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STRENGTH AND CONDITIONING FOR SPECIFIC SPORTS

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KEY POINTS

- All sports differ in the relative importance of agility, speed, aerobic endurance, anaerobic power and capacity, strength, flexibility, balance, and coordination required to excel. Successful strength and conditioning programs take these factors into account when designing programs for individual athletes.
- Age, maturation, body composition, muscular strength, cardiovascular endurance, state of heat acclimation, nutritional status, and psychological and emotional condition should all be considered when designing programs for different populations. In addition, the individual's current medical status must also be addressed. Conditions such as diabetes, asthma, and high blood pressure as well as orthopedic concerns must also be factored into the exercise prescription.
- Large muscle groups of the back, abdomen, shoulders, and hips, commonly called the "core," should be included as part of strength-training sessions.
- After hard workouts, athletes should be encouraged to perform "cool-down" exercises and stretching routines and to consume carbohydrate-rich drinks and foods. Massage and whirlpool therapies can also be useful in hastening recovery.

INTRODUCTION

Strength and conditioning programs led by certified specialists in the field have become fixtures in many collegiate and professional sports enterprises and are becoming more common at the high-school level. In this roundtable, we asked four strength and conditioning experts to help us understand how they modify their exercise prescriptions for athletes who play various positions in specific sports. The certifications listed by the authors' names include Specialist in Sports Conditioning (SSC) and Master of Sports Science (MSS), both awarded by the International Sports Science Association, Certified Strength and Conditioning Specialist (CSCS), awarded by the National Strength and Conditioning Association, and Strength and Conditioning Coach Certified (SCCC), awarded by the Collegiate Strength and Conditioning Coaches Association.

When designing strength and conditioning programs for athletes in specific sports, e.g., tennis, football, basketball, etc., what general characteristics of the sport do you consider?

SATTERWHITE: Sports differ widely in the levels of agility, speed, aerobic endurance, strength, power, flexibility, balance, and coordination required to excel. A strength and conditioning program should prioritize the importance of each of these athletic qualities and adjust the time dedicated to improving each of them accordingly. An understanding of the metabolic demands imposed by the sport and the biomechanics of every task executed by the athlete is necessary. Sports do not usually fall cleanly into one energy-system category or another but rather involve all three (phosphagen system, glycolytic system, oxidative system) to a greater or lesser extent. In soccer, for example, all three energy systems are used. Soccer players must explode to the ball or to mark an opposing player or go up high for a header, but they also must cover a total distance of approximately six miles by the end of the game with rest periods of about 3 seconds every 2 minutes of play.

HILL: The energy system that is primarily used will determine the optimal types of conditioning and strength training for the

sport. For example, jumpers and vaulters don't need to spend a lot of time running distances over 400 meters or doing multiple sets in the weight room of 12 and 15 repetitions. The combinations of sets and repetitions used in strength training should be consistent with the energy requirements and movement patterns of the sport.

It is also important to consider the body parts of the athlete that are most prone to injury in the sport. These body parts need to be strengthened not only to improve the performance of the muscles used in the sport but also to minimize the risk of injury to those muscles. This is sometimes called "prehabilitation" training.

WATSON: I agree that program design should reflect a thorough understanding of the characteristics and skills inherent in each sport in addition to the muscle groups used, mechanical forces involved, and energy systems utilized. Another factor that must be accounted for in program design is the yearly calendar, which reflects the in-season and off-season periods as well as the travel schedule for each sport. This information is vital to the planning of a well-designed strength and conditioning program.

What characteristics of the athlete should be considered by anyone who is designing a program for youngsters, high-school athletes, and/or college athletes?

BATSON: I believe the two most important characteristics of the athlete are age and experience. More mature and experienced athletes can tolerate more intensive strength and conditioning programs, but we have to be very cautious in designing programs for young and/or inexperienced athletes. Other factors are important, too. If the sport emphasizes anaerobic energy utilization, I use the 300-yd shuttle run to help determine the athlete's state of conditioning for that sport. But if the sport is more aerobic in nature, I use the Cooper 12-minute run test to evaluate the athlete's aerobic conditioning status. I test all the important muscle groups used in the sport with a variety of strength evaluations.

WATSON: Age, maturation, body composition, muscular strength, cardiovascular endurance, state of heat acclimation, nutritional status, and psychological and emotional condition should all be considered when designing programs for different populations of people. In addition, the individual's current medical status must also be addressed. Conditions such as diabetes, asthma, and high blood pressure as well as other orthopedic concerns must also be factored into the exercise prescription. Common sense will also guide the design process.

HILL: I think the most important factor is the sport being played and/or the position the person plays within that sport. How much strength and endurance does the athlete need for this sport? What movements are they going to be required to perform? Knowing the answers to these questions, the design of the entire strength and conditioning program is dependent upon the athlete's strength-to-body-weight ratio, positional/sport needs, training history, body composition, aerobic and anaerobic fitness, and injury-prone or previously injured sites that require special attention.

