HOW TO UTILIZE CONTRAST TRAINING FOR STRENGTH, POWER, AND PERFORMANCE

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For athletes and individuals with performance-based goals, it is well-established that performing both strength and plyometric training is far more effective for improving strength, power, speed, and overall performance than performing one or the other exclusively (2,19,59). However, not all forms of combined strength and plyometric training are created equal. In particular, one such method that has garnered widespread attention among strength and conditioning coaches and researchers alike is contrast training (also referred to as complex training).

As popularized by Verkhoshansky and Siff in *Supertraining*, contrast training has become an intriguing method of combined strength and plyometric training for its well-established ability to improve a multitude of athletic qualities simultaneously (15,54). In fact, numerous studies, reviews, and meta-analyses have suggested that contrast training may lead to greater improvements in various measures of performance (e.g., sprint speed, jump height) than any other form of combined strength and plyometric training (12,16,24).

However, contrast training is a complex modality that strength and conditioning coaches should seek to understand prior to its implementation. As such, the goal of this article is to provide an introduction to contrast training. It will be defined, variables will be explored, and examples of contrast training will be provided.

THE BASICS OF CONTRAST TRAINING

At its core, contrast training is a hybrid strength-power modality that involves pairing a heavy resistance exercise with a high-velocity movement of the same biomechanical pattern (e.g., squats and vertical jumps). The physiological underpinnings are based on the phenomenon of post-activation potentiation (PAP), which refers to the enhancement of muscular performance (i.e., quantity and rate of force development) following maximal or near-maximal muscular contractions (16). In practice, the theory is that inducing PAP through heavy resistance exercise can increase muscle force capabilities in subsequent high-velocity movements by 1 – 5% more than is possible in PAP's absence (5). Verkhoshanksky described it in more simple terms: PAP "is like lifting a half-can of water when you think it's full" (54). Performed consistently over the course of 4 – 12 weeks, the overarching purpose of contrast training is to translate PAP's acute effects into chronic improvements in muscle force potential (16).

HOW PAP WORKS

Although the exact physiological mechanisms responsible for PAP are not entirely understood, there are two primary theories as to how it works. The first proposes that the initial stimulus elicited by the heavy lift increases motor-neuron pool excitability (i.e., the force-generating capacity of the working muscle groups), which may occur via H-reflex potentiation, greater central input to the motor neuron, the recruitment of more motor units, enhanced synchronization between motor units, and/or decreased presynaptic inhibition (1,24,50). The second theory is that PAP occurs due to the phosphorylation of myosin light chains (P-MLC), which increases the sensitivity of actin-myosin interactions to calcium ions and thus enhances the force output of successive fast-twitch muscle contractions (23,48,53).

However, Tubman et al. found that P-MLC was not the only mechanism responsible for PAP, while other research has suggested that muscle pennation angles and tendon stiffness may play a role (5,52). It is thus likely that PAP occurs as a result of multiple interactions between neural and intra-/inter-muscular mechanisms (7,15).

CHRONIC BENEFITS OF CONTRAST TRAINING

Most studies investigating contrast training have focused on the acute benefits of PAP, often demonstrating its ability to facilitate significant short-term improvements in sprint speed (10,31), jump height (21,33,37), upper body power (18,20), and muscular strength (32). As a result, its efficacy in the short-term is well-documented and largely supported by most reviews and meta-analyses, although some literature has reported varying results (29,45).

However, there have been far fewer studies looking into the long-term effects of contrast training beyond the short window of PAP, which raises questions as to its effectiveness for producing chronic improvements in power and other performance-related metrics (15). Fortunately, recent research has emerged shedding light on contrast training's long-term effects, most notably as it relates to increasing lower body power (e.g., sprint speed, jump height), upper body power, and muscular strength (5).

LOWER BODY POWER

In looking at contrast training's chronic impact on lower body power—namely, sprint speed and jump height—more research has emerged in the last decade comparing it to alternative forms of strength and power training (5). Among several promising studies, Tsimahidis et al. randomly split up 26 basketball players aged 18 ± 1.2 years into a control group and a "combined training group," the latter of whom performed 30-m sprints after each set of heavy resistance training (whereas the former did not) (51). Prior to the 10-week training period, there were no significant differences in strength, sprint times, or jump height between groups (51). However, after 5 and 10 weeks of training, the combined (contrast) training group experienced marked improvements in acceleration (0 – 10m) and maximal velocity (0 – 30) tests by approximately 0.2 and 0.3 s (9% and 6%) respectively, although the improvements in acceleration between weeks 5 – 10 were not statistically significant (51). The control group, however, experienced no significant changes (51). Furthermore, in looking at three different measures of jump performance (squat jumps, countermovement jumps, and drop jumps), the combined training group showed significant improvements in each of the three jumps after 5 and 10 weeks, whereas the control group did not (51).

Another study of note split up 18 female hockey players aged 25 ± 3.7 years into two groups at random, one of whom incorporated contrast pairings into their training while the other group did not (38). All else being equal, the group who performed contrast training displayed significantly improved sprint performance (by 3% more than the control group) and countermovement jump height (by 16% more than the control group) after eight weeks of training (38). Additional studies in support of contrast training's impact on lower body power have reported similar long-term improvements in subjects' speed, agility, horizontal jump abilities, and peak jumping power (9,34,40,43).

