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The Back Squat Part 2: Targeted Training Techniques to Correct Functional Deficits and Technical Factors that Limit Performance

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Abstract

The back squat is a well-researched and widely used exercise to enhance fundamental movement competency that creates a foundation for optimal mechanical strategies during a broad range of activities. The primary commentary introduced the Back Squat Assessment (BSA): a criterion based assessment of the back squat that delineates 30 potentially observable functional deficits. This follow-up commentary provides a targeted system of training cues and exercises to supplement the BSA to guide corrective intervention. We propose a criterion driven approach to corrective exercise that can support practitioners in their goal to help individuals achieve movement competency in the back squat.

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Introduction

The back squat is a well-researched and widely utilized exercise that can enhance an individual's ability to develop a fundamental movement competency for optimal mechanical strategies during a broad range of activities.(2, 10,13, 21, 25) Technical proficiency during squatting is beneficial for youth to help them correct and master optimal movement strategies during growth and development.(12, 13) Likewise, the squat exercise can help youth and young adults to improve physical performance and health.(18, 21) Adult and elderly populations can employ the squat exercise to promote daily living independence during activities such as sitting and lifting.(26) Based on the lifelong benefit of the back squat, the ideal opportunity to master the movement is likely during youth when the neuromuscular system is highly plastic.(23)

Training interventions that incorporate squatting exercises have been shown to improve physical performance and to decrease modifiable risk factors associated with sports related injuries.(8, 9,16, 17, 21) Correct and consistent squat performance is a prerequisite to safe progression to more intense training activities involving more dynamic or high load squat related exercises.(18) The back squat can function as both a fundamental training exercise and a screening tool to identify and correct functional deficits.(22) Specifically, we have previously outlined ideal back squat technique with 10 position and movement criteria and pinpointed 30 functional deficits that can be identified with the Back Squat Assessment (BSA).(22) The purpose of this follow-up commentary is to provide corrective strategies for each biomechanical deficit criteria.(22) The following proposed exercises to supplement the BSA, inclusive of corrective cues, are designed to be effective training tools to enhance the delivery of back squat exercise instruction by practitioners. It is hopeful that these proposed tools will result in improved physical health and ability for individuals of all training levels through deficit correction and optimal technique acquisition of the back squat.

Correcting Functional Deficits

The underlying deficits for incorrect back squat performance may be due to a myriad of limitations including miscomprehension of exercise instruction, poor neuromuscular coordination and recruitment, insufficient muscular strength or joint stability, and/or joint immobility.(22) The use of systematic analyses may help guide practitioners as they identify the underlying biomechanical or neuromuscular deficits responsible for poor back squat performance.(22) Once deficits have been identified, or are reasonably suspected, targeted corrective interventions can be implemented to begin to ameliorate functional deficiencies.

Practitioners should initiate corrective interventions by first assessing for miscomprehension of task instructions as the potential underlying cause for insufficient back squat performance. Instruction for the back squat must be clear, concise and age-appropriate (refer to Part 1 for script).(22, 23) If an athlete continues to demonstrate incorrect back squat

technique, the practitioner should attempt to re-emphasize the instructions and/or provide a visual demonstration of desired movement (e.g., instructor demonstration, peer observation, video analysis). If performance remains hindered, the practitioner is encouraged to then use corrective cueing in an attempt to improve technique.

Cueing can assist in correction for miscomprehension of instructions and poor neuromuscular coordination and recruitment. Cues can be in the form of verbal instruction, physical manipulation and/or visual aids; all of which have potential to aid an athlete in achieving the desired technique and mechanics during the back squat. Verbal cueing such as simple word instruction can assist a person to modify their technique by helping them to cognitively focus on a specific positional deficit or movement phases. An example of a simple verbal cue for each of the 10 back squat criteria is presented in Table 1.(22) Physical cueing, such as light tactile guidance from a coach or training aid (e.g., resistance bands), can support the desired correct positioning that can benefit a myriad of related deficits. For example, a practitioner can lightly press on the lateral portion of the individual's knees during the descent phase of a squat if they tend to demonstrate active valgus, or inward knee movement, as a means of providing a proprioceptive cue to correct positioning.. In addition, visual cues such as video footage of correct form or the use of a mirror so an individual can self-correct their form are also warranted as initial corrective strategies. Practitioners can significantly help their athletes identify and prioritize back squat deficits with targeted cueing strategies that are specific to an athlete's most egregious deficits. Specific and prioritized cuing can help optimize and individual's performance response and adaptations to the back squat.

Instructions or feedback provided by practitioners is often directed to body movements (e.g., "keep your knees over your toes").(1) In regard to motor learning, this type of attentional focus is termed internal focus. On the other hand, an external focus of attention is induced when an athlete's attention is directed towards an outcome.(1) External focus instructional strategies may enhance cueing and skill acquisition more efficiently than internal focus strategies and increase the transfer of improved motor skills to sports and daily living activities.(1) Research of motor learning has demonstrated beneficial effects of instructions that induce an external focus.(1) For example, newly learned motor skills with an external focus may be more likely to become automatic and retained. An example of using an external focus during the squat is to have an athlete visualize sitting back for a chair.(1) Although the current discussion breaks down squat technique into several position and movement criteria, which may promote internal focus on discrete body movements, it is recommended for practitioners to utilize external focus feedback strategies when possible to improve motor learning and retention of correct squat technique.(1)

If an individual's performance improves immediately through direct means of improved instruction or simple cueing (verbal, physical, visual), it is probable that their primary limitation from performing the back squat with correct form was due to their unfamiliarity with the movement pattern that they were being asked to perform. If the individual is still unable to achieve desired exercise technique through feedback attempts, neuromuscular deficiency, strength and stability, or mobility limitations may be at the root of their

failure(s). Consistent inability to demonstrate desired technique can be addressed next with targeted corrective exercise to ameliorate the specific deficits.(22)

Targeted Exercise Progressions

The corrective exercise progressions presented in this commentary are organized into the three major deficit categories: neuromuscular, strength and stability, and mobility limitations. The BSA differentiates the analysis of the back squat into 10 specific criteria to guide practitioner's assessment of the athlete. In the current commentary, we propose three associated progressive exercises to target each specific deficit category (neuromuscular, strength and stability and mobility) for each criterion.(22) Each proposed exercise is supplemented with a description the desired exercise technique. In addition to each description, a rationale, cue and a picture example of an athlete demonstrating the exercise are provided.

The progression scheme is designed to begin with the first corrective exercise for a category and continue in order to correct a particular biomechanical deficit. However, some athletes may respond to different exercises over others due to variations in anthropometrics, skill sets and training age. Therefore, the progression tool is only a supportive tool second to a practitioner's best judgment that should be based on the principles of pediatric exercise science and practical experience. It is outside of the scope of this commentary to include proposed volume and intensity (e.g., sets, resistance) for these exercises as these factors should be individualized and relative an athlete's entire training regimen. Nonetheless, it is highly recommended that an athlete demonstrates consistent and sound technique at lower intensity activities and volume before increasing these exercise prescription variables. In addition, practitioners should be cognizant and thoughtful of each individual's biological, training and cognitive ages when integrating the back squat into the training program.(23)

The selected exercises utilize a mixture of cueing, compensatory assistance, and resistance. When instructing the back squat, it is important to differentiate between cueing and compensatory assistance. Compensatory assistance from the instructor provides external physical assistance to improve exercise performance, whereas cueing is strictly cognitive feedback that requires the individual to utilize their inherent strength and mobility qualities without additional external assistance. Compensatory assistance makes an exercise easier to perform to guide an athlete's awareness of correct form and how correct form should feel. For example, a practitioner can provide an athlete with assistance such as using a horizontally held dowel rod for the athlete to hold during a back squat. With assistance, the athlete can more easily reach back into a squat to learn what it feels like to properly recruit posterior chain musculature by "reaching back." Resistance provides a stimulus that counteracts an individual's inherent strength and mobility for the primary purpose of strength and stability training. Moreover, resistance training not only promotes the strengthening of muscles, but also may provide a physical stimulus to make an individual more cognitively aware of their technique to promote correction. For example, during a front squat an athlete is made consciously aware of a load pulling their trunk into flexion and they must focus on recruiting their back musculature to counter this tendency. As a result, they are improving their neuromuscular ability to maintain their trunk at the desired angle due to

this physical stimulus. Typically, if an athlete's technique improves when resistance is applied as a stimulus, neuromuscular deficiency or lack of understanding of a desired task may be the most probable the limitation for inadequate performance.

