

Integration of the Kinetic Chain: The Trunk



Integration of the Kinetic Chain: The Trunk

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PEAK PHYSICAL THERAPY & SPORTS REHABILITATION



Central Theme



Objective/Goals



- Review Stabilization strategies/systems
- Review important anatomy
- Assessment of trunk musculature
- Program design
- Integration of exercises
- Proper exercise technique



Stabilizing Systems



- 3 Subsystems
 - Passive
 - Vertebrae
 - Discs
 - Ligaments
 - Active
 - Muscle and tendons that apply force to the
 - Neural



Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *J Spinal Disord.* 1992;5: 383-389.
Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *J Spinal Disord.* 1992;5:390-396.



Clinical Recommendations	
<p>SORT: Strength of Recommendation Taxonomy A: consistent, good-quality patient-oriented evidence B: inconsistent or limited-quality patient-oriented evidence C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series</p>	
Clinical Recommendation	SORT Evidence Rating
A therapeutic exercise program consisting of motor control exercises may help reduce pain and disability in patients with low back pain lasting longer than 6 weeks. (AAS-002)	B
Patients with low back pain lasting longer than 6 weeks may benefit from a therapeutic exercise program consisting of general back-strengthening exercises. (AAS-003)	B



Local vs Global



- **Local**
 - mono-articular deep muscles
 - attachments on or near the vertebrae
 - primary function eccentrically to control movement and maintain static stabilization
- **Global**
 - typically bi-articular superficial
 - muscles that connect the trunk to the extremities
 - Primarily function concentrically to produce large torques for movement and power

Bergmark A. Stability of the lumbar spine: a study in mechanical engineering. *Acta Orthop Scand Suppl.* 1989;230:1-54.
Gibbons SGT, Comerford MJ. Strength versus stability: part 1. Concepts and terms. *Orthop Division Rev.* 2001;2:21-27.



Local vs Global



- **Local**
 - TA
 - Multifidi
 - Intertransversi
- **Global**
 - TA
 - Erector Spinae
 - Rectus
 - Obliques
 - Quadratus Lumborum

Bergmark A. Stability of the lumbar spine: a study in mechanical engineering. *Acta Orthop Scand Suppl.* 1989;230:1-54.
Gibbons SGT, Comerford MJ. Strength versus stability: part 1. Concepts and terms. *Orthop Division Rev.* 2001;2:21-27.



Functional Model



- Local stabilizers
- Global Stabilizers separated into:
 - stabilizers (internal and external obliques, spinalis)
 - mobilizers (rectus abdominus*, iliocostalis).
- Stabilizers generate force eccentrically / isometrically to control movement throughout range of motion,
- Mobilizers concentrically accelerate through range of motion and act as shock absorbers, especially in the sagittal plane

Gibbons SGT, Comerford MJ. Strength versus stability: part 1. Concepts and terms. *Orthop Division Rev.* 2001;2:21-27.



Global system Transfer Load Muscles



- Are muscles with axial-appendicular attachments
 - (ie, gluteus maximus, gluteus medius, hip adductors, rectus femoris, iliopsoas, trapezius, latissimus dorsi, deltoid, pectoralis major)
- Transfer force and momentum between the extremities and core along the kinetic chain.
- Are separate yet integral to core stability because they have fascial attachments that stiffen the core and transfer force through the kinetic chain.

Behm DG, Drinkwater EJ, Willardson JM, Cowley PM. The use of instability to train the core musculature. *Appl Physiol Nutr Metab.* 2010;35(1):91-108.
Cobson M. Core stability, part 1: overview of the concept. *Int J Athl Ther Train.* 2012;17(1):8-13.
Cobson M. Core stability, part 2: the core-extremity link. *Int J Athl Ther Train.* 2012;17(2):10-15.



Target Muscles



- **Uni-segmental**
 - Force transducers
 - Provide feedback on spinal position
 - Work closely with neural system
- EXAMPLES:**
- Intertransversi muscles
 - Interspinalis muscles



McGill SM. *Ultimate Back Fitness and Performance.* 2004
Aster CT, McGill SM. *Medicine and Science in Sport and Exercise.* 1997.
McGill SM. *Low Back Disorders.* 2002.



