FOUNDATIONS OF STRENGTH TRAINING FOR SWIMMERS

A COMPLETE GUIDE TO DEVELOP SWIMMING POWER AND MANAGE INJURIES

DENIZ HEKMATI

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In loving memory of Nejla Hekmati, my late mother, to whom I attribute this book and my career in swimming. Thank you for taking me to swim lessons and for watching over me. To my wife, Jessi, my loving life-anchor. Without you, Swimmer Strength would not exist. To my son, Isak. Thank you for reminding me that life is about growth, smiles and patience. Mom, we made it.

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Contents

Dear reader,

I wrote this book for you. To itch your curiosity for how strength training impacts swimming performance. And I am so grateful that you have picked it up.

I started writing this during my first year of graduate school. This was back in 2014 and I had no clear idea of where it was going. I just knew that strength training for swimmers mattered and that there was scant published material for people interested in this topic. The sport is continuously evolving and world records are still being broken, so it only makes sense that training should keep evolving as well. I hope this book will challenge your own habits and convictions, and give you at least a few ideas of how to refine and improve your training.

Your feedback is welcome. If you don't like this book, tell me; if you like this book, tell others.

Please, enjoy.

Preface

I got my first taste of lactic acid on a cold winter afternoon. Me and my teammates were in the long course pool at Valhalla, the sports complex in the heart of Gothenburg, Sweden, swimming the classic 10x100 best average. I was 13 years old, and just after we had passed the halfway point my arms suddenly started moving slower and felt heavier. I could no longer kick my legs as intensely. The pain began pulsating throughout my limbs. I had heard the older swimmers lob around "lactic acid" before, and figured that may be what caused this uncomfortable sensation in my muscles. I asked my coach. "Don't be silly – you're too young to develop lactic acid," he barked at me. But sure enough, it was lactic acid. That day, my fascination for how the human body moves through the water was born.

Shortly after graduating from high school I moved across the Atlantic Ocean to Daytona State College and began studying exercise science and wellness while swimming for head coach Steve Lochte. Two years later I transferred to Arizona State University. Strength training was a cornerstone at both institutions. My body fat percentage dropped from 13.7% to 5.5 % in one season and I was having lots of fun with my training. My strength coach was a former football player. I have tremendous respect for football and remain indebted for the research and inspiration it has contributed to the field of strength training. But, let's face it – football and swimming are completely different sports.

So I began applying what I had spent years learning in the classroom. I did an unusual taper my senior year and dropped the most time in my best event – the 100 yard breaststroke – in my four years of college. I remember swimming next to Vladimir Morozov, the Russian monster sprinter from the University of Southern California. I got smoked, but at least I was quicker off the blocks – my reaction was 0.54.

Around that time, my sprint coach Scott Goodrich had just left the university and moved to Brazil to coach César Cielo Filho. The reigning world record holder in the 50m and 100m freestyle had just come off two knee surgeries. I kept in touch with Goodrich, sampled out a season and a number of workouts for Cielo and sent them his way. Later that year, Cielo won his third consecutive title in the 50m freestyle at the 2013 World Championships in Barcelona. His reaction time off the blocks went from 0.72 seconds at the Brazilian trials to 0.67 - a 6.9% drop in three months, and his time dropped from 21.6 to 21.32. Speaking to Goodrich about Cielo got me thinking. I realized that traditional methods for strength training only will take you so far, but that each swimmer, particularly the later they are in their careers, need their own way of doing things.

After graduating I landed at the University of Utah as a graduate assistant. I had been brought on staff by Jonas Persson, a fellow Swede who led the sprint group (he assumed the role of associate head coach in 2019). I stayed in Salt Lake City for 4 years and learned a lot. Keeping scores of hormonal college students focused on their sport while earning my graduate degree in exercises and sport science was quite something. They wanted to see big results quickly, and I was no different. I loved those years, but also felt a growing urge to run my own thing and have greater control of the training I assigned my adepts. So I turned down an offer to remain on staff full time. My new focus became Swimmer Strength – a company I had founded.

Swimmer Strength aims to make competitive swimmers more powerful and resilient, and help them work through their injuries. I have worked with a range of athletes spanning from budding talents to scarred veterans who need help to heal their battle wounds and return to the arena as better versions of themselves. I have coached swimmers from all over the world and worked with numerous coaches to develop strength and dryland programs tailored to both novices and Olympic Trial qualifiers. My passion for high-performance strength training and swimming also led me to start one of the country's newest club teams: Arizona High-Performance Swimming Academy.

I wrote this book to share with you my thoughts on strength training and how they relate to fast swimming. There are lots of steps we can take to develop swimmers in a more thoughtful and all-encompassing way, and treat their bodies as if they really only have one, not several. I am still a young coach with lots left to learn, and know that many have viewpoints that differ from mine. I encourage a healthy exchange of ideas. What we should all be able to agree on is that too many stick to old habits and outdated principles. If the last decade was all about "finding the right program" then let us now focus on learning how to move well and live a healthy lifestyle to achieve optimal results in the weight room and the pool. And I hope that this book will inspire all swimmers – old or young, retired or newbies, parents and coaches – to join me on this journey.

Deniz Hekmati
Mesa, Ariz., October 2020

Chapter 1

The Core

Neat rows of large, rectangular flags line the ceiling above the pool at Daytona State College. They are white and blue, matching the lane lines, the tiles and the school mascot – the Falcon. There are nine rows of them, fifteen in each. I got to know them well during my two years at Daytona, and so did my teammates. Every afternoon we spent at least 20 minutes staring at them while churning through yet another endless set of Crunches, Sit-Ups and other core exercises – standard fare for any collegiate swimmer.

Much of what I had learned about swimming in Sweden, where I grew up, was flipped on its head when I arrived in Florida in August 2009 and joined what was then the country's newest junior college swim team. Core work was no exception. The daily at-will routine I had gotten used to back home was replaced with a one-size-fits-all program me and my teammates completed in unison. We easily went through more than 500 repetitions per day of Sit-Ups, Crunches, Supermans and V-Ups before getting into the water. And at colleges, high schools and club teams across the country, legions of swimmers each day still work through essentially the same routine.

The Problem

The core is a complex combination of body parts that plays a consequential role in swimming. It transfers energy between body parts [38]. It helps the swimmer maintain stability and technique in the water when fatigue sets in. It ensures the upper body and the legs remain in sync and makes the swimmer less prone to injuries. And it can be an effective tool to intimidate rivals.

But ask four different coaches to define "core" and you will end up with four different answers. Many core workouts are therefore based on notions rather than grounded in hard facts. And that is how you end up with the status quo: Swimmers churning through hundreds of repetitions of spine-bending movements, day after day, with little or no variation. After a while, boredom takes hold. Corners are cut. Necks and hips drop during bridges and spines end up looking crooked. The slow, controlled movements become hasty and sloppy. And the risk for injuries increases drastically.

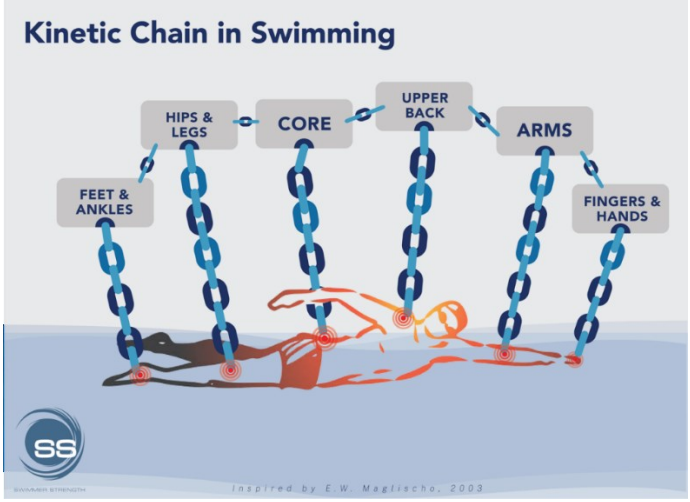
It takes time and effort to fully grasp how it works and how that translates to designing workouts. Dr. Stuart McGill, who is a professor emeritus at the University of Waterloo in Canada, has spent his career studying back movements and pain. He has found that exercises that forcefully bend the spine, such as Sit-Ups and Supermans, put lots of stress on the discs in the lower spine. These movements, according to Dr. McGill, place excessive compressive loads on the lower back, which can cause long-term issues [37].

What if there was a way to do less repetitions but also improve results?

Role of the Core

There are myriad definitions of what constitutes the "core" [5, 59, 69, 70]. My definition is a simple one: It is anything that is attached to the spine and influences movements.

The core binds together the so-called kinetic chain, which is a scientific term for the idea that the movement of one body part influences the movement of another [30, 47]. Imagine, for example, a swimmer with their left arm in the freestyle catch position. The fingers are angled slightly towards the bottom of the pool. The elbow is high. The left shoulder is down while the right is up. As the swimmer pulls through the stroke, the body rotates, starting with the shoulders followed by the hips and legs. The energy powering that kinetic chain is coordinated through the core. With an underdeveloped core, the swimmer will struggle to coordinate movements or apply enough force to reach and maintain high speed in the water.



