ENHANCING MOTOR LEARNING WITH SLED TRAINING

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Strength and conditioning programs for athletic performance can be broken into two main components—physiologic improvement and motor learning. While physiologic enhancement to strength, power, and endurance play a role in athletic success, they are relatively easy things to improve with consistent training. Sport-specific skill acquisition such as swinging a bat or shooting a basketball, however, takes thousands of quality repetitions in order to master and generally progress at a slower rate. Most coaches do not realize that strength training, plyometrics, and core conditioning all contribute to motor learning, when used appropriately.

When analyzing movement patterns, the human body moves through three planes of movement; sagittal (flexion/extension motions), frontal (ab/adduction motions), and transverse (rotary) (1). All movements take place in one of these three planes no matter how simple or complex, or utilize a combination of them simultaneously. Most strength and conditioning programs are made up primarily of exercises taking place in the sagittal plane against the vertical pull of gravity. Teaching athletes how to move more efficiently is more than just adding frontal, transverse, unilateral, or bilateral exercises into a program. It also has to do with the progression of movement patterns athletes learn, the combinations of movements participated in when exercising, and what is most commonly overlooked—the line of pull. This enhances neurological learning, but even more importantly, brain plasticity, or the ability of the brain to synthesize new movement patterns at a faster rate (2). Brain plasticity is promoted by teaching the nervous system a greater number of ways to create motor pathways, which send signals out to the muscular system (2).

Motor learning as a principle is analogous to trails created in a forest by animal traffic. The less a path is traveled, the more difficult it is to traverse the course due to forest overgrowth. The more a path is traveled, the greater the ground is worn, and if more routes from point A to point B are created, the animal can find a path to the destination in a shorter period of time. The nervous system works in a similar manner. The challenge is figuring out an efficient way of teaching athletes how to create plasticity through the training prescribed. Exposing athletes to a variety of movement patterns that simulate actual sport mechanics can enhance and shorten this learning process.

IDENTIFYING FUNDAMENTAL SPORT MOVEMENT PATTERNS

Most sports involve three common sport movements; swinging an implement, throwing an object, and a form of locomotion seen as linear, lateral, or a combination (agility) of the two. The difficulty is breaking these movements into simpler patterns that can be taught using conventional strength training and muscular conditioning. But even beyond this, the greatest challenge is finding exercises and routines that actually translate back to sport moves.

Performing a squat, bench press, jump, or simple medicine ball throw are all good ways to begin teaching gross movement patterns, however they fall well short of reproducing the actual

sport move in most instances. These exercises are dissimilar in both range of motion, tempo, rhythm, and execution when compared to full athletic movements. Even Olympic-style lifts are deficient in reproducing the movement patterns seen in most sports, as these exercises primarily take place in the sagittal plane against vertical resistance.

Most coaches waste a lot of time training their athletes in these areas because it is easy to see immediate improvements in absolute strength and power, which for a common athlete, can have a significant, initial positive influence on their sport performance. However, if the goal is to place the athlete in the best position for long-term success, a revised approach toward motor learning should be considered. In order to promote translation of power application into a sport movement, it is important to develop absolute power using these gross exercises but still perform a portion of the actual sport movement (i.e., swinging a bat).

The three common sport movements can be further broken into three movement patterns; hip flexion/extension, trunk rotation (torque), and a combination of lower body to upper body summation of force in a rhythmic manner.

Hip flexion and extension are critical to enhance hip displacement for jumping, stride length, and stride frequency. When trying to improve an athlete's speed, every movement of the body is about hip displacement across space. The faster the hips move for a given distance, the faster the body travels which is manifested as higher speed. Quicker velocities of movement translate to higher levels of competition in nearly every major sport.