UPPER BODY POWER

Although upper body contrast training has not garnered as much attention as its lower body counterpart, some studies have suggested that it may be effective for producing chronic improvements in upper body power (5,34,43,44). In particular, one eight-week study demonstrated that, among 18 – 23 year-old males performing the same baseline program, those who contrasted plyometric push-ups with bench pressing experienced a mean increase of 8.5% in peak upper body power, whereas those who did not only experienced a 3.4% increase (34). In addition, Santos et al. found that, on top of increasing jump performance and agility times, 10 weeks of contrast training facilitated significant improvements in medicine ball throw power in male basketball players aged 14 – 15 (43). Other studies have observed similar improvements in upper body power following extended periods of contrast training (5,44). However, Burger et al. reported that seven weeks of contrast training had no significant effect on upper body power in Division I football players (perhaps due to their initial strength levels and/or training status) (9).

STRENGTH

In addition to improving power, one benefit of contrast training is its ability to increase strength, or the ability to exert force independent of velocity (40,51). One particularly noteworthy study separated 30 young male athletes aged 19 – 21 years into contrast training and "complex training" (i.e., separate strength and plyometric work) groups and found that, over the course of three months, the former group experienced greater increases in lower body, chest, and back strength by 10.1%, 6.1%, and 6.8%, respectively (40). In addition, the previously mentioned study conducted by Tsimahidis et al. on 18 – 20-year-old basketball players found that the group who performed contrast training displayed significantly greater increases in one-repetition maximum (1RM) squat strength than the control group after 5 and 10 weeks (by nearly 20% and 30%, respectively), despite there being no significant differences in strength between groups prior to training (51). However, some reviews have speculated that combined strength and plyometric training may impede strength gains due to the inhibition of physiological pathways, although that topic has not been addressed directly in other research related to contrast training (13). As an additional note, the impact that contrast training may or may not have on hypertrophy is yet to be investigated, although the positive relationship between strength and muscle mass may warrant further research (55).

IMPLEMENTATION: VARIABLES TO CONSIDER

Like many things in strength and conditioning, there is no pre-written script on how to implement contrast training. There are multiple variables in need of consideration that, depending on the circumstances, may warrant completely different protocols from one individual to the next. The key to implementing contrast training successfully, then, lies in understanding the four primary variables that can impact its efficacy: individual characteristics, exercise selection, loading parameters, and rest periods (5).

INDIVIDUAL CHARACTERISTICS

Most of the research related to PAP has demonstrated that the effects are extremely specific to the individual (20). In particular, training status, strength levels, and muscle fiber type composition all play a significant role in determining the magnitude of PAP's effects (5,12).

- **Training status**: A meta-analysis by Wilson et al. compiled results from 32 studies and observed that individuals who were categorized as "trained" or "athletically trained" demonstrated significantly more favorable responses to PAP than those who were "untrained" or "recreationally trained," although no uniform standards were established to objectify their categorizations (57).
- **Strength levels**: Multiple studies have concluded that stronger subjects respond better to PAP than weaker subjects, although the standards used to quantify strength levels varied between studies (11,47,57).
- **Muscle fiber type composition**: Individuals with a higher proportion of type II fast-twitch muscle fibers have been shown to respond more strongly to PAP, which coincides with the previous point considering the positive relationship between muscular strength and type II muscle fibers (11,20,49).

The different measures used to quantify training status, strength levels, and muscle fiber type composition across numerous studies make it difficult to establish objective guidelines as to how and to what extent individual characteristics influence PAP's effects (or a lack thereof). As a result, it is recommended that personal trainers take a trial-and-error approach when designing contrast training programs (20).

EXERCISE SELECTION

In selecting heavy strength exercises within a contrast pairing, the tried-and-true multi-joint movements are preferable to single-joint movements due to their involvement of multiple muscle groups and higher loading capacities—both of which increase the magnitude of PAP's effects—as well as their functional carryover to sport (58). For paired high-velocity movements, most recommendations suggest choosing exercises with relatively low "skill" demands (e.g., jumps and medicine ball throws), as the complexity of more technical alternatives such as the Olympic lifts may inhibit speed of movement in novice trainees (35).

As an additional consideration, it is suggested that contrast pairings should employ biomechanically similar movement patterns (e.g., squats paired with vertical jumps) to enhance PAP's effects and facilitate the greatest improvements in muscle performance (16). Moreover, Contreras suggested that doing so may be advantageous for ingraining efficient neural patterns, as biomechanically similar pairings may enable individual's to perform the chosen lift in a manner more specific to athletic activity (13). Interestingly, Baker et al. observed that alternating between agonist and antagonist movements may be another effective option for eliciting PAP, which led to the conclusion that agonist-antagonist pairings may be worth exploring in future studies (4).

LOADING PARAMETERS

Most research on PAP has demonstrated that a large range of loading parameters and training intensities can lead to increases in strength and power, with multiple meta-analyses concluding that moderate-heavy loads between 60 – 84% of 1RM are generally ideal (30,57). For competitive athletes and intermediate-to-advanced trainees, some studies have proposed that heavier loads (above 84% of 1RM) may be optimal for strength and power gains (20). For example, a four-week study conducted by Argus et al. found that elite rugby players aged 23 – 25 who performed contrast training with 80 – 98% of 1RM experienced greater improvements in multiple measures of lower body power than those who trained with 55 – 70% of 1RM (3). A separate study conducted by Lowery et al. suggested that loads between 70 – 93% of 1RM are ideal for advanced male trainees (with squat 1RMs of 1.7 ± 2 bodyweight), as indicated by their jump performance following heavy squats (33). Generally speaking, however, most reviews recommend a range of 75 – 90% of 1RM for competitive athletes (20).

