STRENGTH AND CONDITIONING

A concise introduction

John Cissik

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A CONCISE INTRODUCTION

JOHN CISSIK

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STRENGTH AND CONDITIONING

Strength and Conditioning offers a concise but comprehensive overview of training for athletic performance. Introducing essential theory and practical techniques in all of the core areas of athletic training, the book clearly demonstrates how to apply fundamental principles in putting together effective real-world training programs.

While some established textbooks rely on established but untested conventional wisdom, this book encourages students and professionals to think critically about their work and to adopt an evidence-based approach. It is the only introductory strength and conditioning textbook to properly explain the interdependence of aspects of training such as needs analysis, assessment, injury, competition level, athlete age, and program design, and the only book to fully explain how those aspects should be integrated.

No other textbook offers such an accessible, engaging, and reflective introduction to the theory and application of strength and conditioning programs. Including clear step-by-step guidance, suggestions for further reading, and detailed sport-specific examples, this is the perfect primer for any strength and conditioning course or for any professional trainer or coach looking to refresh their professional practice.

John Cissik is the Director of Fitness and Recreation at Texas Woman's University and a human performance consultant to track and field programs. He has authored six books, produced four videos, and written more than 70 publications on strength and speed training. He also serves as an associate editor for the *Strength and Conditioning Journal*.

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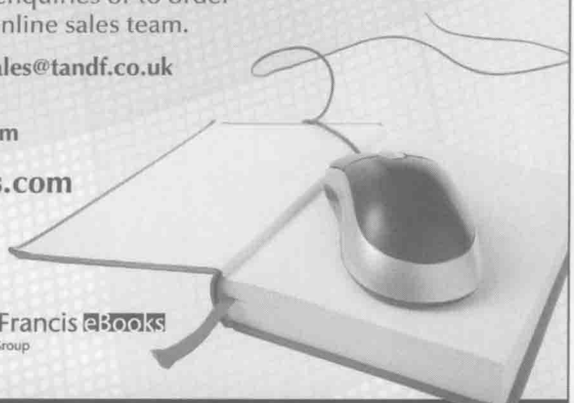

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INTRODUCTION

The field of strength and conditioning is a rich field consisting of application, theory, philosophy, and scientific foundation. This book is meant to tie all those aspects together for the student and practitioner. Quite simply, this book will cover the "hows" of the various aspects of strength and conditioning and will incorporate many of the modern training implements and training approaches that are widely used but not yet widely researched.

Strength and conditioning is a broad field that attracts athletes, parents, the general fitness population, researchers, rehabilitation professionals, sports medicine professionals, fitness professionals, sports coaches, and strength and conditioning coaches. As a field, strength and conditioning consists of a number of tools. These include strength training, plyometrics training, speed training, agility training, conditioning, and sport-specific training.

Strength training refers to overcoming some external resistance to make the muscles stronger, larger, and more explosive. Typically, this is the first thing that one thinks of with regards to strength and conditioning. While important, it is only part of an athlete's training.

Plyometric training involves jumps or throws to make the athlete more explosive. It became very popular about 20 years ago but still is not very well understood today.

Speed training refers to training athletes to run faster. Speed is a critical component to athletics, though overemphasizing this can make it difficult to apply the qualities developed to the sport.

Agility training teaches the athlete to change direction quickly while maintaining his or her balance. It is one of the most difficult areas to coach.

Conditioning gets the athlete in shape for the sport. It can involve running sprints with little recovery, but can involve much more than just running.

Sport-specific training is what the athlete does on the field or on the court to directly prepare for the game. It is an area that many strength and conditioning professionals are deficient in and this makes linking the strength and conditioning to the sport challenging.

This book is going to cover most of these important parts of strength and conditioning and will also address injuries; age differences and its impact on training; how level of competition impacts training; how to put everything together into a program; long-term periodization; and will provide a number of examples using various sports. To my knowledge, no other book addresses these subjects this comprehensively.

There are 12 chapters in this book. The chapters are organized around the following topics:

- Adaptations from training: Why is strength and conditioning important? What exactly happens as a result of it? This section breaks down what we "know" as a result of science on the impact of strength and conditioning.
- Techniques: What are the major tools used to train *athletes*? This section covers the major exercises, but this is not an exhaustive look at exercises – other books do this already. The focus will be on the major ones, how/why they are performed, and safety relative to each exercise.
- Assessments: How do we evaluate athletes to assess their needs and to assess the effectiveness of training? Major assessments under each area (strength, power, speed) are described with an emphasis on assessments that are common to many sports.
- Components of a training session: Each component is covered in isolation. What types of exercises are used in each component? Why? Are the components organized a specific way?
- Principles of training: These are the guidelines for strength and conditioning. They are defined and examples of using them are provided.
- Needs analysis: The needs of the sport, combined with the needs of the athlete, should drive the designing of the training program. However, we often forget this step and jump straight into the program.
- Program design: This is covered on a micro level and a macro level. At the micro level, training for different goals (strength, speed, power, etc.) is described. At the macro level incorporating multiple goals/training modes are presented in a step-by-step manner.
- Periodization of training: With athletes, there is a need to take the long-term view of training and to prepare them to be at their best during a specific moment in time. This is one area that lends itself to being overly complicated. A simple, methodical approach is used to teach the concept.
- Injuries: Unfortunately, this is a common occurrence in athletics. The major ones are described from the standpoint of what is occurring, how they can be accommodated in training, and how they are "fixed."
- Age and training: Most books are typically written for the 18–30-year-old population. Most athletes do not fall into this group. Based upon their age, they are going to have different training needs and are going to respond to training differently.
- Level of competition and training: Many books are typically written for university and elite athlete populations. Most athletes don't fall into these populations and will have different needs.