Additionally, as many as 20% of swimmers are stronger on one side of the body than the other, according to my estimate (these differences will show up when the swimmer runs through the list of tests that are listed in Chapter 10). This imbalance often extends to the core. If not addressed, it will impact the kinetic chain and may increase the swimmer's risk of injury.

The three tenets of core training are stability, strength and power. In short, stability means movement efficiency or strength in a given joint angle. Strength refers to muscle engagement, which manifests itself with that familiar "burning" sensation. Power refers to the speed of that muscle engagement. Dave Salo, the longtime head swim coach at the University of Southern California and the Trojan Swim Club, has argued that stability training is the most important of the three because "strong muscles are useless if they cannot transfer energy into speed efficiently" [51]. The premise of Salo's hypothesis – you are only as strong as your weakest link – is sound. I view the three tenets as entirely dependable – a three-legged stool, if you will – to optimize both health and performance. For fast swimming, muscles need to contract quickly. To do so, they must be able to generate large forces. That will only happen if muscles and joints have proper stability. Besides, most core movements are a mix of stability and strength, or stability and power.

Let's take a closer look at each of the three.

Core Stability

Stability is the body's ability to keep the spine still during movements. In some realms, stability is simply considered strength in certain positions. It facilitates the movement of energy between limbs. Whether it is swimming butterfly or simply getting out of bed, the body needs a baseline of stability to produce smooth movements with ease. If the swimmer lacks stability, the kinetic chain will not be able to efficiently link the forces produced by various limbs. Think of a novice butterflier and you get the idea.

Stability is also synonymous with the concept of "injury prevention", control and beautiful technique. It helps to reduce the rate of injuries. If the swimmer lacks the proper muscular and joint stability, they will not be able to withstand the forces incurred in the pool or the weight room, and can easily get injured. They will also struggle to complete exercises that combine multiple joint movements with an element of balancing. Bottom line: core stability must always be a pillar in strength training for any swimmer.

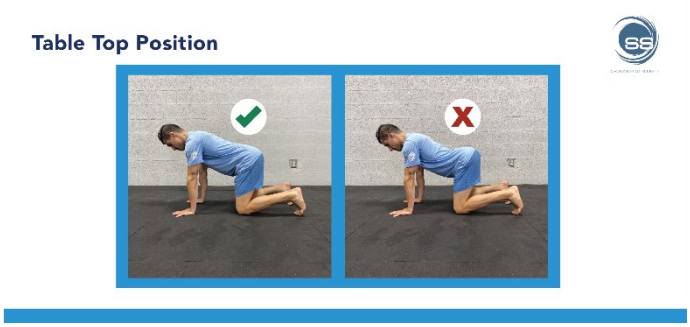


Table Top Position

The table top position is one of the most fundamental starting positions for movements done on the ground. Swimmers must maintain engagement throughout the core and distribute the weight evenly between the upper and lower body. The hands are firmly planted on the ground and the neck remains long.
Faults include the shoulders shrugging to neck, elbow bending, and spine arching.

Core Strength

Strength is the body's ability to generate or withstand forces to its limbs. As theweight load or strain increases, the brain fires signals to the muscles, telling them to work harder. When they near their state of maximal fatigue, you will feel that familiar burning sensation. That means the muscles need to contract more intensely than during core stability training. A swimmer needs to maintain stability to efficiently translate force into speed in the water. Static exercises, such as Bridges and Wall-Sits, develop strength because the longer the hold goes, the more muscle mass must be engaged to maintain stability.

Core Power

Power – the final piece of the chain – is the body's ability to quickly generate force. It is dependent on muscle size, strength, mind-muscle connections, technique and movement speed. Before focusing on power, and to safely contract muscles maximally, swimmers must have a baseline strength and stability. And the brain must be trained to send appropriate signals to the muscles so that they can function optimally. It can take a few months or even years for adolescent athletes to develop and reinforce these neuromuscular connections. If either of these parts are missing, swimmers cannot generate and absorb the forces involved in generating power.

Additionally, once the focus falls on speed– completing a movement quickly – technique often takes a back seat. Remember that the quality of the kinetic chain will dictate how efficiently energy is transferred between arms and legs, via the core. If technique falls apart, power and energy will not be generated optimally.

The Assessment: How Developed Is Your Core?

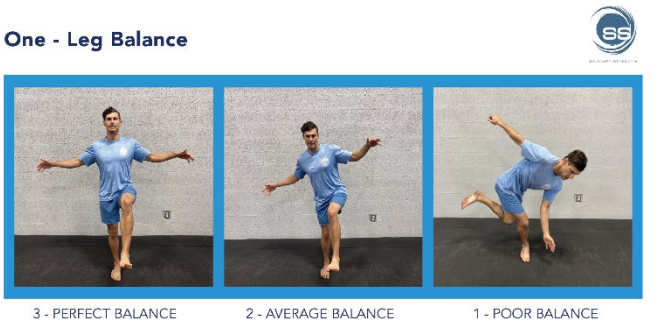
Elbow Bridges – Planks – and Crunches or Sit-Ups for time are among the most frequently used tests in swimming. The former is a static hold that tests overall body strength, stability and endurance all at once. The latter two measure repetitions over a given time and isolate the abs a nd hip flexor muscles, without really giving a gauge of stability. Beware of rushed repetitions, which can muddle the results. A failing Plank hold, on the other hand, you cannot mask.

I employ a two-part test to assess the quality of an athlete's core. The first section focuses on balance, which is synonymous with stability and reducing the risk of injury. I like to call this the subjective test because it is mostly measured with the bare eye. The second section evaluates isometric core strength, endurance and stability. I call this the objective test because it is timed. Core endurance, compared to core strength, helps to reduce injuries at a greater rate [36, 37, 38].

The Subjective Test

A swimmer's ability – or inability – to simply balance on one leg for a period of time provides a wealth of information about how stable their core is. A developed core will help the person comfortably hold for 30 seconds without losing balance or excessiv e movement in the spine. On the other hand, a swimmer with an

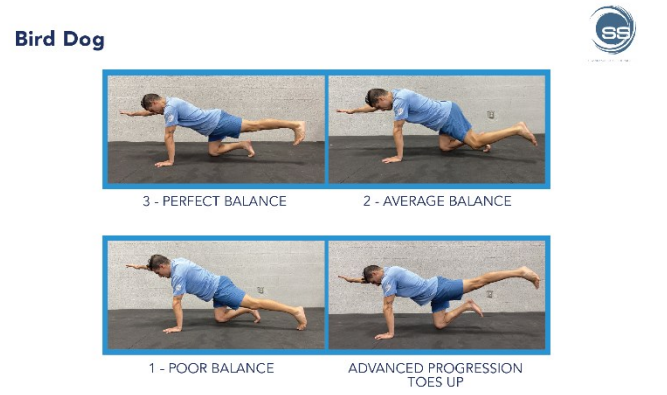
underdeveloped core will likely sway or need to jump around to maintain balance. Another way to assess core stability is through a slow and controlled Bird Dog movement. I typically use a simplescoring scale ranging from 0 to 3 depending on duration and overall execution. The score is automatically a 0 if the swimmer experiences any pain.



One-Leg Balance

Set-up position: Standing with one foot firmly planted on ground, the knee slightly bent and in line with the toes.

Test: Raise the opposite leg with the knee bent in 90-degree angle to the hip. Maintain that hold for at least 30 seconds.



Bird Dog

Set-up position: Swimmer assumes a table top position: The hands positioned beneath the shoulders and the knees beneath the hips and toes on the ground. For advanced progression, lift the back toe off the ground and only keep the knee down.

Test: Simultaneously raise one arm and its opposing leg to a straight position, slowly, while maintaining a straight spine and pelvic position. Hold for one second. Slowly move the arm and the leg underneath the body and connect the knee with the elbow. Return to starting position. Repeat three times per side.

+ all supine bridge variations

These movements are very basic and swimmers of all ages and levels should be able to master them with relative ease. Swimmers scoring below 3 will more likely than not have difficulties balancing in the water. In the pool, stability deficiencies will showcase themselves differently. For instance, swimmers whose hips during freestyle and backstroke tend to sway from side to side rather than rotate in a small cylinder, almost always lack proper core st ability. Similarly, swimmers who cannot keep their arms still during certain drills, or whose hands simply slice through the water during the catch, also often have deficient stability in their core and shoulders.

The Objective Test

I use five different e xercises to establish a swimmer's baseline core strength and track improvements throughout a season: the McGill Sit-Up, Elbow Side Bridge on both the right and left side, Straight-Arm Bridge and Back Extension. See Chapter 10 for a detailed outline of the tests.

Each of these are isometric holds, carried out until failure. Maintaining these positions even for a brief moment requires a baseline of strength and stability relative to the person's body weight. For each second that passes, the body engages more and more muscle mass to maintain its position. Running these tests until failure also makes them good measurements of maximal relative strength, which takes into account the person's strength relative to their body weight. To quantify this, I have developed a scoring system that yields 1 point for every 10 seconds held, capping the test at 20 points, which is at 3 minutes 20 seconds.

