BEYOND THE POOL – IMPROVING SWIMMING PERFORMANCE WITH DRYLAND TRAINING

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INTRODUCTION

Advancements in swimming performance increasingly emphasize integrating evidence-based dryland training methodologies and technological innovations. Modern approaches have shifted from traditional high-volume, in-water training to a more balanced regimen that incorporates strength, stability, and mobility to optimize performance and reduce injury risks. Research underscores the critical role of core stability in stroke mechanics, propulsion, proprioception, and postural control, all of which are essential for competitive success (1,2,11).

Core stability training enhances neuromuscular coordination and supports efficient stroke execution. Dynamic mobility exercises and controlled strength training have been shown to improve shoulder and hip joint function, reducing mechanical stress and injury risk during swimming (15). Lower-body strength training, particularly plyometric exercises, improves starts and turns, which are key determinants of competitive outcomes (10). Additionally, shoulder stabilization exercises help mitigate overuse injuries, such as swimmer's shoulder, a common issue caused by repetitive stroke mechanics (6).

The integration of wearable technology has revolutionized swimming performance by providing real-time biomechanical feedback. This allows athletes and coaches to identify inefficiencies and develop individualized training protocols that address the physiological demands of the sport (7). For instance, moderate-to-heavy resistance training (3 – 6 repetitions at 70 – 85% of one-repetition maximum [1RM]) develops maximal power output and force production essential for sprint events. Conversely, moderate-load resistance training (10 – 15 repetitions at 50 – 70% of 1RM) enhances muscular endurance and metabolic efficiency, vital for longer-distance events (13). Periodized programs ensure optimal adaptation while minimizing overtraining risks and supporting long-term athlete development (9).

Recent advancements highlight the value of functional, sport-specific exercises in improving swimming performance. Plyometric-based dryland training has proven effective for enhancing swimming block starts, while shoulder and core stabilization exercises reduce injury risks and improve stroke mechanics (8,10). Research supports periodization as a structured framework for progressing from general strength to explosive, swimming-specific movements. Tailored dryland programs address the unique demands of sprint and endurance events, ensuring peak performance and injury prevention (9,13).

This article outlines a research-driven framework for dryland training in swimming, emphasizing the integration of strength, mobility, proprioception, and injury prevention. By aligning training methodologies with the biomechanical and energy demands of swimming, athletes can achieve optimal performance, minimize injury risks, and enhance long-term development.

THE ROLE OF DRYLAND TRAINING IN SWIMMING

Historically, swim coaching methodologies have emphasized high-volume pool training, often overlooking the critical role of strength and conditioning in enhancing performance and reducing injury risk (5,13). However, recent sports science research highlights the substantial advantages of integrating evidence-based dryland training programs tailored to the physiological demands of swimming (5). These programs leverage targeted strength, mobility, and proprioceptive exercises to enhance muscle power, stroke efficiency, and overall swimming performance while reducing injury susceptibility (2,9).

Before initiating the dryland training program, athletes should undergo comprehensive testing and evaluation, including assessments of strength, mobility, and biomechanical efficiency, to establish baseline performance metrics. This individualized data allows the program to be tailored to the specific physiological demands, strengths, and areas for improvement of each swimmer, ensuring targeted and effective training interventions. The training volume and intensity are meticulously calibrated based on the athlete's training age and the outcomes of the initial assessments, ensuring alignment with their current capacity and developmental needs. Additionally, the complexity and progression of exercises are tailored to these factors, allowing for a structured and individualized approach that maximizes adaptation while minimizing the risk of overreaching. Training volume and intensity are systematically monitored using metrics such as repetitions, load, and session duration, complemented by the athlete's rating of perceived exertion (RPE) to ensure appropriate workload management and optimize performance outcomes.

A cornerstone of modern dryland training is the emphasis on core stability, a key factor in maintaining proper body alignment, optimizing stroke mechanics, and improving proprioception (1,2). Core-focused exercises, such as planks and rotational throws, can enhance postural control and neuromuscular coordination, directly translating to improved hydrodynamics and stroke efficiency in the pool (4). Proprioceptive exercises, when combined with lower-body resistance training, further bolster joint stability and injury prevention, ensuring swimmers can perform starts, turns, and strokes with greater precision and power (1,7,8).

Specialization within dryland training is essential for addressing the unique demands of sprint versus endurance events, as well as the biomechanical variations between swimming strokes. Sprint events, such as 50-m and 100-m events, rely heavily on anaerobic power and explosive strength, necessitating high-intensity resistance training and plyometric exercises that target fast-twitch muscle fibers and maximize force production (10). Plyometric exercises, such as box jumps and medicine ball catch and throw, are particularly effective in enhancing leg drive and explosive starts, crucial for sprint performance (8). Conversely, endurance events like the 1,500-m freestyle demand aerobic capacity, muscular endurance, and efficient energy utilization.

These physiological requirements are best addressed through lower-intensity, high-repetition strength exercises and sustained core stability training (5,13).

Stroke-specific demands further underscore the need for tailored dryland programs. For example, swimmers who specialize in the butterfly and breaststroke require heightened focus on shoulder stability and hip mobility to accommodate the increased range of motion and rotational forces associated with these strokes (6). In contrast, swimmers who specialize in freestyle and backstroke may benefit more from exercises targeting core strength and streamline positioning to minimize drag and maximize efficiency (12). This individualized approach not only enhances performance but also helps mitigate stroke-specific injury risks, contributing to a holistic and athlete-centered training regimen (15).

The integration of cutting-edge technology has also transformed dryland training in swimming. Wearables and real-time biomechanical feedback tools provide detailed insights into stroke mechanics, allowing coaches to identify inefficiencies and refine training programs with precision (7). These advancements enable athletes to adopt evidence-based strategies that align with their specific performance goals, ensuring a higher return on training investments and fostering sustained athletic development.

By embracing specialized dryland training protocols and leveraging advancements in sports science, swimmers can achieve significant improvements in power, endurance, and injury resilience. This paradigm shift toward individualized biomechanically-aligned training regimens represents a transformative step in the evolution of competitive swimming preparation.

PROPRIOCEPTION AND BALANCE

Proprioception and balance are integral to swimming performance, addressing the unique challenges of the aquatic environment where diminished tactile feedback and altered sensory perception hinder precise motor control. Dryland balance training, utilizing tools such as BOSU balls, balance boards, and single-leg stability drills, has demonstrated efficacy in enhancing neuromuscular coordination and core activation (1,2,11). These adaptations enable swimmers to maintain streamlined body alignment, optimize stroke mechanics, and improve hydrodynamic efficiency in the water (3,4).

The integration of proprioceptive training with strength-based exercises is essential for enhancing movement efficiency and ensuring optimal force transfer during swimming strokes. Evidence suggests that training programs emphasizing instability and dynamic movements stimulate neuromuscular adaptations that translate to improved swimming performance (2,5). Simulating the unstable nature of water through targeted dryland exercises promotes better limb control, enhanced stroke mechanics, and efficient energy transfer during propulsion (6,8). For instance, core stability exercises tailored to swimming improve propulsive efficiency and help reduce injury risks (3,5,9).

TABLE 1. GENERAL BODYWEIGHT STRENGTH AND BALANCE EXERCISE CHOICES FOR SWIMMING

EXERCISE	PURPOSE	SETS AND REPETITIONS
Beginner: Plank **Intermediate: Bird Dogs/Dead Bugs**	Builds core stability for improved body alignment in the water	3 sets, 30 – 60-s hold or 10 repetitions
Beginner: Push-Ups **Intermediate: Shoulder Tap Push-Ups**	Strengthens upper body and shoulders, improving stroke power	3 sets, 10 – 15 repetitions
Bodyweight Squats	Increases lower body strength for powerful kicks and starts	3 sets, 10 – 15 repetitions
Lunges with Twist	Enhances leg strength and balance for better propulsion	3 sets, 6 – 8 repetitions per leg
Mountain Climbers	Develops core and cardiovascular endurance for swim stamina	3 sets, 30 – 45 s
Glute Bridges	Strengthens glutes and core, improving hip extension during swimming	3 sets, 15 repetitions
Superman Extensions	Strengthens lower back for enhanced posture and stability	3 sets, 15 – 20 repetitions
Burpees	Improves full-body endurance and explosive power	3 sets, 10 – 12 repetitions
Single-Leg Balance Drills	Enhances proprioception and balance, improving stroke control	3 sets, 30 s hold per leg
BOSU Ball Squats	Improves lower body strength and stability on an unstable surface	3 sets, 10 – 12 repetitions
Balance Board Planks	Strengthens core and enhances body control on an unstable surface	3 sets, 30 – 45-s hold

While injury prevention remains a critical consideration in swimming, the primary focus is performance enhancement. Scapular stabilization and rotator cuff strengthening exercises play a pivotal role in maintaining shoulder joint integrity, which is vital for sustaining stroke efficiency under repetitive loading (4,9). Overuse injuries, such as swimmer's shoulder, remain prevalent due to the mechanical demands of stroke execution, particularly in competitive settings (10). Integrating prehabilitation strategies, including foam rolling and active release therapy, has shown potential in improving muscle flexibility and readiness, indirectly enhancing performance by facilitating efficient movement patterns (12,14).

