• CLUB INNOVATIONS • MAXIMIZING STRENGTH TRAINING • UNIVERSITY FITNESS

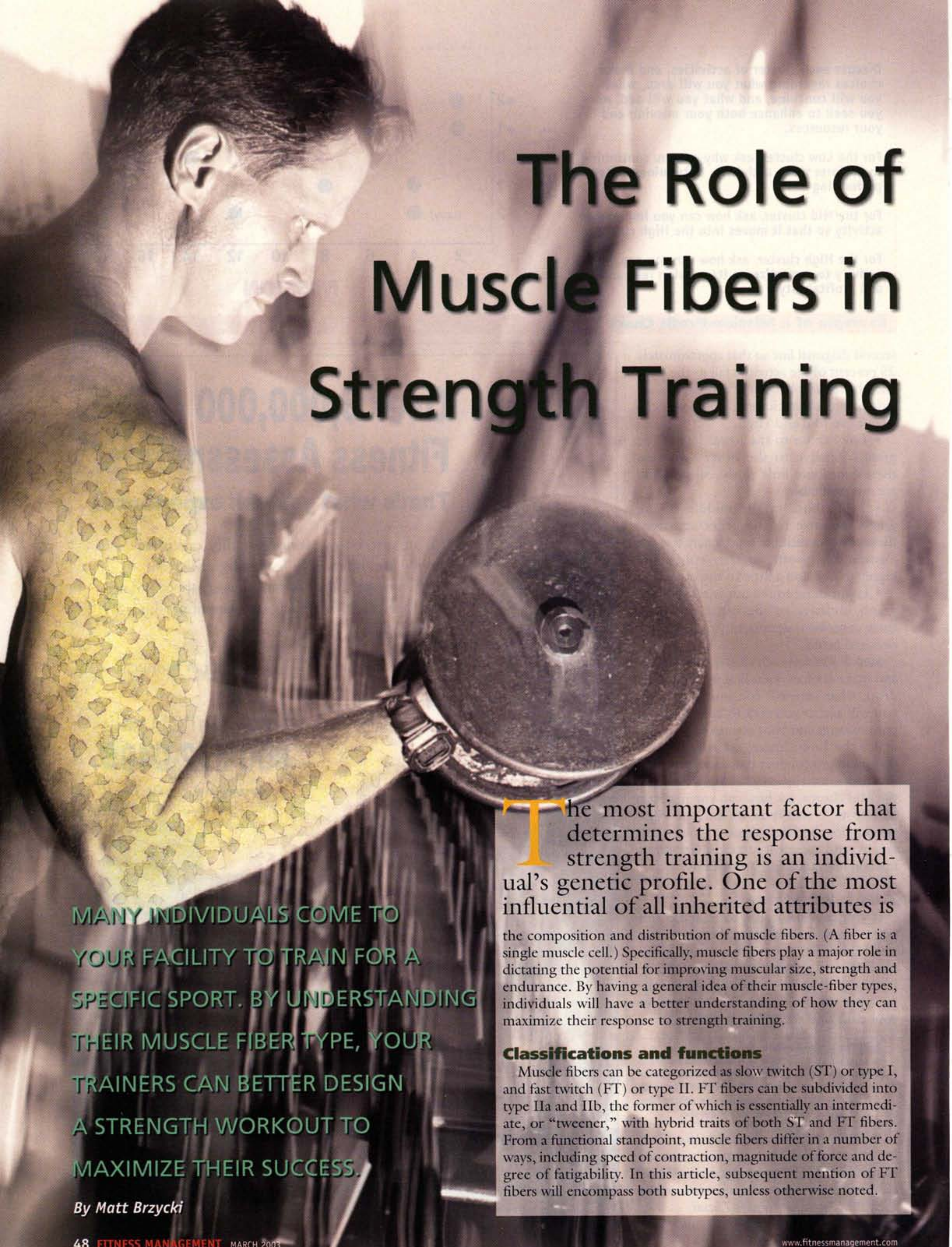
Fitness Management®

ISSUES AND SOLUTIONS FOR FITNESS

MARCH 2003

WINNING *INNOVATIONS*

7 Facilities Stand Out in the 2003 Nova7Awards



The Role of Muscle Fibers in Strength Training

MANY INDIVIDUALS COME TO YOUR FACILITY TO TRAIN FOR A SPECIFIC SPORT. BY UNDERSTANDING THEIR MUSCLE FIBER TYPE, YOUR TRAINERS CAN BETTER DESIGN A STRENGTH WORKOUT TO MAXIMIZE THEIR SUCCESS.

By Matt Brzycki

The most important factor that determines the response from strength training is an individual's genetic profile. One of the most influential of all inherited attributes is the composition and distribution of muscle fibers. (A fiber is a single muscle cell.) Specifically, muscle fibers play a major role in dictating the potential for improving muscular size, strength and endurance. By having a general idea of their muscle-fiber types, individuals will have a better understanding of how they can maximize their response to strength training.