These tests help me determine two things. They reveal disparities between muscles in the front and the back. They also help expose injuries or hard-to-discern weaknesses that could eventually become injuries. Swimmers who lack a base level of stability may end up getting hurt if they try to push too far. It is not uncommon for adolescent or novice swimmers to feel pinchy sensations in the shoulders during Bridge tests. That is a signal to immediately end the test and note that the swimmer needs to correct their technique. It may also signal that the swimmer needs to see a physical therapist and work to strengthen their shoulders until they can perform the test without pain beyond muscle fatigue. These results, in combination with the subjective tests, should give the coach a better idea of how well the swimmers move in the water.

The Work: How to Get Better

The ideal progression of core training and general strength and conditioning looks like this:

To start with stability, there are five key components that should be the focus in all stability training:

- Controlling the pelvis

Imagine lying flat on your back. Now press your lower back down towards the ground, using your abs and glutes. Is it easy or hard? Well, that depends on how much control you have over your pelvis. The pelvis is central to stability because it transfers energy and prevents the lower back and legs from getting injured. This is especially important during more advanced movements. If the stability is not there, the lower the body will find a shortcut to execute the movement, like rounding the lower back, and put the swimmer at greater risk of getting injured. More advanced movements, such as a Hollow Hold or Kneeling Ab Wheel Rollouts challenge this.

- Neutral spine

The spine must remain as straight as possible during many movements. To achieve this, the postural muscles along the spine must be sufficiently developed to stabilize it, especially during advanced movements like Hang Cleans. Hip Hinge exercises help to develop awareness around keeping the spine neutral. These movements create motion from the hips. One example of developing awareness is to perform an RDL with a stick: Position a stick on the spine, stand with only a slight bend in the knees, feet firmly positioned on the ground, and hinge down from the hips as far as the body allows. The stick must remain on the pelvis, middle and upper back, and back of head.

- Long neck

The idea here is to pretend that someone is pulling a string from your spine through your head. To keep the head and neck in line with the spine, the shoulder blades should be angled toward each other and down, the neck pushed back and the chin slightly tilted down. You should feel as if you are almost trying to show off a double chin. If you end up feeling something like a giraffe, you are on the right path. This giraffe-like neck should be maintained during all movements on land, not just for the core, and both on land and also – especially towards the end of races when many fatigued swimmers tend to lose their line in the water and let their heads sink.

- Shoulder blades first

This might not be intuitive at first, but all major dynamic components of an exercise – for example the Pull-Up or the Push-Up – should begin and end with movements from the shoulder blades. This will ensure a full and

healthy range of motion for the shoulders, reduce the risk of injuries and promote proper technique. Same goes for any shoulder rotations or arm lifts: always keep the shoulder blades engaged before moving the arms. The checks for good starting positions are: shoulder blades gently back and down; long neck; and start the movement with the shoulder blades. The most important thing to note here is that the shoulder blades should not excessively squeeze back. This will limit their function. If the arms are moving in an exercise and there is little to no engagement from the shoulder blades, the risk of pain in the shoulders increases.

- Balance

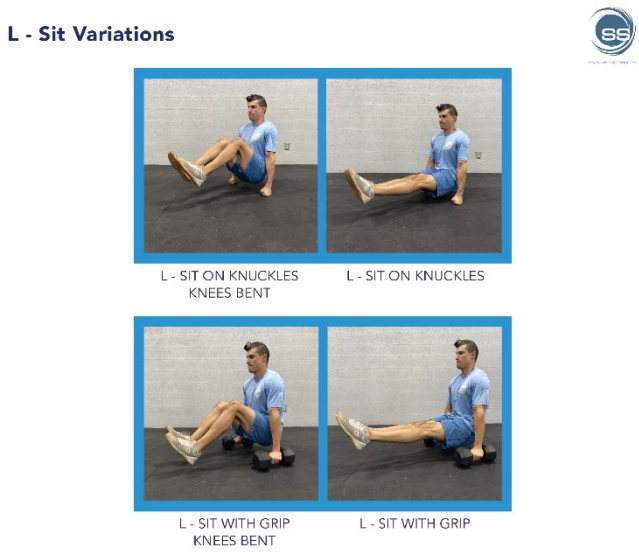
Balance and stability on land both stem from the feet and are synonymous with control. In nearly all movements for strength and stability training of the lower body, they must remain firmly planted. To best illustrate this, imagine three points on the sole of the foot: One by the heel, one beneath the big toe and one beneath the little toe. Each of these need to remain evenly planted on the ground. When jumping, the pressure flows from the heel to the two points in the front. An imbalance at the front of the foot may result in damage to ankles, knees, hips and the back. If the swimmer is frequently losing control, regress to an easier version of the same exercise. Anything that makes for an unstable surface, such Swiss balls, balance pads or discs, increases the overall stability engagement.

Developing Core Strength

Back Extension Variations:

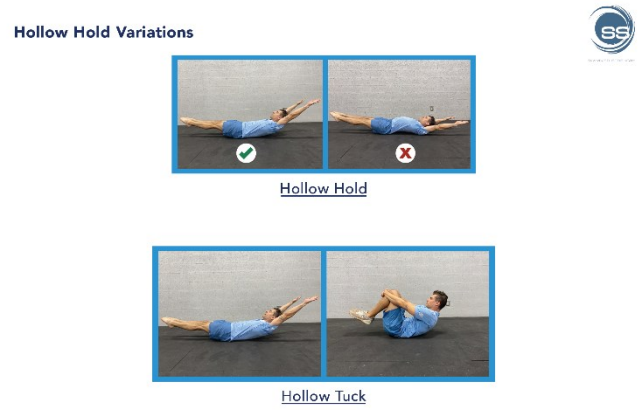
On a GHD : Position the GHD to align the hips at the end of the pad. Safely secure the legs. Extend the body and aim to align the head, shoulders, hips and legs as much as possible (see more in Chapter 5 and 10).

On the ground: Position the body on the ground facing down. Before lifting the upper body off the ground, engage the glutes and abs to avoid the rib cage from opening up. Focus on lifting up the upper half of the body without excessively engaging the lower back muscles. Arms down for beginners, and arms up for advanced swimmers.



L-Sit Variations

Sit on the ground with the legs straight out. Clinch the hands into a fist and press the front of the fists into the ground to lift the body while keeping the legs straight. Maintain a long neck. The swimmer can also elect to use handles to help elevate the body, suc h as dumbbells or bars.

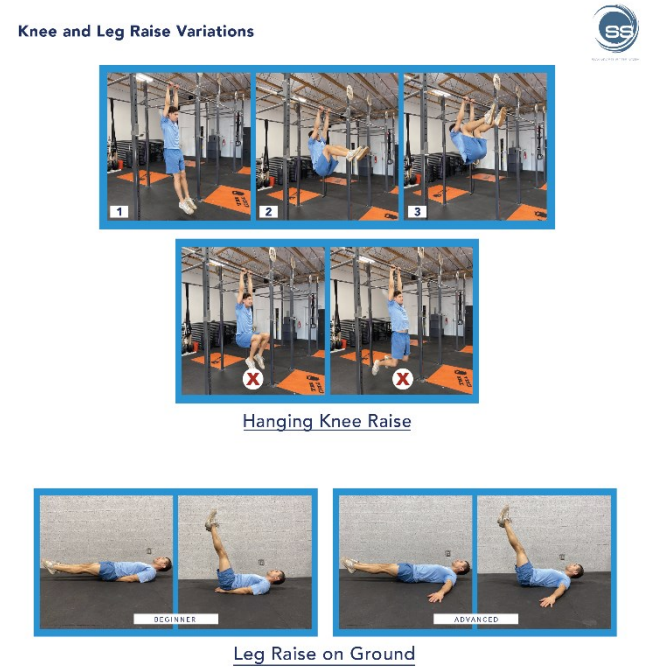


Hollow Hold Variations

Position the body on the ground, facing up. The lower back stays on the ground the entire time.

Hollow Hold: Hug the legs and actively press the lower back to the ground. Extend arms as far as they comfortably go without lower back arching. Keep the arms and legs straight and hover them off the ground into a static hold. The lower the limbs stay to the ground without the lower back arching, the harder this gets.

Hollow Tuck: From the same set -up and starting position as the Hollow Hold, quickly bring the arms and legs back to the tucked position. Rhythmically repeat.



Knee & Leg Raise Variations:

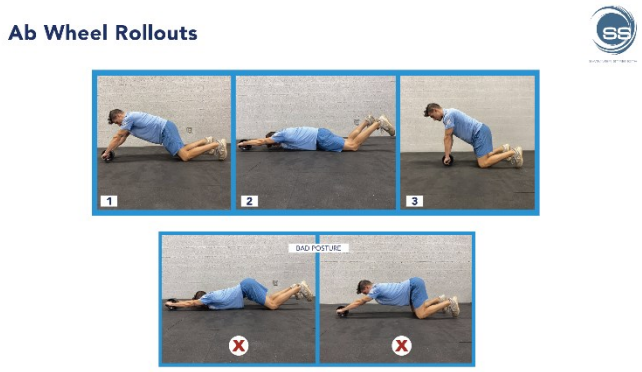
Hanging Knee Raise: Firmly grab a bar, or rings. Engage abs, arms, and back t o stiffen the upper body. Raise the knees in front of the body by pressing the hips forward and up. Get as close to the elbows as possible. Control the legs down. As soon as they get straight, repeat the motion with rhythm.