- Putting it all together: Soccer is used to help illustrate the concepts in the book.

Each chapter includes a "key readings" section, which provides articles and books that are important for understanding some of the concepts covered. Some are controversial, some are outdated, but they are all important for giving the reader a perspective on why things are the way they are today.

At the end of this book is a glossary to help with key concepts and terms, an exhaustive bibliography so that the reader can research concepts in more detail, and an index to assist the reader with locating key concepts.

As a field, strength and conditioning is part science and part philosophy. As this book, hopefully, demonstrates, there is a prodigious amount of research on strength and conditioning. Yet, there are significant holes in the research and these gaps form the foundation of many of the key beliefs held in strength and conditioning. Despite decades of research, our evidence-based knowledge of core beliefs such as the efficacy of core training, hypertrophy, the neural effects of strength training, periodization, plyometrics, and velocity specificity is extremely limited. This means that much of the practice of strength and conditioning is based upon tradition, marketing, and logic.

Approaching strength and conditioning in this manner isn't necessarily a negative. The philosophy frequently drives the science (i.e. we try something and science later verifies it). American track and field coach, William Freeman (1994), in a wonderful article, wrote that "Athletes improve because their training evolves – it changes as they improve. We must try new ideas, new approaches. Most of these will come from unsubstantiated theory."

It is important to highlight and acknowledge where there are gaps in our knowledge of strength and conditioning. Without acknowledging these gaps, they can never be addressed. This book addresses where there are gaps, where the research is inconclusive, where there are conflicting results, and where the applicability of our knowledge is limited. To the author's knowledge, no other book addresses evidence-based strength and conditioning this comprehensively.

This book is appropriate for many audiences. The student, fitness professional, and coach will find a wealth of information about the hows and whys of strength and conditioning. The parent, fitness enthusiast, and athlete will be able to find exercises and programs that can be applied to their situation. The sports medicine professional can read this book and get a sense of what the coach is trying to accomplish. The researcher can read this book and take out of it the wealth of opportunities for advancing our knowledge in this field.

KEY READINGS

Freeman, W. (1994) Coaching, periodization, and the battle of artist versus scientist, *Track Coach*, 127: 4054–7.

William Freeman in this article addresses the debate of art versus science with regards to coaching. He points out that science is important; after all, biology is the basis of movement. However, as he points out, the science has limitations and is frequently behind the practice of coaching. In other words, the art of coaching often drives the science, not the other way round.

CHAPTER ONE

ADAPTATIONS FROM TRAINING

The human body's physiology determines what kinds of adaptations are made from training and drives why training is performed the way that it is. Understanding how and why the body responds to exercise allows one to more effectively perform exercises and design programs.

OUTLINE

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- Muscle fiber types
- Neural structure and function
- Fueling movement

Neural adaptations

Muscular adaptations

- Changes in muscle size
- Changes in pennation angle
- Changes in fiber typing

Hormonal adaptations

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Key readings

BACKGROUND

Muscle structure and function

The skeletal muscle that lies under the skin is surrounded by a layer of connective tissue called the *epimysium*. Under that layer are bundles of muscle fibers, each bundle called a *fasciculus*. Each fasciculus is surrounded by a layer of connective tissue called the *perimysium*. Each fasciculus is made up of many *muscle fibers*, which are the cells of the muscle.

Muscle fibers run the entire length of the muscle and have multiple nuclei. Each muscle fiber is surrounded by a layer of connective tissue called the *endomysium*. The endoymsium consists of two parts: a *basement membrane*, which is on the exterior, and a *plasma membrane* (also known as the *sarcolemma*), which is on the interior. Located between the two parts of the endomysium are *satellite cells*.

The muscle fiber has the appearance of alternating light and dark bands, which is why skeletal muscle is called *striated muscle*. These alternating light and dark bands are the *sarcomere* of the muscle fiber, which is the contractile unit of the muscle fiber.

Sarcomeres consist primarily of two protein filaments, *actin* and *myosin*. Actin filaments are also known as the thin filaments and there are many of them in a sarcomere. Myosin filaments are also known as the thick filaments. There are fewer in a sarcomere and they are surrounded by actin.

Surrounding the sarcomere are a series of interlocking tubular channels called the *sarcoplasmic reticulum*. The lateral ends of the sarcoplasmic reticulum terminate at the end of each sarcomere and contain vescicles that store calcium. Adjacent to the sarcoplasmic reticulum are t-tubules that run into the muscle fibers.