Classifications and functions

Muscle fibers can be categorized as slow twitch (ST) or type I, and fast twitch (FT) or type II. FT fibers can be subdivided into type IIa and IIb, the former of which is essentially an intermediate, or "tweener," with hybrid traits of both ST and FT fibers. From a functional standpoint, muscle fibers differ in a number of ways, including speed of contraction, magnitude of force and degree of fatigability. In this article, subsequent mention of FT fibers will encompass both subtypes, unless otherwise noted.

ST (type I) fibers. Compared to FT fibers, ST fibers have greater amounts of myoglobin (an iron-containing protein that stores oxygen in the cell), mitochondria (the so-called "powerhouse" of the cell) and blood capillaries. These characteristics cause ST fibers to appear red, and also make them highly aerobic, and heavily dependent on oxygen for energy. Because of this, ST fibers are sometimes referred to as "slow oxidative." Relative to FT fibers, ST fibers contract more slowly and produce lower amounts of force (due to their smaller diameters), but they fatigue less readily. (Although ST fibers contract more slowly than their FT counterparts, this is not to say that they don't contract quickly. Indeed, their speed of contraction is measured in milliseconds.)

FT (type IIa) fibers. These intermediate fibers have moderate amounts of myoglobin, mitochondria and blood capillaries. Similar to ST fibers, these fibers look red. Their hybrid nature allows them to possess aerobic and anaerobic qualities, and to use oxygen and glycogen for energy. Therefore, these fibers have been described as "fast oxidative glycolytic." In comparison to ST fibers, they contract more quickly and forcefully and fatigue more easily, but not as much as the pure FT fibers.

FT (type IIb) fibers. Compared to ST fibers (and intermediate fibers), these pure FT fibers have lower amounts of myoglobin, mitochondria and blood capillaries. These characteristics cause these fibers to appear white, and also make them highly anaerobic and heavily dependent on glycogen for energy. Because of this, they are sometimes referred to as "fast glycolytic." Relative to ST fibers (and intermediate fibers), these FT fibers contract more quickly and generate higher amounts of force (due to their larger diameters), but they fatigue more readily.

Composition and distribution

Studies of twins have shown that the composition and distribution of muscle fibers is determined almost entirely by hereditary factors. Most muscles have a blend of about 50 percent FT fibers and 50 percent ST fibers, which are intermingled throughout each muscle. Some people, however, inherit a greater proportion of one fiber type, which allows them to be successful during efforts of varying demands and durations. For example, an individual who has inherited a high percentage of ST fibers has the genetic potential to produce relatively small amounts of force for long periods of time and, therefore, will excel during low-intensity, long-term efforts. On the other hand, a person who has inherited a high percentage of FT fibers has the genetic potential to generate relatively large amounts of force for short periods of time and will, therefore, excel during high-intensity, short-term efforts. It should also be noted that an individual's fiber-type mixture will likely differ from one muscle to another, and may even vary from one side of the body to the other.

This begs the question, "Can one fiber type be converted into another?" Or, to use the words of Mark Asanovich, strength and conditioning coach of the Tampa Bay Buccaneers, "Can you switch the twitch?" While this is the subject of considerable debate, currently no scientific evidence consistently supports the notion that ST fibers can be converted into FT fibers, or vice versa. It appears as if one type of muscle fiber may take on certain metabolic characteristics of another type, but actual conversion doesn't take place. In other words, you cannot convert one fiber type into another any more than you can convert a pack mule into a racehorse. So, if you were to take a pack mule and train it like a racehorse, you might get a slightly faster pack mule … but you'll never get a racehorse.

Fiber recruitment

Consistent with Henneman's Size Principle of Motor Recruitment, muscle fibers are innervated (or recruited) by the nervous system in a sequential pattern according to the force requirements of an activity. Demands that require a relatively low amount of muscular force are met by ST fibers. If they cannot keep up with the demands, intermediate fibers are called upon for metabolic assistance. If the collective efforts of these fibers aren't enough to meet the demands, pure FT fibers are recruited to provide help. To ensure that FT fibers are activated while strength training, it's important for individuals to lift weights with a reasonable degree of intensity (or effort).

Training implications

The results that can be obtained from strength training are influenced greatly by a person's fiber-type mixture. Several different physiological and myological capabilities are affected.

Muscular strength and endurance. An individual's fiber-type mixture has an impact on the potential for muscular strength. FT fibers have larger diameters than ST fibers and, therefore, produce greater amounts of force. Because of this, a person who has a high percentage of FT fibers will have a greater potential for muscular strength than someone who has a high percentage of ST fibers (everything else being equal).

> **Achieving an award-winning physique and/or mind-boggling strength is limited by muscle-fiber type.**

In addition, a person's fiber-type mixture influences the potential for muscular endurance. ST fibers are more resistant to fatigue than FT fibers and, therefore, display greater levels of endurance. As a result, a person who has a high proportion of ST fibers will have a greater potential for muscular endurance than someone who has a high proportion of FT fibers (again, everything else being equal).