Faults include no upward moveme nt from the hips and excessive swinging.

Leg Raise on Ground: Position the body on the ground facing up. Beginners, place the hands underneath the lower back and hips. Keep legs as straight as they go and press the lower back down. Raise the legs and cont rol them down. Advanced swimmers, place the hands out to the side and still remain the lower back on the ground.

Important note: The pelvis must maintain posterior tilt by keeping the abs and glutes engaged before initiating

any leg movement. These can be powerful by increasing the speed of completion, but master doing it slowly first (see Chapter 2 for detail on pelvic tilt).



Ab Wheel Rollouts

From a kneeling position, grab the wheel and evenly distribute the body weight over it similarly to a straight arm bridge – or plank – position. Engage the abs and maintain a long neck. Press the body forward, rolling wheel and moving the hips forward simultaneously. Go to a range where stability in the spine, shoulders and wrists are maintained. Regress by moving the wheel towards a wall, gently tap it, and come back. Each week, step away from the wall.

Faults include rounding of the lower back and the arms and legs not staying synchronized.

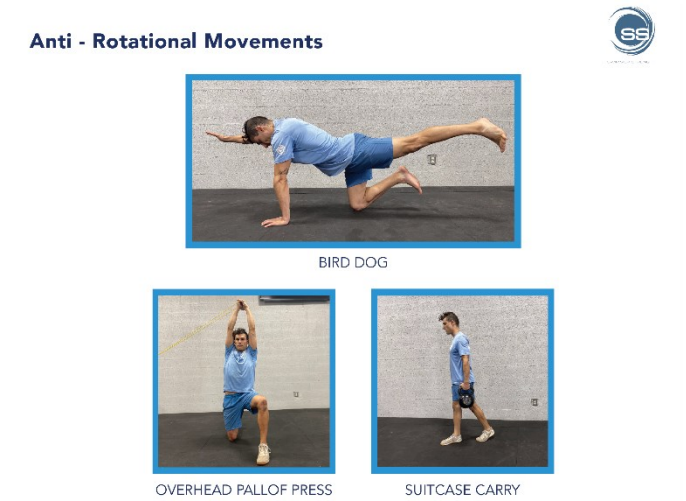
Bridge/Plank Variations: on elbows, hands, side, and suspension trainers etc.

Bridge/Plank Variations: on elbows, hands, side, and suspension trainers etc.

Most important notes are to keep hands and elbow right underneath the shoulders, maintain a long neck, keep spine neutral, and slightly separate the feet for added stability – wider stance counts as a regression.

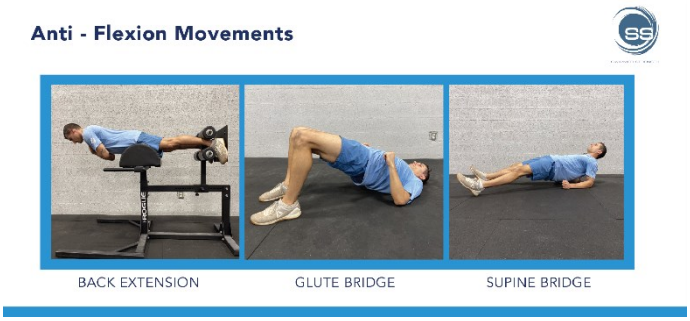
As you can tell, some movements are listed under both stability and strength. How they are performed will dictate whether the emphasis is strength or stability. Sets that are harder on the muscles and longer in nature, such as longer holds, primarily work on strength. In stability training, the balance and the body position are the emphasis.

Developing Core Stability



Anti-Flexion Movements

These involve forces that pull the body to the side and challenge the spine to maintain neutral. You may know them as “side abs” or other exercises that put emphasis on your oblique muscles. Examples include Bird Dog, Side Bridge, Pallof Press variations,and Suitcase Carries (see Chapters 5, 6 and 10 for more details).



Anti-Rotational Movements

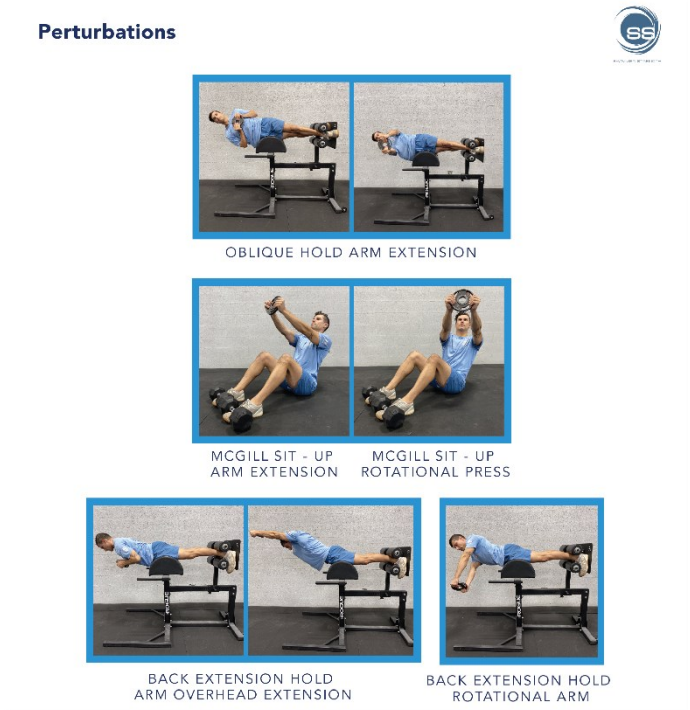
These are meant to promote stability in the lower back, glutes, and hamstrings– so called posterior chain - without moving the spine excessively. The premise is to tilt the pelvis back to flatten the lower back towards the ground. Exercises include Glute Bridge variations, Back Extension variations and Supine Bridge variations.

Anti-Extension Movements

These promote stability in the abdominals and the pelvis - without moving the spine excessively. McGill Curl-Up, Dead Bug, Prone Bridge and Ab Wheel variations are prime examples. Make sure the lower back does not round excessively during these exercises! This will create drag in the water and slow the swimmer down.

Remember, movements are either static or dynamic in nature, and one should come before the other. Master the holds for a minimum of 60 seconds before adding a dynamic movement to the exercise. And some movements, like Bird Dog or Dead Bug, train both stability and strength. Ensure that the swimmer masters the basics and can maintain proper technique before progressing.

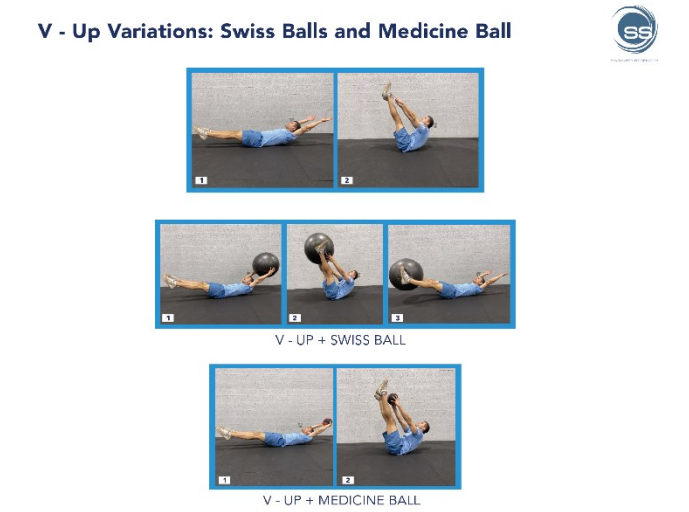
Developing Core Power



Perturbations:

These include movements with extremities, most commonly arms, and by manipulating the surface to become more unstable. They may either be rapid, or controlled depending on the baseline stability and strength of the swimmer. They can also be done with or without weight, such as plates. Some movements include rapid extensions or pulls in changing and stabilizing positions, such as a 45-degree angle, or a straight angle.

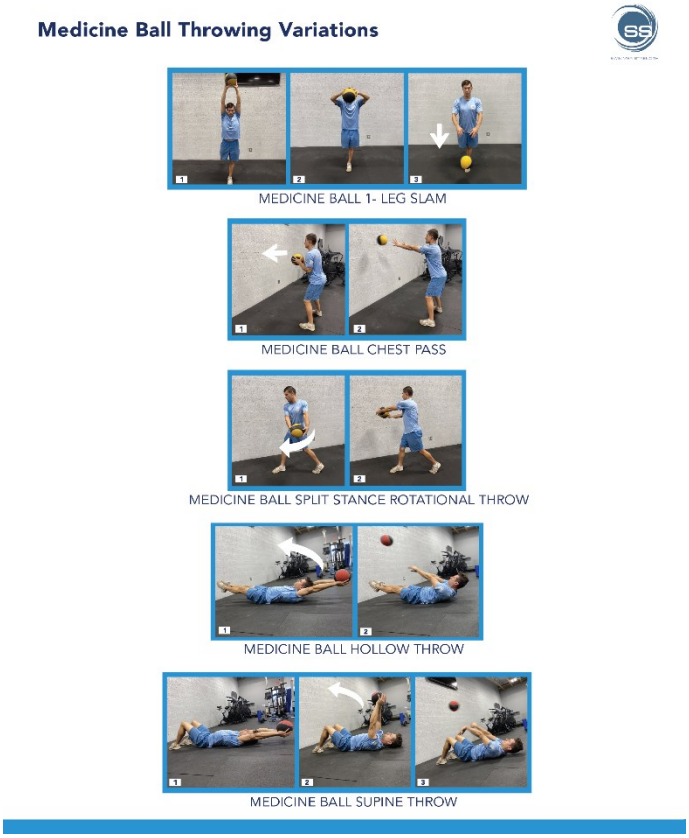
Important note: These movements must be mastered at slower velocities before emphasizing speed.