Trunk rotation provides a mandatory translation of lower body power traveling through the spinal column and delivering this inertia into the trunk, leaving the arms and hands through either a throwing or swinging motion of an implement. Referred to as the serape effect, the velocity of throwing an implement or swinging a club (such as a bat, stick, or racket) is directly correlated to the amount of force transferred from lower body to upper body about the spine (3). By rotating the hips ahead of shoulders, an athlete is effectively "pulling" their shoulders behind their hips in a whipping motion. This creates a summation of forces, and when timed correctly, develops much higher velocities than if the trunk and upper body were used independently.

Finally, developing a slow to fast rhythm promotes maximum velocity for throwing and striking/swinging of an implement. This is achieved by initiating movements with the prime movers of the body (large muscles such as the gluteus maximus, hamstrings, quadriceps, latissimus dorsi, and pectoralis) followed by assisting or secondary movers (smaller muscles of the arms, legs, feet, and hands). Athletes must understand the timing of a movement to excel.

Recall that in order to create speed of an implement (bat or ball), maximum velocity must be achieved during the point in time of release or striking of the implement (i.e., throwing a ball or making contact with a bat). This happens because the athlete knows how to coordinate the kinematic chain of their body and times all of their body movements to achieve max power at the very moment they are needed. The question to coaches is what are you prescribing to your athletes to help them learn this outside of practice? Sled training can provide an invaluable tool that combines both sport movements with relatively unrestricted external, horizontal resistance.

PROMOTING ATHLETICISM THROUGH SLED TRAINING

As already mentioned, most strength and conditioning programs are dominated by sagittal plane exercises. Adding more frontal and transverse plane exercises, while helpful in promoting general motor learning, still may fall short of teaching advanced sport moves. In the context of developing absolute strength and rudimentary power enhancement, Table 1 provides an example of common learning progressions for lower and upper body strength development. While these exercises provide a solid base of strength, they still do not teach actual sport moves efficiently.

The sled is generally misunderstood as a limited training tool, or simply not used, primarily because many coaches consider training in the sagittal plane for straight line, such as with sprinting drills. This is a very limited application of this training tool and minimizes the true value. Sled workouts provide a training stimulus that more closely mimics real-world physical demands of life and sport because they can create horizontal resistance. Sport demands call for a combination of both vertical and horizontal requirements, with the majority being horizontal. Normal weight room exercises predominantly simulate vertical weight displacement; therefore it is necessary to develop strength in a horizontal plane.

Sled training also allows for frontal and transverse plane activities while in locomotion, something not readily available in the weight room. Injuries in these two planes generally occur due to lack of physical preparation at the tempos and intensities seen in competition. Using the sled helps train athletes for these types of physical stressors. It is in this way that sleds can help decrease the likelihood of injuries, and help develop strength, power, and speed that are transferable to performance. Refer to Table 2 for key coaching points related to sled training.

When utilizing sled exercises, coaches should use a modular system composed of three parts:

1. The sled where weight is loaded.
2. A length of rope between the harness/handles and sled, this should be around 6 – 8 ft long.
3. A set of handles tethered to the mid-piece to facilitate most moves. These can be purchased or constructed using simple rope and PVC pipe available at any hardware store. The handles should be at least 10 ft in length to accommodate most wingspans and arm lengths. A harness may be used for basic exercises such as sled sprints and are readily available through most sport equipment suppliers.

Table 3 provides examples of how to incorporate sled training into an overall weekly microcycle. Table 4 provides guidelines for prescribing individual sled workouts. Below are example sled exercises which help take the absolute strength developed with basic strength, plyometric, and medicine ball exercises, and applies them in the context of the three major sport moves. Doing 3 – 5 of these exercises for three sets of 100 yards each can easily occupy a 45-min workout when done with appropriate loading. It should be noted that all exercises could be increased in difficulty by beginning with bilateral execution of the movement and progressing to unilateral execution, and ultimately unilateral alternating execution after a few weeks of each step in the progression.