Several strategies are suggested in this manuscript to help guide the correction of back squat performance. It is warranted that deficits are corrected one at a time and the most egregious deficit should be the targeted focus. By focusing on one deficit at a time, modifying mechanics will be more manageable and goal driven. In addition, more egregious deficits may be driving other observed deficits that may naturally improve after the first deficit is corrected. Some trial and error should be expected, however a practitioner must first and foremost ensure safety of their participants. If an athlete indicates pain or discomfort during any of the following exercises, it is advised to immediately cease training and consult a qualified health care provider.

Back Squat Criteria

Similar to Part 1, corrective intervention of the back squat will be discussed in three comprehensive domains that highlight 10 technique criteria.(22) These criteria are comprised of neuromuscular, strength and stability, and mobility improvement strategies to guide systematic corrective intervention.

Domain 1: Upper Body

- 1 Head Position
- 2 Thoracic Position
- 3 Trunk Position

Domain 2: Lower Body

- 4 Hips Position
- 5 Frontal Knee Position
- 6 Tibial Progression Angle
- 7 Foot Position

Domain 3: *Movement Mechanics*

- 8 Descent
- 9 Depth
- 10 Ascent

Domain 1: Upper Body

Domain 1 focuses on the musculoskeletal components of the head, neck, and torso that are responsible for maintaining postural control during the back squat.

1. Head Position

Corrective Strategy: Most athletes will possess adequate neck stability and mobility to execute the back squat. Neck stability is essential to provide support to the cervical vertebrae.(4) Verbal and tactile cues will generally be sufficient to assist an athlete to recognize and maintain a neutral head position throughout the squat. Adequate strength, stability, and physiological range of motion are imperative for more intense variations of the back squat that integrate external resistance. When instructing head position during the back squat, ensure that the athlete can self-identify and maintain a neutral head position throughout the squat before increasing intensity. It is not recommended to perform corrective training exercises if there is any discomfort to the head or neck. Mobility limitations or pain may indicate a more substantial underlying medical problem. It is warranted to seek advice from a qualified medical professional if the athlete has prolonged neck or head limitations during the unloaded back squat. Table 2 shows exercises that are recommended to improve head position awareness, neck strength and stability, and neck physiological range of motion for the squat:

2. Thoracic Position

Corrective Strategy: Corrective schemes for the thoracic position should focus on ensuring an athlete has the abilities to tightly retract the shoulder blades and hold the chest up and open throughout the squat to promote ideal thoracic spine support. Practitioners may benefit with utilizing neuromuscular focused corrective exercises initially to address lack of scapular retraction, forward rolled shoulders, and/or a chest that is not held upward. The athlete should be given cues which can help them disassociate their upper torso from their lower torso as chest position is independent from trunk angle. Verbal cues such as “keep your chest up”, “pinch shoulder blades together”, and “bend the bar around you” will encourage a proper setup with thoracic position prior to movement initiation. If necessary, a practitioner can provide tactile cueing to the athlete’s shoulders to correct position and to encourage the athlete to maintain correct posture throughout the exercise. A training technique is to place a finger between the athlete’s shoulders and instruct them to pinch the finger with their scapulae throughout the squat. In addition, the wooden dowel used in this assessment serves to assist the athlete in assuming a correct chest and shoulder position. If the athlete continues to demonstrate poor thoracic position during the back squat, then the deficit may be due to strength limitations of the upper back and/or lack of mobility. In particular, excessive tightness of the chest may hinder an individual’s ability to widen their chest and retract their scapulae. For example, Upper Crossed Syndrome, where an individual has tight pectorals and upper trapeziuses with weak deep neck flexors, rhomboids, and lower trapezius, affects posture as seen with increased cervical lordosis and thoracic kyphosis, elevated and protracted shoulders, and rotation or abduction and winging of the scapulae. (14) Mobility exercises of the chest along with strengthening exercises of the upper back may help athletes improve their ability to tightly retract their scapulae. Table 3 shows corrective exercises proposed to improve deficits in thoracic positioning during the back squat:

3. Trunk Position

Corrective Strategy: Trunk position corrections are primarily focused to address excessive trunk flexion and/or rounding (kyphosis) of the lumbar spine. If the athlete demonstrates excessive trunk flexion, verbal commands such as “point your belly button straight ahead” or “straighten your torso” may be helpful for the athlete to improve their posture. Furthermore, instructing the athlete hold their arms overhead or use a light load to hold may provide a physical stimulus to position their trunk more erect.

If posterior pelvic tilt or kyphosis (rounding of the back) is present during the maneuver, corrective strategies should first aim to ensure the athlete learns to obtain and maintain a natural, lordosis of the lumbar spine. This can first be demonstrated during normal standing activities. Once it is clear the athlete understands the desired position, more dynamic spinal extension and anti-flexion exercises may be warranted to help them correct spinal flexion deficits with neuromuscular focused exercises and corrective cueing.

Lack of mobility of the hip flexors (iliopsoas) and trunk flexors (abdominals) can also inhibit the athlete’s ability to obtain correct trunk posture. The squat movement requires sufficient spinal mobility to assume and maintain slight lordotic posture. Otherwise, individuals may tend to take forward posture and place excessive intradiscal pressure to the low back, especially if head is forward as well. If the athlete flexes at the spine at before approximately 120° of hip flexion when squatting, they may have restriction in the posterior fibers of the IT band that inserts into the gluteus maximus or lack of lumbar control. If an athlete demonstrates excessive trunk flexion and/or a kyphotic lumbar spine kyphosis during the back squat, the exercise progressions demonstrated in table 4 are recommended.

Domain 2: Lower Body (Triple Extension)

Domain 2 encompasses the musculoskeletal components of the three major joints (ankle, knee and hip) of the lower body associated with the movement phases of the squat exercise.

4. Hip Position

Corrective Strategy: The hip position criterion focuses on the frontal plane position of the hips. Constructive feedback is encouraged to help the athlete concentrate on keeping their hips level and to resist the tendency to overcompensate with their dominant side as observed with mediolateral hip dropping. Cues such as “stay square” and “keep your hips even” can be verbalized to promote pelvic stabilization. A visualization strategy to employ is to instruct an athlete to envision an invisible column that surrounds them or envision them as a piston of a motor, which can help them stay within the confines of the column by not allowing their hips to move mediolaterally. If hip position remains uneven, asymmetric strength of the hips or hip immobility may be the culprit for an observed deficit. The exercise progressions in Table 5 are recommended to promote level hips throughout the squat.

5. Frontal Knee Position

Corrective Strategy: Knee valgus or varus can be improved with neuromuscular training that incorporates various forms of immediate feedback. Progressions of triple extension

resistance exercises and progressive plyometric training have been shown to decrease valgus knee moments.(21) Cues that instruct the athlete to keep their knees apart during both descent and ascent are recommended. Elastic bands placed around the knees can provide tactile cueing to press out with knees as a corrective strategy to promote proper knee mechanics during the squat. In addition, providing video feedback of frontal plane deficits can help athlete identify this often unknown movement strategy.