Hypertrophy and hyperplasia. An increase in the size of muscle fibers is known as "hypertrophy." (Its inverse — a decrease in the size of muscle fibers — is called "atrophy.") FT fibers have a much greater capacity for hypertrophy than ST fibers. In other words, an individual who has a high percentage of FT fibers will have a greater potential for muscular size than someone who has a high percentage of ST fibers.

An increase in the number of muscle fibers is known as "hyperplasia." The increase is thought to take place by fiber splitting, or "budding." Although hyperplasia has been demon- strated in many animals whose muscles were loaded with a resistance — including birds, cats and rats — there's no definitive proof that it occurs in humans.

What's your fiber type?

In a laboratory, fiber types can be distinguished by doing a biopsy, which involves removing a small plug of muscle tissue and later analyzing it under a microscope. Muscle biopsies aren't ideal for assessing fiber types because they result in the destruction of tissue. Moreover, their accuracy has also been questioned. For one thing, fiber "headcounts" are subject to different interpretations. And since the distribution of fibers varies throughout a muscle, the site from which the biopsy is taken may not be indicative of the overall fiber-type mixture.

In a weight room, fiber types can be guesstimated by evaluating fatigue characteristics via a test of muscular endurance with a submaximal weight — usually 75 to 80 percent of maximal strength. Suppose, for example, that an individual has a one-repetition maximum (1-RM) of 100 pounds on the leg extension. If a relatively high number of repetitions can be performed with the submaximal weight (more than about 14), it's likely that the quadriceps have a high percentage of ST fibers. If a relatively low number of repetitions can be performed with the submaximal weight (less than about six), it's likely that the quadriceps have a high percentage of FT fibers. But remember, since the composition and distribution of fibers can vary from muscle to muscle, the results of an endurance test aren't necessarily reflective of the entire muscular system.

How much do individuals really vary in terms of their muscular endurance? Wayne Westcott reported data on 141 subjects who performed an endurance test with 75 percent of their 1-RM. It would be expected that 10 repetitions could be performed with this workload. And according to the data, the subjects completed an average of 10.5 repetitions. Yet, only 16 of the 141 subjects (11.35 percent) performed exactly 10 repetitions with 75 percent of their 1-RM. Many of the subjects were in the neighborhood of 10 repetitions. In fact, 66 of the 141 subjects (46.81 percent) were able to complete between eight and 13 repetitions. But 75 of the 141 subjects (53.19 percent) performed either less than eight repetitions, or more than 13. At the extremes, two subjects only performed five repetitions, and one managed 24. While other factors may certainly have come into play, the influence that fiber types have on muscular endurance cannot be underemphasized or overlooked.

You can also make a logical guesstimate of fiber types based upon performance. Individuals who are successful in efforts that require muscular endurance probably have a high percentage of ST fibers; those who are successful in efforts that require muscular strength (and/or power) likely have a high proportion of FT fibers.

Another way of making a reasonable guesstimate of fiber type is to consider a person's muscular development. Recall that FT fibers have a much greater potential for hypertrophy than ST fibers. Therefore, individuals who have a significant amount of muscular development probably have a high percentage of FT fibers; conversely, those who have a slight amount of muscular development likely have a high proportion of ST fibers (assuming, of course, that the low degree of muscular development isn't a result of inactivity).

Repetition ranges

To maximize response to strength training, some people — because of a predominant muscle-fiber type — may require repetition ranges that are either a bit higher or lower than that prescribed for the general population. For example, individuals who have a high percentage of ST fibers would probably benefit more by performing slightly more repetitions because their predominant muscle-fiber type is more suited for muscular endurance. On the other hand, those who have a high percentage of FT fibers would likely benefit more by performing slightly fewer repetitions, because their predominant muscle-fiber type is less suited for muscular endurance. In a 1987 study by Westcott, sprinters trained with low repetitions, middle-distance runners with medium repetitions and long-distance runners with high repetitions. His research revealed excellent and equal strength gains in all three groups. Successful sprinters would have a high percentage of FT fibers, and successful distance runners would have a high percentage of ST fibers.

Performance and fiber type

Due to genetics, each individual has a unique blend of muscle fibers that dictates the potential results from strength training. People must realize that achieving an award-winning physique and/or mind-boggling strength is limited by muscle-fiber type. But they should also understand that it's just one of many factors that contribute to their response. **FM**

REFERENCES

Brzycki, M.M. Fiber types and repetition ranges. *Wrestling USA* 3 (10): 9-10, 12, 1998.

Westcott, W.L. Individualized strength training for girl high school runners. *Scholastic Coach* 57 (Dec.): 71-72, 1987.

Westcott, W. *Building Strength and Stamina*. Human Kinetics: Champaign, Ill., 1996.

Matt Brzycki is the coordinator of recreational fitness and wellness programs at Princeton University, N.J. He has authored more than 200 articles on strength and fitness, and is the editor of *Maximize Your Training: Insights from Leading Strength and Fitness Professionals*.