The athlete's training history is crucial. An individual who has never followed any kind of strength and conditioning program must be brought along much more slowly and carefully than an athlete with advanced training experience.

SATTERWHITE: I agree completely that it is important to first establish the level of training already present in the athlete. Neuromuscular adaptation occurs in the first six weeks of a resistance-training program; thus, in the untrained individual, significant strength gains and skill improvements are made with little change in body composition. In the trained athlete, basic adaptation has already occurred and rapid strength gains should not be expected. Age and level of physical maturation must be considered to avoid imposing loads and demands on the younger athlete that might lead to growth disturbances. Assigning an age of 13 years as the "line in the sand" between mature and immature athletes is too ambiguous. Puberty occurs as early as 11 years in females and as late as 15 years in males. Use of the Tanner classification in conjunction with chronological age is more reliable. The Tanner classification outlines the sequential appearance of secondary sex characteristics, e.g., the presence of facial hair in boys or breast development in girls, as a guide to physical maturity.

What should be key differences in a strength and conditioning program for two collegiate athletes, one an offensive tackle in football and the other a shortstop in baseball?

BATSON: For the offensive tackle, the emphasis should be on developing strength, muscle mass, power, quickness, three-step speed, and anaerobic conditioning. For the baseball shortstop on the other hand, strength and muscle mass are not so critical. Training should be designed more to improve speed, explosive power and quickness, and the ability to change movement direction instantly.

HILL: Both athletes should initially follow similar total-body strength and conditioning programs to establish a solid foundation. Obviously, both athletes are trying to get as fast, powerful, explosive, quick, and lean as possible, but the actual demands of their respective sports are very different. The key difference in my mind is that baseball players perform more of their movements in a rotational plane, i.e., rotating shoulders and hips to catch, throw, and bat, than do offensive tackles in football. So the baseball player should be trained in a rotational plane, i.e., rotating the shoulders and/or hips using resistance from medicine balls, weighted pulleys, dumbbells, etc., whereas the offensive lineman needs to train very hard in all planes, with no specific focus placed on the rotational plane.

SATTERWHITE: The offensive tackle requires quickness to get out of his stance and leg power and upper body strength to drive a defensive tackle off his line and onto his back. The shortstop needs to be agile, have quick speed, upper body power, and excellent hand-eye motor coordination to get to a batted ball and make a timely throw or to hit a ball and make it to first base safely. Both position players would benefit from a periodization type of program, but other than a common basic foundation, the programs should differ with respect to resistances used, repetitions performed, and recovery intervals allowed.

WATSON: I'm not convinced that the strength-training portion of these two athletes' programs should vary greatly. The muscles used and the energy systems are similar. A strength-training program should stress the whole body. A baseball player should train the neck and shoulder area just as often as a

football player should—no difference. The conditioning portion of these two athletes' programs will be slightly different because of the demands each sport imposes upon the body's energy systems. The conditioning programs should simply reflect the movements inherent in each sport and seek to enhance them.

What features should be built into a strength and conditioning program for sports that are more skill dependent, e.g., tennis or golf, compared to sports such as running and cycling that are less dependent on motor skills?

SATTERWHITE: For sports that require hand-eye coordination (tennis and baseball) or foot-eye coordination (soccer) versus a non-ball sport (running, swimming, and cycling), drills should be perfected that require a timed response to a moving stimulus. A blinking light board placed on the floor or hung from a wall works nicely. Lights blink in a random pattern at a predetermined frequency, and the athlete must hit the light that has blinked on with one hand or, for a floor board, jump on it with one foot before that light turns off and another one blinks on, etc. For ball sports, power must be developed in the upper and lower extremities such that the force necessary to impart speed on the ball can be maximized. In comparison, endurance strength training is critical for the runner, cyclist or long-distance swimmer.

HILL: The workout must be tailored to the individual athlete. The lifting, running, agility training, and other aspects of conditioning should reflect the actual movements used in the sport. Thus, if the sport includes lots of swinging, there should be a component of the workout the mimics swinging. At the same time, if a sport includes only distance work, such as cycling or distance swimming, the training needs to focus on building endurance.

BATSON: I basically agree with the ideas expressed by Dr. Satterwhite and Coach Hill. For skill-dependent sports, more time should be spent on activities that develop flexibility, balance, proprioception, and core stability.

WATSON: Once again, I am somewhat at odds with the other members of the panel. In my opinion, the strength-training program need not vary for more-skilled versus less-skilled sports because you are simply overloading groups of muscles and then allowing time for an adaptation. If there are more skills inherent in some sports as opposed to other sports, these motor skills, as well as the strategies required to participate in the sport, should be addressed in the sport practice sessions and not in the weight room.