Emphasis on improving the strength and function of the athlete's gluteal complex may have the greatest effect on limiting valgus knee angle during squatting.(3, 7, 8) Weakness of the gluteus medius and maximus may result in coupled femoral internal rotation and adduction during the squat which contributes to observed dynamic knee valgus. Since the gluteal muscles have a large role in both femoral external rotation and abduction, exercise selections that improve the strength and control from these powerful muscles groups will likely translate to the reduction of knee valgus during squatting.(24) Suggested exercises include variants of the squat exercise that have a focus on recruitment and activation of the posterior chain.

Valgus can also be influenced by quadriceps dominant muscle recruitment relative to the hamstrings.(6) Extensive research of anterior cruciate ligament injuries in the female athlete population has shown that low hamstring to quadriceps ratio is directly associated with dynamic valgus knee movement.(6, 9,11, 20, 27) Exercises that strengthen the hamstrings are warranted for those individuals who demonstrate active knee valgus. Phrases such as "knees out", "spread the floor", "tear out of the outsides of your shoes" will help give the athlete some internal cueing, which may lead to improved biomechanics. The exercise progressions in Table 6 are recommended to optimize knee frontal plane control during the back squat.

6. Tibial Progression Angle

Corrective Strategy: Tibial progression angle deficits may be best targeted with movement exercise cues focused at the hip joint and potentially with mobility improving exercises for the lower leg. Practitioners may be best advised to avoid specific cues that restrict forward knee movement as this can migrate more load onto the lumbar spine.(25) Typically tibial progression ankle, influenced by passive dorsiflexion at the ankle joint, will be influenced by flexibility of the calf musculature and mobility of the ankle joint. Alternatively the athlete could maintain their heels on the ground and have excessive tibial progression angle due to a quadriceps dominant squat and cues needed to affect the hip and trunk position. Providing cues such as "sit back into the squat" and "drive through the hips" are appropriate here. Video cueing of the athlete may be appropriate to influence self-evaluation of their tibial progression angle as it may be difficult to self-assess from the lateral perspective in real time. It is imperative that the heel maintain contact with the ground as tibial progression angle is monitored. If the athlete continues to demonstrate excessive forward tibial translation, the exercises in Table 7 are recommended to help ameliorate this technical deficit.

7. Foot Position

Corrective Strategy: The athlete should be encouraged to keep their entire foot on the ground throughout the squat with pressure towards the lateral aspect of the foot and the heel. Verbal cues such as “keep heels down”, “press down with heels”, and “sit through the heels” can help optimize foot and ankle position, especially if the deficit is primarily neuromuscular in nature. If the sides of the foot come off of the ground due to excessive ankle inversion or eversion and cueing does not improve form, the limitation may be associated ankle strength imbalances. The medial aspect of the foot rising off of the ground may not be as egregious of a deficit as the lateral aspect of the foot coming off of the ground. Placing excessive pressure on the inside of the foot may underlie undesirable knee positions, such as valgus. Inability to keep the heels down may be due to tightness in the posterior chain (e.g., gastrocnemius and soleus tightness) Posterior chain stretching and dynamic mobility drills can improve the ability to keep the heels down if the deficit is due to muscle tightness or immobility. It is important to remember that foot pronation can be a normal weight-bearing function of the foot when equal parts are shared by the multiple joints of the foot (rearfoot through forefoot), however excessive pronation may limit the potential for a more rigid and stable base of support. Without an ideal base of support by which force can be adequately directed, squat performance may be diminished. If athlete raises any part of their foot off the ground or demonstrates excessive foot pronation as well as ankle inversion or eversion, the exercise progressions in Table 7 are recommended.

Domain 3: Movement Mechanics

Domain 3 analyzes the kinematics of the squat and discusses the limitations from functional deficits on proper movement mechanics.

8. Descent

Corrective Strategy: The descent should be initiated with the breaking of the hips (‘hip hinging’) while maintaining a rigid, upright trunk.(22) The corrective techniques for proper descent during the squat can include both a physical and proprioceptive stimulus to achieved desired descent performance. The key areas to focus targeted correction for descent deficits are to ensure adequate strength and mobility to utilize a prescribed hip-hinge descent strategy, upright torso, and employing correct eccentric speed control. Practitioners should encourage athletes to initiate the back squat movement with a “break” at the hips and to immediately sit back on the heels. The athlete should be instructed to flex the hips, knees, and ankles to lower the body to the correct depth where the tops of the thighs at least parallel to ground without disjointed deviations noted at the knee, ankle or hips. One of the most common deficits presented with descent of the back squat is the use of a knee focused strategy (pressing knees forward) rather than a hip focused strategy that reaches back with the gluteals during descent. Verbal cues of “reach back” with the hips or having the athlete to perform the wall tap exercise (as described in the Descent Table below) may help influence desired descent strategy. We propose that back squat descent should be prescribed to take at least twice as long as the ascent and descent should maintain a consistent rate throughout the entire range of motion. The athlete should avoid descending too rapidly or “collapsing” due to the loss of eccentric control near the apex of depth.(15) Strengthening

exercises that focus on the eccentric control of the lower extremities can help correct this particular deficit. Additional strength or mobility deficits in the trunk, hip and lower extremity musculature may impair proper descent. Targeted interventions are listed in Table 9 to improve the athlete's ability to utilize the appropriate hip-hinge strategy, maintain a controlled movement speed and maintain an upright torso throughout the back squat.

9. Depth

Corrective Strategy: At the proper depth, the femurs should be slightly below parallel to the ground, hips are back, tibias are positioned vertical, and feet are entirely on the ground. The most common deficit of depth during the back squat is from the athlete squatting to a position that is too shallow. Targeted feedback and cueing may be the most advantageous to correct squat depth deficits. For example, physical cues such as a box at the appropriate depth can be used as a target. Athletes should utilize prescribed descent strategies that achieve thighs at least parallel to the ground. If the athlete cannot demonstrate desired technique throughout descent, it is recommended to use assistive strategies such as a practitioner-held dowel (see table: Depth). While squatting excessively past parallel can occur it is not often detrimental to the athlete. If contraindicated based on existing pathology, excessive squat depth can be easily corrected with targeted cueing and feedback or box squat techniques.

Inability to achieve depth may also be due to a lack of isometric strength of the posterior chain to maintain bodyweight support at the apex of depth. Strengthening the posterior chain utilizing isometric strengthening drills may help an athlete assume and hold a deep hold position at the apex of the squat in good form. Furthermore, tightness in the posterior chain musculature and hip adductors may further limit the ability for an athlete to achieve appropriate depth. Mobility drills that support improvements in mobility of the hip adductors and posterior chain can facilitate an athlete's potential to achieve proper back squat depth. In some cases, inadequate hamstring strength may be the culprit of a back squat that does not achieve proper depth and thus hamstring mobility and stretching drills are warranted in some training scenarios. The exercises in Table 10 are intended to improve squat depth ability and form.

10. Ascent

Corrective Strategy: Assessing the underlying mechanisms associated with improper ascent technique is critical for targeted deficit correction. It is most important to ensure the athlete drives with their hips as the primary mover and ascends while keeping their torso upright. The vertical distance between the hips and shoulders should be kept constant throughout the squat. Cueing that encourages athletes to "lead with their chest" or "rise with the shoulders" may be effective to ensure the athlete does not rise with their hips too quickly. If the athlete does rise with their hips too quickly, the vertical distance between the hips and the shoulder will decrease and will be a sub-optimal movement strategy. Neuromuscular training that promotes hip drive (i.e., hip extension) is recommended as well as drills that encourage an upright torso position during ascent. Hip drive can be improved through various hip extension exercises that improve explosive concentric muscle actions of the posterior chain. Lastly, it is important to ensure adequate mobility of the thoracic spine

and hip flexor mobility to encourage execution of the prescribed ascent technique.(22) The exercises in Table 11 are intended to target correction of the ascent movement strategy.

