STRENGTH AND CONDITIONING

William R. Holcomb,
School of Human Performance & Recreation, The University of Southern Mississippi,118 College Drive #5142, Hattiesburg, MS 39406-0001, USA

Keywords: resistance training, conditioning, strength, power, muscle endurance, flexibility, speed, agility, exercise physiology, exercise science, bioenergetics, aerobic fitness, anaerobic fitness, body composition, health

Contents

Summary

Strength training and physical conditioning can help sustain human life in two important ways. A strong and physically fit person will be more capable of providing essentials for themselves such as food, water and shelter. Secondly, regular physical activity should decrease the risk of premature death caused by preventable diseases such as cardiovascular disease. Exercise Science is a field devoted to the study of exercise and the acute and chronic effects on the human body. Strength and conditioning professionals develop specific exercise techniques and programs for athletes and other healthy individuals that will help to prepare them for competition or other fitness activities. Strength and conditioning professions also work directly with others who want to use exercise to improve overall health. This chapter discusses strength training, conditioning techniques, and the positive effect that exercise has on the human body. The impact of regular exercise on overall health and disease prevention is also discussed.

1. General Introduction

Regular participation in physical activity, including strength and conditioning exercises will prepare athletes and other healthy individuals for competition and other fitness activities and reduce the risk of musculoskeletal injury. Physical activity will also improve quality of life and decrease the risk of a number of preventable diseases which in turn, may decrease the likelihood of premature death. This chapter is intended to provide a guide for those who wish to increase strength and improve conditioning or better understand exercise physiology and the mechanisms of improvements that lead to more physically fit body.

2. Development of Strength, Power and Muscle Endurance

2.1. Introduction

Developing and maintaining strength is important for good health and the performance of activities of daily living, and is essential for most sporting activities. Strength is defined as the maximal force that a muscle can exert in a single maximum contraction. Strength is important in sports but a related variable, power is often more important due to the demands of many sports such as football, baseball, basketball and soccer. Power can be defined as the product of force and velocity or work divided by time. Power is the rate at which a muscle contracts and develops force throughout the range of motion. For sports like cycling and tennis where muscle actions are repeated frequently, muscular endurance, the ability to produce repetitive muscular contractions against some resistance for an extended period of time, is important. Each of these important components of physical fitness can be improved with appropriate physical conditioning and resistance training.

2.2. Anatomy and Function of the Neuromuscular and Musculoskeletal Systems

Muscles are composed of many muscle cells which are called fibers. These fibers are organized in bundles and their integrity is maintained by connective tissue. This connective tissue makes up the parallel elastic component and is continuous with tendons on either end of the muscle. These tendons attach the muscles to bones at a locations referred to as the bony apophysis. The end which is closer to the midline of the body (proximal) is called the origin and the end which is further away from the midline of the body (distal) is called the insertion. The muscles cross joints so when the muscles shorten the origin and insertion are drawn together and the joint will move.

Muscles are excitable which means they can respond to nervous stimulation originating from the central nervous system and traveling along efferent nerve pathways. The stimulation is delivered to the muscle through the alpha motor neuron across the neuromuscular junction. The alpha motor neuron and all of the muscle fibers that are innervated by the alpha motor neuron is called the motor unit. The more motor units that are recruited the more force is produced.

Each muscle fiber is composed of smaller myofibrils which contain contractile proteins called myofilaments. There are thin filaments composed of actin, troponin and tropomyosin, and thick filaments composed of myosin. Myosin filaments have heads called cross-bridges. This portion of the muscle is the primary source of force production during concentric muscle actions. When an electrical nerve impulse called an action potential is generated in the axon of a motor neuron it causes the release of a chemical neurotransmitter, acetylcholine, which crosses the neuromuscular junction and causes an action potential on the sarcolemma that lines the muscle fiber. This action potential causes the release of Calcium ions which attach to troponin on the thin filaments, causing tropomyosin to move from a blocking position so that actin and myosin can bind. Muscle contraction occurs according to the Sliding-Filament Theory. According to this theory the myosin filament cross-bridges bind the actin filaments causing the release of energy (ATP) which provides the fuel for the cross-bridges to fold inward causing the actin filaments to slide over the myosin filaments. This causes the muscle to shorten. This ratcheting movement is referred to as the power stroke. ATP then binds myosin breaking the linkage between actin and myosin. The myosin cross-bridges re-cock and bind actin again to produce further movement of the thin filaments. This process of binding, ratcheting and re-cocking will continue as long as Calcium ions are present to remove tropomyosin from its blocking position. When the nervous stimulation and subsequent action potential end, Calcium is removed and tropomyosin will again block actin and the muscle fiber will relax.