Rotators and Intertransversari



- Small cross-sectional areas
- Contribution to rotation is minimal
- Vertebral position sensors



Longissimus, Iliocostalis and Multifidus group



- Divided into pars thoracic and pars lumborum
- Pars thoracics have a strong extensor moment with low compressive force
- Pars lumborum generates posterior shear forces that support reaction anterior shear force of the upper vertebrae



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Multifidus



- Forces only affect small areas of the spine
- Produce extension torque
- Hypothesis-also provides somatosensory input for positional awareness.



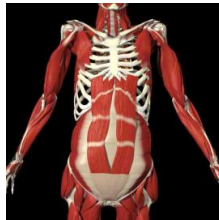
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Target Muscles



- Multisegmental muscles
 - Produce and control spinal motion
- Examples:
 - Transversus Abdominis
 - Rectus Abdominis
 - Lumbar Erector Spinae
 - Quadratus Lumborum
 - Obliques



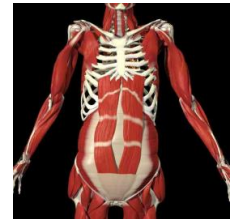
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Transversus Abdominis



- Inner surfaces of cartilage of lower six ribs to linea alba by aponeurosis
- Abdominal hollowing*
- Draw abdomen up and in
- Incorporate into the exercise program



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Rectus Abdominis



- Pubic crest and symphysis to 5th, 6th and 7th rib costal cartilage
- Major trunk flexor*
- All sections of the rectus are activated together
- No functional separation appears to exist between upper and lower abs*



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*Lehman, McGill, 2001



Erector Spinae



- Superman exercises
 - > 4000N of spinal compression
- Quadruped exercises
 - Minimizes spine load



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Quadratus Lumborum



- Attach to TP of all lumbar vertebrae, pelvis and rib cage
- Acts as a buttress to lateral instability
- Appears to be highly involved in spine stability



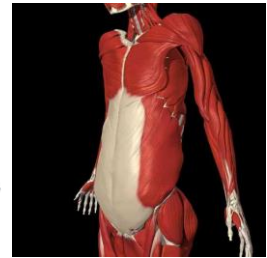
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Internal/External Oblique (Anterior view)



- Anterior and lateral fibers
- IO has upper and lower anterior fibers
- Lower anterior fibers support and compress lower abdominal viscera with TA



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Internal/External Oblique (Posterior view)



- Obliques are regionally activated (superior vs inferior)
- Increase activity when spine is axially compressed*



Jaker, McGill and Kropf, 1998

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Internal/External Oblique



- Assists with active expiration[^]
- Creates "hoop stresses" and stiffness with TA to assist with spine stability



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[^]Henke, et. al., 1988



Don't Forget Important Muscles

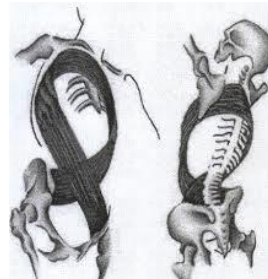


- gluteus maximus
- gluteus medius
- hip adductors
- rectus femoris
- iliopsoas
- trapezius
- latissimus dorsi
- deltoid
- pectoralis major

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Serape Connection



This figure shows the musculature involved in the serape effect.

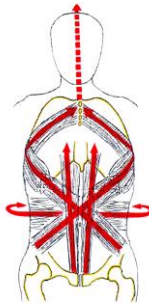
Rhomboids
 Serratus
 External Obliques
 Internal Obliques

McGill SM. Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro, 2014. pp. 111-122.
 Myers TW. The spiral line. In: Anatomy Trains: Myofascial Meridians for Manual and Movement Therapists (2nd ed). London, United Kingdom: Elsevier, 2009. pp. 131-147.