Should core strength training be emphasized for all athletes or just those in particular sports?

BATSON: I place heavy emphasis on core stability training for all athletes during every training session.

HILL: All sports and athletes need core stabilization training. The athlete's success is all geared around how strong and flexible they are in the midsection. To apply force to an opponent, the ground, or an implement, the athlete must have a very sound trunk. Thus, we train and work this area daily.

SATTERWHITE: Core strengthening should be an integral part of all athletes' training programs. The trunk is the platform around which all multi-joint motions occur. Exercising with a weak or dynamically unstable platform compares to running on a rolling log in an angry river. Being out of control or off balance in the trunk increases the need for compensatory motions in adjacent joints, and those motions aren't usually the desired ones. In fact, recent evidence suggests that female athletes with a weak core are more likely to sustain tears of the anterior cruciate ligaments.

WATSON: Once again, I seem to be the rebel of the roundtable. I think core training is a useless term. It was popularized by people who are trying to market or sell some system of training. What is your core? Where does it start and stop? If there are core muscles of the body, does it mean you do not have to train the non-core muscles? You cannot have an effective strength-training program without training the largest muscles in the body. A total body strength-training program, by its very nature, will cover the whole body without exception. It will also incorporate the idea that the body is an integrated system and not just an accumulation of parts and pieces that can be individually spot trained.

What advice do you give athletes on hydration? Does that advice change for different sports?

WATSON: I have studied the research and followed the recommendations on hydration and replenishment published by the Gatorade Sports Science Institute since they first became available. I believe they have utilized the highest quality peer-reviewed research and provide the most important and useful safety guidelines available. There is no need to look elsewhere for better educational materials for my athletes.

BATSON: I tell all my athletes to drink fluids such as water and sports drinks before, during, and after all workouts, including activities such as strength training, conditioning, and practice of the sport.

HILL: The hydration advice that I give the athletes is very simple. I push them to drink water-based fluids as often as possible and to stay away from the alcohol and caffeine-based drinks. Obviously, we are more concerned about hydration for the outdoor sports than the indoor sports, but all athletes need to realize that their hydration status greatly affects their performance.

SATTERWHITE: Fuel is provided in the diet in the form of liquids and solids. Although water is a critical fluid to be consumed, there are times when a sports drink is indicated. The competitive athlete engaging in intense exercise sessions or in activity lasting longer than 45–60 minutes or in hot, humid conditions should drink with the goal of hydrating. As thirst is a poor indicator of hydration status, a hydration schedule should be followed, sports drinks selected regularly, and caffeinated and alcoholic beverages avoided diligently.

What recovery strategies after a hard workout do you recommend?

HILL: Immediately following the workouts we ask the athletes to perform static and dynamic flexibility exercises to start the healing and recovery process. I also recommend that the athletes do cold-tub immersion after the most intense and exhausting workouts. I also recommend adequate hydration and antioxidant supplementation.

SATTERWHITE: Athletes should start their rehydration /nutrition recovery protocol during their workouts, if possible. After their workout is complete, they should follow a rehydration schedule and within two hours consume a meal that emphasizes carbohydrates and protein to initiate restoration of a positive nitrogen balance. Also, a light cool-down program should be followed by a stretching program and then application of ice bags for 20 minutes to any areas that have been injured or strained during the workout. (Instead of ice, a cold whirlpool session may be elected.) I do not mandate massage therapy sessions, but they are popular for many professional athletes.

WATSON: The recovery guidelines published by the Gatorade Sports Science Institute provide great information on improving the repair processes of the body. Ingesting carbohydrates immediately after an exercise bout will boost the body's repair and recovery responses and will help reduce the overall recovery time, especially when coupled with a nutrient-rich meal a couple of hours after the exercise bout. Massage, whirlpool therapies and other adjunctive therapies are great as well. In a collegiate setting, issues of athlete availability and compliance (time and schedule conflicts) and NCAA rules and regulations can often impede the delivery of these services. Hydrate, eat well, rest, and recover: these are actions that are well within the control of the athlete. Compliance with these simple things will bring great benefits to the athlete.

BATSON: We provide high-carbohydrate drinks during the recovery period after a workout, and we recommend massage and whirlpool therapies, which are conducted by the athletic trainers on staff.

SUGGESTED ADDITIONAL RESOURCES:

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STRENGTH AND CONDITIONING FOR SPECIFIC SPORTS: ONE SIZE DOES NOT FIT ALL

Do you train year-round for a single sport, or do you play several sports in a single year? Either way, it's important that you use your strength and conditioning time efficiently as you work to improve your fitness for a specific sport. Although there is obviously some carryover value for any sport in most types of strength and conditioning workouts, you will be better off if you make your training specific to your current sport. Unfortunately, a single program of strength and conditioning is not optimal for every sport.

