter and keeps up with clothing trends. The Gen III team sought advice from outdoor-gear companies—some of which also manufacture elements of the system, under contract with the Pentagon—and, partly as a result, several of the items (except for their camouflage) bear a family resemblance to clothing you might find for sale at REI, or even Edwin Watts.

The similarities go only so far, however, in part because

the Army's designers operate under constraints that civilian designers don't—among them a Congressional requirement that virtually everything a soldier uses be sourced entirely within the United States. That means that Army parkas don't contain goose down, which insulates better than any synthetic alternative but is available in large quantities only from Asia. Another constraint is that everything a soldier wears has to work. Sportswear manufacturers occasionally make claims for their products that the laws of physics haven't quite caught up to yet. The Army is less excitable, and, as a consequence, soldiers aren't issued thin garments that promise to keep them as warm as ones that have more "loft," or insulating thickness. (The fiberglass insulation in your attic keeps your house warm by creating a barrier that slows the loss of heat. The thicker the layer—the greater its loft—the better it is at keeping you warm. Clothes are the same. The clothing material with one of the highest loft-to-weight ratios is goose down. That's why sleeping bags and ski jackets are filled with it.)

Natick's High Performance Fiber Facility is experimenting with fibers that curl when their temperature drops below a certain point and flatten when it rises. If you created a fleece or filling material from a fiber like that, you'd have a jacket that would add loft (more insulation) to itself in cold weather and subtract it in warm, potentially reducing the need for multiple layers. The benefit for heavily laden soldiers—and golfers!—could be huge.

Naturally, there's a catch. Megan L. Hoey, a member of the facility's fiber and textile science team, told me that the fiber's utility might end up being limited by what she referred to as "the human factors." "We've measured a 2-percent change in loft per degree centigrade," she said. "But the question is whether that's something a soldier who is wearing the garment can actually feel. If you're an outdoor-clothing company, that may not matter, because you can say on the tag that it's a cool technology and sell it for $30 more. But the Army actually cares whether it benefits the soldier or not."

"If possible," Hoey said, "we'd love to have a uniform that's not only temperature-adaptive but also is able to sense, store and transmit data, as well as to collect and store solar energy." Under Armour, Nike, Adidas, FootJoy and all the other major sportswear manufacturers are, quite naturally, deeply interested in all such technologies, and are already planning athletic clothing to incorporate them. Last winter, Under Armour released a television commercial in which an attractive young woman changes the temperature of her gauzy, tight-fitting running suit by adjusting a virtual control panel on her sleeve. That's a stretch, but other cool capabilities are coming for all sorts of athletes, including golfers—even if the Army ultimately decides that they aren't right for soldiers.

BEWARE THE WASHING MACHINE

Kevin Haley, Under Armour's innovation executive, told me, "Sometimes it's actually easier to make stuff work than it is to make it work after it's been through the washing machine." The reason is that the desirable qualities of modern sports clothing are often created by applying chemical treatments to the fibers, the fabrics or the finished articles. All such treatments eventually degrade; if they do so after an unreasonably small number of washings, designers have to turn elsewhere. The Army's Natick facility contains an enormous laundry lab in which researchers subject all manner of items to repeated cleanings in a variety of machines. At the time I visited, the lab contained stacked boxes of test clothing that had been impregnated with permethrin, an insect repellent. DEET, the most widely used repellent, was developed by the Army after World War II; it's highly effective, but when it's applied to skin it blocks perspiration—a problem for soldiers already at risk of overheating. The Army's more recent approach has been to put repellent in clothes, and the researchers need to know how long it remains effective.

Probably the most important lesson I learned from the experts at Natick and at various sportswear companies is that you really do need to pay attention to the washing instructions that come with high-performance golf clothes—something I'd mostly ignored before. "You have to follow the care label," Luisa DeMorais, the leader of the Army's textile materials evaluation team, told me, "and that usually means never using fabric softeners or dryer sheets. Most softeners contain silicone, and once silicone gets on something it's virtually impossible to remove." Silicone can smother fabric treatments, such as the ones that promote wicking, and it can ruin raingear, which can also be harmed by detergent residue. (On the other hand, detergent residue enhances the wicking of polyester.)

That doesn't mean you shouldn't wash your rainsuit, DeMorais said. In fact, you should wash it regularly—but without too much detergent, or with a mild cleaner meant specifically for it. (One such product is Nikwax Tech Wash, which is formulated for waterproof, breathable fabrics.) Almost all rainsuits have an outer layer that's treated at the factory with what's known as a durable water-repellent (DWR) finish. This isn't what makes your rain jacket waterproof—that's the function of an inner membrane, made of Gore-Tex or some comparable material—but the DWR finish contributes to the jacket's breathability and overall comfort, by causing water on the outer surface to immediately bead up and slide off. A jacket with a degraded DWR finish can seem to be leaking, even though it's not, because, if the outer fabric layer becomes saturated, vapor migration will be impeded and the whole clammy mass will press against your skin like a wet rag. A gentle washing, followed by tumbling in a warm dryer or (careful) ironing with a warm steam iron, can revive a DWR finish; and if the finish is too far gone for that you can reapply it yourself, using a liquid that washes in or sprays on.

Soldiers periodically send their raingear back for re-treating, assuming they haven't worn holes in it. I accomplished the same thing in my laundry room, when I got home from Natick, by using a wash-in product called Nikwax TX.Direct (but no fabric softener or bleach!). And as soon as my rainsuit was dry I went out and played golf in the snow. ♣