2.3. Factors That Determine Force Producing Capabilities

Strength depends on a number of neuromuscular factors. Some of these are dependent upon the method of strength production and others are dependent upon strength development as a result of resistance training. Those that can be positively affected by resistance training include muscle size, muscle fiber types, motor unit recruitment and coordination of muscular actions. Those that are simply dependent on the method of force production are the length tension relationship and type of muscle action.

There is a direct relationship between muscle size (cross sectional area) and muscle strength. Adaptations within muscle are described by hyperplasia, hypertrophy and atrophy. Hyperplasia is an increase in muscle size due to an increase in the number of muscle fibers within the muscle. This was once thought to occur with resistance training but now is believed to only occur during fetal development. It is believed that after birth we have a determined number of muscle fibers. Therefore, to increase the cross sectional area of a muscle there must be an increase in the size or cross sectional area of individual muscle fibers.

This is referred to as hypertrophy and will occur with appropriate resistance training. Unfortunately, the opposite is also true if there is a significant decrease in activity. Muscles can decrease in size by having a decrease in the size of individual fibers which is referred to as atrophy. These adaptations in muscles are explained by the SAID (specific adaptation to imposed demands) principle. If a muscle is required to work against the ever increasing demands of progressive resistance exercise (PRE) then the muscles will adapt in a specific way which is hypertrophy so that the muscles can meet the greater demands of this progressive resistance exercise. Conversely, if limited demands are placed on a muscle either through inactivity or immobilization as a result of injury, the muscles will adapt in a specific way which is atrophy. This concept was first defined by De Lorme & Watkins (1948) but first practiced by a Greek athlete named Milo who managed to lift a mature bull onto his shoulders. This was made possible by lifting the animal from birth and as it grew to maturity thus Milo was able to work against progressive resistance and develop the strength needed to lift the full grown bull.

Muscles are capable of acting in several ways which also affects force production. These actions can be defined based on change in length or based on a relationship between the force produced and the resistance provided. If the force produced is greater than the resistance provided then the muscle will shorten to produce joint movement.

However, if the force produced is less than the resistance provided the muscle will lengthen and movement will be resisted by the muscle.

And if the force produced is equivalent to the resistance provided no change in muscle length will occur and therefore no movement will occur. In other words if an athlete lifts a weight the active muscle is performing a concentric action, if an athlete lowers a weight under control the active muscle is performing an eccentric action, and if the weight is held in place the active muscle is performing an isometric action. Concentric actions have the least force producing capability followed by isometric muscle actions with eccentric muscle actions capable of producing the most force. When acting eccentrically a muscle can produce 1.1 to 1.4 times as much force because of a contribution from both contractile and series elastic components of the muscle.

The amount of force produced by muscles also depends on the number of muscle fibers that are active. This is determined by the number of motor units that are recruited. If a motor neuron is recruited, each of the fibers will fire according to the all or none principle. If greater force is required to move against resistance additional motor units are recruited to incorporate additional fibers. Conversely, if less force is required less motor units are recruited to delay muscle fatigue.

Strength is also determined by how well muscles work together. When an agonist muscle acts to move a joint, the antagonist muscle that opposes the movement should relax to allow maximum force during the intended movement. With complex movements that involve multiple muscles acting on multiple joints, the muscles should work in a coordinated fashion for smooth and forceful movements against resistance.

There are two basic types of muscle fiber that have different force production capabilities. Sub-groups have also been identified but only the two basic types will be presented here. Type I fibers (slow twitch) produce less force and contract slower but are resistant to fatigue. Type II fibers (fast twitch) produce more force and contract faster but also rapidly fatigue. Therefore, muscles containing a higher percentage of Type II fibers have a greater ability to produce force.

Another determinant of the amount of force that can be produced by muscle is based on the length tension relationship. This relationship differs from muscle to muscle and from person to person but generally speaking, muscles produces less force when either in a lengthened or shortened position, and greater force when working in the middle of a joint’s range of motion. So, for a muscle like the biceps brachii, more force can be produced in the middle of the range of motion for elbow flexion which is roughly 70° as opposed to when the elbow is extended near 0° or flexed near 140°. This will be of particular importance when comparing isotonic and isokinetic exercises in Section 2.6.