This article provides a few tips—in the form of questions and comments—on where your focus should be for a given sport, depending on the principal energy systems used and the skills required in the sport. If you follow the suggested principles, you should be headed toward building better fitness for your sport.

What energy systems are most important in your sport?

■ ***The Phosphagen System***

On the one extreme would be the so-called "phosphagen" system that supplies energy for brief, high-power events like the sprints, jumps, vaults, and throws in track and field; batting, base-running, and fielding in baseball; power lifting and Olympic weight lifting; and much of the blocking and tackling done by interior linemen in American football. Each of these activities lasts only a few seconds, and the energy is provided mostly by the breakdown of phosphocreatine stored in the muscle. Oxygen is not required during the exertion, so the energy is said to be supplied "anaerobically."

If you are using mostly the phosphagen system in your sport, spend most of your strength and conditioning time on brief, near-maximal exertions. In other words, train as you compete. It would be largely a waste of time—and probably detrimental to their performance—for sprinters and interior linemen to train by running repeat miles and lifting light weights for 50 repetitions. Rather, most of the conditioning time should be devoted to repeated maximal-intensity sprints, e.g., 10-100 yards with sufficient recovery time between sprints to allow high-quality repetitions, and heavy lifts, e.g., 3-5 sets of 1-6 repetitions with the maximal load that can be lifted correctly for each repetition and at least 3 minutes separating each set.

■ ***The Aerobic or Oxygen System***

At the other end of the energy-system continuum is the aerobic (oxygen) system that provides most of the energy for activities that last longer than a couple of minutes and for recovery between repeats of brief, high-intensity activities. Other than sprints at the beginning and end of the race, distance runners and swimmers and road cyclists rely almost entirely on aerobic metabolism. Under most circumstances, athletes in these endurance sports are not required to produce high-power outputs, so excessive time spent in the weight room—that may add unwanted muscle mass—would be counterproductive. If yours is an aerobic sport, you should be building up your cardiovascular system and the aerobic capacity of your muscles with longer-duration activities that require less than maximal intensities of exertion. In the weight room, your focus should be on lifting relatively light weights, i.e., those you can lift correctly for 3-5 sets of 15-30 repetitions with about 90 seconds of rest between sets.

■ ***Anaerobic Glycogen Breakdown: The "In-Between" System***

For activities that last longer than about 10 seconds but less than 2 minutes, the majority of the energy is supplied by the anaerobic breakdown of glycogen (a carbohydrate) stored in the muscles. (This is sometimes called the "lactic acid" system.) Events like a 400-m run in track, a 50-m swim, a series of fast-breaks in basketball, or a series of sprints down the field in soccer or football would require energy from this system. Strength and conditioning activities would be intermediate between those recommended for the phosphagen system and those for the aerobic system.

■ ***Mixed Energy Systems***

For most player positions in most sports—soccer, basketball, wrestling, lacrosse, rugby, tennis, ice hockey, field hockey, and rollerblading—athletes must rely on both anaerobic and aerobic metabolism to produce their energy. This means that the optimal training for most sports should include a combination of brief, high-intensity activities along with more-prolonged, lesser-intensity exertions. If you believe that the majority of your movements rely on anaerobic metabolism, you should emphasize more of the high-intensity activities in your program, but if most of your efforts are of an endurance nature, you should focus more on endurance training.

What Sport Skills Can You Improve During Your Strength and Conditioning Workouts?

Determine the most important skills in your sport—especially those you must improve to raise the level of your performance—and then modify your strength and conditioning program to emphasize those skills. For example, soccer players can work on both their aerobic conditioning and their ball dribbling skills simultaneously by dribbling a soccer ball as they do their

running practice. Alternating performance of this conditioning activity with a partner who is simultaneously trying to intercept the ball on the soccer field could be especially useful training. As another example, tennis players can build their endurance while simultaneously improving their skills by working with a partner who intermittently hits lobs and drop shots, requiring sprinting back and forth from net to baseline.

In the weight room, it makes sense to design your strength exercises so that they reflect the general movement patterns used in your sport. It's not necessary (or even possible) to truly mimic sports skills in the weight room, but what is important is to develop increased strength in the muscle groups used in the activity. For example, part of a baseball pitcher's strength-training program should be designed to strengthen the pectoral and anterior/posterior deltoid muscles in both shoulders, not just in the throwing arm.

Get Some Help

In this short article it is obviously impossible to tell you everything needed to develop a customized strength and conditioning program on your own. Ask a qualified strength and conditioning coach, personal trainer, or sports coach for more comprehensive guidance.

SUGGESTED ADDITIONAL RESOURCES:

Baechle, Thomas R., and Roger W. Earle (Eds.) (2000). *Essentials of Strength and Conditioning.* Champaign, IL: Human Kinetics.

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