1. **Walking Bench Press** – Walk, performing a bench press. Take long, exaggerated steps almost like a lunge step. (Figures 1 and 2)
2. **Walking Lat Pull** – Same as a lat pull however walking backwards (Figures 3 and 4)
3. **Squat to Press** – Squat, lean forward against weight, stand explosively, and finish with an overhead press. (Figures 5 and 6)
4. **Walking Batter Ups** – Perform a swinging motion similar to throwing or swinging a bat. This exercise can be performed with a "crow's hop" movement similar to a baseball outfielder making a long throw. (Figures 7 – 10)
5. **Bear Crawl** – Use a harness and perform a forward bear crawl, similar to pushing a sled in football but with the load being dragged. (Figures 11 – 13)
6. **Squat to Pull** – Perform the squat to pull moving backwards. Perform a squat with arms extended, stand, execute a lat pull, then take backward steps while extending the arms back out until fully extended. (Figures 14 and 15)
7. **Crossover Step Jump** – Perform a crossover step and flex the lead leg, keeping the trail leg extended. Push off the lead leg and perform a jump. (Figures 16 – 18)
8. **Lateral Walk with Arms Extended** – Make a "triangle" by extending both arms holding the handles in front of the chest. This greatly works the trunk and other stabilizers. (Figures 19 – 21)
9. **Single-Joint Movements** – Any typical single-joint exercise, such as a biceps curl or triceps extension, can be simulated. Make sure to keep the sled moving at all times by constantly keeping the feet in motion.

When setting up a comprehensive strength and conditioning program, it is important to choose a variety of exercises that set up foundational strength yet still link the exercises back to the three common sport moves. While development of absolute strength and power with conventional strength training and conditioning is an integral component to performance enhancement, it is even more important to be able to convert this into usable athletic strength. Using sleds on a regular basis provides coaches with an avenue to complete this challenge.

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TABLE 1. COMMON EXERCISES TO ENHANCE ABSOLUTE STRENGTH AND RUDIMENTARY MUSCULAR POWER

TARGETED BODY SECTION	INTRODUCTORY EXERCISES	NOVICE EXERCISES	VETERAN EXERCISES	ADVANCED EXERCISES
Lower Body Strength	Bodyweight squat	Dumbbell or barbell squat or deadlift	Olympic-style lifts, rack squats or deadlifts	Deadlifts or squats using resistance bands or chains
Upper Body Strength	Push-up (modified/ regular), inverted row	Dumbbell or barbell bench press, pull-ups	Pressing exercises executed with unilateral movement, or partial ROM with lockouts or board presses, weighted pulling exercises	Pressing or pulling exercises using resistance bands or chains
Trunk Strength	Crunch, plank, sit-up, prone trunk extension (superman)	Lateral bends off raised platform, any variety of bodyweight abdominal work with external resistance	Modified deadlifts and squats to create low-leverage scenarios for trunk stability (e.g., good mornings)	Tire flips, medicine ball throws
Lower Body Power	Double-leg hurdle hop with soft landing, box jump with step down	Continuous double-leg hurdle or box hops	Single-leg hurdle or box hops	Depth jumps off a platform
Upper Body Power	Medicine ball chest thrust	Plyometric push-ups	Heavy weighted throws using a barbell, clapping push-ups	Depth drop off a platform into a push-up
Trunk Power	Medicine ball rotational throw or overhead throw with follow-through	Single-arm medicine ball throws	Medicine ball throws with a partner, or throws off a rebounding surface such as a wall	Medicine ball throws in reaction to striking an implement (use of a sling)

TABLE 2. KEY COACHING POINTS FOR SLED TRAINING

1. For the majority of exercises, there should be no 'slack' in the line connecting the sled, to the athlete.
2. The athlete should almost always have their feet moving with an upright trunk posture. If they are constantly walking, there should be almost no slack on the line as a result.
3. Execute most moves with an explosive, high velocity acceleration phase, and a controlled, 2-3 second long deceleration phase.
4. While momentum can be used, there should be a balance between control and speed to promote motor learning and overall quality of execution.
5. Start with basic moves and build to more complex ones.
6. Always control the movement. Some exercises call for aggressive pushing/pulling to facilitate body mechanics. However, all exercises should have a controlled deceleration phase to the lift.
7. Doing multiple sets substantially increases intensity, particularly for exercises late in the workout.
8. When form is bad, switch to something easier or stop the workout. Quality is more important than quantity.
9. Always emphasize correct body mechanics. While form/technique may breakdown, it should not be done completely wrong (i.e., rounded back, overuse of the rotator cuffs, etc.)
10. Don't train haphazardly. Write down distances, reps, and weights and progress. This will make athletes very strong when done regularly.