Conclusion

The corrective strategies for the back squat exercise are aimed to teach and generate competency in an essential functional movement for physical and daily living activities. The proposed corrective interventions are not intended to train athletes with the goal for maximum competitive load during the squat and the authors acknowledge that technical variants exist which may increase the potential to achieve maximum back squat load. However the current systematic approach is aimed to teach bodyweight squat technique that can serve as a precursor for more intense physical activity and training exercises.(5, 18, 19) Furthermore, optimal movement strategy retention gained from the proposed targeted training plan may decrease the risk of injury during anticipated and unanticipated physical activity.(23) The described methods for targeted exercise correction are designed to provide a systematic guide focused to improve biomechanical squat performance rectify deficits which underlie undesirable movement patterns. Through the implementation of a corrective intervention plan for biomechanical back squat deficits, athletes young and old will be poised to achieve substantive gains in physical performance, decrease the risk of sports-related injury and hopefully increase their quality of life by promoting a movement pattern that will support life-long participation in physical activity.

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Table 1

Verbal Cues for the Back Squat

Criteria	Cue example
1. Head Position	"Hold head flat"
2. Thoracic Position	"Widen your chest"
3. Trunk Position	"Point bellybutton forward"
4. Hip Position	"Square your hips"
5. Frontal Knee Position	"Point knee caps straight ahead"
6. Tibial Progression Angle	"Straighten your shin"
7. Foot Position	"Grip the floor with your heels"
8. Descent	"Reach back for a chair"
9. Depth	"Hips are at least knee height"
10. Ascent	"Lead with your chest"

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Table 2

HEAD POSITION

NEUROMUSCULAR				
DEFICIT: Insufficient head and neck proprioception for maintaining a neutral head position throughout the back squat. Poor disassociation of gaze from head position.				
TARGETED CORRECTION: Obtain ability to self-identify neutral head position. Disassociate neutral head position from gaze during squat. Must be careful with exercises for the neck by performing only smooth and controlled motions that do not cause pain or discomfort.				
Exercise	Description	Purpose	Cue	Example
1. Head Tilt and Return to Neutral: Lateral and Flexion/Extension	Tilt head to side, moving ear towards the shoulder on the same side, approximately half way to shoulder and return the head to neutral position. Hold the rest of the body still and rigid. Repeat on other side. Perform same instructions for cervical flexion and extension by tilting chin upward and downward.	Identify neutral head position.	"Slowly tilt chin"	
2. Bean Bag Head Drills	Perform back squat while a balancing bean bag (or similar lightweight object) on head as a guide for neutral head position.	Promote constant neutral head position throughout the squat with a physical cue.	"Flat head"	
3. Gaze Target Drills	Place a target on a wall at approximately eye level of the athlete 5–8ft away. Retain eye focus on the target without deviating head position from neutral throughout squat.	Disassociate head position from gaze.	"Keep eyes on the target"	
STRENGTH/ STABILITY				
DEFICIT: Insufficient neck stabilization strength to maintain the head in neutral alignment throughout the entire squat.				
TARGETED CORRECTION: Improve strength and stability of trapezius, cervical extensors, and cervical flexors. Must be careful with exercises for the neck by performing only smooth and controlled motions that do not cause pain or discomfort.				
Exercise	Description	Purpose	Cue	Example
1. Isometric Head Press: Lateral	Place open hand against the same side of the head. Press hand firmly against the side of the head, while also pressing the head against the hand to equally counter force. Hold the rest of the body still and rigid. Hold for 10 seconds. Repeat on other side.	Improve lateral cervical flexor strength.	"Firmly press head against hand"	
2. Isometric Head Press: Forward and Backward	Forward: Place one hand on the forehead and press firmly, while also pressing the head against the hand to equally counter force. Hold the rest of the body still and rigid. Hold for 10 seconds. Backward: Place one hand over the other on back of the skull above the inion, while	Improve cervical isometric strength.	"Firmly press head into hands"	














	also pressing the head back against the hands to equally counter force. Hold the rest of the body still and rigid. Hold for 10 seconds.			
3. Trapezius Shrug	Stand upright with arms relaxed to the sides. Raise shoulders to pull them towards ears without bending elbows. Pause and hold, then lower shoulders back to starting position. Hold the rest of the body still and rigid. Hand held resistance may be used to increase intensity.	Improve cervical and scapular strength, important for proper head and shoulder positioning.	"Pull shoulders up to ears"	
MOBILITY				
DEFICIT: Insufficient physiological range of motion of the neck.				
TARGETED CORRECTION: Obtain sufficient mobility of the neck. Must be careful with exercises for the neck by performing only smooth and controlled motions that do not cause pain or discomfort.				
Exercise	Description	Purpose	Cue	Example
1. Cervical Flexion/ Extension	Tilt chin towards the chest. Attempt to touch the chin to the chest or as far as possible without pain or discomfort. Then, tilt chin upwards as far as possible without pain or discomfort. Move head in a slow and controlled manner. Hold the rest of the body still and rigid.	Improve cervical mobility in the sagittal plane.	"Chin to chest"	
2. Lateral Flexion	Tilt head to the side towards shoulder. Only tilt head 45° or as far as possible without pain or discomfort. Pause and return to neutral position. Hold the rest of the body still and rigid. Repeat on opposite side.	Improve cervical mobility in the frontal plane.	"Ear to shoulder"	
3. Neck Rotations	Slowly rotate head approximately 90° or as far as comfortable up to 90°. During rotation, hold the body still and rigid. Pause and then return to the starting position.	Improve cervical mobility in the transverse plane.	"Look over shoulder"	

Table 3

THORACIC POSITION

NEUROMUSCULAR				
DEFICIT: Lack of scapular retraction, flexed spine or shoulders rolled forward during squat. Difficulty dissociating upper torso from lower torso.				
TARGETED CORRECTION: Obtain tight scapular retraction and a rigid chest up position throughout the entire squat. Generate ability to disassociate upper torso from lower torso.				
Exercise	Description	Purpose	Cue	Example
1. Scapular Pinch Throughout Squat	Perform back squat while trainer holds fingers between an athlete's shoulder blades. Attempt to pinch trainer's fingers by retracting shoulder blades and holding chest up. Maintain pinch throughout the entire exercise.	Physically cue athlete to retract shoulders and hold chest up.	"Pinch my fingers with your shoulder blades"	
2. Good Morning	Assume half squat stance and position chest up with dowel rod in back squat position. Perform isolated trunk flexion while maintaining chest up. Maintain tight upper back throughout the exercise. Knee joint should slightly flex on the descent and straighten out on the ascent.	Exercise fortifies chest up position independent from trunk angle.	"Lower torso forward while keeping chest up"	
3. Squat with Overhead Press	Perform back squat. At apex of squat, hold position and press dowel straight up over head by extending elbows. Return dowel to back squat position and ascend back to starting position.	This exercise improves chest up position during the apex of squat depth.	"Press dowel directly overhead"	
STRENGTH/ STABILITY				
DEFICIT: Inability to maintain chest up position or scapular retraction, which may be due to weakness of the spinal erectors, trapeziuses or rhomboids.				
TARGETED CORRECTION: Improve upper back strength to develop stable upper torso for squat.				
Exercise	Description	Purpose	Cue	Example
1. Band Pull Apart	Make two fists and hold arms straight out in front with palm side down. Pull arms slightly past 90° backward until shoulder blades pinch. Slowly return to start position. Grab both halves of the band and try a	To strengthen trapeziuses and rhomboids (parascapular muscles).	"Keep arms straight"	

