

# The Physics of Tennis Racket Strings

**When watching the pros at the U.S. Open** hit with superhuman pace, it's natural to look for a shortcut to attain that kind of power. Most weekend hackers might focus on the racket, assuming that if they could dip into a top pro's racket bag, they too could pummel the ball like a pro.

They may be only part right. Defending champion Roger Federer uses a frame that is a direct descendent of the racket used by Pete Sampras—a small-head, low-power model introduced way back in 1982. But conventional frames like his contain a secret weapon: specialized, high-tech string. So, it's not the frame, but it may be the string. And it comes from an unlikely company.

Pros are more particular about their string jobs than about their post-match massages.

"They have their rackets in their hands hours and hours every day," says Roman Prokes, president of PRNY Tennis in New York and personal stringer to stars like Maria Sharapova and Andy Roddick, "So if you mess it up by a pound of tension, they know it." Or in the words of Andre Agassi, one of Prokes' most famous clients: "A string job can be the difference in a match. A match can be the difference in a career. And a career can mean the difference in countless lives."

What do they string with? Most pros are using polyester from Luxilon or other companies. The small Belgian company also makes elastics for bras and other women's undergarments. Its climb to fame began when a young Brazilian player named Gustavo Kuerten tried the then-obscure string, almost on a whim, and won three French Opens with it. Other players gradually followed suit, and now virtually every player on the men's and women's tour who runs the stringing room at the U.S. Open uses Luxilon or a Luxilon play-alike.

The polyester string is both stiffer and thicker than conventional gut and nylon strings, and the result is a unique set of playing characteristics. "Polyester strings grab the ball—

it's almost like suction cups," says Prokes, who oversees the stringing room at the U.S. Open. It will churn out more than 3000 string jobs over the course of the fortnight.

Why do players love Luxilon? In a word: "Control," Prokes says. And in modern tennis, control means topspin. Topspin is the forward rotation of the ball, imparted by an exaggerated low-to-high swing. The forward rotation disrupts air pressure around the ball, creating a zone of high pressure above the ball and low pressure below—the same forces that are at work on a bat-breaking baseball pitch. This unequal pressure forces the ball to dip down, allowing players to swing hard, aim higher over the net and still land the ball inside the baseline. "You can hit the ball hard and it stays in the court," Prokes says.

This extreme spin from polyester-strung rackets also allows players to hit angles that simply aren't possible with conventional string. Topspin also gives players a secondary advantage in that the spin makes the ball bounce higher, forcing opponents to hit the ball at shoulder height, out of their comfort zone.

The dramatic difference in spin isn't subtle. Tennis researcher John Yandell analyzed slow-motion video and determined that No. 1-ranked player Rafael Nadal hits his average forehand with 3200 rotations per minute (rpm) and sometimes reaches a mind-boggling 4900 rpm. By comparison, Federer's forehand averages 2700. And Pete Sampras and Andre Agassi, two of the top players of the previous generation, hit their forehand at a mere 1800 rpm, imparting slightly more than half as much spin as Nadal.

While the next generation of strings have taken the pro game by storm, they're not a panacea for the recreational player. They require a full, fast swing to create the spin, and the stiff string bed causes vibrations that can aggravate tennis elbow.

Albeit minor, the downside of polyester strings is that they lose their tension quickly. And pros are particular about their string tension. To maintain a consistent tension throughout the match, Federer started the trend of changing rackets at predetermined intervals, usually every eight games with each ball change. Most top players have followed suit.

Many pros will have all their rackets restrung every night whether they played with them or not. Overnight, Prokes explains, rackets will lose a pound to a pound and a half of tension, and that's enough to put it outside the margin for error. Players can detect differences of a half-pound of tension or less just by tapping a racket against the palm. "To them that's the difference between the ball flying and it doesn't."

Most players will carry a small arsenal of rackets strung at a narrow range of tensions so they can grab a slightly different racket if the conditions change or they need a little more power or control. Prokes explains that he had strung rackets at three different tensions—58 pounds, 59 pounds and 60 pounds—for Andy Roddick's first-round match, increasing the tension slightly to help control the lively ball under hot conditions. Top-seeded Nadal is the exception to this array-of-rackets rule. All of his Babolat frames are strung at exactly the same tension—56 pounds—and he makes the adjustments in his game depending on the conditions. "In a way, he adjusts to the string," Prokes says.