2.4. Adaptation to Anaerobic Training

Resistance training and interval training that include high intensity, intermittent bouts of exercise are considered to be anaerobic training. This type of training will cause many significant adaptations that will increase strength and power.

2.4.1. Neural adaptations

The neural adaptations are complex and occur earlier during a training program than muscular adaptations. Increased neural drive from the central nervous system leads to greater recruitment of fast-twitch motor units. Untrained individuals have been demonstrated to recruit an average of only 71% of available muscle fibers when performing at maximum effort (Adams et al., 1993). When high intensity eccentric resistance training was used for 4 weeks the average recruitment increased from 80% to 91%. (Pensini et al., 2002).

Resistance training will lead to increased recruitment, rate of recruitment and synchronization of motor unit firing (Sale, 1987).

Therefore, more motor units will fire at a faster rate and at the same time for maximum force production. Motor units are typically recruited according to the size principle where slow-twitch motor units with smaller motor neurons are recruited first followed by fast-twitch motor neurons if additional force is required to move against the applied resistance. With high intensity training like plyometrics (see 2.7.1), selective recruitment of fast-twitch motor units may occur for a more rapid development of force (Newton et al., 1996).

2.4.2. Muscular Adaptations

There is a correlation between the cross sectional area of muscles and strength. Resistance training results in hypertrophy which is an increase in the cross sectional area of existing muscle fibers. The increased muscle size results from an increase in the number of myofibrils (MacDougall et al., 1976), and the number of myofilaments within the myofibril, (MacDougall et al., 1979) which are the contractile proteins actin and myosin. Therefore, the myofibrils increase in both size and number resulting in an increased cross sectional area of the individual muscle fibers and the muscle as a whole.

With training the repetitive activation of a muscle fiber type will cause a transition to a more oxidative fiber subtype. This adaptation does not result in greater strength but rather greater muscle endurance because of the oxidative shift. However, it is unlikely that repetitive activation will lead to a transition from fast twitch Type II muscle fibers to slow twitch Type I muscle fibers.

2.4.3 Connective Tissue Adaptations

Stronger and larger muscles will place greater stress on bone as the tendons pull on the bony attachment sites during movement. The results of this added stress are a corresponding increased bone mineral density and bone diameter resulting in a stronger bone. Therefore, resistance training is recommended for osteopenia and osteoporosis where bone mineral density has been reduced. The stronger bone is capable of supporting hypertrophied muscle. In addition, there is an increase in the tendon-bone junction that results from forceful pull from the contracting muscle during resistance training. (Ratamess, 2008)

The forceful contraction of muscles during intense resistance training is also thought to increase the tensile strength of ligaments and tendons. There is an increase in the strength of attachments to bone as well as with the collagen fibrils that make up the body of connective tissues. (Ratamess, 2008)

2.5. Warm-Up and Stretching

There are conflicting research findings with regard to performance but what is clear is that a loss of flexibility as a result of injury will adversely affect performance and should be corrected.

Before stretching, muscles should be warmed with light intensity exercise to a temperature of at least 39 ºC to increase elasticity. (Prentice, 2011) Efforts should be made to promote relaxation and the stretches should gradually increase from repetition to repetition. To improve flexibility it is recommended that stretching should be performed at least three days per week and at least one day per week to maintain flexibility.

2.5.1. Ballistic and Dynamic Stretching

Ballistic stretching is a technique where the stretch is not held and thus involves bouncing in and out of the stretch. Ballistic stretching is not effective for improving range of motion because the rapid stretch triggers the stretch reflex which will bring about a reflex shortening of the muscle that is not desired. However, ballistic stretching is an important part of a dynamic pre-activity warm-up that prepares muscles for forceful, explosive movements that occur during many physical activities (Samuel et al., 2008). Dynamic stretching uses ballistic movements that are similar to the movements that will be required in for the forthcoming physical activity. Therefore, dynamic stretching is recommended as a part of all pre-activity warm-ups.

2.5.2. Static Stretching

Static stretching is a technique where the stretch is held for an extended period of time, with 30 seconds being recommended. Static stretching is a preferred method because it is simple and can be done with or without a stretching partner. Because the stretch is held for an extended period of time the stretch reflex can be avoided and inhibition in the muscle being stretched may occur due to tension that occurs when the stretch is sustained. This inhibition should lead to a greater stretch magnitude than a stretch that is not held for an extended period of time.