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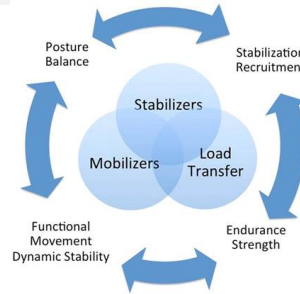


Serape



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Rare KP, Griggs M, Cadby T. Lumbar stabilization: a review of core concepts and current literature, part 2. *Am J Phys Med Rehabil*. 2007;86(1):72-80.

Bliven K, Anderson B. Core Training for Injury Prevention. Sports Health 2013

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EVALUATION



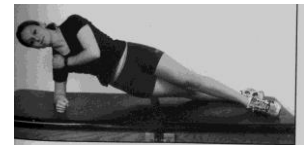
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Testing Muscle Endurance

• Side Bridge test

- Tests lateral muscles (obliques)
- Top foot placed in front of bottom foot
- Failure occurs when straight line position is lost and hip touches table



McGill SM. Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro;2014.

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Testing Muscle Endurance

• Flexion Test

- Tests abdominal muscles (rectus)
- Hips and knees at 90° angle
- Trunk rests against a board angled at 60° off the horizontal
- Board is pulled back 4 in.
- Failure occurs when any part of the back touches the board



McGill SM. Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro;2014.

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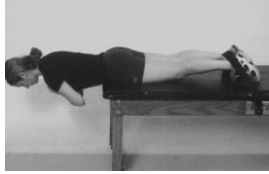
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Testing Muscle Endurance



- **Extension Test**
 - Tests back muscles (erector)
 - Hold in horizontal position
 - Failure occurs when upper body drops from horizontal



McGill SM, Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro, 2014.



Endurance Norms



- | | |
|--|--|
| <ul style="list-style-type: none"> • Men <ul style="list-style-type: none"> – Extension <ul style="list-style-type: none"> • 160 sec. – Flexion <ul style="list-style-type: none"> • 135 sec. – Side bridge <ul style="list-style-type: none"> • 96 sec. | <ul style="list-style-type: none"> • Women <ul style="list-style-type: none"> – Extension <ul style="list-style-type: none"> • 185 sec. – Flexion <ul style="list-style-type: none"> • 134 sec. – Side Bridge <ul style="list-style-type: none"> • 76 sec. |
|--|--|

McGill SM, Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro, 2014.



Endurance Ratios



- Right-sb/Left sb endurance < 0.05
- Flexion/extension endurance < 1.0
- SB (either side)/extension endurance < 0.75

McGill SM, Ultimate Back Fitness and Performance (5th ed). Waterloo, Canada: Backfitpro, 2014.



Neutral Spine



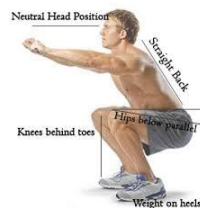
- Helps decrease shear loads
- Very important to teach
 - Hip Hinge
 - Depth
 - Foot width
 - Squat
 - Pull height
 - Deadlift
 - Kettlebell



Finding the Best Exercise(s)



- Access Athlete
- Access Sport Demand
- Choose best exercise



Program sessions



- Remove the cause
- Preparation / prehabilitation / warmup
- core work
- movement patterns
- specific athleticisms
- specific concerns



Training



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Considerations



- Peak / taper
- Phase and periodization
- Rest and recovery
- Injury history

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Guidelines



- Groove motion patterns, motor patterns, corrective exercise
- Build whole body and joint stability
- Improve Speed & Agility
- Build Strength
- Increase Endurance
- Develop Power & Explosiveness

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Goals of Training



- Produce high levels of muscle activation
- Low level of spinal loading
- Consider strength, endurance and neuromuscular factors

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Things to consider



- The spine needs to move – but is limited in the number of bends. The more the load while bending, the fewer the tolerable bends. Choose best way to use these.
- Loading and work causes adaptation but also temporary weakening. Muscle, bone, connective tissue will adapt. Discs do not. Repeated bending will eventually tip the balance to cumulative damage outstripping the pace of repair.
- Sparing the spine while training will lead to higher tolerable volume of training. Hundreds of situps will limit training volume.
- Restoration and interval training – more frequent rest intervals for tissue repair than muscle intervals.

