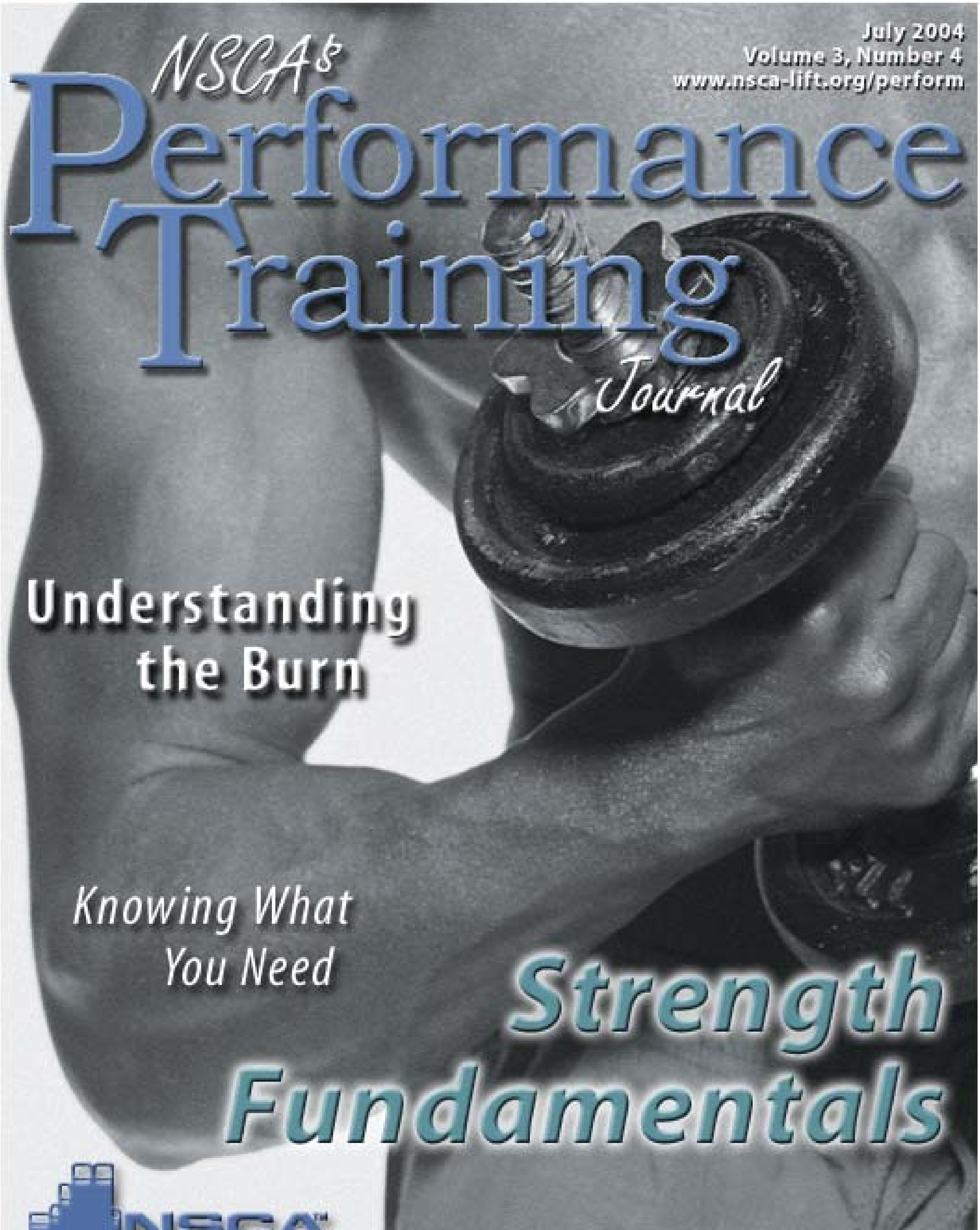

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NSCA's Performance Training Journal

Understanding the Burn

Knowing What You Need

Strength Fundamentals

NSCA

Volume 3, Number 4

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Feature: Strength Fundamentals

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NSCA's Performance Training Journal

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Editorial Office

1885 Bob Johnson Drive
Colorado Springs, CO 80906-4000
+1 719-632-6722

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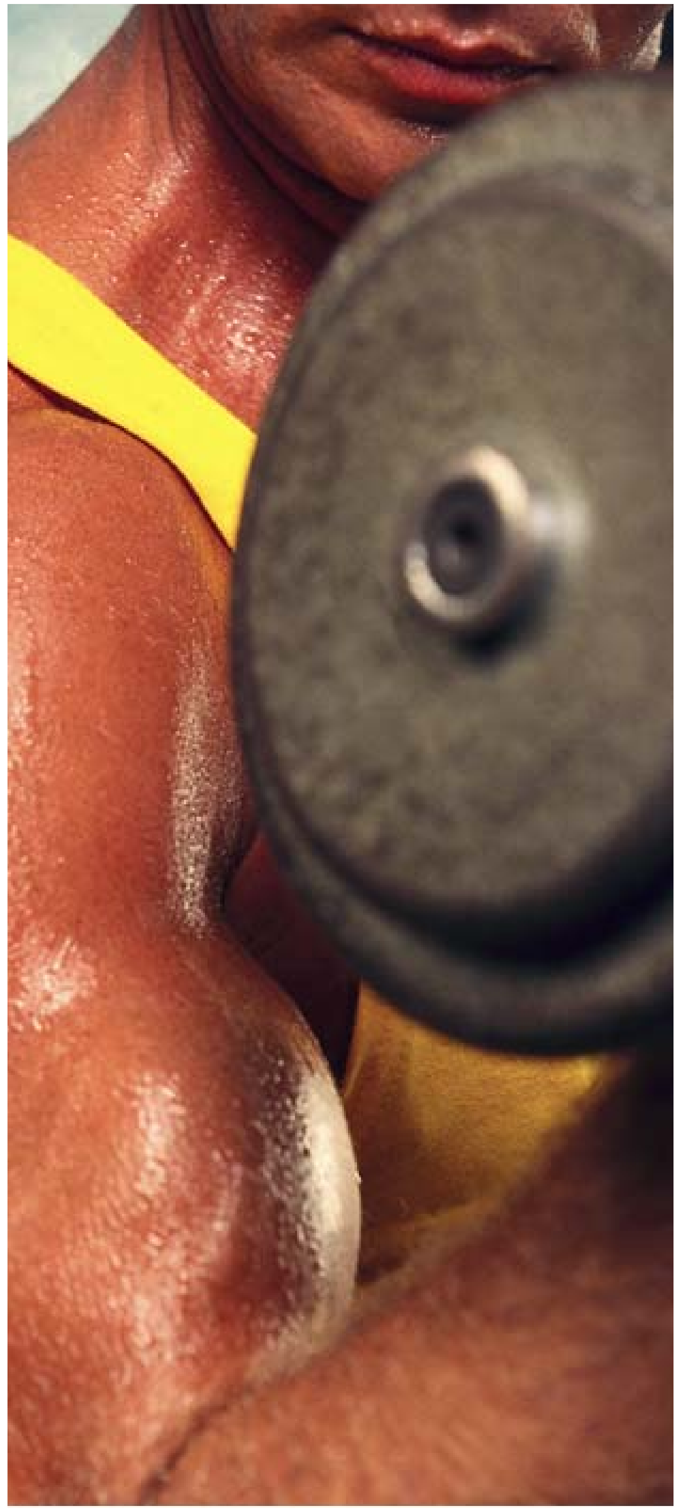

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FitnessFrontlines

G. Gregory Haff, PhD, CSCS

Does maximal squat strength correlate to sprinting and jumping capabilities of elite soccer players?

Recently, researchers from the Norwegian University of Science and Technology in Trondheim, Norway examined the relationships between maximal quarter squat strength, sprinting, and jumping ability with elite soccer players. Sprinting ability was determined with the use of a 10-meter sprint and a 30-meter sprint. Vertical jump displacement was determined with the use of a force plate analysis system. After analyzing the data collected the researchers determined a strong relationship between the soccer players who could quarter squat the most weight and the players who could jump the highest and sprint the fastest. The researchers concluded that the strength training programs for soccer players should center on the development of overall maximal strength and power. These characteristics seem to relate to the ability of soccer players to run faster and jump higher.

Wisloff U, Castagna C, Helgerud J, Jones R, Hoff J. (2004). Strong correlation of maximal squat strength with sprint performance and vertical jump height in elite soccer players. *British Journal of Sports Medicine, 38(3)*: 285 – 288.

Post exercise recovery drink consumption—is it worth it?

Drinking a recovery beverage that contains creatine, amino acids, whey protein, and carbohydrates (Treatment) after each training session during a 10 week training period does not appear to promote greater adaptations than the consumption of an a carbohydrate-only beverage (Control). Researchers at Mississippi State University compared markers of muscular strength, muscular endurance, body composition, and a 30-second cycle ergometer test before and after 10 weeks of strength training coupled with a post exercise supplementation regime. There were no significant differences between the training adaptations between the treatment and control groups when assessing muscular strength, muscular endurance, and cycle performance. A trend was determined which suggested that the treatment group (+3.4 kg) was able to increase fat free mass to a greater extent than the control group (+1.5 kg). However, the alterations in fat free mass were not statistically different between the two groups tested. The results of this study seem to indicated that using a post exercise recovery supplement that contains creatine, amino acids, whey protein, and carbohydrates does not stimulate greater adaptations in strength and power performance than consuming a carbohydrate-only beverage.

Chromiak JA, Smedley B, Carpenter W, Brown R, Koh YS, Lamberth JG, Joe LA, Abadie BR, Altorfer G. (2004). Effect of a 10-week strength training program and recovery drink on body composition, muscular strength and endurance, and anaerobic power and capacity. *Nutrition, 20(5)*: 420 – 427.

Plyometric Training May Improve Neuromuscular Attributes Which May Reduce the Risk of Anterior Cruciate Ligament Injury in Female Athletes

Nineteen female basketball (n=11) and soccer (n=8) players were divided into two training groups. Group 1 participated in an off-season conditioning program, which contained a structured plyometric training component. The plyometric training consisted of 3 phases of training with each phase progressively increasing in complexity and intensity. Group 2 was a control group, which primarily participated in a conditioning program. All athletes were evaluated before and after a 6-week training period for isokinetic quadriceps and hamstring peak torque values. Additionally, the subjects were tested for vertical ground reaction forces with a forceplate system in order to evaluate impact forces generated from stepping off of a 20.3 cm platform. Finally, agility was evaluated.

The results of the study indicated that plyometric training might strengthen the lower extremity. This was indicated by the significant increase in the peak torque generated by the hamstring after participating in the plyometric training program. Additionally, there was a significant increase in the hamstring to quadriceps ratio in response to the plyometric training protocol. When assessed at 60 degrees per second the plyometric group was able to increase their ratio from 0.53 to 0.60, while they increased from 0.70 to 0.78 when 300 degrees per second was tested. The authors suggested that the alterations in hamstring strength associated with the plyometric training program played a large role in improving the athlete's risk for ACL injury. Additionally, the authors suggest that hamstring to quadriceps ratios of 0.60 or greater at 60 degrees per second or .80 or greater at 300 degrees per second are realistic goals for collegiate basketball players.

Wilkerson GB, Colston MA, Short NI, Neal KL, Hoewischer PE, Pixley JJ. (2004). Neuromuscular changes in female collegiate athletes resulting from a plyometric jump-training program. *Journal of Athletic Training, 39(1)*: 17 – 23.

Circuit Weight Training Improves Strength and Muscle Fiber Size in Untrained Men

Recently researchers from The University of Memphis put untrained males through a 10-week circuit weight-training program consisting of 10 upper and lower body exercises. Subjects participating in the circuit weight training protocol experienced significant increases in maximal strength in 9 of the 10 exercises trained. The control group, which did not participate in any training, experienced no changes in overall strength. The circuit weight-training group also experienced significant alterations in muscle fiber cross-sectional area. However, these alterations in fiber size did not result in significant changes in lean body mass, fat mass, or body weight. The authors concluded that circuit weight training can increase strength in untrained individuals, but these alterations are not as large when compared to other resistance training modalities.

Harber MP, Fry AC, Rubin MR, Smith JC, Weiss LW. (2004). Skeletal muscle and hormonal adaptations to circuit weight training in untrained men. *Scandinavian Journal of Medicine and Science in Sports, 14(3)*: 176 – 185.

About the Author

G. Gregory Haff, PhD, CSCS, is an assistant professor, the Human Performance Laboratory Director, and Kinesiology Department Chair at Midwestern State University in Wichita Falls, TX. He is a member of the National Strength and Conditioning Association's Research Committee and the USA Weightlifting Sports Science and Sports Medicine Committees. Dr. Haff received the National Strength and Conditioning Association 's Young Investigator Award in 2001.

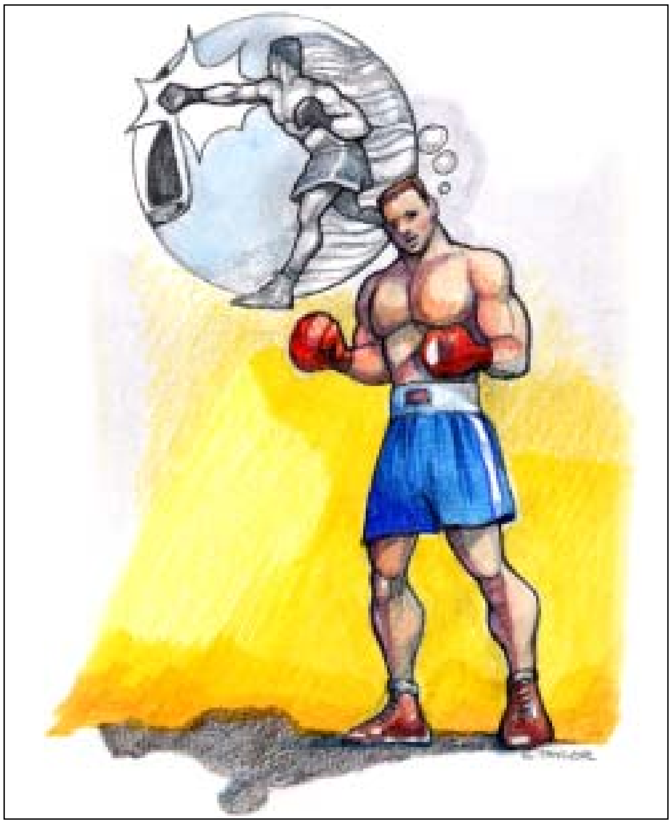
MindGames

Suzie Tuffey Riewald, PhD, NSCA-CPT, *D

Targeting Effective Self Talk

What you say to yourself can have a significant influence on performance. It makes sense that if you tell yourself you're not going to be able to lift the weight or make your goal time, chances are you are not going to make it. This article will present a slightly different way for you to conceptualize self talk and hopefully assist you in managing how you talk to yourself.

The following activity serves as an analogy to help in our efforts to manage self talk:



Since you are probably reading this article online, you are most likely at a desk in front of your computer, sitting in a chair and focusing your attention on the computer screen. Maybe there is a slight hum coming from the computer as the hard drive spins. While keeping your eyes and ears on the computer, start to become aware of what is around you. Is there a window nearby, a bulletin board, books, a printer, maybe a telephone, or another computer? Is there a radio or TV on, are people talking or are fluorescent lights humming? You are focused on the computer screen, but also vaguely aware of the other stuff around you. This part of the activity is not too tough to do, is it?

Now comes the real challenge. Your task is to totally block out all visual and auditory distractions so the only things you are aware of are the computer screen and the hum from the computer. It's difficult to do, isn't it? It takes a lot of mental energy to block these objects and sounds from your mind. And this is energy that could probably be put to better use.

The two scenarios presented above ask you to do essentially the same thing—focus on the computer. However, the way you go about focusing on the computer can greatly impact the mental energy you expend to accomplish the task and your success in accomplishing the task. This difference is subtle but important—consciously focusing on one thing versus trying to get rid of everything but the one thing.

What does this have to do with self talk?

The computer screen represents effective thinking. It is all the "good stuff" you want going on in your head that helps performance. The other things like the lights, the papers on your desk, the printer, or your co-workers talking are similar to negative self talk that can detract from performance. In the activity above, you learned that it is quite difficult to try to erase from your mind the "other objects" in the room. So too is it with self talk and performance. It is a tough challenge trying to banish any negative self talk from your mind and rid yourself of any doubts, concerns, and negativity.

Instead, you may find it easier to direct your focus and energy towards effective thinking just as you directed your focus and energy to the computer (and didn't worry about the "other stuff"). Fill your "eyes and ears" with effective, positive, beneficial words and images.

Identify Effective Self Talk

So, what is effective thinking and what are the things you need to "grab on to"? What is your "computer screen" of positive self talk? It should consist of all the things you can and should say to yourself to enhance your performance in practice and competition such as:

- Technique reminders
- Confidence builders
- Performance-related cues
- Motivating words

Identify the self talk that is going to help YOUR performance; the internal dialogue that is going to best set you up for success. Now, commit to using this self talk on a consistent basis. Place your mental energy on this positive, productive self talk rather than placing all your energy and focus into purging the negative self talk.

About the Author

*Suzie Tuffey Riewald, PhD, NSCA-CPT,*D, received her degrees in Sport Psychology/Exercise Science from the University of North Carolina – Greensboro. She has worked for USA Swimming as the Sport Psychology and Sport Science Director, and most recently as the Associate Director of Coaching with the USOC where she worked with various sport national governing bodies (NGBs) to develop and enhance coaching education and training. Suzie currently works as a sport psychology consultant to several NGBs.*

Training Table

Debra Wein, MS, RD, LDN, NSCA-CPT

Snacking for Strength

While many strength athletes still associate snacking with "junk" foods like chips and cookies, there is research showing that athletes who eat snacks may be better able to achieve their performance goals. According to Dr. Dan Benardot, Co-Director of the Laboratory for Elite Athlete Performance at Georgia State University, "The longer you go without eating, the more likely you are to have more body fat and less muscle." Furthermore, "frequent eating helps maintain an athlete's metabolic rate, good energy balance, lower body fat, lower weight and lower serum lipids."[1] So, don't be so quick to shun a snack. If well-planned and wisely chosen, snacks can be an important part of your daily food intake and your overall performance.

Who should be snacking? Now that we know that snacking is not a "bad" thing but probably even beneficial to futher your training goals, ask yourself the following questions:

- Do your regular meals often lose out to a busy schedule?
- Do you eat only small amounts of food at each meal?
- Do you find yourself eating the same foods all the time?
- Do you workout or play sports on a daily or regular basis?
- Do you want to reduce your intake and lose weight?

If you answered "yes" to any of these questions, you may not be getting the recommended amounts of protein, carbohydrates, calories, or vitamins and minerals that an active adult body needs. Therefore, you have earned the right to be a "snacker." However, this is where healthy and nutritious choices become important. Choosing wholesome foods that are low in fat, cholesterol, sugars, and sodium and high in carbohydrates and fiber will curb your hunger, fuel your body, and provide essential nutrients you may otherwise miss. Read on for helpful tips on how to choose healthful snacks as well as categories of snacks which will help you to identify how to make snacking work to promote your healthful eating patterns.

Tips to help you nibble sensibly

- Stock up on healthy snack foods at home and at the office.
- Carry a naturally sweet fresh fruit in your bag, such as grapes or a pear, rather than buying candy from a vending machine.
- If a snack is replacing a meal, chose meal-type foods —a small entree, a sandwich, or a hearty salad.
- Choose snacks that provide dietary fiber, such as fresh fruits with edible seeds (berries) or skins (apples, peaches), dried fruits, raw vegetables, and whole-grain breads or crackers (whole wheat, oatmeal, bran).
- Keep various sized plastic bags, plastic cutlery, small containers, and thermoses around for transporting snacks.
- If you use a plastic or laminated tote (or if your children do), wash it out nightly to deter bacterial growth in seams and corners and rinse weekly with baking soda to eliminate odors.
- Freezing certain items (sandwich breads, grapes, beverages) until you leave for work will keep them fresh and cool.
- Refrigerate sliced vegetables in a covered container of water and they will stay crisp and fresh for several days.
- Sprinkle cut fruits with orange or lemon juice to keep them from turning brown.

Styles of Snacks

Finger foods

These are portable and therefore easy for the person always on the go.

Examples

- Blueberries, grapes, strawberries, cherry tomatoes, raisins
- Dried fruits—dates, figs, apricots, apples, pears

Crunchies

These are great fot those people who prefer a snack with a crunch. These may help satisfy psychological hunger as well.

Examples

- Carrot sticks, cauliflower pieces, celery sticks, cucumber slices, pepper strips (green, red, yellow), zucchini slices
- Air popped popcorn (make a big batch at home and bag it) or buy the microwavable kind with < 3 grams of fat
- Rice cakes and popcorn cakes
- Whole grain crackers graham crackers, melba toast, Wasa, Swedish flatbreads (fat-free varieties available at health food stores and some supermarkets)
- Pretzels—sourdough and whole wheat (try low salt)
- Breadsticks, baked bagel chips, fat-free granola bars
- Dill pickles (high in sodium, limit frequency)

Refreshers

Use these snacks on hot days or really exhasuting training sessions.

Examples

- Sherbet, frozen yogurt—low fat or nonfat, Italian ice, all fruit Popsicles
- Cantaloupe wedge, honeydew melon wedge or grapefruit half
- Vegetable juice—tomato , carrot or V-8
- Fruit juice—orange, pineapple, cranberry (on ice)

Carbo Loaders

For those heavy traning days when you need a bit more energy.

Examples

- Bagel with jelly/jam or nonfat cream cheese
- Baked potato (white or sweet) with nonfat sour cream or yogurt
- Cereal (whole grain—hot or cold) with skim milk
- Pasta salad or bean salad (prepare with nonfat mayo, lemon, or flavored vinegar), animal crackers, fig, apple or berry bars, gingersnaps, Rice Crispie treats

Protein Packed

For those days when the protein intake from the rest of your meals seems inadequate. If you miss a meal, for instance, these are important.

Examples

- String cheese, hard boiled egg whites, low fat cottage cheese with fruit, water packed tuna or shrimp, tofu cubes
- Sliced lean turkey or ham

Prepared foods & leftovers

These are great for people on the run with little time to snack or prepare foods.

Examples

- Applesauce, fruit salad
- Cup-of-soup (just add hot water)
- Yogurt—low fat or nonfat (add your own fruit)
- Pudding—low fat or nonfat

About the Author

Debra Wein, MS, RD, LDN, NSCA-CPT is an adjunct faculty member at the University of Massachusetts, Simmons College and The Boston Conservatory, and chairs the Women's Subcommittee of the Massachusetts' Governor's Committee on Physical Fitness and Sports. She is the President of The Sensible Nutrition Connection, Inc. (www.sensiblenutrition.com).

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Ounce *of* Prevention

Jason Brumitt, MSPT, CSCS, SCS, ATC

Training the Ignored Middle Back

To develop a "Mr. Olympia" style physique, bodybuilders employ weightlifting exercise programs to maximize muscular size. The media presents these "larger than life" bodies through forms of entertainment such as movies and television. Athletes often assume incorrectly that this type of training or body type is ideal for athletic competition.

Popular exercises utilized to develop bodybuilding physiques, when over performed, can lead to musculoskeletal injury. Strength imbalances usually develop between opposing regions of the body. These imbalances can potentially affect athletic performance or precipitate injury. Nowhere is this more apparent than in the mid-back. Many athletes will not hesitate to perform 15 to 20 sets of chest exercises, but will fail to train the muscles of the mid-back (thoracic spine and scapula).

The purpose of this article is to help the reader appreciate the importance of training the muscles of the mid-back/scapular region, recognize postural implications from deficient training, and provide an exercise program for these muscles.

Functions of the Scapula

The scapula (aka shoulder blade) is the triangular shaped bone located on each side of the mid-back. Dr. Ben Kibler of the Lexington Clinic Sports Medicine Center has identified several roles of the scapula for athletic performance[1]. The scapula functions as an integral component of the shoulder complex linking the trunk with the arm. The scapula helps to elevate the arm for throwing and serving as well as moving the upper extremity forward and backward (protraction and retraction) along the thoracic wall. Several muscles attach to the scapula to facilitate these movements.

Key Muscle Groups

The rhomboids (major and minor) and the trapezius muscles work to provide scapular stabilization. Rhomboid muscle action retracts and slightly elevates the scapula. The trapezius muscle has three parts; the upper, middle, and lower regions. The upper trapezius elevates the scapula, the middle trapezius retracts it, and the lower trapezius rotates and lowers it. The ultimate purpose of scapular stabilization is to orient the scapula to maximize the arm's performance.

Poor Training Implications

Substandard training habits by unsupervised or inexperienced athletes can lead to detrimental postural implications. When an athlete performs a routine dominated by chest exercises, he or she potentially sacrifices necessary training time for other muscle groups. A chest-dominated program for the upper body can lead to poor posture highlighted by forward or rounded shoulders, a rounded mid-back or hunchback, and muscular tightness in the chest, shoulder, and neck regions. Over time, degenerative conditions can develop requiring rehabilitation and/or surgery.

Exercise Program

The following sections describe a strengthening exercise program for the scapular/mid-back muscles. Each exercise should be performed for 3 to 4 sets of 8 to 10 repetitions, 2 times a week. Key stretches to address postural issues are also presented.

Seated Row *(Figure 1 and 2)*

The row is an outstanding exercise for strengthening the rhomboids and middle trapezius. A seated position or the long sitting position machine may be used. The starting position is performed sitting with an erect posture (avoiding forward head or shoulder positions) and gripping the row bar. Initiate the movement by retracting or pulling your scapulae toward your spine. As the rowing motion occurs, your elbows will bend toward your waist. The motion is completed when the elbows have bent to approximately 90 degrees of flexion and are positioned by your side.

Figure 1. Seated Row—start position

Figure 2. Seated Row—finish position

Straight Arm Pulldown

This exercise trains the inferior trapezius. Gripping a high positioned pulley/bar, start with arms raised to shoulder height. The pulley/bar is pulled toward the body while the scapulae are retracted and inferiorly depressed (lowered). The movement is completed when the bar is at your waist.

Three Point Shoulder Abduction *(Figures 3 and 4)*

Start with one arm and both feet supporting the body. Grasp a weight with the other arm (fourth point). Raise your arm to the side, retracting the shoulder blade. The shoulder will elevate the arm to the side approximately 90 degrees.

Figure 3. Three Point Shoulder Abduction—start position

Figure 4. Three Point Shoulder Abduction—finish position

Latissimus (Lat) Pulldown *(Figure 5)*

This classic exercise is good for scapular retraction and depression. Start in a sitting position , gripping the lat bar. Initiate the movement by retracting and lowering your scapulae toward the mid to low back. Pull the bar toward the top of your chest. To avoid shoulder injuries, pull the bar toward your chest instead of behind your neck.

Figure 5. Latissimus Pulldown

Stretching Program
If you or your training partner(s) present with the aforementioned postural issues, a few key stretches should be incorporated into your daily stretching routine. Each stretch should be performed for 2 to 3 repetitions with 30 second hold periods.

Doorway Stretch *(Figure 6)*
The doorway stretch targets the pectoral muscles. Place each forearm along the side of the door entrance. Position one foot in a lead position. Lean your weight toward the lead leg. The stretch should be felt through the chest on each side.

Figure 6. Doorway Stretch

Cross Arm Stretch *(Figure 7)*
Forward shoulder posturing created by a chest exercise dominated program can cause tightness in the posterior shoulder. These restrictions can lead to impingement of the shoulder. To perform the stretch, reach one arm across the body. The opposite arm supports at the elbow providing a pull.

Figure 7. Cross Arm Stretch

About the Author
Jason Brumitt is a board-certified sports physical therapist currently working at Southwest Washington Medical Center. His clientele include both orthopedic and sport injuries. He provides athletic training services to area high schools through a hospital community program.

Reference
1. Kibler WB. (1998). The role of the scapula in athletic shoulder function. *American Journal of Sports Medicine, (26)*:325 – 337.

Lactic Acid: Understanding the "Burn" During Exercise

Travis Triplett-McBride, PhD, CSCS,*D

Everyone has experienced the burning sensation that accompanies intense exercise, such as a fast lap around the track or the last few repetitions of a high-repetition set of leg presses. The cause of this type of discomfort is different from the muscle soreness and tenderness that occurs a couple of days after a hard exercise session. The "burn," as it is commonly known, is from a build-up of a substance called lactic acid, which is a by-product of the breakdown of carbohydrate sources for energy to perform exercise, a process known as glycolysis.

Glycolysis is the breakdown of glucose from the blood or of glycogen, a stored form of glucose, from the muscle and liver. The purpose of glycolysis is to supply energy for the body's cells to operate. The process of glycolysis involves several enzymes that control a series of chemical reactions. Along the way there are various by-products that are either used as energy, used in other chemical reactions, or are excreted as waste[3].

The process of glycolysis may advance at different rates, labeled fast glycolysis and slow glycolysis. The end-product of fast glycolysis is a substance called pyruvic acid, which is converted to lactic acid when pyruvic acid starts to accumulate. This pace of glycolysis provides energy for the cells at a faster rate compared with slow glycolysis, in which pyruvic acid is transported to another part of the cell for energy production through the oxidative, or aerobic system. The outcome of the end products is controlled by the energy demands within the cell. If energy needs to be supplied very quickly, such as during sprinting or heavy resistance training, fast glycolysis is primarily used. If the energy demand is not as high and there is enough oxygen is present in the cells, slow glycolysis is primarily used[3].

Fast glycolysis also occurs during the very beginning of exercise or later in an exercise session when exercise intensity is high enough that the oxidative system cannot keep pace with the muscular demands for energy. Muscular fatigue experienced during exercise is often associated with high concentrations of lactic acid in the muscle[6]. Lactic acid accumulates when the body cannot clear it out of the muscle and other tissues quickly enough. The problem with lactic acid accumulation is that there is a corresponding increase in hydrogen ion concentration. High concentrations of hydrogen ions are believed to inhibit the reactions of glycolysis and to directly interfere with muscle contraction[9]. Also, the decrease in pH levels from the increased hydrogen ion concentration, which makes the muscle cell environment more acidic, inhibits the activity of other enzymes of the cells. The overall effect is a decrease in available energy and the force of muscle contraction during exercise[6].

The terms lactic acid and lactate are often used interchangeably, but this is not entirely correct. Lactic acid is eventually converted to the salt form lactate, by buffering systems in the muscle and blood. Unlike lactic acid in the muscle, lactate is not believed to be a fatigue-producing substance[2]. Instead, lactate is often used indirectly as an energy source itself, especially in slow twitch skeletal and cardiac muscle fibers[1]. It is also used to form glucose by combining lactate and other non-carbohydrate sources, which occurs during prolonged exercise and during recovery[2]. However, blood lactate concentrations do reflect lactic acid production and clearance. It is difficult to measure muscle lactic acid levels but it is very simple to measure lactate levels in the blood. The clearance of lactate from the blood is an indicator of a person's ability to recover from exercise. Lactate can be cleared by breakdown within the muscle fiber in which it was produced, or it can be transported in the blood to other muscle fibers to be broken down. Lactate can also be transported in the blood to the liver, where it is converted to glucose and is often stored as glycogen[2]. (See Figure 1).

Normally there is a low concentration of lactate in blood and muscle. The normal range of lactate concentration in the blood is 0.5 to 2.2 mmol/L at rest[5]. As previously mentioned, lactic acid production increases with increasing exercise intensity. However, lactic acid production is also related to muscle fiber type. The faster-contracting muscle fibers, also labeled fast-glycolytic (FG) and fast oxidative-glycolytic (FOG), show a higher rate of lactic acid production. This is mainly due to the fact that these muscle fibers are preferentially called upon for intense physical activity requiring a large amount of strength, power, and speed. In addition, the FG and FOG muscle fibers generally reflect a higher concentration or activity of glycolytic enzymes than that of the SO, or slow oxidative, muscle fibers[1]. Although the highest possible concentration of lactate accumulation is not known, complete fatigue can occur at blood concentrations between 20 and 25 mmol/L. The highest reported concentration of blood lactate is >30 mmol/L, which was measured after multiple bouts of dynamic exercise[6]. Along with exercise intensity and muscle fiber type, exercise duration, level of training, and initial glycogen levels can also influence lactate accumulation. For example, lactate tends to build up more with longer duration exercise, in untrained individuals, and when the muscle has high initial glycogen levels[5].

Blood lactate accumulation is greater following high-intensity, intermittent exercise (e.g., resistance training and sprints) than following lower-intensity, continuous exercise, where it does not accumulate until >55% VO_2 max[6]. Most studies have reported the highest blood lactate concentrations after maximal bouts of anaerobic exercise (1 – 3 min). One investigation[8] observed that multiple sets of the squat exercise to failure with increases in resistance resulted in higher blood lactate concentrations in trained individuals than in untrained individuals, because the time to failure and total work accomplished were greater in trained people than in untrained people. However, trained people experienced lower blood lactate concentrations than untrained people when exercising at the same absolute workload (the same resistance)(see Figure 2). This indicates that resistance training results in alterations in the lactate response similar to those from higher-intensity aerobic training[5]. These alterations include a lower blood lactate concentration at a given workload in trained individuals and higher blood lactate concentrations in trained individuals during maximal exercise[7].

Most studies have reported that blood lactate concentrations return to pre-exercise values within an hour after the exercise session is over. Light activity, known as an active recovery, during the post-exercise period has also been shown to increase blood lactate clearance rates, and aerobically trained and anaerobically trained individuals also have faster lactate clearance rates than untrained people[5]. Peak blood lactate concentrations occur approximately five minutes after the cessation of exercise, mainly due to the time required to buffer and transport lactic acid from the tissue into the blood[5].

The point of build-up, or lactate threshold, is used as an estimate of anaerobic effort in exercise. This is because anaerobic systems increase energy production when exercise intensity increases past the point where the body can supply the needed energy oxidatively. The lactate threshold is marked by a significant increase in blood lactate, but can be inaccurate because the measured blood levels also may be from reduced clearance, not just increased production. To try and account for this, an arbitrary value of 4 mmol/L is commonly used and is known is the onset of blood lactate accumulation (OBLA). The lactate threshold is used more to determine at what percent of max VO_2 the threshold occurs since it usually occurs in trained individuals at 70 – 80% of max VO_2 and at 50 – 60% of max VO_2 in untrained individuals. It is beneficial to increase the lactate threshold, which means one can exercise longer at a given intensity before lactate accumulation (from the corresponding lactic acid buildup) occurs and fatigue sets in[4]. (See Figure 3).

Training to Improve Your Lactic Acid Tolerance

Any athlete who needs to be able to maintain a high level of intensity for 1 – 3 minutes can benefit from training specifically designed to increase the lactate threshold. Improving lactic acid tolerance and the lactate threshold is generally best accomplished by interval training. Intervals should typically be in-line with the event that one is training for, although some workouts can consist of longer or shorter intervals to focus more on pure speed or speed-endurance, for example. Intervals that are approximately 30 seconds to 1.5 minutes in duration will focus more on fast glycolysis while intervals of 1.5 to 3 minutes in duration will focus more on slow glycolysis, although fast glycolysis is still a major part of the effort. The rest periods between the intervals should be approximately 2 minutes for the shorter intervals and 3 – 6 minutes for the longer intervals if the intervals are performed at maximal effort. Coaches sometimes choose to shorten the rest period so that full recovery is not achieved even though this means not being able to perform every interval at top pace. This is dependent on the goal of that training session and where the athlete is in the training year. Intervals are usually set up so that a certain total distance is covered, i.e. 8 x 400 m intervals for a total of approximately 2 miles. Interval training is a great alternative to long, slow distance training where VO_2 is not diminished yet lactic acid tolerance can be improved, which will potentially result in a better athlete.

Figures

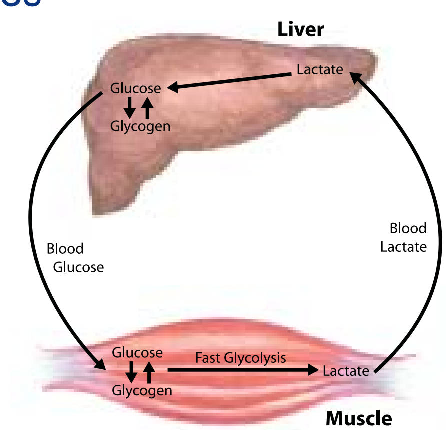

Figure 1. Lactate can be transported in the blood to the liver, where it is converted to glucose and is often stored as glycogen.

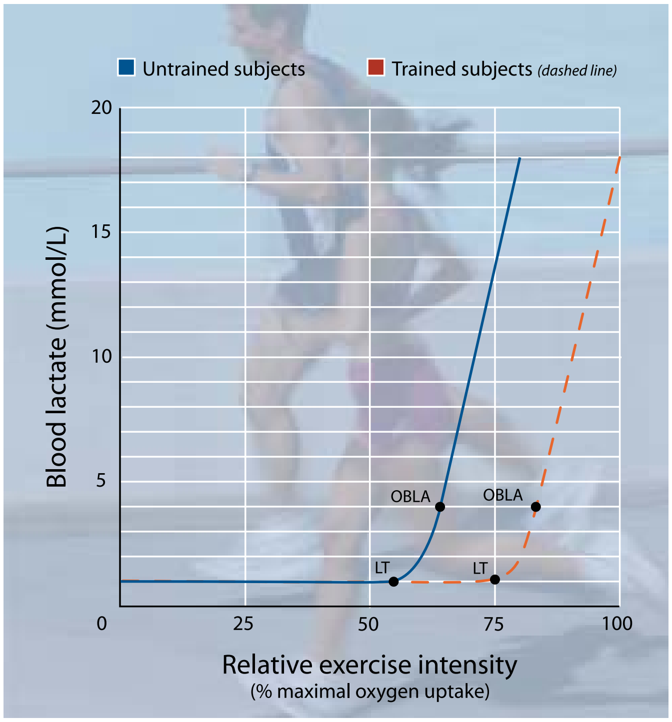

Figure 2. A generalized graph showing the relationship of blood lactate to exercise intensity in trained and untrained individuals.

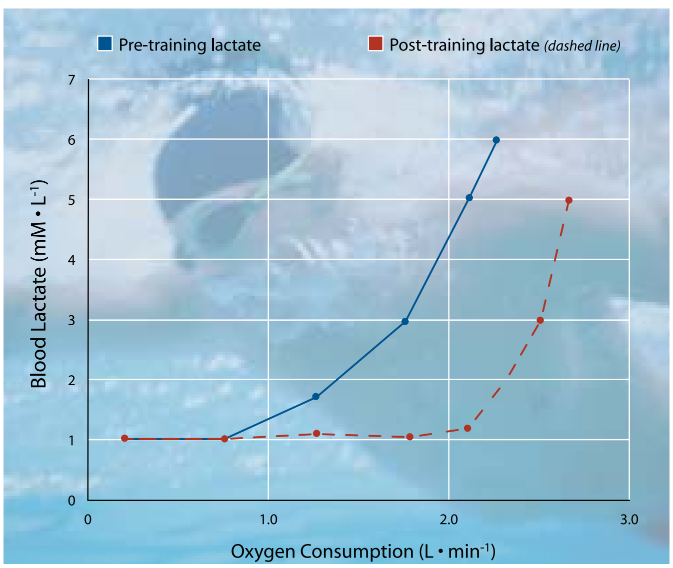

Figure 3. A generalized graph showing the relationship of blood lactate to oxygen consumption before and after a training program designed to increase lactate threshold.

About the Author

*Travis Triplett-McBride, PhD, CSCS,*D, is currently the Director of the Neuromuscular Laboratory and the Strength and Conditioning Concentrations for the BS and MS degrees in Exercise Science at Appalachian State University. After receiving a BS in Health and Sport Science from Wake Forest and an MS in Exercise Science from Appalachian State, Dr. McBride completed a research assistantship in Sports Physiology at the Olympic Training Center in Colorado Springs. Dr. McBride then completed her PhD in Physiology of Exercise at Penn State and a postdoctoral research fellowship at Southern Cross University in Australia. Dr. McBride is an associate editor for the Journal of Strength and Conditioning Research, and is on a NASA review board for developing resistance exercise countermeasures to micro-gravity for the International Space Station.*

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Knowing What You Need

Jason D. Vescovi, MS, CSCS

There are a multitude of resources (books, articles, conferences) that claim using a particular training routine or a certain set of exercises will improve your performance. They list a variety of exercises that will potentially increase your jumping ability or improve your driving distance or your serving velocity. With all of that information it can become difficult to decipher what is helpful and what should be ignored.

Since every sport is different and every athlete unique, it would stand to reason that developing a training program for an individual should take these factors into consideration. It might seem obvious that a female golfer wouldn't train the same way as a male tennis player. On the other hand, you might be inclined to say soccer players run a lot and volleyball players jump constantly. Therefore, a training program consisting of long distance running and several jumping exercises are appropriate for each sport, respectively. While there is some truth to that, you are only scratching the surface. If you do not go beyond superficial characterizations the most likely outcome will be a general training program for any athlete within a particular sport, in turn minimizing performance improvements.

This article will help you to determine which exercises are advantageous to include in your training program and which should take a back seat. Below are simple questions to answer, which will allow you to match the requirements of the sport with your athletic attributes. In other words, you will perform a needs analysis. A needs analysis is a way to create a clear understanding of a particular sport or activity as well as determine an athlete's physical and physiological characteristics. The result will lead to the design of a specific training plan focused on the needs of a particular athlete within the context of his or her sport.

Sport Analysis

The brief list below provides specific questions that should be answered prior to developing a training program. By first examining the sport or activity for its biomechanical and physiological characteristics we can determine subsequent test selection and then create your athletic program.

Biomechanical

- What types of movements are typically performed (running, jumping, swinging or throwing an object)?
- How often are those movements performed while participating in the activity (frequently, infrequently)?
- How does the core function (rotation, flexion, extension, stability)?
- What are the primary actions and planes of motion of the extremities?

Physiological

- Does the sport require a lot of movement (running, skating, walking, throwing)?
- Is the movement continuous or intermittent?
- What is the intensity (low, medium, high)?

Answering these questions will provide you with an understanding of the essential elements of your sport, which allow for appropriate selection of tests for your assessment protocol. With this information you can develop your training routine. Based on the answers above you, should be able to determine which of the following attributes are appropriate to assess.

Testing

The list below is not all-inclusive, nor should all of the attributes listed be tested in every person or every sport. Since each sport and participant are unique, the testing protocol should be unique as well. It is beyond the scope of this article to describe in detail the variety of testing protocols that can be used within each of the areas, however there are several excellent references which provide detailed descriptions on physiological assessment [1, 2].

- Physical characteristics (e.g. height, weight, body composition)
- Acceleration and speed (e.g. 40 yard sprint)
- Agility (e.g. T-test)
- Strength and power (e.g. 1RM)
- Aerobic and anaerobic capacity (e.g. 300 yard shuttle)
- Flexibility (e.g. sit-and-reach)

Another factor related to understanding the athlete is finding out training history and training age. In other words, what types of training have been performed in the past and for how long.

Program Design

Determining the characteristics of the sport as well as creating a profile of strengths and weaknesses will dictate the exercises you select (specificity), when they should be trained (prioritization), and how often you may need to change the program (variation and progression). Let's examine a hypothetical athlete to see how all of this information is put to work.

Our hypothetical athlete: An apparently healthy 27 year old woman who plays golf 1 – 2 times/week. She averages 90. She is average height and weight. She performs 10 – 15 minutes of stretching before she plays golf. Other exercise includes bike riding 5 times/week; never performed any type of resistance training.

So, let's use this information to answer our needs analysis questions.

What types of movements are typically performed? Golf swing and walking.

How often are those movements performed? There is a high volume of swings, but they occur intermittently; more specifically there are 50 – 60 high intensity swings (drives and fairway shots) and approximately 40 low intensity swings (putts); walking occurs frequently. So there is intermittent high intensity swings with variable periods of continuous low intensity walking during a round of golf.

How does the core function? The core primarily acts to rotate the torso and secondarily acts as a stabilizer.

What are the primary actions and planes of motion of the extremities? Each swing requires the legs to generate the necessary forces to initiate the movement. The core rotates and transfers the power into the upper body and extremities. The arms move across the body in the frontal plane.

Knowing this, the assessment protocol included tests to determine her aerobic capacity, core power and flexibility, and upper and lower body strength. The results indicated she has high aerobic fitness, poor flexibility in the core and legs, and average upper and lower body strength.

Based on all of this information, an appropriate training program can now be designed which specifically targets her needs within the context of playing golf.

Training priority

1. Flexibility—should be performed almost every day. Focus on low back and legs.

2. Strength—performed regularly (2 – 3 times/week), but be cautious in the beginning since she has no experience with this form of exercise.

3. Aerobic Fitness—already rides a bike 5 times/week. Would not recommend any additional exercise.

Training Specificity

1. Flexibility—this will be dictated by the specific tests performed and their results, however typical problem areas for golfers are:

- Hip flexors
- Hamstrings
- Buttocks
- Low back

2. Strength

- Leg Press, Squats
- Pulldowns, Seated Rows
- Chest Press

3. Aerobic Fitness

Training Variation and Progression

1. Flexibility

- Static stretching to dynamic stretching

2. Strength

- Machine to free weight exercises
- Simple free weight exercises to dynamic/complex body weight movements.

3. Aerobic Fitness

Without examining the details of the sport or the characteristics of the athlete, inappropriate or ineffective exercise selection could have occurred and ultimately produced insufficient results. Performing a needs analysis prior to designing a training program provides the necessary understanding of a particular activity and personal characteristics for each athlete.

About the Author

Jason D. Vescovi, MS, CSCS is a Doctoral Research Assistant in the Human Performance Laboratory at the University of Connecticut. He received his undergraduate and graduate degrees from James Madison University and The George Washington University, respectively. He has worked as a sports performance consultant and adjunct instructor at The George Washington University. He is also a member of the Education Committee for the National Strength and Conditioning Association.

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Sport-Specific Program Design

Michael Doscher, MS, CSCS

Training of athletes today involves many training philosophies, programs, and equipment gimmicks. This leads to confusion for athletes as to the best way to train for their sport. For the body to perform at its best takes hard work and commitment to a sound training program appropriate for the sport. There are no shortcuts or magic wands for attaining peak performance, nor is it instantaneously available. This article describes a fundamentally sound, structured program that will help your physically development for your sport.

To begin with, the year must be divided into training zones. Zone 1 is the in-season period, the time of the year when you are competing and need to be at the top of your game physically. Zone 2 is the post-season period that is used for recovery from the competition stress, relaxation, and fun. Zone 3 is the off-season; this time period is devoted to getting the body back to its top form, and improving on those physical variables that determine performance in your specific sport. Zone 4 is the pre-season, when the body is fine-tuned back into sport-specific shape, with the goal of being able to perform at a new and higher level in your sport.

These training zones have basic structures with time-specific priorities. Within these zones, the training is focused on the specifics of that zone such as strength, conditioning level, skill level, power, endurance, speed, or some combination of these factors. In the following sections we will analyze and break down each zone and give general guidelines to follow as to training emphasis, frequency, intensity, volume, as well as numbers of exercises and types of exercise that should be performed.

Zone 1 (in-season)

Emphasis in Zone 1 should be on preserving current strength levels, keeping explosive power high, and maintaining sport conditioning and skills at peak levels. Zone 1 breaks down as follows:

- Frequency: 2 – 3 full body workouts per week.
- Duration: 20 – 30 minutes
- Number of exercises: 4 – 6

The exercises in this zone should concentrate on explosive types of lift for power and be multi jointed in nature. Examples of these types of lifts include cleans, snatches, push presses, clean and jerks, and variations. Explosive lifts performed in Zone 1 should fall into the following ranges:

- Sets: 3 – 10
- Repetitions: 1 – 3
- Intensity: 60% to 85 % of 1RM (repetition max load.)

Strength exercises in Zone 1 should be combinations of squat to press, front squat to press or multi- jointed close chain exercises, such as squat and variations, bench press (incline or flat), over head presses. Strength exercises performed in Zone 1 should fall into the following ranges:

- Sets: 2 – 3
- Repetitions: 5 – 8
- Intensity: 65% to 80 % of 1RM

Other training areas to consider in Zone 1 include:

- Core training: At least twice a week.
- Plyometric training: Once a week.
- Speed training: Performed daily.
- Agility training: Sport specific and performed daily.
- Conditioning: Sport specific and built into practice.

Zone 2 (post-season)

The season has just ended and the body needs time to recover. The emphasis is on active recovery during this 2 – 4 week period. Zone 2 breaks down as follows:

- Frequency: 2 full body workouts per week
- Duration: 30 – 45 minutes
- Number of exercises: 8 – 12

Exercises are performed on either low impact machines or with free weights in a circuit format. The exercises must hit every part of the body from head to toe, with intensity in the low to medium range.

- Sets: 1 – 3
- Repetitions: 10 – 20
- Intensity: 55% to 70 % of 1RM

Other training areas to consider:

- Core training: At least twice a week.
- Speed training drills: Twice a week (may be used as warm up).
- Agility training drills: Once a week with 1 – 2 exercises.
- Conditioning: 2 – 3 times a week for 20 – 30 minutes with low-impact activities.
- Neither sport specific training nor plyometrics are prescribed.

Zone # 3 (off-season)

By now, the foundation should be complete. In this zone, usually 8 – 12 weeks in length, you are trying to become bigger, stronger, more explosive, and faster then you have ever been.

- Frequency: 3 – 4 split routine workouts per week
- Duration: 50 – 75 minutes
- Number of exercises: 6 – 10

The training design for this zone is a four-day a week split workout. Monday and Thursday you perform snatches and exercises that target the legs and back. Tuesday and Friday you perform power cleans, bench presses, and exercises that target the shoulders. Wednesday is used as a recovery day. Halfway through Zone 3, I change the workout and perform the Olympic and explosive lifts (power cleans and snatches) on Monday and Thursday and the full body strength training (squats, bench presses, back, shoulders) on Tuesday and Friday.

Olympic and explosive lifts performed in Zone 3 should fall into the following ranges:

- Sets: 3 – 10
- Repetitions: 1 – 5
- Intensity: 60% to 105% of 1RM

The strength exercises (squats, bench presses, back, and shoulder exercises) performed in Zone 3 should fall into the following ranges:

- Sets: 2 – 6
- Repetitions: 1 – 10
- Intensity: 60 – 105 % of 1 RM

Other training areas to consider:

- Core training: Performed at every training session.
- Plyometric training: Performed four days a week. Lower body on Monday and Thursday, and upper body on Tuesday and Friday. When the transition occurs halfway through the program, lower body plyometrics should be performed on the olympic and explosive lifting days, with upper body plyometrics performed on full body strength training days.
- Speed training: Performed every day as a warm up.
- Agility training: Performed on the same days as lower body plyometrics (twice a week).
- Conditioning: Performed two days a week on the same days as upper body plyometrics, after the lifting session. The conditioning program should consist of sprints of 400 yards or shorter, with work to rest ratios reflecting the competitive circumstances in the particular sport.
- Sport specific drills: held on agility days and on Wednesdays.

Zone 4 (pre-season)

During this phase you are converting all the new and improved physical attributes that you have developed in the off-season into explosive power, speed, and endurance for your sport. This phase usually lasts between 3 and 8 weeks.

The number of workouts performed per week in Zone 4 is similar to the Zone 3 three schedule. Olympic lifts and explosive exercises are performed on Mondays and Thursdays and full body workouts on Tuesdays and Fridays. Wednesdays are not off days in this zone because on those days we are doing sport-specific drills and conditioning. Halfway through the training I switch to a 3-day-a-week program (Monday-Wednesday-Friday). Monday is a heavy Olympic lift day, medium leg day, and medium upper body day. Wednesday is a light Olympic day, heavy upper body day, and light leg day. Friday is a medium Olympic day, heavy leg day, and light upper body day.

- Frequency: 4 days a week to 3 days a week.
- Duration: 45 – 60 minutes
- Number of exercises: 6 – 10

The training parameters for this zone break down in the following manner:

Olympic and explosive exercises:

- Sets: 1 – 10 sets
- Repetitions: 1 – 3 reps
- Intensity: 70% to 95% of 1RM

Strength exercises:

- Sets: 3 – 4 sets
- Repetitions: 3 – 6 reps
- Intensity: 70% to 85% of 1RM

Other training areas to consider:

- Plyometric training: Performed twice a week in the first part of the training session (on Olympic and explosive lifting days) and changes to 3 times a week in the second part of the program. Plyometric training is done on the same day as, and before or in conjunction with, the lifting workouts.
- Agility training: Follows the same pattern as the plyometric training. Drills become more sport-specific, and are performed in game day work to rest intervals.
- Conditioning: Performed twice a week opposite of plyometrics and agility training. Conditioning also becomes more sport-specific in terms of distances (5 – 50 yards) and more metabolic with the rest interval becoming sport-specific.
- Sport specific drills: Performed every day.
- Speed training drills are performed every day with warm up.

This is a basic outline of sport-specific program design. The most critical part of training is knowing what training zone you are in, and what the goals of that training zone are.

Remember to always keep the program intensities changing from heavy days to medium days to light days so your body can recover and reach its optimal genetic potential. To help keep the workouts fun, challenging, and to promote better grow and strength development for your sport, change assistant and strength exercise every 3 – 4 weeks.

Make sure that your program design provides for balanced muscle development. Never neglect the opposite muscle groups (antagonists). For example, if you work the quadriceps, do not forget the hamstrings.

After reading this article you have a basic idea of how to develop a sport-specific workout program for your needs. I would still look for a Speed/Strength & Conditioning Coach in your area who is CSCS certified to help you and look over what you have designed. They are the experts in the field and can help you improve even more in your sport.

About the author

Michael Doscher, MS, CSCS received his BS from Springfield College and his MS at Mississippi State University. Coach Doscher has worked at Boston College as an intern, UNLV as an assistant, MSU as a graduate assistant and is currently in his seventh year at Valdosta State University as the head of Speed/Strength & Conditioning. He has presented at several clinics on a variety of subjects.

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