2.5.3. Proprioceptive Neuromuscular Facilitation Stretching

Proprioceptive neuromuscular facilitation (PNF) stretching should provide the best flexibility results because it involves specific techniques that facilitate muscular inhibition during the stretch, and it includes the beneficial static stretching as well. The disadvantage is that the stretch requires a partner with some expertise. Three different PNF stretches are described below and each includes three phases (Holcomb, 2000):

a. Hold-Relax. Ten seconds passive stretch of the antagonist followed by ten seconds isometric contraction of the antagonist followed by 30 seconds passive stretch of the antagonist
b. Hold-Relax with Agonist Contraction. Ten seconds passive stretch of the antagonist followed by ten seconds isometric contraction of the antagonist followed by 30 seconds passive stretch of the antagonist with simultaneous contraction of the agonist.
c. Contract-Relax. Ten seconds passive stretch of the antagonist followed by ten seconds concentric contraction of the antagonist followed by 30 seconds passive stretch of the antagonist.

The terminology included in a-c is defined as follows:
Hold- isometric muscle contraction
Contract- concentric muscle action
With agonist contract- muscle opposite stretched muscle performs concentric action
Relax- passive stretch
Antagonist- muscle being stretched
Agonist- muscle opposite muscle being stretched

-
-
-

Bibliography

American College of Sports Medicine. (1998) The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in health adults. *Med Sci Sports Exerc* 30:975-991. [This is a position paper by one of the leading exercise science organizations. The paper provides exercise prescription required to maintain cardio-respiratory and musculoskeletal fitness].

Adams GR, Harris RT, Woodard D, Dudley G. (1993) Mapping of electrical muscle stimulation using MRI. *J Appl Physiol* 74:532-537. [This study provided percentage muscle fiber recruitment when working at maximum effort].

Amason A, Andersen TE, Holme I, Engebretson L, Bahr R. (2008) Prevention of hamstring strains in elite soccer: An intervention study. *Med Sci Sports* 18:40-48. [This paper reported results from a study that showed a decrease in hamstring strains when static stretching was combined with eccentric training].

Anderson P, Henriksson J. (1977) Training induced changes in the subgroups of human Type II skeletal muscle fibers. *Acta Physiol Scand* 99:123-125. [This paper reported results of a study that showed changes to occur within Type II fiber subgroups with training].

Baechle TR, Earle RW, Wathen D. Resistance training. (2008) In: *Essentials of strength and conditioning*, Baechle TR, Earle RW, eds. Champaign, IL: Human Kinetics. pp. 386-410. [This is a portion of a chapter from the NSCA's essentials of strength and conditioning that discusses anaerobic exercise prescription].

Cross KM, Worrell TW. (1999) Effects of a Static Stretching Program on the Incidence of Lower Extremity Musculotendinous Strains. *J Athl Train* 34: 11–14. [This paper reported results from a study that showed a decrease in musculoskeletal strains in football when static stretching was used in training].

De Lorme TL, Watkins AL. (1948) Techniques of progressive resistance exercise. *Arch Phys Med* 29:263-273. [This was the original paper that described the training technique referred to as progressive resistance exercise].

Earle RW, Baechle TR. (2004) Resistance training program design. In: NSCA's Essentials of personal training, Earle RW, Baechle TR, eds. Champaign, IL: Human Kinetics. pp. 362-384. [This is a portion of a chapter from the NSCA's essentials of personal training that discussed resistance training program design].

Hejna WF, Rosenberg A, Buturusis DJ, Krieger A. The prevention of sports injuries in high school students through strength training. *NSCA J* 4:28-31. 1982. [This paper provided the results of a study where high school students who completed general resistance training experienced a decreased incidence of injury].

Hewett TE, Lindenfeld TN, Riccobene JV, Noyes FR. (1999) The effect of neuromuscular training on the incidence of knee injury in female athletes: A prospective study. *Am J Sports Med* 27:699-706. [This paper presented the results of a study that showed a decreased risk of knee injury in female athletes who completed plyometric training].