Wearable technology and real-time biomechanical feedback have further revolutionized dryland training for swimmers. These tools allow for precise monitoring of stroke mechanics and physiological responses, providing athletes and coaches with data-driven insights to tailor training programs (7). By combining biomechanical feedback with proprioceptive and strength training, swimmers can achieve a more individualized and evidence-based approach to their development, ensuring alignment with their specific biomechanical and physiological needs (13,15).

The strategic combination of proprioceptive training, strength-based exercises, and technological innovations equips swimmers with the capacity for powerful, coordinated movements that align with the demands of competitive swimming. Using this combination of training, Table 1 provides general bodyweight strength and balance exercise choices for swimming. This comprehensive approach ensures that training interventions remain performance driven, scientifically validated, and tailored to the unique biomechanical and physiological demands of the sport (5,8,14). By addressing these factors, athletes can optimize performance, mitigate injury risks, and sustain long-term success in the pool.

IMPORTANCE OF MOBILITY AND JOINT INTEGRITY

Swimming places substantial mechanical demands on the shoulder and hip joints, requiring a precise combination of strength, stability, and mobility to optimize stroke mechanics and reduce the risk of injury. The repetitive nature of swimming strokes often leads to overuse injuries, highlighting the importance of evidence-based dryland training programs that target these critical areas. Research underscores that such programs enhance functional stability, stroke efficiency, and resilience against injuries by addressing the specific biomechanical demands of swimming (4,8).

Although not the primary focus of this article, dynamic mobility exercises are an ancillary yet integral component of a comprehensive swimming training program. Exercises such as controlled articular rotations play a crucial role in enhancing joint control and range of motion, particularly in the shoulder and hip joints, which are pivotal for efficient swimming strokes. These exercises contribute to joint integrity by reducing compensatory movement patterns and mitigating the effects of fatigue-induced declines in proprioception and mobility, both of which are essential for sustaining high-performance swimming mechanics (4,14).

By addressing fatigue's impact on joint stability, mobility exercises support the maintenance of optimal biomechanics during prolonged training and competition. This, in turn, helps reduce the risk of overuse injuries and enhances stroke efficiency (3,9). While mobility and joint integrity are not the central focus, they represent a critical supplementary element that reinforces the effectiveness of primary training modalities, providing a foundation for sustained performance and injury prevention.

MEDICINE BALL TRAINING FOR EXPLOSIVE POWER

Incorporating medicine ball exercises, such as slams and rotational throws, into a dryland training program can enhance key performance factors including upper-body power and rotational strength. These exercises are supported by evidence suggesting their role in improving muscular power, balance, and core stability, which are critical for maintaining proper body alignment and optimizing propulsion during swimming strokes (5,10,11). For example, rotational throws simulate the twisting forces essential for freestyle and backstroke, while overhead slams develop explosive power necessary for starts and turns, targeting muscle activation patterns directly transferable to swimming (6,13).

A carefully structured approach to medicine ball training is essential to maximize its benefits while minimizing the risk of overtraining and repetitive strain. For each week, a grouping of 4 – 6 medicine ball exercises can be selected, with a different cluster chosen for a second session to ensure variability and balanced muscle activation. Repetitions for each medicine ball exercise should be adjusted based on the athlete's fitness level, with ball weights typically ranging from 2 – 10 kg, depending on the specific exercise and the athlete's strength capacity. This individualized approach ensures that the workload remains appropriate and progressive, preventing excessive volume in particular movement patterns while addressing varied performance goals such as power, stability, and coordination. The program should be tailored to the athlete's training age, assessment results, and overall workload, ensuring it aligns with their individual capacity and training progression (11).

Table 2 provides a sample progression for these exercises, with an emphasis on modifying intensity, volume, and repetitions based on the athlete's weekly training schedule and fitness level. Incorporating variation in intensity, such as alternating between moderate- and high-load sessions within a training cycle, is critical for preventing non-functional overreaching and promoting adequate recovery. Research by Sadowski et al. highlights that structured resistance training, including medicine ball drills, can significantly enhance in-water performance, particularly when designed within a sport-specific framework that complements the unique biomechanical demands of swimming (9).

While not the primary focus of a swimming dryland program, medicine ball drills serve as an ancillary component to mobility and stability exercises. When integrated strategically, they enhance performance adaptations without contributing to unnecessary fatigue or overload, ultimately supporting the broader objectives of the training program. Proper attention to programming variables, such as session frequency, exercise variation, and load progression, ensures that medicine ball training is both effective and sustainable within the athlete's overall regimen (11).

LONG-TERM ATHLETIC DEVELOPMENT

A rigorous dryland training program tailored to swimming performance not only optimizes competitive readiness but also supports long-term athletic development by integrating bodyweight exercises, medicine ball drills, and resistance training. This approach emphasizes explosive strength and functional power, addressing the sport's biomechanical demands while inherently promoting mobility gains as a secondary benefit. By incorporating principles of long-term athlete development (LTAD), these structured programs ensure athletes progress through appropriate training phases, balancing immediate performance enhancements with sustained development and injury prevention, ultimately fostering resilience and peak performance across their careers (1,7).

STRENGTH AND POWER DEVELOPMENT

Strength and power development are critical determinants of swimming performance. However, the training approach must be carefully designed to meet the unique demands of the sport, avoiding potential pitfalls associated with inappropriate volume or exercise selection. While general strength and hypertrophy training contribute to overall muscular development, evidence suggests that overemphasis on non-specific hypertrophy can compromise swimming-specific biomechanics by increasing drag and altering stroke efficiency. A targeted approach focusing on functional strength and power exercises, closely aligned with swimming's biomechanical demands, is essential for maximizing performance and minimizing injury risk (3,6).

Rotational strength plays a pivotal role across all swimming strokes by enhancing torque production, leading to more powerful propulsion and improved stroke efficiency (3). This specificity ensures that training reinforces muscle activation patterns directly transferable to swimming. Exercises such as medicine ball slams and rotational cable pulls effectively target core and upper body musculature, improving both stroke efficiency and stability (8,11). However, careful consideration must be given to program design to prevent overuse of any specific movement pattern, such as excessive overhead pressing, which could lead to shoulder fatigue or injury. Program adjustments should include varying exercise selection and load distribution to optimize recovery and training adaptations.

Explosive lower-body strength is equally vital, particularly for starts and turns, which are critical to race performance. Exercises like split squats and resisted jumps enhance leg drive and contribute to generating maximum velocity during these high-intensity phases (5). Plyometric exercises, including box jumps, have been shown to improve explosive leg power, further augmenting starts and turns by increasing speed and strength (6). These movements, when combined with appropriate training volumes and intensities, provide the foundation for optimized performance in competitive swimming.

PROGRAM ADJUSTMENTS AND PRACTICAL CONSIDERATIONS

To ensure a functional and balanced training program, Table 3 includes recommended intensity ranges for key exercises. For instance, upper-body movements like the bench press could be programmed with varied intensities across training sessions (e.g., Tuesday: 75% 1RM, Friday: 60% 1RM, etc.) to prevent non-functional overreaching and facilitate recovery. Incorporating intra-week variation in intensity helps reduce cumulative fatigue

TABLE 2. MEDICINE BALL TRAINING FOR SWIMMERS

EXERCISE	PURPOSE	SETS	SETS AND REPETITIONS
Medicine Ball Slams	Develops explosive upper body power, improving start and turn performance	3	8 – 12 repetitions
Medicine Ball Rotational Throws	Enhances rotational core strength, aiding in stroke efficiency	3	6 – 10 repetitions per side
Medicine Ball Overhead Squats	Improves lower body strength and core stability for better balance and propulsion	3	10 repetitions
Medicine Ball Chest Passes	Builds upper body power and shoulder strength for a stronger pull phase	3	10 – 12 repetitions
Medicine Ball Russian Twists	Increases core strength and stability, helping maintain body alignment during strokes	3	20 repetitions (10 per side)
Medicine Ball Push-Ups	Strengthens chest and triceps while improving balance	3	12 – 15 repetitions
Medicine Ball V-Ups	Targets core muscles for enhanced core stability and body position	3	10 – 15 repetitions

and promotes long-term progress. Additionally, the inclusion of rotational and explosive exercises such as medicine ball throws or power cleans ensures athletes train across multiple planes of motion, critical for swimming's unique biomechanical demands.

Volume considerations are also paramount. The program must balance sufficient stimulus to drive adaptations with the need to avoid overreaching and potential overtraining, particularly in high-volume sports like swimming, where athletes already experience significant training loads. For example, limiting overhead pressing to two days per week and substituting alternative pulling or stabilization exercises can maintain shoulder integrity while ensuring adequate strength development.

By emphasizing movement specificity, balanced volume, and intra-week intensity variation, this approach aligns with the sport's demands, promoting improvements in stroke efficiency, power output, and overall performance (11). This evidence-based framework ensures that swimmers develop the functional strength and power needed to excel in competition while mitigating risks of injury and overtraining.

INTEGRATED ATHLETE MONITORING AND FUTURE DIRECTIONS

The integration of technological innovation within the sports industry has transformed athletic performance enhancement, particularly in swimming. Wearable devices and advanced monitoring systems now serve as indispensable tools for tracking critical performance metrics, such as workload, recovery rates, and training intensity during both in-pool and dryland workouts. These technologies enable precise biomechanical analyses, offering real-time data that inform evidence-based adjustments to training protocols (9,15). By identifying inefficiencies in stroke mechanics and highlighting potential injury risks, these systems empower athletes and coaches to optimize performance while mitigating the risk of overuse injuries, fostering sustainable athletic development (15).

TECHNOLOGICAL ADVANCEMENTS IN ATHLETE MONITORING

The ability of wearable devices to deliver instantaneous feedback represents a paradigm shift in how training programs are designed and evaluated. Metrics such as heart rate variability, stroke count, and force output allow coaches to monitor physiological responses and biomechanical performance with unprecedented accuracy. This continuous feedback loop supports informed decision-making, enabling tailored adjustments to optimize training loads, promote recovery, and prevent maladaptive responses such as non-functional overreaching (15). Moreover, wearable technologies enhance injury prevention strategies by identifying biomechanical anomalies and workload imbalances that could lead to overuse injuries if left unaddressed.

EVOLVING DRYLAND TRAINING PARADIGMS

The evolution of dryland training methodologies over the past few decades reflects a broader shift toward interdisciplinary and individualized approaches. By integrating insights from swim coaches, strength and conditioning specialists, and sports

TABLE 3. WEEKLY DRYLAND TRAINING FOR SWIMMERS

Monday and Thursday (Power-Based Exercises)

EXERCISE	PURPOSE	SETS AND REPETITIONS
Power Cleans	Develops explosive power for starts, turns, and overall speed	5 sets of 2 – 4 repetitions
Box Jumps (24 – 30 in. Box, Concentric)	Enhances explosive lower body power and improves leg drive for starts	4 sets of 4 – 6 repetitions
Medicine Ball Slams	Builds upper body power for stronger strokes and turns	3 sets of 10 – 12 repetitions
Push Press	Increases shoulder and arm explosiveness for faster arm recovery during strokes	4 sets of 4 – 6 repetitions
Kettlebell Swings	Enhances hip drive and core stability for better propulsion	3 sets of 12 – 15 repetitions

Tuesday and Friday (Strength-Based Exercises)

EXERCISE	PURPOSE	SETS AND REPETITIONS
Bench Press	Strengthens chest and triceps for more powerful strokes	3 sets of 4 – 6 repetitions
Lat Pulldowns	Targets lats for a stronger pull phase in swimming strokes	3 sets of 10 – 12 repetitions
Barbell Squats	Develops lower body strength for stronger kicks and stability	3 sets of 4 – 6 repetitions
Overhead Press	Strengthens shoulders and core for improved stroke recovery and control	3 sets of 10 – 12 repetitions
Single-Leg Romanian Deadlifts	Improves balance and strengthens hamstrings and glutes for better propulsion and injury prevention	3 sets of 10 – 12 repetitions per leg
Seated Rows	Builds upper back and shoulder strength for more powerful pulls	3 sets of 10 – 12 repetitions

scientists, contemporary dryland programs have moved beyond traditional weightlifting to emphasize functional strength, power, and mobility development tailored to the unique demands of swimming (14). For example, rotational strength exercises and plyometric drills are increasingly incorporated to mimic the biomechanical patterns of swimming strokes, starts, and turns (6,9). These targeted interventions address the specific physiological and biomechanical needs of each swimmer, enhancing both performance and injury resilience.