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McGill SM. Low Back Disorders. 2002.

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Integration vs Isolation



- Isolation
 - Crunch
 - Oblique crunch
 - Planks
- Integration
 - Plank with extremity movement
 - Four point kneeling with extremity resistance
 - Pallof / Pistol presses
 - Battling ropes

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Stabilization Myths

- Sit ups
 - Replicates potential injury mechanism
 - Cause increase compression of lumbar spine and discs
 - Do not press low back against floor
- Leg raises
 - Increase psoas activation and spine compression

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Loads During Sit Up

Exercise	Moment (Nm)	Compression (N)	Shear (N)
Straight Leg	66	3234	257
Bent Knee	64	3413	302



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Spinal loads for specific exercises

Table 5.7 Low Back Moment, Abdominal Muscle Activity, and Lumbar Compressive Load During Several Types of Abdominal Exercises

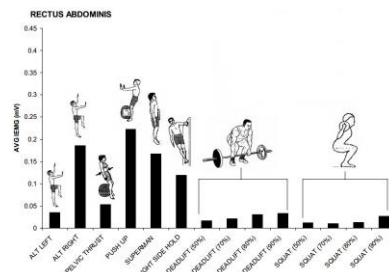
	Muscle activation			
	Moment (Nm)	Rectus abdominis (% MVC)	External oblique	Compression (N)
Straight-leg sit-up	148	121	70	3306
Bent-leg sit-up	154	103	70	3350
Curl-up, feet anchored	92	87	45	2009
Curl-up, feet free	81	67	38	1991
Quarter sit-up	114	78	42	2392
Straight-leg raise	102	57	35	2525
Bent-leg raise	82	35	24	1767
Cross-knee curl-up	112	89	67	2964
Hanging, straight leg	107	112	90	2805
Hanging, bent leg	84	78	64	3313
Isometric side bridge	72	48	50	2585

MVC, contractions were isometric. Activation values higher than 100% are often seen during dynamic exercise.

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Rectus Abdominals



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Stabilization Myths

- Strength
 - Poor association with low back health
- Range of Motion
 - Increased ROM may lead to greater risk of back injury
 - Must have enough stability for all motions
- Endurance
 - Most important in preventing back dysfunction

Biering-Sorensen. Spine 9:106-119, 1994

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Transverse Abdominal Contraction

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*Abdominal Crunch*

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*Stir the pot*

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*Plank to side plank*

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*Pray to side plank*

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*Four point Kneeling*

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Four point kneeling square



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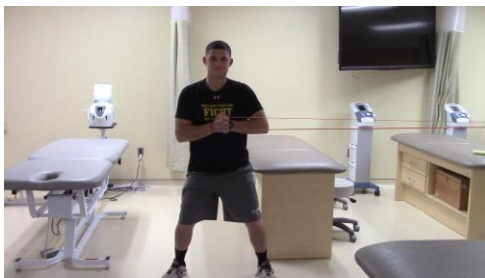
Pistol / Paloff press (Lateral flexion)



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Pistol / Paloff press (rotation)



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Pistol / Paloff press (flexion)



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Exercise Progression Abdominal Bracing Exercises (NWB)



Exercise	Criterion for Progression
Abdominal bracing (supine)	30 reps with 8 second hold
Abdominal bracing (supine) with heel slide	20 reps per leg on 4 second count
Abdominal bracing (supine) with leg lifts	20 reps per leg on 4 second count
Abdominal bracing (supine) with bridging	30 reps with 8 second hold
Abdominal bracing (supine) with single leg bridging	30 reps with 8 second hold

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*. 86:1753-62

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Exercise Progression Abdominal Bracing Exercises (WB)



Only progress to this group if patient is able to complete 20 reps second hold of abdominal bracing with bridging