For determining repetition counts, an extensive review by Banks concluded that 1 – 5 repetitions per set is ideal for maximizing PAP's effects while mitigating factors such as fatigue (5). As noted by Ebben et al. and Contreras, the overall volume of contrast training should be kept relatively low (e.g., 2 – 4 sets) to maximize quality and reduce injury risk (13,17).

REST PERIODS

Determining how much rest is needed between movements is a balancing act rooted in the fitness-fatigue paradigm, which essentially refers to the simultaneous potentiation and fatigue that occur following a pre-stimulus (49). Although many studies have sought to quantify the "optimal" amount of rest, no definitive answers have emerged. In looking at a combined 334 subjects, two meta-analyses by Wilson et al. and Gouvêa et al. reported that ideal rest times varied between 7 – 10 and 8 – 12 min, respectively (22,57). However, other research has suggested that an even wider range of 3 – 12 min may be ideal, which suggests that the "sweet spot" may lie within 3 – 12 min (6,11,21,24,36,41).

In particular, factors such as intensity, volume, exercise selection, and individual differences have been shown to influence how much rest is needed to maximize performance (28,49). Generally speaking, recovering from higher intensities (e.g., 90% of 1RM) and/or higher volume sets requires more rest, and vice versa (5). In addition, whereas untrained individuals and/or those with relatively low strength levels may be able to recover after 3 – 4 min of rest, stronger and more advanced trainees often require upwards of 7 – 12 min for optimal performance (11,21). Fortunately, it has been shown that fatigue subsides more rapidly than PAP, which means that the performance benefits of potentiation can be realized after full recovery has occurred (49).

If the research has come to any definitive conclusion, it is that a one-size-fits-all approach to rest periods does not exist (5). Therefore, the key to determining optimal rest times lies in considering intensity, volume, exercise selection, and individual differences through a trial-and-error approach.

CONTRAST PAIRINGS

Albeit basic, the big three lifts (the squat, bench, and deadlift) and their derivatives are among the most popular movements in the application of contrast training. This is due to their relative simplicity and effectiveness. In breaking down all three, here is why (and how) to implement contrast training for each of the big three lifts.

SQUAT CONTRAST PAIRINGS

The squat and vertical jump pairing is one of the most classic examples of contrast training, and for good reason: for building lower body strength and power, squats and jumps are hard to beat. In comparing the two movements, both involve vertical propulsion as well as similar lower body actions via triple extension/flexion at the hips, knees, and ankles (5). Depending on the specificity of the goal, the paired jump variation(s) can be chosen to pinpoint rate of force development (RFD) or elastic power (i.e., force generation through the stretch-shortening cycle).

EXAMPLES

- Squat variations: back squats, front squats, and safety bar squats
- Jump variations (RFD focus): box jumps, vertical jumps, and static box/vertical jumps
- Jump variations (elastic focus): depth jumps and continuous squat jumps
- Example pairings:
  - Front squat + vertical jump
  - Paused back squat + static box jump

BENCH PRESS CONTRAST PAIRINGS

Like the squat, the pressing pattern of the bench press and its derivatives make the selection of high-velocity movements fairly straightforward. As per most recommendations, the two primary high-velocity options to pair with the bench press are medicine ball (MB) chest throws and plyometric push-ups (17). After selecting the chosen exercises, all that is left to do is plug and play different variations of one or both movements in alignment with the intended adaptations. Like static and reactive jumps, both medicine ball throws and plyometric push-ups can be tailored to specifically target RFD and/or elastic power.

EXAMPLES

- Bench press variations: barbell bench press, floor press, and specialty bar bench press
- Power variations (RFD focus): MB chest throws and dead-stop plyometric push-ups
- Power variations (elastic focus): reactive MB chest throws and continuous plyometric push-ups
- Example pairings:
  - Barbell bench press + continuous plyometric push-up
  - Floor press + tall kneeling MB chest throw

DEADLIFT/HIP HINGE CONTRAST PAIRINGS

In comparison to squats and vertical jumps, what separates the pairing of deadlifts (and similar hip hinge movements) and broad jumps is its increased emphasis on the posterior chain (39). Of course, squats and deadlifts are similar in that both movements are compound knee and hip extensor exercises; however, their biomechanics are markedly different, as the barbell deadlift (like the broad jump) requires comparatively more effort from the hip extensors (25,42). As a result, deadlifts and similar hinge movements are especially fitting in concert with broad/horizontal-oriented jumps for contrast training. Like squat and bench press pairings, the exercises chosen can be manipulated to target RFD or elastic power.

EXAMPLES

- Deadlift variations: barbell deadlifts, trap bar deadlifts, and Romanian deadlifts
- Jump variations (RFD focus): broad jumps and band-resisted broad jumps
- Jump variations (elastic focus): continuous broad jumps and depth to broad jumps
- Example pairings:
  - Trap bar deadlift + broad jump
  - Barbell deadlift + continuous broad jump

UNIQUE CONTRAST PAIRINGS

Although the squat, bench, and deadlift are the most common lifts associated with contrast training, failing to consider some additional options can leave a lot of untapped strength and power potential on the table. Especially for athletes, training to build strength and power should account for different body positions, multiple planes, and movement through space via actual physical displacement. To address these elements of sport, three unique contrast pairings—unilateral, multi-planar, and locomotive—can be extremely beneficial for athletes.

UNILATERAL CONTRAST PAIRINGS

Given that almost all athletic movement (e.g., sprinting, jumping, changing direction, etc.) occurs primarily on one leg at a time, unilateral training is particularly valuable for improving athletic performance as well as for reducing injury risk (8). When implemented within a contrast training program, it is proposed that the added element of PAP can enhance its efficacy even further for developing single-leg strength and power (17). Like the big three lifts, single-leg contrast training can be biased to target either RFD or elasticity, as well as to emphasize varying degrees of hip- versus knee-dominance and horizontal versus vertical propulsion.