Holcomb WR, Lander J, Rutland R, Wilson G. (1996) The effectiveness of a modified plyometric training program on power and the vertical jump. *J Strength Cond Res* 10:89-92. [This paper described a plyometric program that included depth jumps for the ankle, knee and hip, and tested the effectiveness of the program in improvement of power and the vertical jump].

Holcomb WR, Lander J, Rutland R, Wilson G. (1996) A biomechanical analysis of the vertical jump and three modified plyometric depth jumps *J Strength Cond Res* 10:83-88. [This study analyzed the contribution of the muscles acting on the ankle, knee and hip for three depth jumps that were designed to isolate the ankle, knee and hip, respectively].

Holcomb WR, Kleiner DM, Chu DA. (1998) Plyometrics: Considerations for safe and effective training. *Strength Cond* 20:36-39. [This paper discusses several factors that should be considered when developing a plyometric program to increase safety and effectiveness].

Holcomb WR. (2000) Improved stretching using proprioceptive neuromuscular facilitation. *J Strength Cond Res* 22:1-3. [This paper presents three separate proprioceptive neuromuscular facilitation stretches and includes a discussion of mechanism that improve stretching effectiveness].

Holcomb WR, Rubley MD, Lee HJ, Guadagnoli MA. (2007) Effect of hamstring-emphasized resistance training on hamstring:quadriceps strength ratios. *J Strength Cond Res* 21:41-47. [In this paper it was found that the addition of two hamstring exercises to training significantly improved the hamstring:quadriceps ratio in female soccer players].

Lytle ME, Vanderbilt J, Pandav RS, Dodge H, Ganguli M. (2004) Exercise Level and Cognitive Decline: The MoVIES Project. *Alzheimer Disease & Associated Disorders* 18:57-64 . [This paper discusses the results of a study that tested the effect of exercise on cognitive decline].

MacDougall JD, Sale DG, Elder G, Sutton JR. (1976) Ultrastructural properties of human skeletal muscle following heavy resistance exercise and immobilization. *Med Sci Sports Exerc* 8:72. [This paper presented results from a study that demonstrated morphological changes within a muscle after heavy resistance training].

MacDougall JD, Sale DG, Moroz JR, Elder G, Sutton JR, Howald H. (1979) Mitochondrial volume density in human skeletal muscle following heavy resistance training. *Med Sci Sports Exerc* 11:164-166 . [This paper presented results from a study that demonstrated morphological changes within a muscle after heavy resistance training].

Mandelbaum BR, Silvers HJ, Watanabe DS, Knarr JF, Thomas SD, Griffin LY, Kirkendall DT, Garrett W. (2005) Effectiveness of a neuromuscular and plyometric training program in preventing ACL injury in female athletes: 2-year follow-up. *Am J Sports Med* 33:1003-1010. [This paper presented results from a long term study that showed a reduction in the incidence of ACL injury when neuromuscular and plyometric training were used].

Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. (1953) Coronary heart-disease and physical activity of work. *Lancet* 265:1111-1120. [A landmark study where risk factors were controlled so that the benefits of physical activity on coronary heart-disease risk reduction were demonstrated. This was done by comparing London bus drivers who were less active at work with bus conductors who were more active].

Newton RU, Kraemer WJ, Hakkinen K, Humphries BJ, Murphy AJ. (1996) Kinematics, kinetics, and muscle activation during explosive upper body movements: Implications for power development. *J Appl Biomech* 12:31-43. [This study tested the effect of explosive training such as plyometrics on the recruitment of fast-twitch muscle fibers].

Paffenbarger RS, Hale WE. (1975) Work activity and coronary heart mortality. *N Engl J Med* 292:545-550. [A landmark study where risk factors were controlled so that the benefits of physical activity on coronary heart-disease risk reduction were demonstrated. This was done by comparing Longshoremen who had different levels of activity at work but lived in an isolated and controlled environment].

Pensini M, Martin A, Maffiuletti MA. (2002) Central versus peripheral adaptations following eccentric resistance training. *Int J Sports Med* 23:567-574. [This is a report of a study that showed the percentage increase in fiber recruitment after four weeks of eccentric training].

Petersen JP, Thorborg K, Nielsen MB, Budtz-Jorgensen E, Holmich P. (2011) Preventive effect of eccentric training on acute hamstring injury in men’s soccer: A cluster-randomized controlled trial. *Am J Sports Med* 39:2296- 2303. [This paper reported results from a study that showed a decrease in hamstring injury when eccentric exercises were added to training].