Exercise	Criterion for Progression
Abdominal bracing (standing)	30 reps with 8 second hold
Isometric Torsion (row, cable)	20 reps per side on 6 second count
Abdominal bracing walking	10 minute with abdominal brace

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*. 86:1753-62

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Exercise Progression Anterior Trunk Exercises



Exercise	Criterion for Progression
Curl up elbows down with TAC (brace)	30 reps with 6 second hold
Curl up elbows up with TAC (brace)	40 reps with 6 second hold

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*; 86:1753-62



Exercise Progression Posterior Trunk Exercises



Only progress to this group if patient is able to complete 10 reps X 8 second hold of abdominal bracing in supine

Exercise	Criterion for Progression
Palms on counter: Alternating UE	30 reps X 8 seconds per side
Palms on counter: Alternating LE	30 reps X 8 seconds per side
Palms on counter: Alternating UE/opp LE	30 reps X 8 seconds per side
Elbows on counter: Alternating UE	30 reps X 8 seconds per side
Elbows on counter: Alternating LE	30 reps X 8 seconds per side
Elbows on counter: Alternating UE/opp LE	30 reps X 8 seconds per side

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*; 86:1753-62



Exercise Progression Posterior Trunk Exercises (cont)



Exercise	Criterion for Progression
Bolster: Alternating UE	30 reps X 8 seconds per side
Bolster: Alternating LE	30 reps X 8 seconds per side
Bolster: Alternating UE/opp LE	30 reps X 8 seconds per side
Quadruped: Alternating UE	30 reps X 8 seconds per side
Quadruped: Alternating LE	30 reps X 8 seconds per side
Quadruped: Alternating UE/opp LE	30 reps X 8 seconds per side

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*; 86:1753-62



Exercise Progression Lateral Trunk Exercises



Only progress to this group if patient is able to complete 10 reps X 8 second hold of abdominal bracing in supine

Exercise	Criterion for Progression
Abdominal brace with leg lift (sidelying)	30 reps X 8 seconds per side
Side bridge on wall with brace	30 reps X 8 seconds per side
Side bridge on wall with brace (↑ distance)	30 reps X 8 seconds per side
Side bridge with knees bent	30 reps X 8 seconds per side
Side bridge with knees bent and TAC	30 reps X 8 seconds per side
Side bridge with knees extended	30 reps X 8 seconds per side
Side bridge with knees extended and TAC	30 reps X 8 seconds per side

Hicks GE, Fritz JM, Delitto A, McGill SM. (2005). Preliminary development of a clinical prediction rule for determining which patients with low back pain will respond to a stabilization exercise program. *Arch of Phys Med Rehabil*; 86:1753-62



Advanced Exercises



- Rotation with tubing, physioball/standing
- Roll outs/walk outs
- Plate or ball tornos
- Stir the Pot on ball
- Bird Dogs with arm and leg movement
- Flutters
- Inverted pull ups
- Staggered push ups
- Single arm DB snatches
- Kettlebell Swings (snatches)
- Overhead squat
- SA overhead squat
- Suspension training
- Band/chain squats
- Crawling
- Bears
- Battling ropes



Glut/Ham Row Press



Slide Board Runs



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Band Planks



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Cable Planks



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Stability Push-Up



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Stability Push-Up Hold



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Fall Outs



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Flutter Fall Outs



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Tricep Extensions



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Overhead Squat



- Neutral spine a must
- Incorporates thoracic and lumbar extensors
- Increases demand by using weights in the hands



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Overhead Squat



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Overhead Band Squat



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Corner Barbell Squat Press



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Exercise Progression

Gluteal Integration with Abdominal Bracing Exercises



Exercise	Criterion for Progression
Single leg hip ER with ankle together and TAC (clam shells)	30 reps X 8 second hold side
Supine gluteal sets	30 reps with 8 second hold
Bridge with gluteal activation	30 reps with 8 second hold
SL bridge maintaining hip position	40 reps with 8 second hold



QUESTIONS



THANK YOU



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