	narrower grip for increased resistance.			
2. High Pull	Set up in quarter squat position with chest up and arms down straight. Hold dowel in overhand grip. Forcefully pull the dowel to clavicle height. Increase resistance as appropriate.	Improve upper back strength especially the trapezius muscles.	"Pull straight up"	
3. Front Squat	Hold lightweight object such as a small medicine ball or kettlebell at chest height. Perform squat exercise. Focus on maintaining upright torso. Increase resistance as appropriate.	Strengthen back musculature and promote postural control during squat.	"Lead with the object during ascent"	
MOBILITY				
DEFICIT: Excessive tightness in chest, potentially due to upper crossed syndrome, which hinders an individual's ability to open chest and retract scapulae.				
TARGETED CORRECTION: Improve pectoral and shoulder mobility.				
Exercise	Description	Purpose	Cue	Example
1. Backward Arm Circles	Stand tall with arms straight and out to sides with palms up. Perform 10 reverse circles in a slow controlled motion. Start with small circles and work up to larger circles.	Improve pectoral and shoulder mobility.	"Slow, large controlled circles"	
2. Wall Slides	Stand tall with back, head, and buttocks against a wall. Hold arms against the wall at 90 degree angles with palms outward. Extend arms upward as high as possible while attempting to keep back, head, and buttocks in contact with the wall. Hold for 10-15 seconds and return to starting position. Work to maintain maximum contact on the wall with the body as mastery improves.	Improve shoulder mobility.	"Keep back on the wall"	
3. Scapular Press	Stand tall with dowel in back squat position. Perform a press to move the dowel above head with elbows extended. To accentuate the upward rotation of scapula, lift the	Correct lack of upward rotation of the scapula.	"Press shoulders up and extend"	

	shoulders upper towards the ears and feel the scapular rotate upward. Hold for 10 seconds.			
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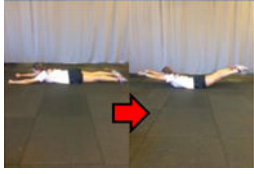
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Table 4

TRUNK POSITION

NEUROMUSCULAR				
DEFICIT: Excessive trunk flexion and/ or rounding (kyphosis) of the lumbar spine during squat.				
TARGETED CORRECTION: Improve awareness for and proprioception of appropriate trunk angle parallel to tibias and neutral, slight lordosis lumbar spine position.				
Exercise	Description	Purpose	Cue	Example
1. Cat/Cow	Assume quadruped position on knees and hands. Practice alternating from rounded back posture to arched back posture.	Identify difference between lordotic and kyphotic positions.	"Dip spine down and round spine up"	
2. Ball Wall Squat	Pin a ball (similar to small Swiss ball) between the lower back and wall. Squat down while keeping ball pinned against the wall. The ball will roll up to the shoulder blades. Ascend and repeat.	Exercise facilitates a more vertical trunk position because horizontal force from wall serves as assistance. Ball rolling encourages the correct spinal curve.	"Slide down the ball"	
3. Pole Squat and Fix	Perform squat near a sturdy pole or column. At apex of squat, use column as assistance to pull torso into correct position and hold. Heels must remain on the ground.	Assistance to help athlete self-generate and learn correct deep hold position.	"Hold pole and fix"	
STRENGTH/ STABILITY				
DEFICIT: Inadequate core strength to maintain torso parallel to tibias and lack of lower back tightness to generate stability. May be due to trunk extensor weakness and hip extensor weakness.				
TARGETED CORRECTION: Improve trunk stability, trunk extensor strength and hip extensor strength to maintain slightly extended lordotic position and trunk parallel to the tibias throughout the squat.				
Exercise	Description	Purpose	Cue	Example
1. Plank	Hold plank position with emphasis on maintaining lordosis throughout exercise.	Improve isometric strength of the back musculature and promote correct lumbar spine position.	"Straight as an arrow"	
2. Superman	Lay flat on stomach with your arms straight out in front and legs straight out behind. Keep arms and legs shoulder-width apart for the duration of the exercise. Lift your legs and arms simultaneously at least 6 inches off the ground. Keep each movement slow and	Strengthen the lower back musculature.	"Raise chest and arms together"	




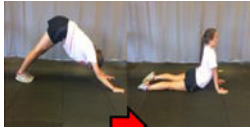



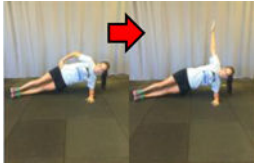

	controlled to prevent pulling muscles.			
3. Overhead Squat	Perform squat with dowel in overhand grip overhead with elbows extended.	Strengthen back musculature and promote erect trunk during squat.	"Keep the dowel behind your eyes"	
MOBILITY				
DEFICIT: Lack of mobility of the hip flexors (iliopsoas) and trunk flexors (abdominals).				
TARGETED CORRECTION: Improve spinal extension mobility to assume and maintain slight lordosis posture. Mobility of trunk flexors and hips flexors necessary for appropriate trunk angle.				
Exercise	Description	Purpose	Cue	Example
1. Standing Back Arch	Stand up straight with hands on hips and thumbs on the lower back. Extend hips forward and push abdomen forward, while maintaining a slight arch in back. Hold for 10 seconds.	Improve hip flexor mobility.	"Push hips forward"	
2. Cobra	Lay on stomach with hands flat just outside of the shoulders. Extend elbows to lift torso off of ground. Place small arch in lower back and pull shoulders slightly backward. Keep hips on the ground for this exercise. Hold for 10 seconds.	Improve trunk flexor mobility.	"Lengthen your abdomen"	
3. Chaturanga	Begin in downward dog position. Extend hips, bend elbows, and lower torso into push-up position. Push up into cobra position by arching back and raising chest. Keep hips elevated off of the ground for this exercise. Reverse back into push-up position and then back to downward dog.	Improve trunk flexor mobility and core strength.	"Smoothly transition between each position"	

Table 5

HIP POSITION

NEUROMUSCULAR				
DEFICIT: Hips are asymmetrical in frontal plane during squat with observation of mediolateral dropping.				
TARGETED CORRECTION: Develop proprioception to maintain even hips and pelvic control throughout squat.				
Exercise	Description	Purpose	Cue	Example
1. Single Leg Hip Tilts	Stand tall on one leg. Tilt trunk and hip to one side, pause, and then correct back to neutral hip position.	Obtain and identify even hip position.	"Even out hips"	
2. Single Leg Squat	Stand tall on one leg with hips in a neutral position. Squat to at least parallel, while maintaining the line of the hips in frontal plane parallel to the ground. Push through the heel to return to the starting position. Perform box squat variation to start and graduate to no box as athlete gets stronger and masters the lift.	Maintain even hip position during more difficult task.	"Keep weight on heel"	
3. BOSU/ Balance Board Squat	Perform squats on an unstable surface (i.e., balance board, Airex pad, BOSU). Can further challenge individual by attempting single leg squats on an unstable surface.	Maintain even hip position during more difficult task.	"Keep hips square"	
STRENGTH/ STABILITY				
DEFICIT: Lack of strength or stability of hip musculature or asymmetrical strength of hips.				
TARGETED CORRECTION: Focus on hip abductor strength. Hip abduction exercises are important because they strengthen the muscles that stabilize the femur into the hip joint.				
Exercise	Description	Purpose	Cue	Example
1. Side Plank	Lie on side with feet stacked and with forearm on ground perpendicular to the body. Lift body off of ground so only forearm and lower foot are contacting the ground. Isometric hold.	High recruitment of gluteus medius motor units.	"Stack hips and feet"	
2. Split Squat	Perform squats in lunge position. Let back knee come to a few inches above ground. At apex, front foot should remain flat and back foot heel can slightly raise off of the ground. Torso and front tibia are upright and parallel to each other.	Generate higher demand from unilateral hip musculature in deeper hip and knee angles	"Keep front shin straight"	