V-Up Variations: Swiss Balls, Medicine Balls

These are advanced movements and require swimmers to have a strong base of stability and control of the pelvis before training these exercises. The lower back must stay on the ground as the body extends down and there must be rhythmic movement through each repetition.

- Rapid Knee & Leg Raise variations (see above).



Medicine Ball Throwing Variations

Here, the main key is to maintain a neutral spine and avoid excessive movements. When slamming the balls, bonus points are given for "high -elbow" slams, similar to how swimmers hold and pull water. When releasing the balls, the body must maintain stiffness. The same goes for when catching them.

Exercises that involve movements, such as squats, can develop both strength and power depending on the speed they are performed at, whereas exercises that inv olve static holds, like Wall Sits, generally only develop strength.

Dosage

Each swimmer needs a program tailored to their unique skills and abilities. Core training is no exception. But as any coach will tell you, it is impossible to keep training tailored to each person's abilities unless you are one of the few who coach only one swimmer. Do not despair. I recommend three different dosing methods that work effectively with all swimmers.

For static holds, instead of a fixed time, I prescribe a number of breaths. I usually vary between 5 and 10 deep and rhythmic breaths – the longer they are, the better. And based on the test results, I prescribe a percentage of a maximal hold. If a swimmer maxes out at 100 seconds, I progress sets from 50% to 90% before retesting.

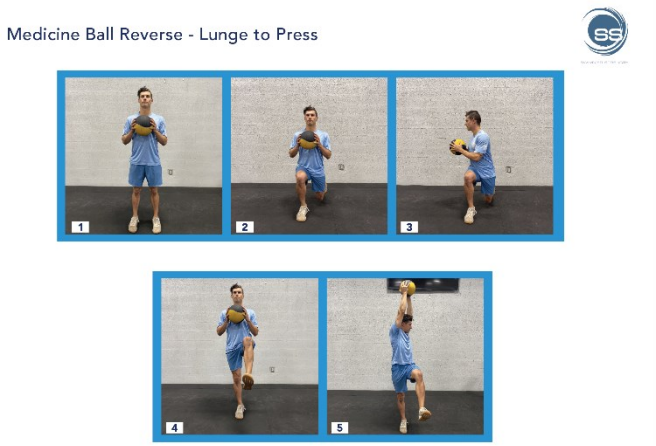
Another method is to use the *rate of perceived exertion* (RPE), scaled from 1 to 10, from easy to maximum effort. Most often I prescribe an RPE progression from 6 to 9 over cycles that range from 38 weeks, while adding variations to movements. New research suggests that prescribing intensities based on RPE is highly effective and safe, both in the weight room and in the water[13, 46].

How strong is strong enough? That is difficult to know. I argue that a 3 minute 20 second impeccable plank hold proves the swimmer has sufficient core stability, strength and endurance. At that point, the swimmer is more than ready to safely move onto advanced power and power endurance training.

Every strength workout should include at least one major core set. And I recommend that swimmers do at least 5 to 15 minutes of core training daily, either before or after swimming based on their needs.

Key Points for Safe Progression

I cannot stress this enough: The spine must maintain neutral. During full body complex movements, such as a Medicine Ball Reverse -Lunge to Overhead Rotational Press, the body can easily sway and lose balance. That is, unless the swimmer is able to ward off the imbalance. Be on the lookout for excessive movement from the spine and ankles, or slouc hed backs. They are all signs that the swimmer may be doing a movement they are not yet ready for! In that case, take a step back, choose a less complex movement that the swimmer controls, and wait 2-4 weeks before trying again.



Medicine Ball Reverse – Lunge to Pass

Stability and strength are prerequisites for developing power. The body is not able to do so until the mind-body connections have been properly wired and reinforced. The best way to do so is by progressing slowly and moving slowly. Additionally, slow-motion repetitions help cement stability, which is extra important with novice and adolescent swimmers.

Risks

Two inherent risks remain: that the swimmer gets injured, or that the training does not actually make the swimmer faster.

I welcome creativity. Albert Einstein once said, "*creativity is the intelligence having fun."* The issue with creativity is that coaches may get a bit too frisky and prescribe funky exercises that are borderline dangerous. Always choose safety over fancy.

Lastly, if advanced swimmers who have broadly mastered stability training continue to emphasize core stability over core strength and power, they may not see speed develop to its fullest. Swimming speed comes from the force placed on the water and the power generated by the muscles. Once core stability has been mastered, the swimmer must emphasize the development of strength and power in the core, while maintaining stability training.

Chapter 2

Streamline and Underwaters

"Your streamline is awful," the coach used to tell my 16-year-old self. "Just keep stretching your shoulders."

His name was Henning Degerman and for years he reiterated how I needed to improve my streamline if I ever wanted to win medals. This pointer became a constant throughout my career, even as I swapped one coach for another. My last coach, Scott Goodrich, kept making jokes about my inability to keep a proper streamline. That's despite me having done everything I was told for over a decade. I had been a Pac-12 Conference finalist and won a silver medal at the Swedish National Championship, and several honors at Youth- and Junior Nationals. But my streamline was, and still is, mostly crap.

To be a really fast swimmer, that cannot be the case, because the streamline coupled with underwater kicking is the fastest position in swimming. The two also set up each lap, carrying over speed from turns to strokes. That makes superior underwaters a distinct differentiator between good and great swimmers and often tips the scale of a race. Remember the 200 freestyle final at the 2007 World Championships in Melbourne, where Pieter van den Hoogenband decidedly outswam Michael Phelps but got smoked off every wall and lost the race by a full body length – showcasing to the entire world of swimming the importance of underwaters.

The Problem

Some swimmers have bodies that seem to have been shaped solely to form a perfect streamline and fire away butterfly kicks. But not everyone – myself included – is so lucky. Some swimmers have insufficient joint function and others have limited range of motion. Swimmers with tighter joints will always struggle far more to form a proper streamline than those with loose joints. Being in that position puts a lot of stress on their shoulder blades and arms. And swimmers who easily can put on muscle may see their joint function – and streamline quality – decline unless they balance this out with proper countermovements.

In both cases, swimmers may end up facing scorn from coaches who cannot accurately identify their adepts' anatomical differences and prescribe different exercises to balance out those shortcomings. The inevitable result is frustration and increased risk of injuries. And many swimmers simply do not have enough core strength to control the force in their underwaters, especially the postural muscles that hold the core together. That deficiency should be addressed before underwaters are emphasized.

Developing Body Alignment

The key body parts that impact a person's ability to form a good streamline include the spine, shoulder blades, pelvis, knees and ankles. Trying to change or even slightly tweak the functions of those can be a lifelong battle. Asking the body to change shape to swim faster is no cakewalk. But there are ways to slowly and deliberately begin to chip away at deficiencies or disadvantages in a safe and sound manner.

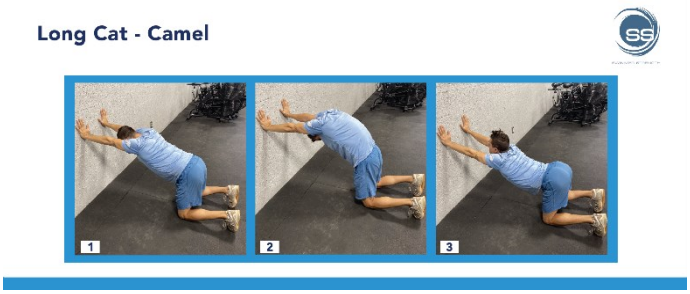
It begins with carefully selecting movements that fit the individual swimmer. Below are major body parts to manipulate for swimmers. When doing these exercises, always remember to maintain tension in the areas you are working. Tension equals muscle engagement. As long as the positions are in the desired patterns, finding ways to contract muscles to maintain tension will further improve range of motion. Remember, too loose is equivalent to less stability and becomes more stressful on the joints.

Upper Spine

Every single core muscle – involving those in a person's abdomen, pelvis and back – are engaged when a person does underwaters. Additionally, the upper part of the spine must be able to extend back beyond its natural

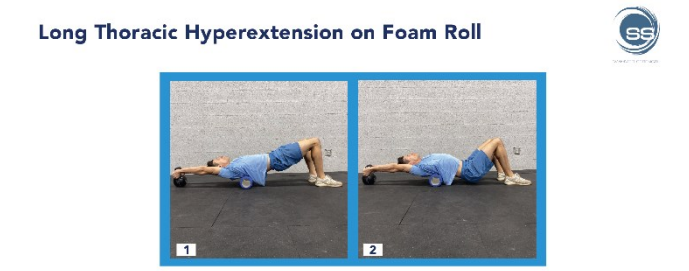
range in order to initiate the upward motion of the hands to initiate the upbeat kick. This is called “thoracic hyperextension.” To improve joint and muscle function, which collectively are known as mobility, the postural muscles must guide the spine through the extension and actively attempt to go further. For this to be effective, the pelvis must stay locked and the arms should be overhead, preferably in a streamline position.

Exercise samples:



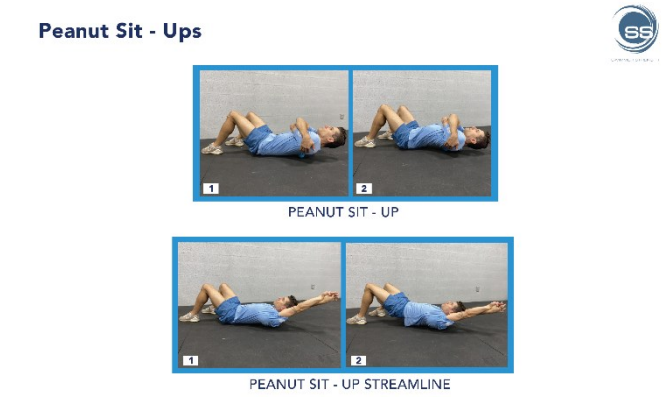
Long Cat-Camel

From a kneeling position, place the hands on a wall and keep the arms in line with the shoulders. Hunch the back, then arch the back by engaging the abs and postural muscles rhythmically. Let the movement flow from the pelvis to the lower back and finish with the upper spine and head. Maintain tension against the wall and a long neck while going through the motions.



Long Thoracic Hyperextension on Foam Roll

Position the middle-to-upper back on the foam roll, keep the arms and hands overhead and grab a stationary object, such as a weight or a rack. Keep the arms as straight as possible and keep the hips up. Exhale and bring the hips down. Maintain tension in the abs so that the rib cage does not open up. Do 35 repetitions per area from the middle of the back and up.



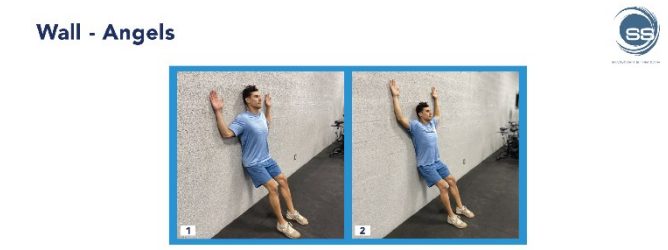
Peanut Sit-Ups

Place the ball in the middle of the back, with the spine in the middle of the two spheres. Exhale and gently lean into the ball, and gently engage the postural muscles on the ball to bring the body down. Keep the core engaged and make sure the rib cage does not open up. To intensify pressure, get in to a streamline position and gently bring the hips up and down without arching the lower back.

Shoulder Blades

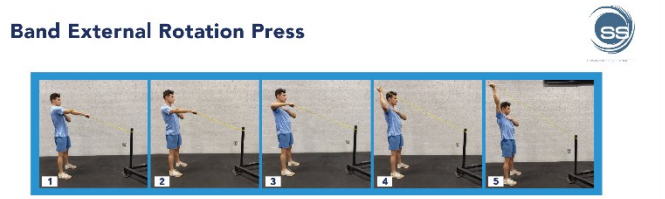
In order for the arms and hands to perfectly get in line with the rest of the body, the shoulder blades must be able to move freely. In fact, the shoulder blades must rotate upward and tilt backward to place the arms in an optimal position. This, in combination with the thoracic extension, will rhythmically initiate the underwater upbeat kick. For this to be effective, the middle back muscle right underneath the shoulder blades, called the lower trapezius, must be engaged.

Exercise samples:



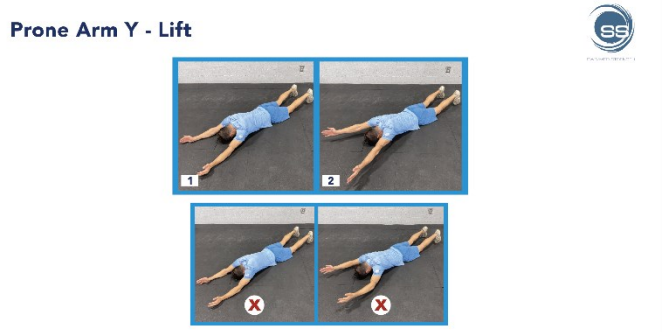
Wall-Angels

Lean against a wall with the legs slightly bent. The lower and middle back and head should be touch ing the wall. Place the arms in a W-position. Actively press the lower back and the arms against the wall and gently slide up until you can no longer maintain proper form. Rhythmically repeat and attempt pressing the arms up higher per repetition.



Band External Rotation Press

Grab a light band with one arm. Pull the band back so that the elbow gets in line with the shoulder and the hand remains in line with elbow. Externally rotate the shoulder to the end of its range. Press the band up overhead and slowly bring it down. The spine must remain neutral at all times, especially the lower back.



Prone Arm Y-Lift

Position the body on the ground facing down with the arms overhead in a Y-position. Engage the abs and glutes to keep the rib cage locked, the lower back straight and the forehead hovering just above the ground. Initiate the movement with the back rather than with arms by gently bringing the shoulder blades back and down to Initiate the lift and keep the elbows straight. Immobile swimmers that struggl e to lift the arms off the ground should focus on hovering the hands and elbows off the ground. As the arms get off the ground, reach forward. Elbows remain straight.

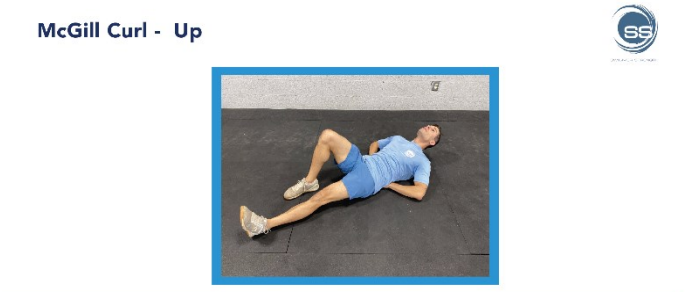
Pelvis

The movement of the pelvis is responsible for flattening the lower back. The deep abdominal muscles and glutes are responsible for tilting the pelvis backward to create a flat lower back, which will reduce drag. For instance, Caeleb Dressel has been described to have “no butt” by Ryan Murphy in an interview with FloSwimming. “It’s just a flat line from his back to his legs,” Murphy said [(40)]. This naturally minimizes his drag in the water. Meanwhile, I have a naturally curved lower back. This is called lord osis and is not good for fast swimming or quality strength training. The way to get around this is to develop the abs and glutes to be able to actively flatten the lower back.

Exercise samples:

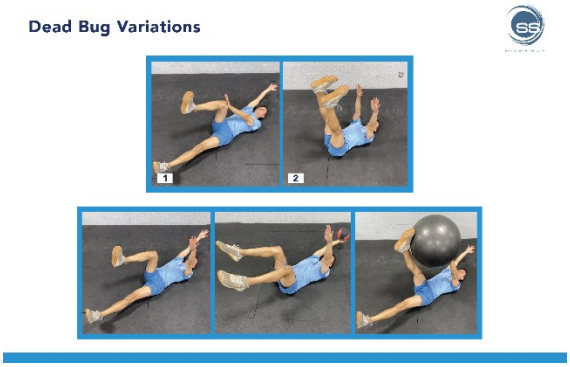
Pelvic Tilt: Anterior vs. Posterior

In swimming, the lower back is aimed to be as flat as possible to reduce drag in the water– this is a posteriorly tilted position for the pelvis. Squeeze the glutes and engage the abs to tilt the pelvis back. An excessive anterior tilt slows swimmers down in the water and is a sign of disengaged glutes and abs and is borderline dangerous if the spine is loaded in this position.



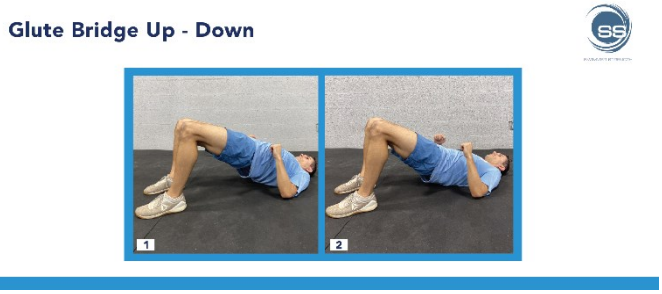
McGill Curl-Up

Position the body on the ground, facing up, with one leg bent and one straight. Slide the hands underneath the lower back. Create pres sure on the hands by pressing down from the abs and lift the head, upper back and elbows off of the ground. Maintain a long neck and take deep breaths.



Dead Bug Variations

Position the body on the ground, facing up, with arms and legs straight up, keepi ng the in line with the hips. Press the lower back down. Move the opposing arm and leg away from each other, almost touch the ground, then return and repeat the motion with the other pair. Variations can be done with Swiss Balls, Medicine Balls, bands and varying body positions.



Glute Bridge Up-Down

Position the body on the ground, facing up. Bend the legs and keep the heels underneath the knees. Press the body into a slanted bridge and try to engage the glutes and hamstrings more than the lower back. Lower the hips just a touch – a few inches at most – and bring them back up. The glutes and hamstrings are the primary muscle groups that should be engaged. Keep the lower back flat.

Knees

The knees transfer the force created in the upbeat kick to the downbeat kick. Hypermobile knees with a range of motion that is bigger than normal are ideal for developing underwater speed, but it is very challenging to develop hypermobility if you were not blessed with it at birth. Rather, you can develop strength and stability in the knee while seeking to gain as much extra range as possible.

Banded Mini Knee Extensions Wrap a semi-heavy band around a rack and the back of your knee. Step back so that the banded leg experiences a comfortable level of resistance. Stand firmly on the leg without the band. Keep a slight bend in the hips and knees on the band. Press the heel down and push the knee back as far you comfortably can to straighten the leg, without moving the rest of the body.

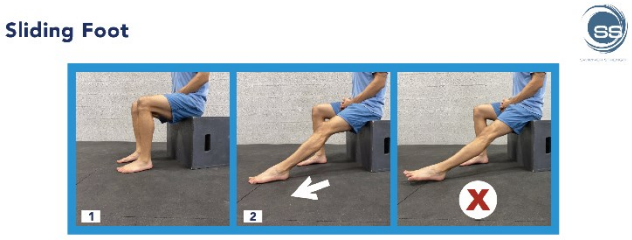
Toe & Heel Walks

Toe Walk: Walk on your toes, pressing the body and heels up as much as possible.

Heel Walk: Point the toes up and walk on the heels. Remain straight legs.

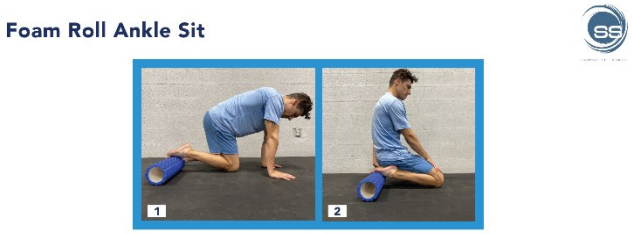
Ankles

The ankles release all the energy that is built up by the entire body during the full cycle of the dolphin kick. A flexible ankle will help the swimmer keep the body in a straight line and generate power far more efficiently than a stiff ankle. As a result, ankle flexibility is an important part of fast underwaters. But it is important to proceed with caution. Static stretching of ankles in positions that angle the toes away from the leg is highly unnatural for the foot and makes the ankle less stable. Some feet are so tense that they may cramp during these movements. If that happens, quickly stop and give yourself some massage and put pressure on your feet with your hands, really digging in, and also point your toes up and down to release tension.



Sliding Foot

From a seated position, slide the leg forward as far as possible while maintaining pressure on all three points. Bring the foot back in a controlled motion.



Foam Roll Ankle Sit

From a kneeling sit, place a foam roll on the top part of the feet or foot. Gently sit down on the heel and feel the stretch in the ankles. Protect the ankles by contracting muscles to point the toes up and down.

Use caution: Too much time spent passively stretching the ankles can make them more unstable. Spend no more than 2 minutes per leg every other day if you are experiencing limitation in the flutter and dolphin kicks.

Ankle Mobility: Ball under Foot and Foam Roll Calf

Ball Mobility Feet: Step onto a hard object, such as a mobility ball, either from a standing or s eated position. Gradually load more pressure onto the ball, and move it around underneath the foot. At tender areas, create more pressure and keep moving the toes up and down.

Foam Rolling Calves: Place one leg on top of a foam roller and cross the other on top, putting pressure on the bottom leg. Roll the leg in slightly circular motions, and apply more pressure on tender areas.

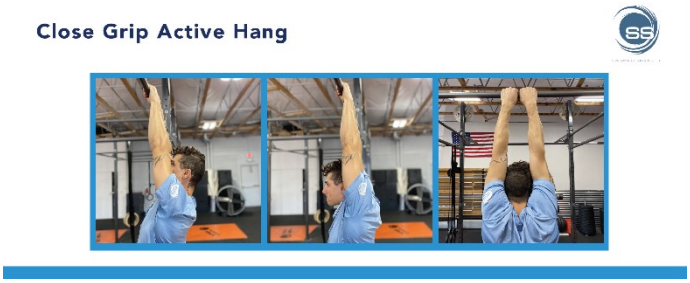
Generating More Power

The two phases of the dolphin kick are the upb eat and downbeat kick The upbeat kick mainly aims to minimize the drag on hands and arms, which are in a streamline, while the downbeat kick generates the bulk of the speed. Below are a few ideas for how certain muscles can be developed to generate more power in the underwaters.

Upper Body: Strength & Stability

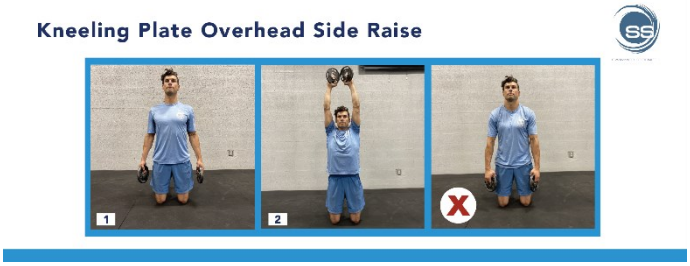
Lower Trapezius Activation Exercises

See Y-Lift.



Close Grip Active Hang

On a bar, place the hands closely together with the whole thumb wrapped around it and the knuckles pointing up. Push the head forward and relax the shoulder blades. Keep the core engaged and engage the shoulder blades every few seconds to protect them.



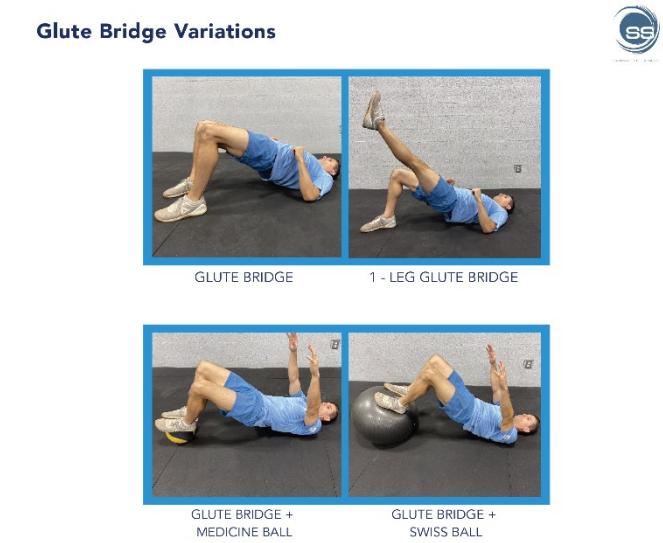
Kneeling Plate Overhead Side Raise

While in a kneeling position, grab a plate in each hand and keep the wrist rigid. Maintain an upright starting position with a neutral spine. Bring the arms up to as close to a streamline position as possible and reach up. The spine must remain neutral the entire way. Control the arms and weight back in a controlled manner.

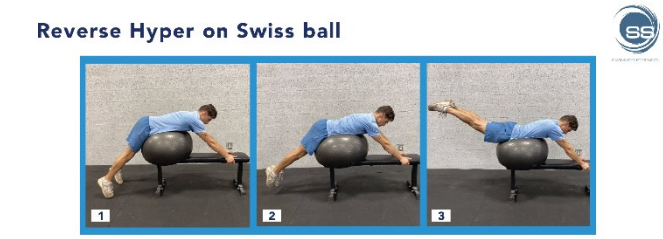
Lower Body Half: Strength & Stability

Terminal Knee Extension Variations

See banded mini knee extensions.



Glute Bridge Variations



Reverse Hyper on Swiss ball

Place an SB on a bench. Place the belly on the SB and hold onto the sides of the bench. Lift the heels up as high as possible and keep the back engaged back. Maintain a long neck and engage the hamstrings and glutes more than lower back. This exercise can also be done with a Roman Chair/GHD.

Nordic Hip Hinge

Start from a tall kneeling position with the feet locked either by an object or by a partner keeping them down. Keep the hips right above the knees. Slowly fall forward

and keep a neutral spine and the core engaged. Hips remain in line with knees.

Full Body: Rhythm, Coordination, Strength

L-Sit Variations

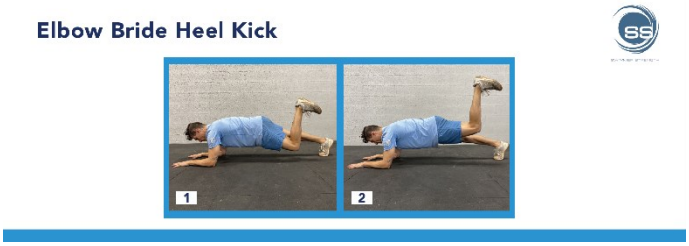
See Chapter 1.