TABLE 3. EXAMPLE MICROCYCLE SCHEDULING

MONDAY	Heavy lower body lift, core conditioning with medicine ball, plyometrics
TUESDAY	Heavy upper body lift, total body sled training
WEDNESDAY	Conditioning with sprints, cardio, aerobic training with sleds as a recovery activity
THURSDAY	Total body strength training with dynamic effort/speed/hypertrophy
FRIDAY	Total body sled work with rotary and frontal plane work; not linear/sagittal exclusive, conditioning with the sled

TABLE 4. RECOMMENDATIONS FOR INDIVIDUAL SLED WORKOUT PRESCRIPTIONS

1. Use a straightaway that is at least 25 yards long.
2. Each exercise should be for a total of at least 100 yards (two 25-yard trips up and back).
3. The number of exercises and sets prescribed is dependent on time available.
4. Generally, doing 5-8 exercises for 100 yards each takes about 30 minutes. This takes into account explaining, demonstrating, coaching, and swapping weights or reconfiguring apparatus between exercises if necessary. This is the equivalent of ½ mile of externally resisted work involving total body sports mechanics. When was the last time you did this as part of your workout?
5. Rest for 1-2 minutes between sets, and emphasize, control, accuracy, high-intensity, and explosive movements.
6. This will be very challenging and taxing for the novice athlete. Remember that if form breaks down, choose a simpler exercise or provide recovery to promote overall quality.
7. Make sure athletes record the weights they are able to use for each exercise in the same manner they would a normal strength training routine. This is important to promote progression, consistent challenge, and increase self-confidence by seeing personal improvement.

FIGURE 1. WALKING BENCH PRESS

FIGURE 2. WALKING BENCH PRESS

FIGURE 3. WALKING LAT PULL

FIGURE 4. WALKING LAT PULL

FIGURE 5. SQUAT TO PRESS

FIGURE 6. SQUAT TO PRESS

FIGURE 7. WALKING BATTER UP

FIGURE 8. WALKING BATTER UP

FIGURE 9. WALKING BATTER UP

FIGURE 10. WALKING BATTER UP

FIGURE 11. BEAR CRAWL

FIGURE 12. BEAR CRAWL

FIGURE 13. BEAR CRAWL

FIGURE 14. SQUAT TO PULL

FIGURE 15. SQUAT TO PULL

FIGURE 16. CROSSOVER STEP JUMP

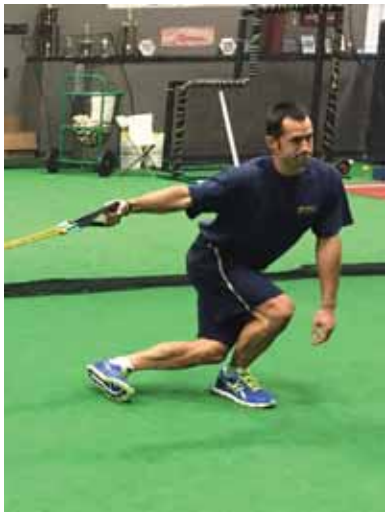

FIGURE 17. CROSSOVER STEP JUMP

FIGURE 18. CROSSOVER STEP JUMP

FIGURE 19. LATERAL WALK WITH ARMS EXTENDED

FIGURE 20. LATERAL WALK WITH ARMS EXTENDED

FIGURE 21. LATERAL WALK WITH ARMS EXTENDED