EXAMPLES

- Hip-dominant variations: single-leg deadlifts and slideboard reverse lunges
- Knee-dominant variations: rear-foot elevated split squats, split squats, and single-leg squats
- Jump variations (horizontal)*: single-leg broad jumps and single-leg hurdle hops
- Jump variations (vertical)*: single-leg box jumps and alternating split squat jumps
- Example pairings:
    - Single-leg deadlift + single-leg broad jump with two-leg landing
    - Rear-foot elevated split squat + single-leg box jump with two-leg landing

**Note: To reduce injury risk, jumping off of one leg and landing with two legs is recommended (56)*

MULTI-PLANAR CONTRAST PAIRINGS

The negative aspect to pigeonholing contrast training into the category of the big, basic lifts is that doing so fails to address another pivotal component of sport and life: multi-planar movement. Given that being able to move with strength and power rotationally (in the transverse plane) and laterally (in the frontal plane) is essential for well-rounded performance, doing so with the added benefits of contrast training can pay huge dividends for athletes and non-athletes alike.

EXAMPLES

- Lower body strength: lateral lunges, lateral squats, and lateral sled drags/crossovers
- Upper body strength: rotational landmine presses and rotational cable presses
- Lower body power: single- or two-leg lateral jumps, lateral hurdle hops, and 45-degree bounds
- Upper body power: rotational MB chest throws and rotational MB scoop tosses
- Example pairings:
    - Lateral lunge + lateral bound
    - Rotational landmine press + rotational MB chest throw

LOCOMOTIVE CONTRAST PAIRINGS

Locomotion (i.e., moving through space in some way, shape, or form) is perhaps the most important movement pattern of all as it relates to sport and life. However, training to improve critical locomotive qualities like acceleration, top speed, and agility is often tough to do in a weight room setting due to logistical limitations. However, with some strategic planning, adequate equipment, and enough space, it is likely that doing so via contrast training is one of the best ways to improve the aforementioned qualities simultaneously (26).

EXAMPLES:

- Resisted locomotive variations: heavy sled pushes/drags, lateral sled drags, and resisted sprints/shuffles
- Explosive locomotive variations: sprints, lateral sprint starts, and explosive crossover/shuffle steps
- Example pairings:
    - Heavy sled push + sprint
    - Lateral sled drag + lateral sprint start

ADDITIONAL METHODS OF CONTRAST TRAINING

Like other training modalities, contrast training can be implemented and performed in multiple ways. In particular, one of the more well-researched protocols is maximal voluntary isometric contrast (MVIC) training, which entails performing maximal isometric contractions of 3 – 10 s in the place of heavy lifting. Although some literature has reported mixed results on MVIC, Banks et al. examined 11 relevant studies and concluded that the majority of them found it to be effective for eliciting PAP (5). Several other studies utilizing ballistic exercises (i.e., maximal velocity movements) and whole-body vibration platforms in the place of heavy resistance exercise have shown similarly promising results (5). However, a lack of extensive data suggests that further research may be warranted to investigate the efficacy of both methods.

More recently, the French contrast method has garnered attention as an alternative method of contrast training. As popularized by Dietz and Peterson in *Triphasic Training*, French contrast training differs from conventional contrast training in that it consists of four exercises rather than two: a heavy compound movement, a plyometric jump, a drop set or weighted jump, and a plyometric or accelerated plyometric movement (14). Despite its popularity, however, more research is needed to observe its acute and chronic effects.

APPLICATION: PUTTING IT ALL TOGETHER

If the research has agreed upon anything, it is that contrast training is best implemented through a trial-and-error approach (20). In particular, the successful implementation of contrast training lies in accounting for individual characteristics (e.g., training status, strength levels, muscle fiber type composition) and goals to guide exercise selection, volume/loading parameters, and rest periods as well as the overall length of its prescription. Therefore, the key to maximizing contrast training's potential for performance enhancement is based on the careful monitoring of an individual's progress (or a lack thereof) and adjusting as necessary.

From a long-term programming standpoint, 4 – 6-week blocks of contrast training have been shown to yield significant improvements in strength, power, and a number of other performance metrics (16). However, several of the aforementioned studies found that many of their subjects continued to improve performance after 8 – 12 weeks of contrast training (27,40,51). It is thus suggested that contrast training may continue to facilitative positive adaptations for up to (and potentially beyond) 8 – 12 weeks, although future long-term studies may be needed for more specific recommendations.

CONCLUSION

With an array of studies, reviews, meta-analyses, and anecdotal observations in support of its value, contrast training has deservedly garnered the attention of researchers, strength and conditioning coaches, and personal trainers for its performance-enhancing potential (16). In many cases, it has been suggested that contrast training may be more effective than other forms of combined strength and plyometric training for improving sprint speed, jump height, upper body power, and strength (34,38,40,43,51). Additionally, like many other training methods, contrast training can be performed in a wide variety of ways with many options for exercise pairings, loading parameters, rest periods, and more. Although future research may be needed to provide more clarity on how to best implement it, contrast training has proven to be a viable method for fitness professionals with a vested interest in performance enhancement.