Prentice WE. (2011) Restoring range of motion and improving flexibility. In: *Rehabilitation techniques for sports medicine and athletic training*, Prentice WE, eds. New York, NY: McGraw-Hill. pp. 180. [This is a portion of a chapter in an athletic injury rehabilitation textbook that provides specific guidelines for effective stretching].

Ratamess NA. (2008) Adaptations to anaerobic training programs. In: *Essentials of strength and conditioning*, Baechle TR, Earle RW, eds. Champaign, IL: Human Kinetics. pp. 103-108. [This is a portion of a chapter from the NSCA’s essentials of strength and conditioning that deals with the physical adaptations to anaerobic training].

Reuter BH, Hagerman PS. (2008) Aerobic endurance exercise training. In: Essentials of strength and conditioning, Baechle TR, Earle RW, eds. Champaign, IL: Human Kinetics. pp. 490-501. [This is a portion of a chapter from the NSCA’s essentials of strength and conditioning that discusses aerobic exercise prescription].

Ross MD, Denegar CR, Winzenried JA. (2001) Implementation of open and closed kinetic chain quadriceps strengthening exercises after anterior cruciate ligament reconstruction. *J Strength Cond Res* 15:466-473. [A review of the related literature with recommendations for the inclusion of both open and closed kinetic chain quadriceps strengthening exercises in post-surgical ACL rehabilitation].

Sale DG. (1987) Influence of exercise and training on motor unit activation. *Exerc Sport Sci Rev* 15:95-151. [This paper discussed the impact of resistance training on the recruitment of motor units].

Samuel MN, Holcomb WR, Guadagnoli MA, Rubley MD, Wallmann H. (2008) Acute effects of static and ballistic stretching on measures of strength and power. *J Strength Cond Res* 22:1422-1428. [This paper demonstrated the negative impact of acute static stretching on strength and power performance and discusses the importance of dynamic stretching prior to competition].

Stone MH, O’Bryant HS, Garhammer J. (1981) A hypothetical model for strength training. *J Sports Med Phys Fitness* 21:336, 342-351. [This paper presents a resistance training program that divides a training period into separate phases so that athletes may peak during competition].

Stone MH, O’Bryant HS, Garhammer J, McMillan J, Rozenek. (1982) A theoretical model for strength training. *NSCA J 4*:36-40. [A discussion of the training program commonly referred to as periodization with evidence from the literature along with observations to provide support for this method over methods more commonly used at the time of publication].

Warburton DER, Nicol CW, Bredine SSD. (2006) Health benefits of physical activity: the evidence. *CMAJ* 174:801-809. [A review of literature that found sufficient evidence to conclude that regular exercise and physical fitness will decrease the risk of premature death in men and women from many causes especially cardiovascular disease].

Wathen D, Baechle TR, Earle RW. Periodization. () In: *Essentials of strength and conditioning*, Baechle TR Earle RW, eds. Champaign, IL: Human Kinetics. pp. 507-522. [This is from a chapter in the NSCA's essentials of strength and conditioning that discusses the popular resistance training program known as periodization].

Wenger HA, Bell GJ. (1986) The interactions of intensity, frequency, and duration of exercise training in altering cardiorespiratory fitness. *Sports Med* 3:346-356. [This paper discusses the results of a study that provides support for parameters required to improve cardiovascular fitness].

Yaffe K, Barnes D, Nevitt M, Lui L, Covinsky K. (2001) A Prospective Study of Physical Activity and Cognitive Decline in Elderly Women . *Arch Intern Med* 161:1703-1708. [This paper discusses the results of a study that tested the effect of exercise on cognitive decline].

Biographical sketch

Dr. Bill Holcomb is a certified and licensed athletic trainer, and a certified strength and conditioning specialist with distinction, as well as a Fellow in the National Strength and Conditioning Association. Dr. Holcomb is an elected member of the National Strength and Conditioning Association's Board of Directors. He played tennis for Berry College in Georgia and served as a teaching professional from 1980-1991. He has served as a professor of sports medicine and athletic training for the last 20 years and is currently Director of the Athletic Training Education Program in the School of Human Performance & Recreation at The University of Southern Mississippi. Dr. Holcomb is an active member of the NATA and served as the NATA's liaison to the NSCA from 1997-2006. His primary teaching and research emphasis is rehabilitation and reconditioning following athletic injuries.