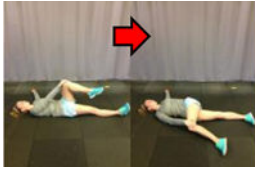






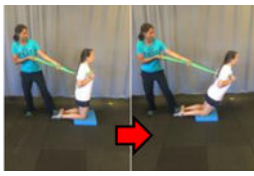

<p>3. Duck Walks</p>	<p>Stand with hands on hips and feet hip width apart. Squat down keeping torso upright. Step forward with right foot with toes pointing slightly outward. Pause. Repeat with left foot, returning feet to hip width.</p>	<p>Trains gluteus medius and maximus, which are primary movers in the squat. Encourages upright torso position.</p>	<p>"Stay low with belly button pointing forward"</p>	
<p>MOBILITY</p>				
<p>DEFICIT: Lack of hip flexion range of motion.</p>				
<p>TARGETED CORRECTION: Improve hip musculature to obtain physiological range of motion necessary to perform full squat, while keeping hip line parallel to the ground in the frontal plane.</p>				
Exercise	Description	Purpose	Cue	Example
<p>1. Crossover Stretch</p>	<p>Lie on back with legs extended. Lift left leg and bend the knee to the chest. Cross left leg over the right side of the body. Press the left leg to the floor with the right hand to feel a stretch. Repeat with the opposite side.</p>	<p>To stretch hip musculature.</p>	<p>"Press the knee towards the floor"</p>	
<p>2. Fire Hydrant</p>	<p>In quadruped position, lift one knee laterally. Maintain constant knee angle and flat back.</p>	<p>Improve lateral hip mobility.</p>	<p>"Keep back flat"</p>	
<p>3. Hip Circles</p>	<p>Start in quadruped position (on hands and knees with flat back). Point one knee up and outward 90° while keeping knee bent at about 90° of flexion. Trace large circles with knee while maintaining flat back with slight lumbar lordosis. Perform 10 reps clockwise and 10 reps counterclockwise. Repeat on other leg.</p>	<p>Improve hip mobility.</p>	<p>"Draw a circle with your knee"</p>	

Table 6

FRONTAL KNEE POSITION

NEUROMUSCULAR				
DEFICIT: Active valgus during squat; increased hip adductor activation and increased co-activation of the gastrocnemius and tibialis anterior muscles leads to valgus.				
TARGETED CORRECTION: Remove tendency to utilize active valgus strategy during squat.				
Exercise	Description	Purpose	Cue	Example
1. Wide Stance Squat	Remove teBody weight squats with 1.5–2x shoulder width. Have athlete focus on keeping knees apart	Wide stance will promote knees to track over feet and avoid valgus collapse.	"Push knees outward"	
2. Band Squats	Use Theraband or practitioner's hands to encourage athlete to press outwardly against during body weight squat	A physical cue to push knees outward.	"Push knees outward"	
3. Squat Jump	Perform forward countermovement jump. Land softly in deep hold position with chest up.	To promote keeping knees apart when jumping forward.	"Land with knees apart"	
STRENGTH/ STABILITY				
DEFICIT: Passive valgus during squat motion.				
TARGETED CORRECTION: Improve hip abductor, hamstring, and gluteus strength to reduce medial knee displacement.				
Exercise	Description	Purpose	Cue	Example
1. Single Leg Romanian Deadlift	Stand with feet shoulder-width apart with hands slightly more than shoulder-width apart. Move one foot slightly behind the other, holding it a few inches off the ground. With back flat, slowly lower the torso toward front foot and allow free leg to float behind you for balance. Once the weight reaches mid-shin level, push through grounded heel to return to the upright position, and repeat on the opposite leg.	To improve single leg knee stability.	"Make a T"	
2. Russian Hamstring Curls	Kneel on the floor with feet behind and torso up straight. Hook feet under a bench or ask someone to hold ankles down. Cross arms on chest and keep hips extended. Slowly lower down to the floor. Be prepared to catch	To improve eccentric hamstring strength.	"Lead with your hips when descending"	

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	yourself. Lower yourself forward as low as possible, and then raise yourself back up.			
3. Single Leg Isometric Squat and Hold	Stand tall on one leg with line of hips parallel to the ground. Single leg squat to at least parallel and keep heel on the ground. Hold at apex of depth and return to extended knee position. Focus on keeping torso vertical and prevent medial knee movement of stance leg. Increase intensity of exercise by standing on an unstable surface.	Single leg knee stability and strengthening exercise.	"Point knee straight"	

MOBILITY

DEFICIT: Joint hypomobility causing altered front plane position (i.e., valgus) during squat.

TARGETED CORRECTION: Improve range of motion of hip adductors and hip internal rotators.

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Exercise	Description	Purpose	Cue	Example
1. Standing Leg Swings	In standing position, swing leg laterally from side to side.	To improve hip adductor mobility.	"Isolate hip"	
2. Side Lunge	Step out with one leg laterally and perform a lunge to one side. Repeat on opposite side.	To improve hip adductor mobility.	"Keep non-lunging leg straight"	
3. Carioca	Move laterally by stepping lead leg sideways and alternating the trailing leg in front of and behind the lead leg	To improve Hip adductor and internal rotator mobility.	"Maintain upright posture"	

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Table 7

TIBIAL PROGRESSION ANGLE

NEUROMUSCULAR				
DEFICIT: Knee translates excessively over toes during squat, even with heel on the ground.				
TARGETED CORRECTION: Develop awareness for correct tibial progression angle.				
Exercise	Description	Purpose	Cue	Example
1. Lunge and Hold	Athlete lunges. Trainer assists to improve tibial progression angle. Use trainer assistance (i.e., elastic band, dowel) if necessary.	Identify correct tibial progression angle.	"Straight shin"	
2. Walking Lunges	Start with reverse lunges. Place weight in rear to keep shank upright. Step into next lunge without intermediate step (one foot should always be in front of the other). Use skills and technique developed in reverse lunging to keep knee from excessive TPA even when moving forward.	Inhibit excessive tibial progression angle when moving forward.	"Transfer bodyweight to back heel when moving backward"	
3. Wall Squat	Perform body weight squats with barrier (i.e. wall) at limit of tibial progression angle. Knees should not forcefully press against barrier at apex of depth.	Physical cue to prevent excessive tibial progression angle.	"Reach bottom away from heels"	
STRENGTH/ STABILITY				
DEFICIT: Lack of strength of posterior chain to keep knee from translating excessively over toes. Excessive tibial progression angle can be a result of weakness in calf and soleus, weak hamstrings, weak gluteus or excessive quadriceps dominance relative to the hamstrings.				
TARGETED CORRECTION: Improve posterior chain strength, especially calves, hamstrings and gluteus maximus.				
Exercise	Description	Purpose	Cue	Example
1. Step Up	Find a box or step approximately 1 ft. of the ground. Step onto box with one foot and use that foot to press other foot to the box. Step down first with second foot on the box. 10 reps. Repeat with other foot as the lead. Can use resistance to increase intensity.	Ensure knee on step tracks in line with foot and without excessive tibial progression angle.	"Straight shin on ascent"	
2. Heel Touches	Stand on a step or box approximately 1 ft. off of the ground. Have one leg hang off of the side. Perform single leg squat with opposite leg moving towards the ground. It is important to keep the pelvis even throughout the movement. Just before contact of the foot with the	Ensure knee on box is without excessive tibial progression angle and functions as a unilateral leg strengthening exercise to promote side to side strength symmetry.	"Press on box to ascend"	

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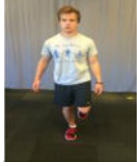


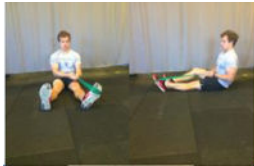





	ground, use the foot on the step to press back up.			
3. 1 and 1/4 Squat	Squat down for a 5-second count until thighs are parallel to the ground. Come up a quarter of the way at a slow and deliberate pace then descend back to parallel. Ascend to starting position.	To ensure recruitment and strengthening of the vastus medialis oblique at the bottom of a squat.	"Slow and controlled speed"	
MOBILITY				
DEFICIT: May not have adequate mobility of knee in sagittal plane. Lack of mobility of soleus and gastrocnemius.				
TARGETED CORRECTION: Ensure adequate mobility of knee in sagittal plane by improving mobility of calf and quadriceps.				
Exercise	Description	Purpose	Cue	Example
1. Toe Touches	Stand upright. Reach down for toes. Stretch posterior chain.	Improve mobility of knee and hip musculature.	"Reach for toes"	
2. Straight Leg March	Walk forward with straight leg and opposite arm forward reach. Alternate sides on each step.	Improve mobility of knee and hip musculature.	"Bring toes to straight arm"	
3. Leg Kicks: Forward and Backward	Stand upright and swing one leg forward and backward. Athlete may need a support to balance during this exercise.	Improve hamstring and gluteal mobility.	"Swing toes to eye level"	

Table 8

FOOT POSITION

NEUROMUSCULAR				
DEFICIT: Foot comes off of ground during squat not due to strength or mobility limitations.				
TARGETED CORRECTION: Promote squatting mechanics that emphasize placing body weight on heels and even distribution of weight side to side of foot.				
Exercise	Description	Purpose	Cue	Example
1. Single Leg Balance	Stand on one leg on stable surface with slight bend in knee, place other leg so foot is touching stance leg knee. Can use unstable surface more challenging variation.	Develop flat foot stability awareness and balance.	"Grip the ground with your toes and heel"	
2. Y Balance	Standing on left foot with a slight bend in knee, attempt to touch 3 points with the right foot. Touches should be as light as possible and no weight transfer should occur. The whole stance foot should remain in contact with the ground the entire time. First touch out in front as far as possible in good form, then 125° to the right and then 215°. Return to the original position. Repeat on opposite side in opposite direction.	To maintain entire foot on ground even when shifting weight on a single leg.	"Do not place pressure on tapping foot"	
3. Toes-Up Squats	Squat with toes off of ground, place weight onto heels.	Promote heel down mechanics.	"Lift toes off the ground"	
STRENGTH/ STABILITY				
DEFICIT: Lack of or asymmetrical ankle strength and/or poor stabilization of ankle and foot. Foot rolls onto either side during squat.				
TARGETED CORRECTION: Improve ankle and foot strength for drive and to keep whole foot on ground. Improve stabilization of ankle inverters and everters as well as intrinsic foot muscles to allow foot to pronate. Strengthening the plantar flexors with direct heel raises can enhance ankle joint stability.				
Exercise	Description	Purpose	Cue	Example
1. Ankle Band Strengthening	Plantar flexion: Using a resistance band around forefoot, hold the ends of the band with hands and gently push ankle down as far as you can comfortably and hold for about 10 seconds, then relax.	Strengthen ankle plantar flexors, inverters, and everters.	"Isolate ankle movement"	

	Inversion/Eversion: Start by sitting with foot flat on the floor and pushing band outward against a band. Then, pull band in opposite direction.			
2. Calf Raises	Start by transferring body weight towards your toes. Contract your calves and lift heels off of ground. Do not to rotate ankles. Lower down slowly, keeping body weight forward on your toes. Can also perform single leg calf raise for more challenge.	Strengthen plantar flexors.	"Press down on balls of feet"	
3. Single Leg Hops	Stand on one leg and hop in place attempting to land in the same spot each time. Repeat on opposite leg.	To promote single leg eccentric control.	"Soft landings"	
MOBILITY				
DEFICIT: Lack of dorsiflexion mobility if heels come up off ground due to restricted Achilles tendon and tight soleus and gastrocnemius.				
TARGETED CORRECTION: Achieve adequate ankle mobility to keep foot on ground throughout squat through lengthening of calf muscles.				
Exercise	Description	Purpose	Cue	Example
1. Ankle rolls	Lie on back with hands to the side. Raise one leg up about 6–12". Roll ankle clockwise 10 times and then counterclockwise 10 times. Maintain knee angle with slight flexion throughout. To increase complexity, attempt to draw the alphabet with the big toe.	Achieve ankle mobility in three planes.	"Draw circles with the big toe"	
2. Static Calf Stretch	Stand facing the wall. Place both of your hands onto the wall at chest height. Position your right leg back and your left leg forward -- it should look like a staggered stance. Keep both heels on the ground and lean forward toward the wall. A tolerable stretch on the back of the extended calf should be felt. Hold for 20 to 30 seconds, switch legs and repeat three to four times.	Stretch gastrocnemius and soleus.	"Press heel towards the ground"	

3. Heel Walks	Walk on heels with toes off of the ground. Do not continue if pain or discomfort.	Promote dynamic mobility of gastrocnemius and soleus	"Point toes upward"	
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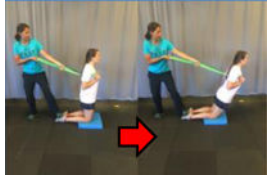
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Table 9

DESCENT

NEUROMUSCULAR				
DEFICIT: Knee dominant strategy instead of hip hinge strategy as seen with excessive trunk flexion, excessive tibial progression angle, and/or heels coming off of the ground.				
TARGETED CORRECTION: Teach athlete to utilize hip hinge movement pattern. Time hip, knee, and ankle flexion together at even pace. Descent should be twice as long as ascent in duration.				
Exercise	Description	Purpose	Cue	Example
1. Wall Taps	Keep feet planted 2–3 feet in front of wall. Reach back to touch rear to wall and return. Focus on reaching back.	Instill hip hinge movement strategy by reaching back.	"Reach back for the wall"	
3. Tempo Squatting	Set exaggerated ratio for decent: ascent of squat (e.g., 5:1)	Fortify slow descent pace.	"Slowly lower to the box"	
3. Assisted Squatting	Trainer provides assistance (e.g., dowel rod or elastic band) for athlete to perform slow, continuous decent with hip hinge strategy that recruits posterior chain musculature.	Provide assistance to learn correct descent strategy.	"Sit to a chair"	
STRENGTH/STABILITY				
DEFICIT: Lack of lower limb eccentric strength control, evidenced by an overall lack of control of the tempo of the descent, with the athlete 'dropping' into the apex of the descent. Decent timing is not 2:1 ratio with ascent.				
TARGETED CORRECTION: Enhance eccentric muscle strength of the posterior chain musculature.				
Exercise	Description	Purpose	Cue	Example
1. Eccentric Focused Kneeling Fall	Kneel on comfortable surface with partner supporting ankles. Lean forward with neutral hips and attempt to hold body up as long as possible before catching yourself with arms in a push-up position. Do not perform this exercise if the athlete is unable to catch themselves and support their bodyweight with their arms. Can use band assistance similar to Russian hamstring curl.	Eccentrically strengthen posterior chain.	"Lower as slowly as possible"	




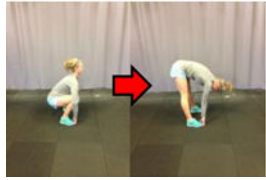

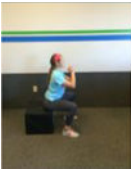




2. Box Drop Deep Hold	Drop from a box with both feet landing simultaneously. Drop into deep hold position (position at apex of squat). Recommend to start at 1 ft. height for depth jump and increase height systematically.	Dynamically strengthen posterior chain during eccentric muscle action.	"Quiet landings"	
3. Pause at Descending Levels	Divide decent into 5 even segments. Lower to each segment and pause before further descending. Consider using a box. Instructor can use verbal cueing to signal athlete when to move to each segment.	Eccentric and Isometric strengthening of posterior chain. Isolate lower phase of descent to strengthen corresponding posterior chain musculature.	Signal 5 depth levels using countdown of "1-2-3-4-5"	
MOBILITY				
DEFICIT: Lack of lower limb mobility, leading to a forward trunk lean.				
TARGETED CORRECTION: Improve lower limb range of motion with hip extensor emphasis.				
Exercise	Description	Purpose	Cue	Example
1. Hurdler Stretch	Sitting on bottom, extend one leg with toes up and bend the opposite leg so the sole of foot is on medial thigh of the extended leg. Reach forward with both arms in attempt to touch the toes (or past) of the extended leg to stretch the hip extensors.	Stretch posterior chain relative to the squat.	"Reach past your toes"	
2. Hamstring Stretch to Squat	Stand with feet shoulder width apart. Squat down and grab tips of toes. Knees should shoot outside of arms. Slowly try to straighten legs as you stand until stretch is felt along back of thighs. Immediately descend again for the next repetition without letting go of feet.	Stretch posterior chain relative to the squat.	"Slowly rise"	
3. Pigeon Pose	Sit on ground and tuck one leg underneath body, keeping knee bent. Fold body over the top of bent leg as the opposite leg is maintained straight.	More intense posterior chain stretch.	"Reach forward"	

Table 10

DEPTH

NEUROMUSCULAR				
DEFICIT: Athlete does not achieve depth of thighs at least parallel to the ground.				
TARGETED CORRECTION: Athlete improves awareness/proprioception of desired depth with good form.				
Exercise	Description	Purpose	Cue	Example
1. Box Sit	Athlete sits on box of desired depth height.	Identify correct squat depth.	"Sit up tall"	
2. Tactile/ Verbal Cueing	Athlete descends to depth. Instructor utilizes verbal cueing to provide feedback as to proper depth or distance still to achieve max depth.	Identify depth while supporting body weight.	Indicate correct depth	
5. Eyes Closed Depth	Athlete performs squat with eyes closed to build proprioception for correct depth.	Improve proprioception for depth awareness.	Indicate correct depth	
STRENGTH/ STABILITY				
DEFICIT: Athlete lacks posterior chain isometric strength to maintain deep hold.				
TARGETED CORRECTION: Improve isometric strength of posterior chain.				
Exercise	Description	Purpose	Cue	Example
1. Assisted Squat and Hold	Assisted squat to provide assistance at apex of squat for isometric hold.	Provide assistance to train with isometric muscle action for the desired depth.	"Reach buttocks away from heels"	
2. Pole Hold	Athlete uses a study column or pole to assume and maintain deep hold as long as possible. Athlete should try to use pole as little as possible and only use assistance to fix position as needed.	Train with isometric muscle action for the desired depth with assistance to fix.	"Straighten shins and torso"	


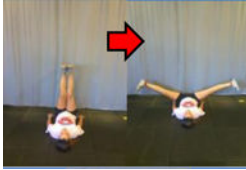







3. Deep Hold	Athlete maintains chair position with thighs parallel to ground and torso parallel to tibias.	Train with isometric muscle action for the desired depth with no assistance at correct depth.	"Sit as if in a chair"	
MOBILITY				
DEFICIT: Difficulty achieving depth due to tightness in posterior chain and hip adductors.				
TARGETED CORRECTION: Improve mobility of lower extremity musculature to achieve depth.				
Exercise	Description	Purpose	Cue	Example
1. V Stretch	Sit on ground. Positions legs straight above on wall. Spread legs apart for groin stretch.	Stretch hip adductors.	"Spread legs until you feel a stretch and hold"	
2. Sumo Stretch	Squat down with bottom lower than knees and torso upright. Press outside of elbows against the inside of the knees to feel groin stretch.	Stretch hip adductors.	"Push out against knees"	
3. Figure 4 Stretch	Lay on back with knees bent and feet off of the ground. Cross the left leg over the right thigh. Reach through legs and gently pull the right thigh toward the chest until a stretch is felt in the buttock and hip of the right leg. Repeat for opposite leg.	Stretch piriformis.	"Pull thigh to chest"	

Table 11

ASCENT

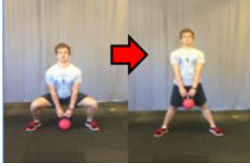


NEUROMUSCULAR				
DEFICIT: Athlete does not drive with hips as primary mover or hips rise too quickly in relation to the shoulders.				
TARGETED CORRECTION: Athlete uses hips as primary mover and maintain shoulders and hips the same distance apart throughout ascent.				
Exercise	Description	Purpose	Cue	Example
1. Glute Bridge	Lay supine with feet flat on the floor with heels close to buttocks. Place hands palm down by sides. Push hips upward with shoulders still in contact with ground. Hold and lower.	Emphasize hip drive.	"Hips to the ceiling"	
2. Hip Thrusts	Perform continuous glute bridges in a controlled manner. Emphasize driving upward with the hips.	Emphasize hip drive.	"Hips to the ceiling"	
3. Ball Lead Squat	Hold ball chest height. Perform squat with emphasis of leading with the ball during ascent.	Promote leading with the chest during ascent.	"Lead with the ball"	
STRENGTH/ STABILITY				
DEFICIT: Posterior chain and hip extension concentric muscle action weakness.				
TARGETED CORRECTION: Improve concentric strength of posterior chain.				
Exercise	Description	Purpose	Cue	Example
1. Box Sit to Stand	Place a plyometric box or chair behind the athlete. The height of the box should be slightly higher than the approximate depth of their observed fault. The height of the box should gradually be reduced in order to work towards full depth capability.	Promote hip drive and pushing through heels to ascend.	"Press down on heels and use hips to stand"	
2. Vertical Countermovement Jump	Athlete squats down to available depth while maintaining form and immediately jumps vertically.	Train using an explosive concentric exercise of posterior chain.	"Explode upward and use soft landings"	

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<p>3. Sumo Deadlift</p>	<p>Squat down to weights/bar, grasp them, and stand up by raising hips and shoulders at same time, keeping the weights/bar close to thighs. Finish in neutral, extended position. Reverse in a slow and controlled manner to lower back to the ground.</p>	<p>Strengthen posterior chain and improve postural control.</p>	<p>"Keep chest up, press down on heels, through with hips"</p>	
<p>MOBILITY</p>				
<p>DEFICIT: Lack of thoracic spine and hip flexor mobility.</p>				
<p>TARGETED CORRECTION: Improve thoracic spine and hip flexor mobility.</p>				
Exercise	Description	Purpose	Cue	Example
<p>1. Lunge Hip Flexor Stretch</p>	<p>Lunge with back knee on the ground. Extend torso backward. Repeat on opposite side.</p>	<p>Static hip flexor stretch and thoracic spine stretch to improve mobility.</p>	<p>"Lean back"</p>	
<p>2. Donkey Kicks</p>	<p>In quadruped position, kick backwards with sole of foot towards the ceiling. Maintain knee flexion angle.</p>	<p>Hip flexor mobility exercise that emphasizes a postural position relative to the squat.</p>	<p>"Plant footprint on the ceiling"</p>	
<p>3. Scorpion</p>	<p>Lay flat on stomach with arms straight out to the sides and with legs together and extended. Flex the left knee to raise lower left leg toward the ceiling. Twist at the hips to reach the left foot over to the right side of the body. Attempt to keep arms and chest flat on the ground. Once opposite foot is as close to opposite hand as possible, return to start and immediately go the other direction with the other leg.</p>	<p>To stretch the lower-back, gluteus, and hamstring mobility.</p>	<p>"Keep chest on the ground"</p>	