THE ROLE OF PERIODIZATION IN MODERN TRAINING

A well-structured, periodized dryland program aligns training goals with different phases of the competitive season, maximizing performance while minimizing injury risks. Such programs, as outlined in Table 4, integrate bodyweight, medicine ball, and resistance exercises with appropriate variations in intensity and volume to ensure continuous adaptation. Balancing explosive power development for starts and turns with endurance and mobility training is essential for addressing the diverse biomechanical and physiological demands of various swimming strokes and distances. Evidence suggests that integrating these components into a structured program enhances athletic performance by targeting specific energy systems and movement patterns required for both sprint and endurance events (4). The application of periodization principles allows for the systematic manipulation of training variables, such as intensity, volume, and recovery, to ensure athletes achieve peak performance at critical moments in the competitive season (11). By progressively overloading and tapering workloads, periodization mitigates the risks of overreaching and non-functional overtraining, which can impair performance and recovery. Evidence supports that periodized training enhances physiological adaptations, including neuromuscular efficiency and energy system optimization, enabling athletes to achieve optimal readiness for competition while minimizing the risk of injury and burnout (1,5,9).

FUTURE DIRECTIONS

The integration of cutting-edge technologies and interdisciplinary expertise promises to further refine dryland training methodologies. Innovations, such as artificial intelligence-driven performance analytics and machine learning algorithms, are poised to enhance the precision and customization of training programs. Additionally, the collaboration between biomechanics researchers and applied practitioners will continue to yield evidence-based strategies that enhance functional strength, mobility, and overall performance.

Advancements in athlete monitoring systems and dryland training paradigms underscore the transformative potential of combining technology with sports science. These developments not only enhance performance but also ensure the long-term sustainability of athletic careers by addressing the intricate interplay between biomechanics, physiology, and recovery. The integration of wearable technology, targeted training protocols, and interdisciplinary approaches solidifies the foundation for future progress in swimming performance enhancement.

This periodized approach facilitates a structured progression from foundational strength and mobility exercises to highly specific, explosive movements that align with the biomechanical and physiological demands of competitive swimming. Grounded in evidence-based principles, this methodology enhances critical performance components, such as strength, power, mobility, and injury prevention through a blend of functional, sport-specific exercises. Research underscores the efficacy of periodization in optimizing athletes' physiological adaptations, enabling swimmers to peak at strategic points during the competitive season while simultaneously mitigating the risk of injury (3,5). By carefully aligning training phases with competition goals, this approach ensures swimmers are fully prepared to meet the demands of high-intensity performance, balancing power development with endurance and mobility training to address the diverse needs of various strokes and events (6,14).

TABLE 4. PERIODIZED DRYLAND TRAINING PROGRAM FOR SWIMMERS

PHASE	TRAINING FOCUS	EXERCISES	SETS AND REPETITIONS
General Preparation Phase	General strength and mobility	Plank, push-ups, bodyweight squats, lunges, glute bridges (Table 1)	3 sets of 10 – 15 repetitions or 30-s hold
Specific Preparation Phase	Power development	Power cleans, box jumps, medicine ball slams, push press (Table 3)	4 sets of 4 – 6 repetitions
Early–Mid Competitive Phase	Strength and proprioception	Single-leg Romanian deadlifts, seated rows, balance board planks (Tables 1 and 3)	3 sets of 8 – 12 repetitions or 30 – 45-s hold
Peaking Phase	Explosiveness and event-specific training	Medicine ball rotational throws, kettlebell swings, lat pulldowns (Tables 2 and 3)	3 sets of 8 – 12 repetitions

CONCLUSION

Dryland training has revolutionized modern swimming by incorporating evidence-based, movement-specific, and power-focused exercises that directly enhance in-water performance. A key component of this transformation is the strategic use of periodization, which systematically integrates phases emphasizing general strength, power development, and mobility to meet the evolving demands of the competitive season. Research supports this approach, demonstrating that periodized training not only optimizes athletic performance but also aligns exercise intensity and volume with swimmers' physiological and biomechanical requirements at different stages of their training cycles (3,5,6). This structured strategy maximizes functional power, improves movement pattern specificity, and minimizes injury risk, fostering both immediate competitive success and long-term athletic development.

By tailoring dryland training programs to the unique demands of swimming, athletes gain the physical capacity and resilience needed to excel in high-pressure competitive environments. The integration of targeted strength and power exercises with mobility and injury prevention strategies ensures a comprehensive and scientifically grounded approach, solidifying dryland training as an essential component of elite swimming performance.

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