During a muscular contraction, an electrochemical signal (called the *action potential*) is sent from the brain, down the spinal cord, to a motor nerve, to all of the muscle fibers that the motor nerve innervates.

The action potential changes the charge of the nerve and the muscle fiber. At rest, muscle and nerve fibers are negatively charged inside. As the action potential moves down the nerve and muscle fiber, this changes and the fibers become positively charged inside, which is called *depolarization*. As the action potential travels across the muscle fiber, it also travels down the t-tubule, depolarizing it. This depolarization causes the sarcoplasmic reticulum to release calcium into the t-tubule. The calcium travels down to the actin filament and causes it to shift its structure, allowing myosin to reach out and attach to the actin. This attachment is known as a *cross-bridge*.

Once the cross-bridge is formed, myosin will expend energy and flex the cross-bridge, causing actin to shorten. When this happens on a big-enough scale, the muscle fiber will shorten, causing movement. As long as calcium and energy are present, cross-bridges will continue to be formed. The more cross-bridges that can be formed, the more force can be exerted.

When it is time for movement to stop, repolarization changes the charge of the muscle and nerve fibers back to resting values, halting the release of calcium. Without calcium the cross-bridges cannot form.

Muscle fibers attach to bone via *tendons*. All the layers of connective tissue that are present in the muscle (epimysium, perimysium, and endomysium) run into the tendon, so that when the muscles shorten they are able to move bone.

Muscle fibers either run parallel to the tendon's line of pull or obliquely to it. When they run parallel they are said to be *in series* and they shorten more quickly than fibers that run obliquely to the line of pull. When they run obliquely they are referred to as *pennate muscle fibers* (Narici, 1999). Pennate muscle fibers allow for more sarcomeres to be located in parallel, allowing for more cross-bridges to form and more force to be generated (Kawakami *et al.*, 1995; Komi, 1979; Narici, 1999).

Muscle fiber types

Muscle fibers have several different classification systems depending upon the textbook or article that describes them. This can make interpreting literature challenging. According to Staron (1997), muscle fibers may be classified according to:

- Contraction speed: *Fast-twitch muscle fibers* can generate a large amount of force, quickly, for a very short period of time. *Slow-twitch muscle fibers* can generate a smaller amount of force, at a slower speed, but can maintain it for long periods of time.
- Color: Muscle fibers can be red or white. Red muscle fibers have a better blood supply due to the presence of more capillaries and would also be known as slow-twitch muscle fibers. White muscle fibers do not have as many capillaries and would also be known as fast-twitch muscle fibers.
- Enzymatic properties and speed of contraction: With this classification system, muscle fibers can be slow oxidative (SO), fast oxidative glycolytic (FOG), or fast glycolytic (FG). SO muscle fibers have a slow contraction speed and produce small amounts of force, but are difficult to fatigue. FOGs have a faster contraction speed and produce moderate amounts of force, but maintain it for a shorter period than SOGs. FGs have the fastest contraction speed and produce the greatest amounts of force, but fatigue very rapidly.
- Myofibrillar ATPase sensitivity: Differences in pH sensitivity are correlated with myosin heavy chain content and contractile properties. There is a gambit of muscle fiber types ranging from Type I (slow-twitch muscle fibers) to Type IIb (fast-twitch

muscle fibers) to fibers with characteristics of both, to greater or lesser degrees (IIa, IIab, etc.).

Muscle fiber types are a limiting factor in athletic potential. Individuals are all born with a certain percentage of slow- and fast-twitch muscle fibers. It appears that the percentage of fast-twitch muscle fibers cannot be increased as a result of training, though it can be decreased. This means that an individual that is born with a higher percentage of slow-twitch muscle fibers will be limited in their success at events requiring speed, explosivity, or great strength.

Strength and conditioning programs develop different types of muscle fibers depending upon the exercise selection, speed of movement, loading, and rest/recovery. Programs that emphasize heavy weight training, explosive exercises, or sprints develop fast-twitch muscle fibers. Those that emphasize endurance training develop slow-twitch muscle fibers.

Neural structure and function

The brain controls movement via the motor cortex. *Neurons*, or cell bodies, located in the motor cortex extend into the spinal cord and terminate in the spinal cord's gray matter at the motor neuron. This is known as the *corticospinal tract* or the *pyramidal pathway*.

Some reflexes exist outside this pathway and allow for faster control, freeing up the higher centers of the brain for more important matters; for example, jerking one's hand away when touching a hot stove.

Once a command has reached the spinal cord, a motor neuron transmits the message to the muscle fibers. The body of the motor neuron is located in the gray matter of the spinal cord. The axon extends from the neuron to the muscle fiber, where dendrites receive the impulses and conduct them to the muscle fiber. A motor neuron and all the muscle fibers that it innervates is called a *motor unit*. Motor units innervate the same classification of muscle fiber. In other words, motor unit A will consist of all slow-twitch muscle fibers or all fast-twitch muscle fibers.

Fueling movement

At the most basic level, the body uses a compound called *adenosine triphosphate* (ATP) to fuel movement. The body uses three different energy systems to find and break down ATP for fuel. While these energy systems are all presented in isolation, they do not operate that way. The energy systems are: