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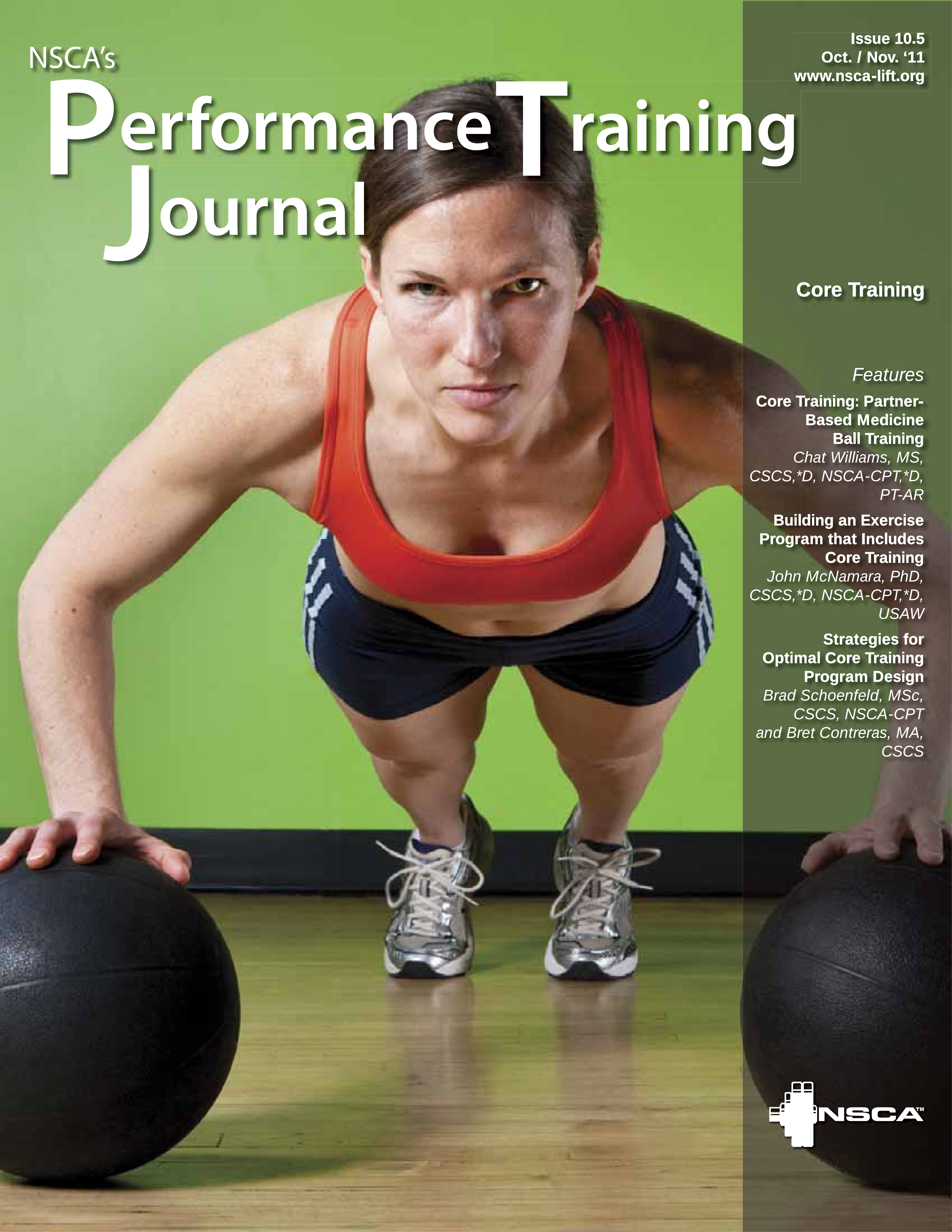

Core Training

Features

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about this PUBLICATION

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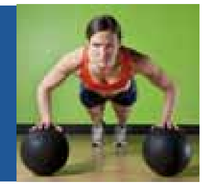

departments



New Membership Opportunities on the Horizon for the NSCA

The National Strength and Conditioning Association (NSCA) is launching a new membership category created for exercise enthusiasts and individuals who are new to the strength and conditioning field. The goal of the Associate Membership is to expand the reach of the NSCA's mission, "to support and disseminate research-based knowledge and its practical application, to improve athletic performance and fitness." This new channel gives individuals seeking more knowledge to improve job performance or those planning their professional development the fundamental resources and information on strength and conditioning.

As part of the NSCA's commitment to provide Members with the latest in educational content, the Performance Training Journal (PTJ) and the TSAC Report will now become an exclusive benefit to NSCA Members. Professional Members who currently receive the Journal of Strength and Conditioning Research and the Strength and Conditioning Journal will receive this content at no additional cost. Associate Members will receive the PTJ and TSAC Report along with additional web-based content developed specifically to fit their needs.

Individuals that do not wish to become NSCA Members but still want to receive free content from the NSCA can sign up for NSCA Connect, a new email alert. NSCA Connect will alert non-members to selected feature articles each month from every NSCA Publication. Visit http://nsca-lift.org/mainnews.shtml to sign up for this feature, update your profile and receive NSCA Connect.

To continue receiving the PTJ and TSAC Report, the NSCA is offering current subscribers a limited-time, introductory annual rate of $19.95 for Associate Membership from November 1, 2011 through March 31, 2012. Qualifications apply for the Associate Membership level, so please visit the NSCA Website on November 1, 2011 for more details and take advantage of this special pricing. However, there are many new and exciting developments of member benefits on the horizon. Beginning in April 2012, the NSCA will be enhancing the way cutting-edge content is delivered to Members through innovative media and educational resources.

G. Gregory Haff, PhD, CSCS, FNSCA

about the AUTHOR

Gregory G. Haff is a senior lecturer and the course coordinator for the Masters of Strength and Conditioning program at Edith Cowan University in Perth, Australia. He is a Fellow of the National Strength and Conditioning Association. Dr. Haff received the National Strength and Conditioning Association's Young Investigator Award in 2001.

Do Tests of Core Stability Have Any Relationship with Athletic Performance?

Over the past decade there appears to be an increasing focus on training the core. While there are a plethora of devices that target core stability there is little evidence that directly targeting core stability will actually translate to improvements in athletic performance. Recently, researchers from the University of Kentucky attempted to answer the question of whether or not tests of core stability have any relationship to actual markers of athletic performance. Thirty-five volunteers were recruited to assess their core stability with the use of a double-leg lowering test and several performance tests including the 40-yard dash, t-test, vertical jump, and two-handed medicine ball chest pass. Correlations between each of the measurements were performed with the use of a Pearson's product-moment correlation. As a whole, the stability test was only weakly correlated to the two-handed medicine ball chest pass (r=-0.389, p=0.023). This relationship was strengthened when only examining the top performers (r=-0.527, p=0.025). No significant correlations were noted between the test of stability and the 40-yard dash, t-test or vertical jump performance. Based upon these findings it appears that the double-leg raise core stability test offers little evidence of a relationship between core stability and performance. These results need to be taken with some caution as more research is required to determine if core stability is related to performance as only one test of core stability was performed.

Sharrock, C, Cropper, J, Mostad, J, Johnson, M, and Malone, T. A pilot study of core stability and athletic performance: Is there a relationship? *International Journal of Sports Physical Therapy* 6: 63–74, 2011.

Can the Functional Movement Screen™ Indicate Risk of Potential Injury?

It is believed that athletes who display poor dynamic balance or asymmetrical strength and flexibility, which could be considered a poor development of fundamental movement patterns, are more at risk for experiencing an injury. One method that has been proposed for diagnosing these issues is the Functional Movement Screen™. Despite being very popular in the strength and conditioning community no data has been presented in the scientific literature which actually links this battery of tests with actual injury risk. In order to address this question researchers from the University of Evansville and Belmont University examined the relationship between the Functional Movement Screen™ and injury risk in professional football players. The movement screen was performed prior to the start of the season and serious injury was considered to be anything that placed the athlete on the injured reserve for at least three weeks. A total of 46 players from one professional football team were utilized as subjects in the present investigation. This retrospective descriptive study revealed that a low score on the Functional Movement Screen™ was able to predict serious injury with a specificity of 0.91 and a sensitivity of 0.54. Based upon these findings, the researchers suggested that the decrements in functional movements are an identifiable risk factor in predicting injury rates in professional football players. As such, football players who have deficiencies in fundamental movements are more likely to experience a serious injury. Therefore, these researchers recommend that some form of movement screening be performed periodically in order to assess fundamental movement capacity.

Kiesel, K, Plisky, P, and Voight, M. Can serious injury in professional football be predicted by a pre-season functional movement screen? *N Am J Sports Phys Ther* 2: 147–158, 2007.

Using the Functional Movement Screen™ to Predict Injuries in Military Officer Candidates; Does it Work?

In the military, musculoskeletal injuries are the primary causes of missed training days during basic training, which may directly relate to a reduction in combat effectiveness. One method that has been proposed to reduce musculoskeletal injuries is to perform a Functional Movement Screen™ which employs a series of movements that are designed to diagnose deficiencies in fundamental movement abilities. Even though some research suggests that the Functional Movement Screen™ may be a useful diagnostic tool for evaluating musculoskeletal risk, no large scale studies have been done to date to examine the efficacy of this screen tool. Based upon previous studies with athletes it was hypothesized that a score of ≤14 on the functional movement screen would be predictive of musculoskeletal injuries. A total of 874 Marine Corp. officer candidates where assessed with the Functional Movement Screen™ during their medical in-processing prior to entering into either a long cycle (68 days; n=427) or short cycle (38 days, n=447) training cohort. Injuries were then tracked throughout the duration of each training cycle. The average Functional Movement Screen™ score was 16.6±1.7 and approximately 10% of the officer candidates had a score ≤14. Statistical analyses revealed that a Functional Movement Screen™ score ≤14 predicted the occurrence of an injury with a sensitivity of 0.45 and a specificity of 0.71 and serious injuries with a sensitivity of 0.12 and a specificity of 0.94. As a whole, regardless of the training cycle length, officer candidates with a Functional Movement Screen™ score ≤14 had a much higher risk of injuries as compared to candidates who had a score >14. This was noted by a 13.8% higher incidence of all injuries, a 5.9% increase in overuse injuries, and a 3.4% increase in serious injuries in this group. The vast majority of the individuals who had ≤14 on the Functional Movement Screen™ also exhibited a lower fitness score on the standardized Marine Corp. fitness test (<280 points) as compared to those who had >14 on the Functional Movement Screen™ (≥280 points). Interestingly, it was noted in the study that the Marine Corp fitness test was also able to predict injury rates, as those who were less fit tended to get injured more frequently. Overall it was concluded that the Functional Movement Screen™, when performed as part of a military in-processing medical screen, was able to predict an individual soldier's injury potential. However, it was also noted that fitness status was also related to injury rates. Therefore, further research is needed to differentiate if the fitness factors or deficiencies in functional movement are the primary predictors of potential injury. ■

O'Connor, F, Deuster, P, Davis, J, Pappas, C, and Knapik, J. Functional movement screening: Predicting injuries in officer candidates. *Med Sci Sports Exerc* (ahead of print).

Kyle Brown, CSCS

Hula Hoop Your Way to a Strong Core

Before you roll your eyes or scowl at the concept of hula hoop training as yet another fad exercise, think back to your childhood and how strong and flexible most kids are growing up. There are many things we do as kids that disappear as we get older that fall into the category of "child's play." From skipping to jumping rope to hula hooping; these activities that once were part of our daily play rituals are actually valuable tools to keeping fit.

Gymnasts, for example, have incredible core strength and stamina without using an isolated abdominal machine. You should start with a standard plastic hula hoop and then progress to a weighted hula hoop. Weighted fitness hula hoops are different than the traditional hula hoops we all grew up with as they are much larger and heavier. This provides for a fun yet more challenging core workout.

How can a hula hoop possibly be good for your core? All of your core muscles, from your obliques to your transverse abdominis to your gluteals, need to constantly and synergistically contract and release to maintain the motion of the hula hoop. Also, hula hoop abdominal training is similar to a plank in that it is not a hypertrophy (muscle building) exercise as much as it is a muscular endurance exercise. The focus on both of these exercises is to isometrically contract these core muscles while maintaining proper form for as long as possible.

How do you know you have the right size hula hoop for you? According to Mayo Clinic physical medicine and rehabilitation specialist Dr. Edward R. Laskowski, "The hoop should reach somewhere between your waist and chest when it's resting vertically on the ground. The weight of the hoop is up to you. The smaller and lighter the hoop, the more energy it takes to keep the hoop going. But the bigger and heavier the hoop, the easier it is to keep going, which means you may be able to do it for a longer period of time," (1). Try hula hooping for 20–30 min with each individual set lasting as long as you can maintain good posture. Your goal should be to build up both core strength and stamina while having fun.

Here is a sample core workout that incorporates hula hooping. Complete each exercise then repeat through three supersets. ■

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1. Laskowski, E. Do weighted hula hoops provide a good workout, or are they just a gimmick? TheMayoClinic.com. 2011 Retrieved August 2011 from, http://www.mayoclinic.com/health/weighted-hula-hoops/AN01638.

about the AUTHOR

Kyle Brown is a health and fitness expert whose portfolio includes everything from leading workshops for Fortune 500 companies and publishing nutrition articles in top-ranked fitness journals, to training celebrity clientele—from pro athletes to CEOs to multiplatinum recording artists. Kyle's unique approach to health and fitness emphasizes nutrition and supplementation as the foundation for optimal wellness. After playing water polo for Indiana University, as well as in London, Kyle became involved in bodybuilding and fitness for sport-specific training. Kyle is the creator and Chief Operating Officer for FIT 365—Complete Nutritional Shake (www.fit365.com).

Exercise	Supersets	Time	Description
Moving Plank	3	1 min	1. Start face down with your weight on your forearms and palms on the floor. 2. Lift your torso off the floor so all your weight is on your elbows and toes. 3. Maintain a flat back, contracting your core and gluteals. 4. Push your body weight up on your palms, lifting your elbows off the floor and your arms straight. 5. Switch back down to your elbows and repeat for as long as you can maintain proper alignment.
Speed Hula Hoop	3	2 min	1. Stand with your feet shoulder width apart in an athletic position, with the hula hoop around your hips. 2. Begin with a quick forward and backwards rocking motion at your hips as fast as possible while keeping the hoop swinging around your hips. 3. Keep your movement slight and focused on contracting your core muscles.
Hanging Abdominal Raises	3	40 s (15–20 reps)	1. Start hanging from a pull up bar with your elbows in arm slings (if available). 2. Keep your knees bent and raise your legs up towards your chest by rotating your pelvis while contracting your core muscles. 3. Slowly lower your legs to the starting position and repeat without swinging your legs.

about the AUTHOR

Chat Williams is the Supervisor for Norman Regional Health Club. He currently sits on the National Strength and Conditioning Association Board of Directors and is the past NSCA State Director Committee Chair, Midwest Regional Coordinator and State Director of Oklahoma (2004 State Director of the Year). He also served on the NSCA Personal Trainer SIG Executive Council. He is the author of multiple training DVDs. He runs his own company, Oklahoma Strength and Conditioning Productions, which offers personal training services, sports performance for youth, metabolic testing, and educational conferences and seminars for strength and conditioning professionals.

Core Training: Partner-Based Medicine Ball Training

Chat Williams, MS, CSCS,*D, NSCA-CPT,*D, PT-AR

This article will define the muscles of the core, discuss exercises to train the core, and provide some of the benefits associated with training the core. No matter the population, adult, youth, or athlete, the core is a vital part to every training program.

Core Defined

There are actually several regions of the body and muscles that encompass the core musculature (2). Core muscles and movements include the abdominals, back, and hips (Table 1). It is vital to train all of these regions of the body to help maintain posture, improve muscular balance and coordination, improve power, and provide fluid movements to the upper and lower body (several muscles attach at the pelvis and spine). This can be accomplished by training the core in all three planes of motion (Table 1) (5).

Core Exercises

There are several modalities and exercises associated with improving core performance. Body weight can be used to perform sit-ups and crunches. Stability balls may be used to create an unstable environment challenging balance and coordination. Kettlebells and dumbbells may be used over the head to challenge core stability (4). Finally, medicine balls may be used to help develop strength, power, and incorporate movements in all three planes of motion (1).

Benefits of Core Training

As mentioned earlier, there are several benefits that can be achieved by training the core including increased power production, improved stability, improved balance, and a reduced risk of injury (3). Power production is essential for many rotational sports sports including golf, baseball, and tennis. A strong core allows for more power to be delivered through the entire kinetic chain (3). Many of these movements can be performed using a medicine ball in a closed chain fashion through the transverse plane (1). Stronger upper and lower body muscles that attach in the core region of the pelvis and spine allow the individual to be better coordinated, more stable, and more efficient when completing movements (3,5). Core training can benefit one's balance and may improve proprioception and body awareness allowing them to maintain a specific position in space (5). When the core, upper body, and lower body are strong, stable, and powerful this creates a scenario that may provide the individual with a decreased chance of getting injured while performing an activity.

Partner-Based Medicine Ball Training

Adding medicine ball movements to a strength and conditioning program can be advantageous for several reasons. As previously stated, there are the general benefits achieved by training the core. Specifically, adding a medicine ball into a training program can enhance sport-specific body movements in all three planes of motion, increase angular velocity and intensity, and allow the individual to perform the exercises in multiple body positions (e.g., standing, lying, kneeling) (1). Intensity and volume can easily be modified by increasing or decreasing the weight of the ball depending on the goal for the specific movement, exercise, or program type. For example, if trying to increase speed and endurance a lighter medicine ball would be used. Conversely, if power and strength are the goal for the individual a heavier medicine ball would be used. Selecting the correct weight of the ball should depend on the fitness level of the individual and their specific goals for the current training program. Partner training also creates a situation where both individuals are engaged in the workout and continuously moving at all times. This is great for small group training and programs focused on youth.

Exercises

The following are just a few of the medicine ball exercises that can be integrated into a training program. The examples will incorporate multiple planes of motion and movements performed standing and lying down. Examples will include individual exercises and how the exercises can be arranged to perform a core circuit.

Trainer or Partner Setup (Catch and Return) (Figure 1)

First of all, the trainer or partner must be able to catch and receive the ball effectively so that the medicine ball can be returned to the trainee in a timely and efficient manner. The partner is very critical to the movement pattern so that there is a smooth transition between repetitions to maximize the exercise. The partner will stand with knees slightly bent and arms extended in front of the body. When the ball is received, slight eccentric recoil in the elbows will occur and the ball should be returned to the trainee quickly and accurately. The partner and trainee should work as a team and focus on throwing the ball to each other so there is a smooth exchange and not at each other, which could create an interruption while performing the set. The partner will have the same setup for all of the following exercises.

Medicine Ball Toss (Figures 2, 3, and 4)

The trainee will start in a seated position with the legs out in front and slightly bent. Hands should be in front of the face ready to receive the ball. The partner will perform a chest pass aiming slightly above the head. The trainee will catch the ball, go back and tap the ball to the ground creating an eccentric load on the core. Then, quickly and explosively return the ball back to the partner following through with the arms. The concentric toss back is done with one movement with the hands over the head; it is not a sit-up and chest pass.

Reverse Medicine Ball Toss (Figure 5)

The trainee will start in a prone position with the legs out in front, slightly bent and facing away from the partner. Simultaneously, the partner will chest pass the ball towards the middle of the body and the trainee will catch the ball while sitting up, tap the ball to the ground and return the ball back to the partner finishing in the prone position.

Medicine Ball Toss/Knee Punch Combo (Figures 6, 7, 8, and 9)

The trainee will start in a seated position with the legs out in front and slightly bent. Hands should be in front of the face ready to receive the ball. The partner will perform a chest pass aiming slightly above the head. The trainee will catch the ball, go back and tap the ball to the ground creating an eccentric load on the core. Next, the trainee will explosively punch the knee to the ball, eccentrically load the core by tapping the ball to the floor and explosively punch the other knee to the ball. Then, the trainee will tap the ground behind them, perform a sit-up and tap the ground between the legs. Finally, the trainee will eccentrically load the core one more time by tapping the ground behind them and return the ball back to the partner in one explosive movement.

Standing Rotations (Figures 10 and 11)

The trainee and the partner will both be in standing positions; the trainee will have their back to the partner holding the ball in front of them with arms extended. The trainee will rotate the trunk through the transverse plane allowing the hips to move freely with arms extended; follow the ball with the eyes and explosively toss the ball to the partner. The partner will return the ball to the other side and repeat the movement.

Standing Axe Chops (Figures 12, 13, 14, and 15)

The trainee will stand with arms extended in front of the body and perform a semi-circle to the side of the body raising the ball above and behind the head eccentrically loading the core. The trainee will then follow through by slamming the ball to the floor under control.

Seated Shoulder Thrusts (Figure 16)

The partner will stand at a 45° angle facing the trainee. The trainee will be in a seated position with legs out in front and slightly bent. The partner will toss the ball to the trainee across their body. When the trainee receives the ball, they will rotate following the ball with their eyes and explosively thrust the ball back to the partner. It is important for the trainee to keep their elbows up and thumbs down during the movement. This exercise is intended to be a shoulder thrust and not a rotation.

Seated Rotation (Figure 17)

The trainee will be in a seated position with legs out in front and slightly bent and the partner will stand perpendicular to the trainee. The partner will toss the ball to the trainee across their body. When the trainee receives the ball, they will rotate with arms extended following the ball with their eyes and explosively toss the ball back to the partner.

Seated Isometric Chest Pass (Figure 18)

The partner will stand directly above the trainee holding their legs together. The trainee will lean back at 45° angle. The trainer will toss the ball to the chest and the trainee will then explosively perform a chest pass back to the partner.

Seated Overhead Toss (Figure 19)

The partner will stand directly above the trainee holding their legs together. The trainee will lean back at 45° angle. The trainer will toss the ball behind the head and the trainee will catch and return the ball back to the trainer performing a tricep extension movement.

Program Design, Volume, and Circuit Design

A few questions must be answered before integrating the medicine ball into a training program. What is the current fitness level of the individual? What are the training goals? What size of medicine ball should be used? If the goal of the individual is to increase power then performing 3–5 repetitions with a heavier medicine ball relative to their fitness level would be the correct volume. If they want to improve muscular endurance then ball performing 12–15 repetitions with a lighter medicine ball would be the preferred volume (Table 2). A medicine ball circuit can be created by combining five of the previous exercises; this is a fun and challenging way to work the core. The medicine ball toss, shoulder thrust, seated rotation, isometric chest pass, and isometric overhead press are the five exercises in the circuit for the purpose of this article. The basic circuit has a total of 13 exercises and totals 39 repetitions (Table 3). The intensity and volume of the core circuit can be increased by modifying the weight of the ball and the repetitions completed (Table 4). ■

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Figure 1. Catch and Return

Figure 2. Medicine Ball Toss

Figure 3. Medicine Ball Toss

Figure 4. Medicine Ball Toss

Figure 5. Reverse Medicine Ball Toss

Figure 6. Medicine Ball Toss / Knee Punch Combo

Figure 7. Medicine Ball Toss / Knee Punch Combo

Figure 8. Medicine Ball Toss / Knee Punch COmjbo

Figure 9. Medicine Ball Toss / Knee Punch Combo

Figure 10. Standing Rotations

Figure 11. Standing Rotations

Figure 12. Standing Axe Chops

Figure 13. Sanding Axe Chops

Figure 14. Standing Axe Chops

Figure 15. Standing Axe Chops

Figure 16. Seated Shoulder Thrusts

Figure 17. Seated Rotation

Figure 18. Seated Isometric Chest Press

Figure 19. Seated Overhead Toss

Table 1. Planes of Motion

Plane	Description
Sagital	Decelerates lumbar extension during anterior motion of the pelvis when the foot hits the ground
Frontal	Decelerates the drop of the pelvis when the foot hits the ground then accelerates the trunk helping the leg swing through
Transverse	Decelerates the hips and shoulders
Body Regions	
Region	Muscle Groups
Abdominals	Internal and external obliques, transverse abdominus, rectus abdominus
Back	Paraspinals, trapezius, psoas major, multifidus, erector spinae, quadratus lumborum, iliocostalis loborum and thoracis, latissimus dorsi and serratus anterior
Hips	Obturator internus and externus, quadratus femoris, periformis, psoas, rectus femoris, sartorius, tensor facia latae, pectenius, adductor brevis, magnus, and longus, gemellus superior and inferior, pectenius, gluteus maximus, medius, and minimus, semitendinosus, semimembranosus, and biceps femorus.

Table 2. Basic Program Design Suggestions (muscular endurance and muscular strength)

Skill Level	Med Ball Weight	Sets	Reps
Beginner	4–6 Pounds	2–3	8–12 per set
Intermediate	6–8 Pounds	3–4	12–20 per set
Advanced	8–10 Pounds	4–5	20–30 per set

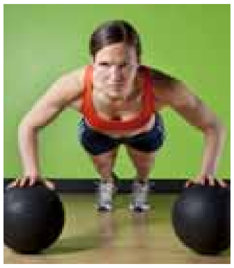
Note: Training for Power Goals: Repetitions should range from 3-5

Table 3. Medicine Ball Circuit

Order	Exercise	Reps	Order	Exercise	Reps
1	Ab Toss	3	8	Rotation Right	3
2	Shoulder Thrust Left	3	9	Ab toss	3
3	Ab Toss	3	10	Isometric Chest Pass	3
4	Shoulder Thrusts Right	3	11	Ab Toss	3
5	Ab Toss	3	12	Isometric Over-head	3
6	Rotation Left	3	13	Ab Toss	3
7	Ab Toss	3			
Total Repetitions: 39					

Table 4. Circuit Volume Examples (Based on 13 Exercises in Circuit)

Medicine Ball Weight	Repetitions Per Exercise	Total Repetitions	Total Volume
4	3 x 13	39	156 pounds
	4 x 13	52	208 pounds
	5 x 13	65	260 pounds
6	3 x 13	39	234 pounds
	4 x 13	52	312 pounds
	5 x 13	65	390 pounds
8	3 x 13	39	312 pounds
	4 x 13	52	416 pounds
	5 x 13	65	520 pounds



Building an Exercise Program that Includes Core Training

John McNamara, PhD, CSCS,*D, NSCA-CPT,*D, USAW

about the AUTHOR

John McNamara is an Associate Professor at St. Francis College in Brooklyn, NY. He received his Bachelor's and Master's degrees at the University of Alberta in Canada, and his Doctorate in Kinesiology from Temple University in Philadelphia, PA. He is currently a Certified Strength and Conditioning Specialist® and NSCA-Certified Personal Trainer® with distinction from the National Strength and Conditioning Association (NSCA). He is also a Level One Sports Performance Coach with USA Weightlifting. He teaches exercise physiology as well as conditioning courses for applicants of the New York City Police and Fire Department. His research focus is training theory and flexible nonlinear periodization. He also competes in Olympic weightlifting, track and field, and ice hockey.

Core strength can be defined as the ability to transfer force from the feet, through the legs, to the midsection, and finally to the upper body (3,4). For example, in track and field a shot-putter drives with the legs, then twists at the midsection, and finally releases the shot from the fingers of the hand. There are several methods of increasing sport performance and strength through core training. There is also a wide range of activities, movements, and training strategies that can be used in program development such as strength, balance, and sport-related activities, all of which engage the midsection of the body. For example, a weighted medicine ball can be used to improve chest pass basketball performance for an athlete, or it can be used as a personal training activity for someone who does not play basketball but wants to improve his or her fitness level. This article takes the perspective that core training, when included in an overall exercise program, can enhance sport performance and overall fitness.

General parameters for creating and maintaining an exercise program that includes core training and adheres to the principles of physical training and safety are paramount. The program can be used for athletes wanting to improve competitive performance, or the general public hoping to improve their fitness. It is encouraged that coaches and educators not limit themselves to traditional core exercises but see that exercises used to develop core strength and coordination are limited only by one's imagination. For this reason, general categories of activities and movements are listed in Table 1, allowing for individuals to choose from a wide range of specific activities of their choice when designing their own program.

The most important component in building an exercise program that includes core training is the safety of the participants. A health history questionnaire given prior to participation can provide valuable information regarding readiness to exercise. If someone has an injury or illness they might not be ready to engage in a core exercise program and a physician's clearance should be obtained.

For healthy individuals, or those cleared to participate conditionally, core training should be part of a comprehensive exercise program. A comprehensive program is one in which participants follow healthy eating guidelines such as those outlined in www.myplate.gov, and get adequate sleep each night for recovery and the rebuilding of muscle tissue (5). With proper nutrition and rest, core exercise programs will be much more effective. Any exercise program should also adhere to the principles of training, which include progressive overload and specificity. An exercise program should not focus solely on core training but involve other aspects of strength and conditioning to provide the most benefits to the participant (3). However, an exercise program that includes a core training aspect may improve sport performance and thus, is an important component to an overall exercise program. With that being said, there are five steps to building an effective exercise program that includes core training.

Step one: Decide on the days of the week that the training will take place. Three days per week with one or more days of rest between them should allow adequate recovery and significant stimulation of the neuromuscular system (1).

Step two: Determine the duration of the workouts. Fifteen minutes of exercise per training session can stimulate change and help to avoid the potential for injury and overtraining. As tolerance is built up, the length of time can slowly be increased.

Step three: Choose the intensity of the exercise. It is important to start at a low intensity level. By doing this, the chance of injury and soreness is reduced and the chance for success is increased which can be encouraging to participants. Some core exercises are difficult because of the extreme balance, strength, and power needed to execute them properly. It would not be practical to start a beginner on movements that would be nearly impossible for them to perform, or put them at risk for injury.

Step four: Select the exercises or activities that will make up the core training exercise program. There are at least three general categories of exercises to choose from, all of which can vary in difficulty level and can be used in a progressive format. Core strength exercises, balance drills, and sport-specific movements provide a large amount of choice and variation to training programs (6). Almost any exercise or activity that does not isolate an extremity involves activation of the core. For example, a cable triceps pushdown, throwing a baseball, and long jump all require core strength, balance, and neuromuscular control and coordination. Table 1 lists general categories and some specific exercises that can be used to create an exercise program that includes core training.

Step five: Monitoring the exercise program is of high importance to the overall success of the program. Continuous evaluation is important because the program might be too stressful, and needs to be made easier, or it might be too easy and requires exercises of greater difficulty. The core component can be made easier simply by reducing the amount of exercise time and decreasing the exercise difficulty. To make the program more difficult, the exercise time can gradually be increased by five minutes each month for several months at which point intensity will be increased but not workout time. Another way to make the workout harder is to replace easy exercises with moderate to difficult ones. Variation is also important to reduce boredom and maximize physiological adaptation. Gradually, new exercises can be introduced. It is also acceptable to change a planned workout at the last minute depending on the participant's energy level. This takes advantage of the concept of flexible nonlinear periodization (2). If the participant feels well rested and strong, a harder workout can be implemented. Alternately, if the participant feels tired on a particular day a planned workout with high difficulty can be changed to an easier one that is less intense. ■

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Table 1. Core Training Exercise List

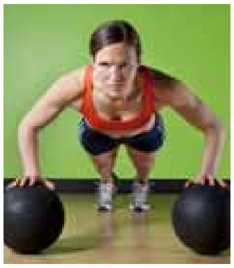
Strength	Balance	Sport-Specific
Crunches	Swiss ball	any sport in an unstable environment
Low back extensions	BOSU ball	any sport with a weighted vest
Sit-ups	Bridges	golf shot from one leg
Supermans	Yoga	basketball pass with medicine ball
Leg raises	Gymnastics	boxing with heavy gloves
V-ups	Break dancing	tennis with weighted racquet
Hanging leg raises	Free weights	hockey with a heavy puck
Twisting cable crossovers	Tubing	sprinting in sand
Lateral oblique raises	Kettlebells	volleyball in sand
Inverted sit-ups	Weightlifting	water polo with weighted ball
Reverse back extensions	Calisthenics	football routes in sand

Table 2. Core Training Exercise Program

Day	Monday	Wednesday	Friday
Time	15 min	15 min	15 min
Exercise	Strength: 5 min Balance: 5 min Sport-specific: 5 min	Strength: 5 min Balance: 10 min	Sport-specific: 15 min
Intensity	Low	Medium-high	Medium

Strategies for Optimal Core Training Program Design

Brad Schoenfeld, MSc, CSCS, NSCA-CPT and Bret Contreras, MA, CSCS



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A well-balanced core program should form an integral part of an athlete's training regimen. Core training is an evolving science, and the art of core program design encompasses many facets. In this article we will hash out some fundamental topics currently surrounding core training and provide recommendations for designing a comprehensive athletic core training program. The focus will be on core training for healthy, athletic populations; core training for rehabilitative purposes is beyond the scope of this article.

What Comprises the Core?

Richardson et al. states that the core is a box with the abdominals in the front, the paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom (14). Willson et al. defines the core as the lumbopelvic hip complex, consisting of the lumbar spine, pelvis, and hip joints and the active and passive tissues that produce or restrict motion of these segments (19). Fig describes the core as all the anatomy between the sternum and the knees with a focus on the abdominal region, low back, and hips (7). Tse et al. states that the core musculature includes muscles of the trunk and pelvis that are responsible for maintaining the stability of the spine and pelvis and are critical for the transfer of energy from larger torso to smaller extremities during many sports activities (16). Behm et al. provides the most expansive definition, describing the core as the axial skeleton and all soft tissues with a proximal attachment originating on the axial skeleton, regardless of whether the soft tissue terminates on the axial or appendicular skeleton (upper and lower extremities) (2).

It is important to understand that the core musculature receives substantial work during the course of an athletic workout. Structural exercises such as squats, deadlifts, and rows heavily involve the muscles of the core. For this reason, we propose that targeted core exercises should supplement a good strength training session for structural balance.

What Types of Core Training Exist?

The core can be trained for multiple purposes including activating muscles and correcting dysfunction, increasing different types of stability, and/or developing muscular strength, power, and endurance. The following sections cover these topics.

Activation and corrective exercise

Strength coaches often include low-load activation work into programs during warm-ups or in between sets of compound exercise for the purpose of corrective exercise or "prehab" (i.e., future injury prevention). While corrective exercise is intended to restore fundamental movement patterns by increasing joint mobility, joint stability, or motor control, the premise behind prehab methodology is to enable muscles that typically become dormant to keep firing. Furthermore, even though corrective exercise is proactive while prehab is preventative, the exercises and drills used for both methodologies are similar. Placing these movements at the beginning of a training session into a dynamic warm-up confers several benefits including warming the muscles, controlling the joints through full ranges of motion, priming the nervous system, and correcting or preventing future dysfunction. Alternatively, these drills can be employed during rest periods to increase training session density and make productive use of downtime. Bird dogs and x-band walks are two examples of "prehab" exercises that can be utilized to activate vital core muscles in efforts to keep them contributing properly to functional movement and prevent overcompensation from synergistic musculature.

More recently, activation work performed prior to explosive movement has been shown to increase strength and power. Specifically, seven glute activation exercises including glute bridges and side-lying clams were shown to increase peak power in the countermovement jump by 8% (3). Moreover, a case study by Wagner et al. found that activation drills significantly increased hip extension strength while diminishing extraneous hamstring activation during terminal swing and the first half of stance phase in a triathlete suffering from recurrent hamstring cramping (18). Activation work should be performed with low loads at lower neuromuscular thresholds with the focus on correct form.

Stability

Core stability training can refer to exercise intended to improve segmental, spinal, or whole-body stability (11). Since the core has been said to provide "proximal stability for distal mobility," a weak and unstable core can be associated with issues further down the kinetic chain (6). Core stability training includes both functional balance training as well as traditional core stability exercise.

Functional balance and sensorimotor training are sometimes included in an athletic training program to improve proprioception and coordination. Several studies have found that sensorimotor training can have a favorable impact on power production (9). Unstable surface training is often included in this category, which involves the use of devices such as BOSU balls, inflatable discs, and wobbles boards. It should be noted, however, that balance training does not require specialized equipment as any single-leg movement that involves dynamic extremity motion, such as the single-leg Romanian deadlift, pistol squat, or high step-up with knee lift, will effectively challenge the sensorimotor system provided that loading is matched according to the athlete's abilities. For this reason, strength coaches should incorporate a mixture of bilateral and unilateral movements in their programs.

Though dynamic contractions can be used to increase segmental stability of the spine, typical core stability exercises require isometric contractions in the core to prevent the lumbar spine and pelvis from buckling and enable efficient transfer of energy throughout the entire body. There are two common types of core stability exercise; whole-body isometrics and core isometrics with dynamic limb movement. An example of a whole-body isometric exercise is a plank, where the entire body is maintained in a fixed position. An example of a core isometric with dynamic limb movement exercise is a 3-point plank, where the core remains stable while one limb moves through a range of motion. Many sports require high force and high-velocity isometric core contractions, which likely warrants combined training methods.

Strength

Core strengthening movements can include dynamic or isometric exercises. The previous section described core stability exercises, which encompassed isometric strength. The focus in the next section will be on dynamic exercise, which includes concentric and eccentric contractions. Many sport actions require core actions that are relatively slow but with higher levels of force. For example, the deadlift has been shown to involve dynamic spinal flexion with elite powerlifters, and many situations in mixed martial arts require sustained lumbar flexion, especially in the clinch or on the ground (10). Dynamic core exercises are likely superior to isometric exercises for the purpose of muscular hypertrophy (5).

Power

The core must also be able to produce powerful dynamic contractions in many sport actions. This often involves a rapid stiffening effect to transfer kinetic energy between the lower and upper bodies. For example, most throwing, swinging, and striking motions involve varying levels of hip and spinal rotation, and even sprinting requires high levels of core contractions to produce, reduce, and transfer force. A variety of training methods and contraction velocities involving core stability exercise, ballistics and plyometrics, explosive strength exercises, and heavy resistance training can help to maximize core power.

Endurance

Core endurance is an integral component to many different sports and sport actions such as rowing, boxing, and rugby. Higher repetition sets are likely valuable to enhance core muscular endurance for these purposes. Core muscle endurance is purported to be more important for the prevention of low back pain and injury than core strength (12).

Program Considerations

A strength coach needs to take into consideration many different factors when designing a proper core training regimen. The following sections will cover many of these considerations and help strength coaches address the necessary factors when designing a training program.

Joint actions

Since generally accepted definitions of the core loosely revolve around the muscles attaching at the spine, pelvis, and hips, it therefore follows that all of the joint actions and types of contractions involved in these joints must be considered when designing a core training program. The lumbar spine can flex, extend, laterally flex, and rotate. The pelvis can tilt posteriorly, anteriorly, laterally, in addition to being able to rotate. Finally, the hips can flex, extend, adduct, abduct, and produce internal and external rotation. It is important to note that each of these joint actions can occur dynamically (concentric and eccentric actions) or statically (isometric action).

In general, the spine, pelvis, and hip joints work as a unit to produce synchronized, coordinated movement. Spino-pelvic stiffening is modulated to prevent or allow for varying amounts of movement depending on the task. During sprinting, for example, the lumbar spine extends and the pelvis anteriorly rotates to allow the hip extensors to produce greater torque (15,20). A weak core will not be able to control accessory movement, which will result in energy leaks, thereby impairing the ability of the hips to produce maximum ground reaction force. Moreover, a lack of hip mobility can alter the normal functioning of the lumbopelvic region. For example, if hip flexion mobility is limited during a hurdle step, the lumbar spine will overcompensate by inadvertently flexing to allow the desired range of motion to be reached. Finally, postural issues related to force couples across the lumbopelvic region can affect flexibility. For example, an individual who exhibits excessive posterior pelvic tilt will likely struggle to keep an arch at the bottom ranges of a squat or to maintain athletic positions in sports. Given these factors, it is apparent that the lumbopelvic-hip complex requires optimal strength, flexibility, and coordination to produce maximum power and movement efficiency.

Force vector specificity

All of the aforementioned types of core training, including core activation, core stability, core strength, core power, and core endurance, are specific to the vector of force. For example, squats and deadlifts primarily tax the strength of the erector spinae and therefore act predominantly on spinal extension and anterior pelvic tilt, or more accurately the prevention of spinal flexion and posterior pelvic tilt. Though this quality is a vital component of strength training, it would be of limited utility to a fighter who is on his back with an opponent straddling him or to a soccer player trying to throw a ball in bounds. We believe multiple vectors must be trained through varying methods in order to maximize or increase overall athleticism.

Safety

Based on available evidence, dynamic spinal exercises appear to be safe as long as three different criteria are met (5). First, athletes must progress gradually along a continuum to allow for positive structural adaptations to take place within the discs. Progressing too quickly will likely have deleterious effects on the discs, whereas proper progression will likely confer a positive effect on disc health. Second, excessive end-range spinal motion must be avoided in every direction. It is important to remember that some sports require end-range flexion. Some motion in the spine appears to be beneficial to spinal health, but too much motion may be detrimental. Proper form during dynamic spinal exercises must be taught and strictly enforced, with a blend of motion occurring across the spinal motion segments and no individual segment approaching the end of its range of motion. For example, a crunch should involve approximately 30° of trunk flexion with the majority of movement occurring in the thoracic spine while cable woodchops should have most of the motion occurring at the hips and thoracic spine with minor amounts of motion in the lumbar spine. Finally, volume must be kept in check with dynamic spinal movements. For the purpose of core strength, we recommend 2–4 sets of 8–15 reps for most dynamic core exercises.

Sport actions

A good strength coach will always rely heavily on tried and true core strengthening exercises. For example, squats, deadlifts, bent-over rows, and loaded carries, such as farmer's walks, will strengthen the core. Provided the lumbopelvic region is kept stable, pull-ups and push-ups will strengthen the anterior core musculature. Targeted core exercises such as side planks, ab wheel rollouts, and hanging leg raises can be employed to ensure a comprehensive core workout.

With that said, the principle of specificity should always be a primary consideration when designing an individualized core routine. Many sports require unique core movements and therefore exercises can and should be adopted to specifically address these movements. For example, a throwing motion might involve varying amounts of spinal lateral flexion, flexion, and rotation. A long bar or rope handle attached to a high cable can be used to mimic this core contraction which could strengthen the core in the desired range of motion and therefore add to power production via increased neural drive and muscle physiological cross-sectional area, especially when performed in concert with the specific sport skill.

Exercise order

The ideal placement for core exercises within a workout is often debated by strength coaches. As previously noted, core training is occurring throughout the entire session. We believe that activation work should be performed in the dynamic warm-up and possibly interspersed between rest periods between sets of heavy exercise if workout time is limited. Power and speed work for the core consisting of various sprints, agility drills, towing, plyometrics, ballistics, and explosive strength movements should follow the dynamic warm-up. Next, total body strength training should be performed with a focus on multi-joint movements. Finally, targeted core exercises should be performed at the end of the workout to avoid prematurely fatiguing the core.

Rotary training

Standing rotary exercises are usually performed with loads held at arm's length which create exceptionally long levers and high torques at the spine which are countered through ground reaction forces at the feet. For this reason, all of the joints between the arms and the feet are called into play, making rotary training a highly effective form of "total body training." Despite the fact that modest levels of resistance are often used during rotary training, the long levers and multiple muscles involved in producing or preventing rotation produce large compressive loads on the spine and require high thresholds of neuromuscular and metabolic activity. We believe that rotary training is a vital component to total athleticism and that rotary training helps bridge the gap between general weight room strength and rotational power on the field or court.

Recent research has shown that standing rotary training can improve landing mechanics in the absence of jumping exercise (13). Elite golfers show greater angular velocities of trunk rotation than less-skilled golfers (21). Furthermore, research found that rotary motion was indeed healthy for the lumbar discs as long as end ranges were avoided (4). Standing rotary exercises can be performed with bands and cables to simulate various chopping and lifting motions in different positions including kneeling, half-kneeling, split stance, and parallel stances.

Hollowing, bracing, or neither

Many fitness professionals have made broad recommendations as to how the core should function during exercise. Hollowing and bracing are two of the most popular recommendations. It is important to know several things regarding this topic. First, although abdominal hollowing has been advocated following low back injury, it should never be used during heavy strength training (1). Abdominal hollowing decreases spinal stability, thereby impairing one's ability to generate force and potentially leading to injury (17). Bracing has been shown to offer much more stability than hollowing and should be the preferred strategy during heavy strength training (8).

Progressions and regressions

A good strength coach understands how to adjust the difficulty of a core exercise depending on the level of fitness of the athlete. Lever lengths, ranges of motion, and amounts of resistance can be modulated to place athletes at their precise levels of fitness and provide the optimal challenge to their core. Beginners should master the basics before attempting more challenging core exercises. For example, the front plank must be mastered before a more challenging exercise such as the ab wheel rollout is ever attempted.

Core Exercise Categorization

Table 1 is intended to serve as a guideline to assist in creating customized core routines. Exercises labeled as "anti" are intended to resist force and therefore are performed for core-stability purposes, whereas the other exercises are intended to produce or reduce force and thus are performed for dynamic purposes.

Several things should be noted when reading Table 1. First, the core musculature is worked during the performance of traditional strength training exercises. Second, core training requires many different types of actions and movement patterns, and it is simply not realistic to target each of these aspects in a single session. Hence, strength and conditioning coaches should strive to cover a broad range of these categories in a given training week to ensure the athlete receives complete core conditioning. ■

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Table 1: Core Exercise Movement Patterns and Example Exercises

Type of Core Movement	Exercise Examples
Anti-spinal extension/Anti-anterior pelvic tilt	Push-ups, front planks, ab wheel rollouts
Anti-spinal flexion/Anti-posterior pelvic tilt	Squats, deadlifts, good mornings
Anti-spinal lateral flexion/Anti-lateral pelvic tilt	Side planks, suitcase holds, farmer's walks
Anti-spinal rotation/Anti-pelvic rotation	Cable anti-rotation presses, landmines, single-arm dumbbell bench presses
Spinal extension/Anterior pelvic tilt	Supermans, 45° spinal extensions
Spinal flexion/Posterior pelvic tilt	Reverse crunches, hanging leg raises
Spinal lateral flexion/Pelvic lateral tilt	Side bends, 45° side bends
Spinal rotation/Pelvic rotation	Cable chops, Russian twists
Anti-hip extension	Band hip flexor holds, Bulgarian split squat (rear leg), static lunge (rear leg)
Anti-hip flexion	Standing cable chest presses, half-kneeling anti-rotation presses
Anti-hip abduction/adduction	Side planks, top leg elevated side planks
Anti-hip external/internal rotation	Cable anti-rotation presses, landmines
Hip extension	Squats, deadlifts, lunges, 45° hip extensions
Hip flexion	Cable standing hip flexion, band lying hip flexion, ankle weight standing hip flexion
Hip abduction/adduction	Cable standing abduction, cable standing adduction, x-band walks
Hip external/internal rotation	Side-lying clams, band standing hip rotation, cable woodchops

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To Eat or Not to Eat: The Truth Behind Exercising on an Empty Stomach

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Even today, there are still many aspects of diet, exercise, and weight that remain controversial. Some health professionals believe that it is all about what is put on your plate that determines the number on the scale whereas others are more prone to rely on physical activity to keep the pounds at bay. The reality is that whether you are looking to manage weight or maximize athletic performance, the key is in balancing both diet and exercise, especially when fueling with food before a workout.

Among others, Bill Phillips, a former competitive bodybuilder and author of "Body for Life" has argued that performing cardiovascular exercise on an empty stomach will force the body to use stored fat rather than burning available carbohydrates. The reasoning may sound convincing, but in fact, recent research has found that the opposite is true.

A review published by Brad Schoenfeld in the February 2011 issue of the *Strength and Conditioning Journal* states that although overnight fasting for greater results may sound like a tempting idea, the science just doesn't support the theory (4).

All Fat Burn is Not Equal

The reaction of the human body to a workout is affected by a multitude of factors. Fuel is certainly one of them, but Schoenfeld also lists hormone secretions, transcription factors, and enzyme activity as potential limiting factors in fat burn during exercise (4). Additionally, fat burn during exercise alone is not indicative of fat burn over the course of a longer period. Based on the outcomes of prior studies, Schoenfeld explains that although the blood flow to fat tissue is lower during high-intensity exercise, those who engage in high-intensity versus moderate-intensity exercise experience greater fat loss over time, meaning that the immediate effect during the training period is less important than how your body sustains that burn.

Fasting and Fat Oxidation

Although previous studies have found that the breakdown of fatty acids is greater in fasting individuals performing low-intensity activities for a long period of time, no differences have been found in individuals performing moderate-intensity activities (1). Additionally, Schoenfeld discusses a study in which endurance-trained athletes cycled after being given a placebo, a placebo and a carbohydrate drink, or only a carbohydrate drink with variations on the timing before or during exercise. The study found no difference in impaired fat oxidation between the carbohydrate and placebo-fed groups (1). Together, these findings demonstrate that consuming a carbohydrate-rich meal before exercise will not impair the breakdown of fat. The increase of carbohydrate intake before an event, known as carbohydrate loading, is known to increase the stores of muscle glycogen, and potentially lead to increased athletic performance. However, this is only seen in activities greater than 90 min in duration. According to research, unless exercising for more than 90 min at a continued low-intensity, fasting will not lead to greater fat oxidation (5).

Quality Food is Fuel

Additional research has found that it isn't just when you eat, but what you eat that can affect the quality of your workout. Research found that individuals given lentils, a low-glycemic index food, experienced enhanced endurance running capacity when compared to individuals given potatoes, a high-glycemic index food or a placebo (2).

Table 1: Sample Meals

Breakfast	Lunch	Dinner	Snack
2 pieces whole wheat toast, 2 Tbsp Peanut Butter + ½ banana	Amy's Brown Rice and Vegetable Stir Fry Bowl + ½ cup low-fat yogurt and ¼ cup mixed berries	1 ½ cups Whole wheat penne, 1 can white tuna packed in water, 1 cup spinach + ½ cup grape tomatoes	1 cup lentil soup with 1 Tbsp low-fat sour cream
1 cup oatmeal topped with 1 Tbsp raisins and 5 sliced strawberries	2 slices whole wheat bread, 3 oz deli turkey, ¼ avocado + Clementine/orange	3 Whole wheat tortillas, 4 oz grilled chicken, ½ cup black beans and ¼ salsa–Make 3 individual soft tacos and top with sliced black olives	1 small whole wheat wrap spread with 1 Tbsp almond butter and 1 Tbsp sunflower seeds

Sample Meals for Fueling a Successful Workout

The key to a beneficial pre-exercise or pre-event meal is finding something that works well for you. Try some of the sample breakfasts, lunches, dinners and snacks in Table 1 to see which gives you the most energy and the least amount of discomfort during activity.

Exercise on an Empty Stomach Will Only Slow You Down

In order to fuel a workout properly, your body needs proper nutrition. A focus on what goes into your body before exercise can lead to enhanced performance during exercise. A healthy, high-carbohydrate meal eaten prior to exercise is important to ensuring that you reach your athletic goals (3). Make sure you leave enough time for digestion after a meal in order to strike a balance between feeling energized versus weighted down. Finally, understand that the best way to fuel is different for every athlete. For some, a larger meal 2 – 3 hr before sustained activity is best whereas for others, a smaller meal 30 min before is more effective (3). The key to optimal performance is to find just what food combinations work best for you. ■

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Exercises to Strengthen the Gluteus Medius Muscle

The gluteus medius (GM) is a laterally oriented hip muscle that contributes to core stabilization and athletic performance. It originates from the anterior and posterior gluteal lines on the lateral (external) surface of the ilium (pelvic bone) and attaches to the greater trochanter (the palpable lateral section) of the femur (thigh bone). The concentric muscle function of the GM is to abduct (move leg away from the body) and to rotate the thigh (either inward or outward depending on which section of the muscle). The primary functional role of the GM is to stabilize the pelvis during gait.

An athlete with dysfunctional GM strength may be at risk for lower extremity injuries including patellofemoral pain and low back pain (1,2). Improving GM strength may help to reduce the risk of injury and/or help return an athlete back to sport after an injury.

An individual with GM weakness may present lower extremity dysfunction during functional tests. For example, an athlete with GM weakness may possess "medial collapse" of the forward movement during a lunge, as seen in Figure 1. This article presents functional exercise progressions to improve GM strength.

Table or Floor Exercises

The clamshell (Figure 2) and the side-lying hip abduction (Figure 3) are effective exercises to train the GM in an open kinetic chain position. The clamshell is performed in a side-lying position with the hips slightly flexed and knees flexed to approximately 70–80 degrees. The top leg is lifted off of the bottom leg by rotating the thigh (separating the knees) without any trunk movement. The thigh is returned to the start position and the exercise is repeated for the desired number of repetitions. Another exercise is the side-lying, straight-leg raise which is also performed in a side-lying position. The legs and hips are positioned in a straight (or neutral) position. With the foot in a neutral position, or slightly rotated toward the ceiling, lift the leg 8–10 in. without any trunk movement. Perform 2–3 sets of 8–10 repetitions two times per week.

Integration into Functional Training Positions

As strength improves, the routine should progress from non-weight-bearing exercise positions to functional, weight-bearing exercises. This will emphasize GM stabilization and help overcome poor motor patterns. Exercises, such as lateral step-downs, lunges, and squats help to activate the GM. Perform 2–3 sets of 6–8 repetitions.

Seeking Help

Performing any exercise incorrectly may limit its effectiveness and/or contribute to injury. Consider working with a Certified Strength and Conditioning Specialist® (CSCS®). An NSCA-certified coach will be able to evaluate technique performance and guide proper progression. ■

References

1. Brumitt, J. Successful rehabilitation of a recreational endurance runner: Initial validation for the Bunkie test. *Journal of Bodywork and Movement Therapies* 15: 384–390, 2011.

2. Brumitt, J, McIntosh, L, and Rutt, R. Comprehensive sports medicine treatment of an athlete who runs cross-country and is iron deficient. *North American Journal of Sports Physical Therapy* 4(1): 13–20, 2009.

Figure 1. Medial Collapse of Leg During the Lunge

Figure 2. Clamshell

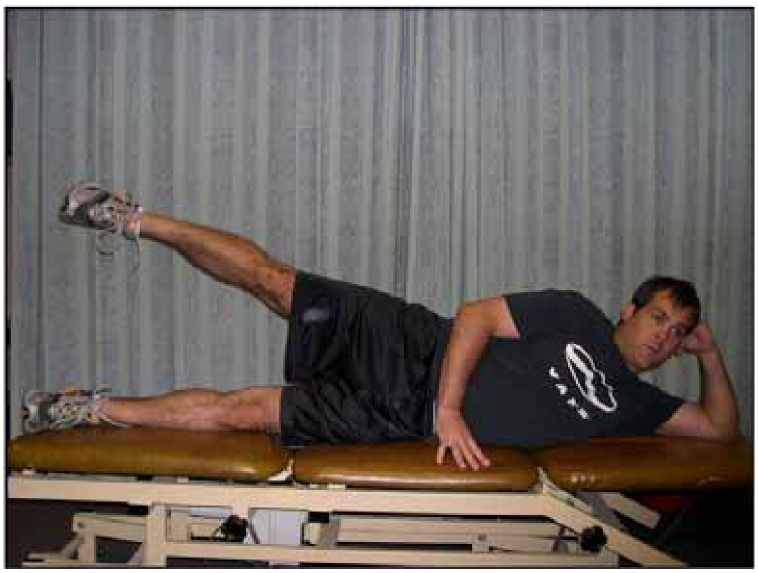

Figure 3. Side-lying Hip Abduction

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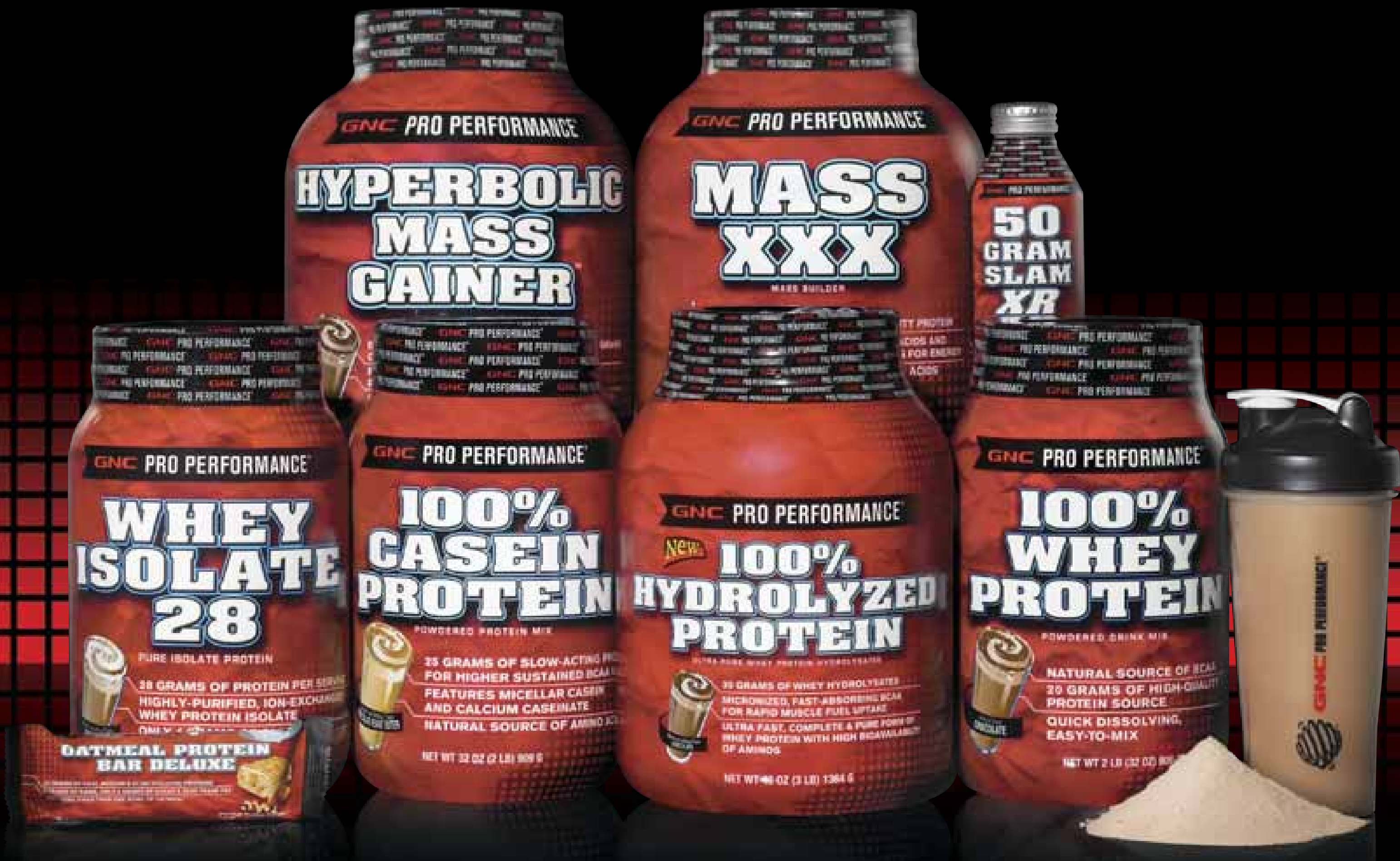

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