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FIGURE 1. BOX JUMP - SQUAT PAIRING EXERCISE

FIGURE 2. BOX JUMP - SQUAT PAIRING EXERCISE

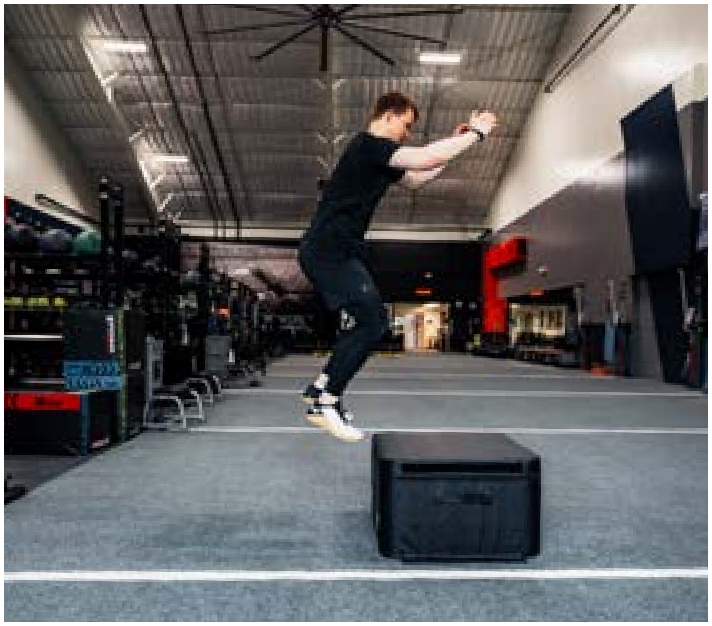

FIGURE 3. BOX JUMP - SQUAT PAIRING EXERCISE

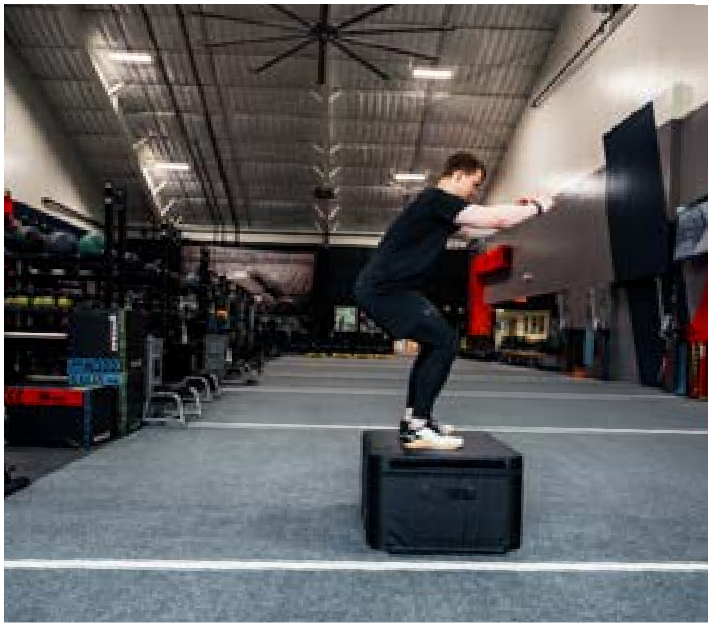

FIGURE 4. BOX JUMP - SQUAT PAIRING EXERCISE

FIGURE 5. BACK SQUAT - SQUAT PAIRING EXERCISE

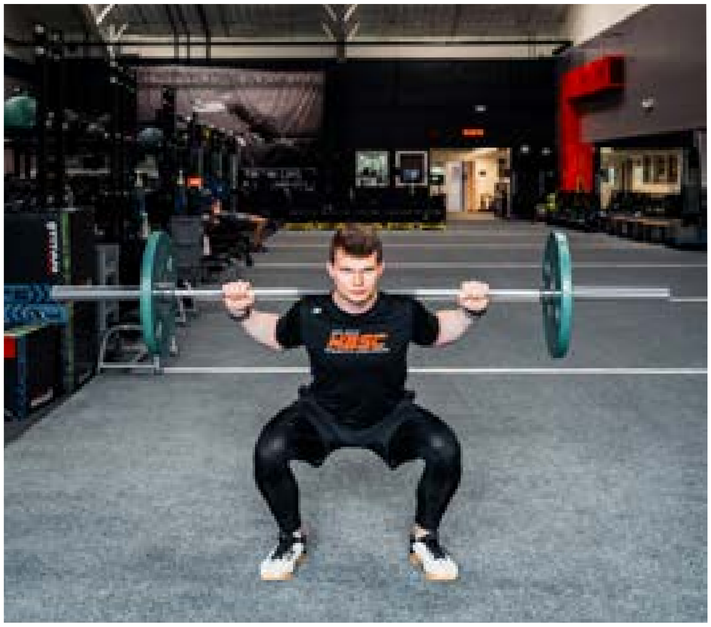

FIGURE 6. BACK SQUAT - SQUAT PAIRING EXERCISE

FIGURE 7. PLYOMETRIC PUSH-UP - PRESS PAIRING EXERCISE

FIGURE 8. PLYOMETRIC PUSH-UP - PRESS PAIRING EXERCISE

FIGURE 9. PLYOMETRIC PUSH-UP - PRESS PAIRING EXERCISE

FIGURE 10. TALL KNEELING MEDICINE BALL CHEST THROW - PRESS PAIRING EXERCISE

FIGURE 11. TALL KNEELING MEDICINE BALL CHEST THROW - PRESS PAIRING EXERCISE

FIGURE 12. TRAP BAR DEADLIFT - HINGE PAIRING EXERCISE

FIGURE 13. TRAP BAR DEADLIFT - HINGE PAIRING EXERCISE

FIGURE 14. BROAD JUMP - HINGE PAIRING EXERCISE

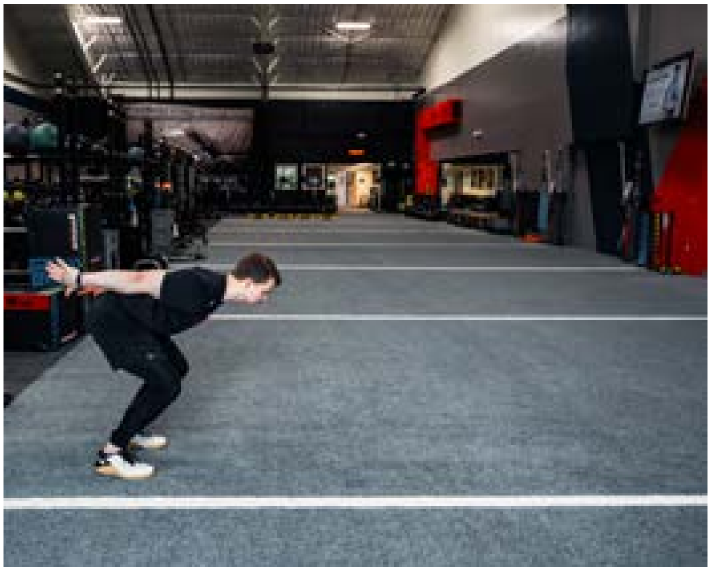

FIGURE 15. BROAD JUMP - HINGE PAIRING EXERCISE

FIGURE 16. BROAD JUMP - HINGE PAIRING EXERCISE

FIGURE 17. BROAD JUMP - HINGE PAIRING EXERCISE

FIGURE 18. LATERAL SLED DRAG - LOCOMOTIVE PAIRING EXERCISE

FIGURE 19. LATERAL SLED DRAG - LOCOMOTIVE PAIRING EXERCISE

FIGURE 20. LATERAL SLED DRAG - LOCOMOTIVE PAIRING EXERCISE

FIGURE 21. SLED PUSH SPRINT - LOCOMOTIVE PAIRING EXERCISE

FIGURE 22. SLED PUSH SPRINT - LOCOMOTIVE PAIRING EXERCISE

FIGURE 23. LATERAL SPRINT - LOCOMOTIVE PAIRING EXERCISE

FIGURE 24. LATERAL SPRINT - LOCOMOTIVE PAIRING EXERCISE

FIGURE 25. LATERAL BOUND - MULTIPLANAR PAIRING EXERCISE

FIGURE 26. LATERAL BOUND - MULTIPLANAR PAIRING EXERCISE

FIGURE 27. LATERAL BOUND - MULTIPLANAR PAIRING EXERCISE

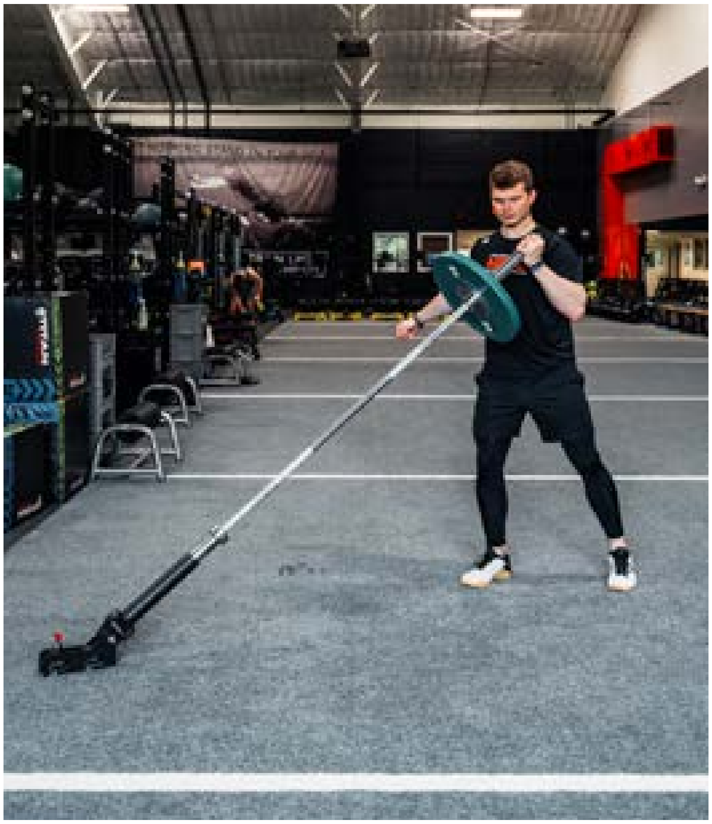

FIGURE 28. ROTATIONAL LANDMINE PRESS - MULTIPLANAR PAIRING EXERCISE

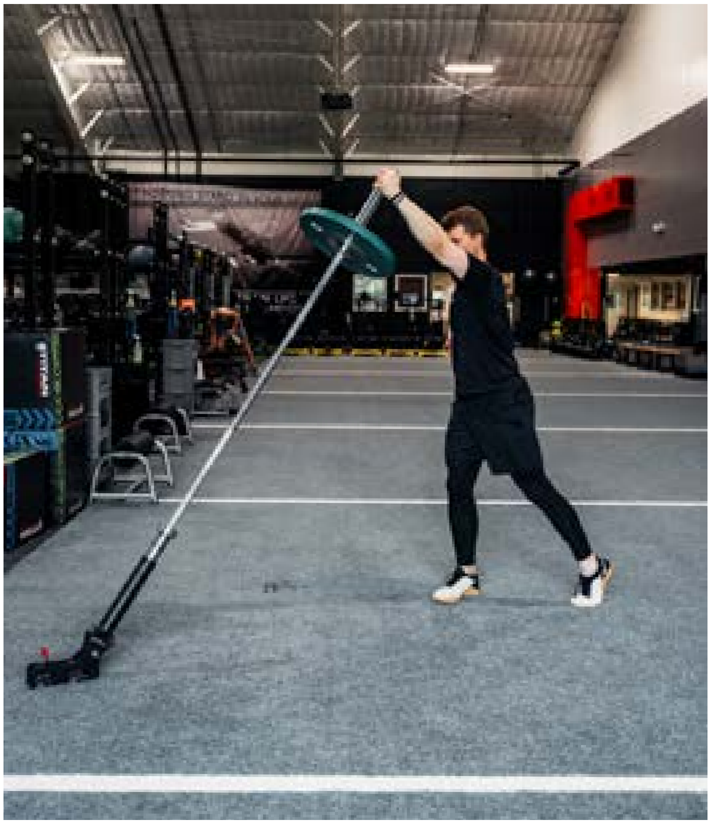

FIGURE 29. ROTATIONAL LANDMINE PRESS - MULTIPLANAR PAIRING EXERCISE

FIGURE 30. ROTATIONAL MEDICINE BALL CHEST THROW - MULTIPLANAR PAIRING EXERCISE

FIGURE 31. ROTATIONAL MEDICINE BALL CHEST THROW - MULTIPLANAR PAIRING EXERCISE

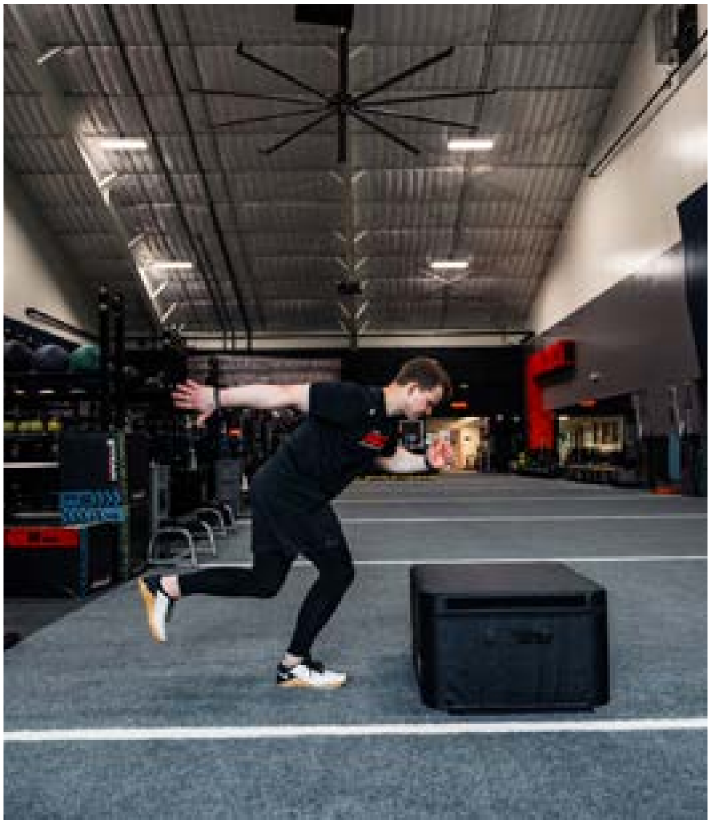

FIGURE 32. SINGLE-LEG BOX JUMP - UNILATERAL PAIRING EXERCISE

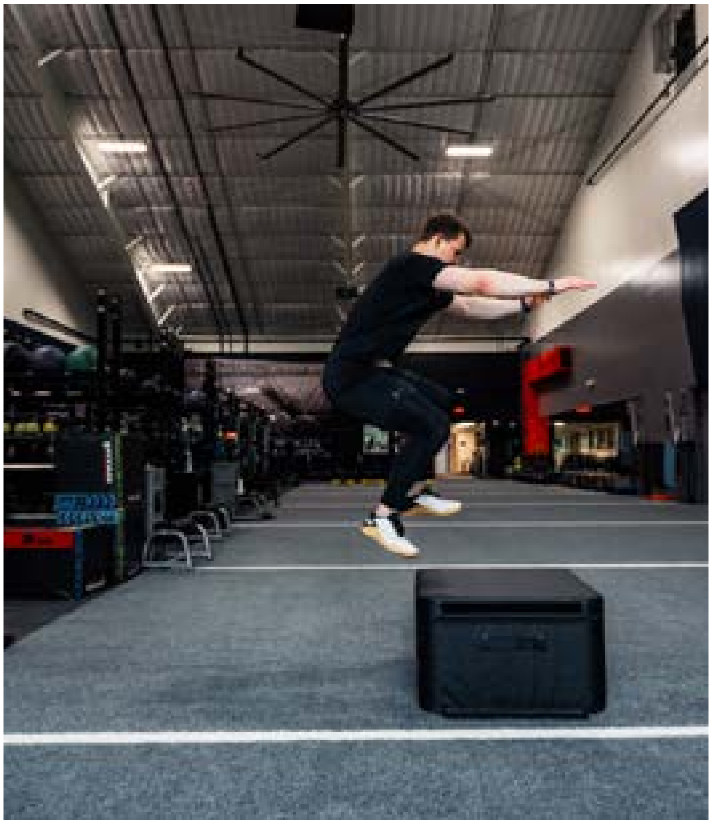

FIGURE 33. SINGLE-LEG BOX JUMP - UNILATERAL PAIRING EXERCISE

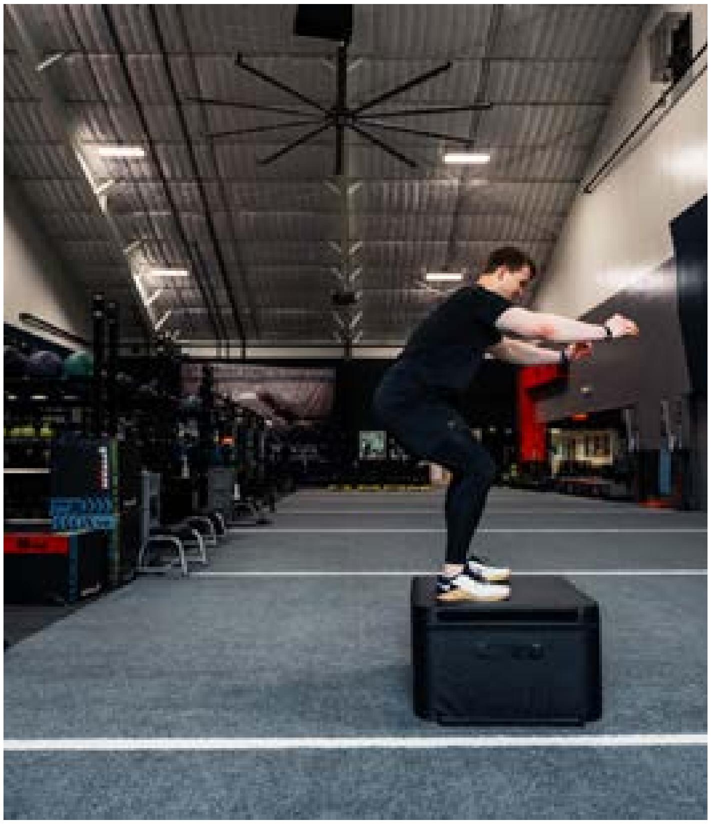

FIGURE 34. SINGLE-LEG BOX JUMP - UNILATERAL PAIRING EXERCISE

FIGURE 35. SINGLE-LEG BROAD JUMP - UNILATERAL PAIRING EXERCISE

FIGURE 36. SINGLE-LEG BROAD JUMP - UNILATERAL PAIRING EXERCISE

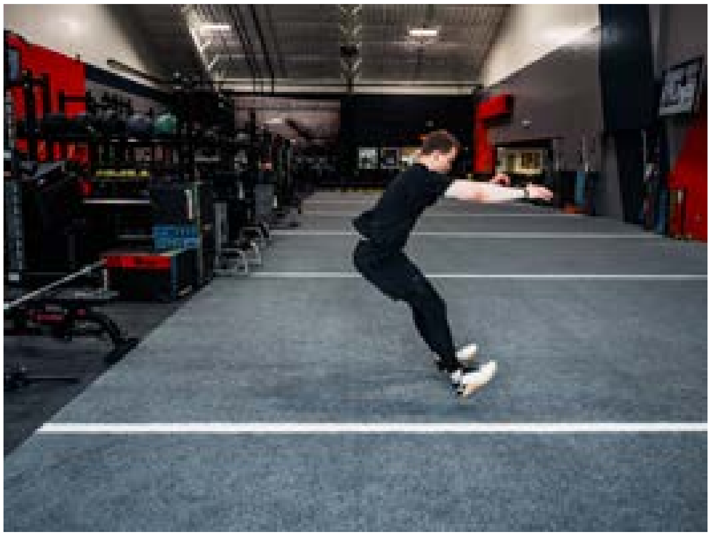

FIGURE 37. SINGLE-LEG BROAD JUMP - UNILATERAL PAIRING EXERCISE

FIGURE 38. SINGLE-LEG BROAD JUMP - UNILATERAL PAIRING EXERCISE

FIGURE 39. REAR-FOOT ELEVATED SPLIT SQUAT - UNILATERAL PAIRING EXERCISE

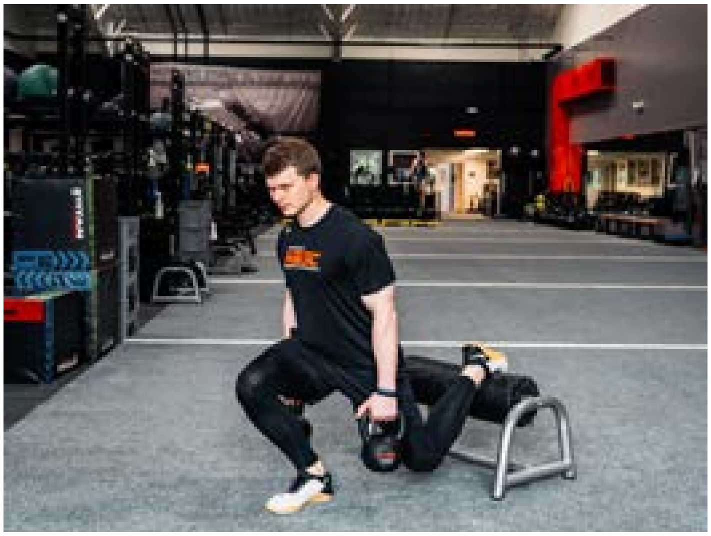

FIGURE 40. REAR-FOOT ELEVATED SPLIT SQUAT - UNILATERAL PAIRING EXERCISE