Hanging Dolphin Kick Simulation

Hanging from a bar with arms in a close -grip position, try to replicate the same movement pattern as in underwater kicking, but slowly and rhythmically. Swimmers must have a decent baseline strength in grip and stability in shoulder blades.

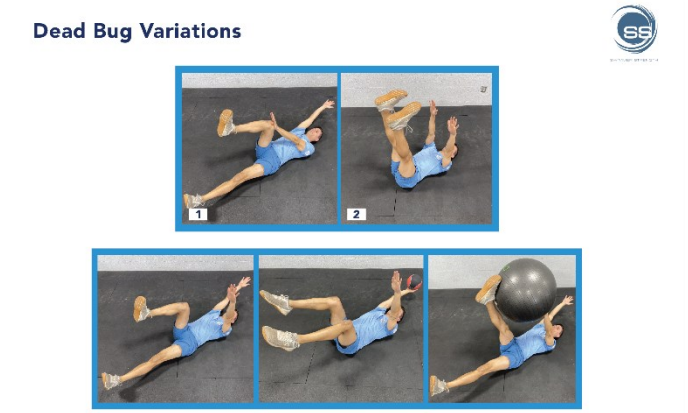
Hanging MB Dolphin Kick

This builds on the exercise above. Keep a medicine ball locked between the feet. Undulate back into the upbeat kick, quickly transition to the downbeat kick and release the ball with as much speed as possible.

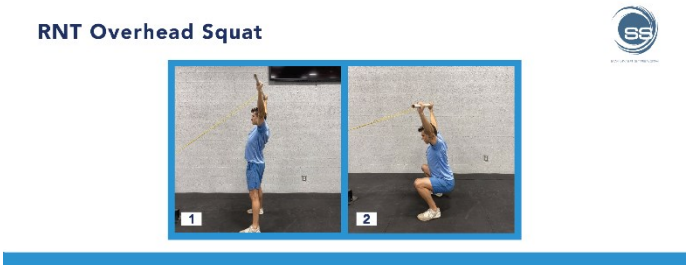


Elbow Bride Heel Kick

Bridge on both elbows. Bend one knee to get the heel above the knee. Kick the heel up and down. The spine must remain neutral and the remainder of the body should remain still.



Dead Bug Variations



RNT Overhead Squat

Wrap a small band around an object of rack. Place a stick around the band and grab the stick in a wide grip. Push stick overhead and step back to create a gentle tension in the band. Get into a squat stance. Take a deep breath, do a full-range squat, and stand back up. The stick arms to remain in line with toes.

Side-note: RNT means reactive neuromuscular training which, in this position, helps to engage the postural muscles more.

Full Body: Power

Hang Clean Variations

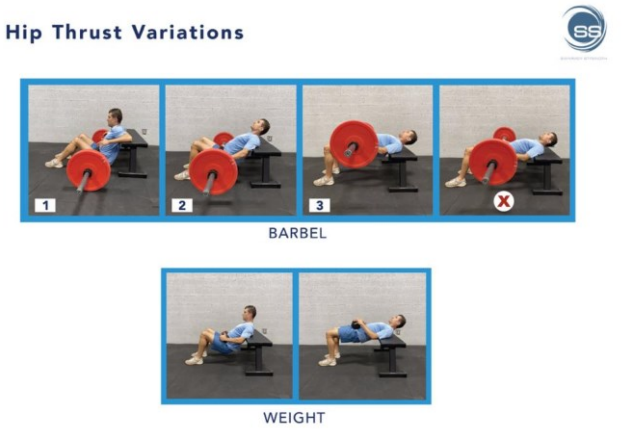
Starting position: Grab the barbell or dumbbells firmly with feet hip width apart and toes forward or slightly pointed. Shoulder blades are gently together and down. Distribute the body weight evenly on the feet.

Set-up position: Bend the knees and maintain a relatively upright position wi th a slight lean forward. Spine stays neutral. Body weight is distributed in the middle of the foot. The bar is right above the knees close to the thighs.

Jump Shrug: Push through the ground to straighten the legs. As the legs get straight, pull the shoul ders up in to a jump. The arms remain straight. Land softly and evenly distribute the weight on the feet without swaying.

Hang Clean High-Pull: Same starting sequence as the Jump Shrug without the jump. As the legs get straight, quickly pull the bar up to the chest close to the body. Softly catch the bar on its way down. Evenly distribute the weight on the feet without swaying.

Hang Power Clean: Same starting sequence as the High-Pull. As the pull with the arms finish, dip under the bar and rapidly turn th e elbows underneath the bar to catch in on the front end of the shoulders. Evenly distribute the weight on the feet without swaying.



Hip Thrust Variations

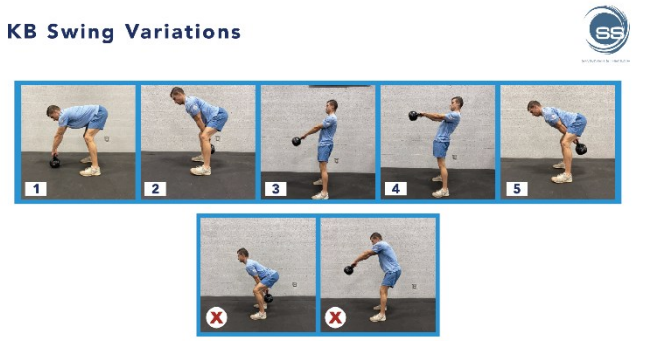
Position the body on the ground with the back facing a bench or a box.

Barbell: Position the body underneath the bar. Place a soft cushion on the bar to protect the pelvis.

Weight: Place the weight by the hips and secure it with the arms.

Bend the legs and place the arms on a bench. Bridge up and keep the weight secure with arms. The heels should be close to right underneath the knees. Pull the hips up while evenly distributing the weight over the feet. Control back to a full range and repeat.

Faults include the feet sliding away, the head moving excessively, and lower back overarching.



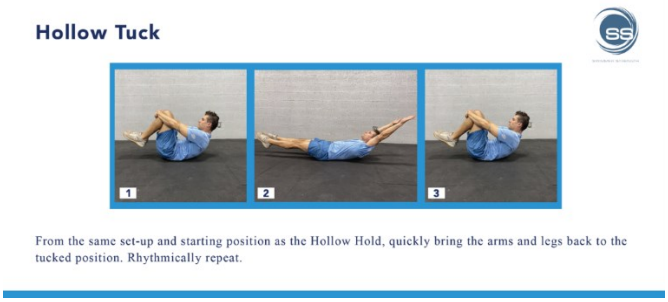
KB Swing Variations

Main key is to maintain a neutral spine with the legs remaining slightly bent. Maintain even weight distribution over the feet. Lift the kettlebell off of the

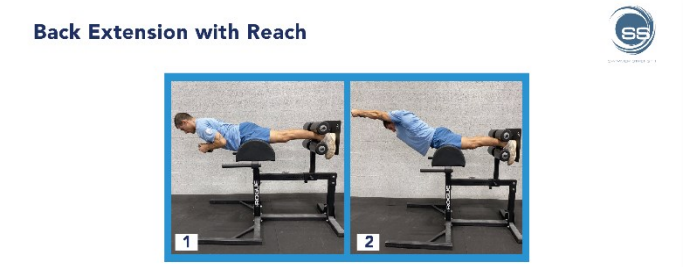
ground and let it slide between the legs, then use the momentum to swing it up to the first swing.

Common faults include knee and spine bending, knees caving in, and the weight pressure on the feet is swaying with the kettlebell.

Core

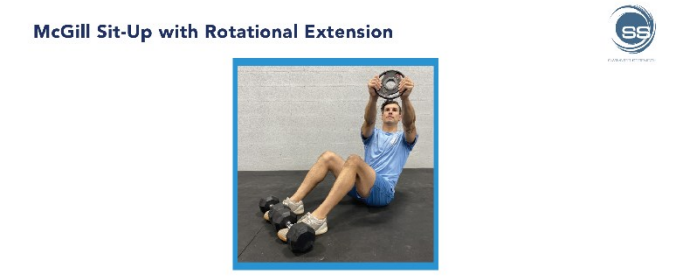


Hollow Tuck



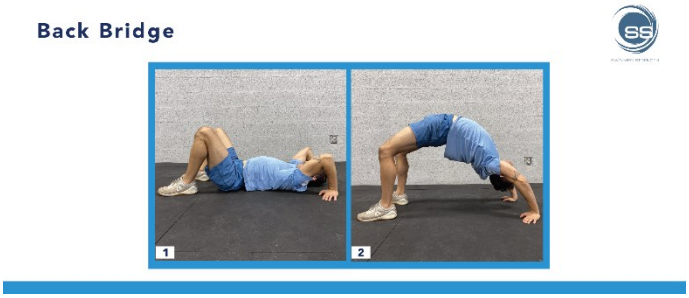
Back extension w/Reach

Position the body in a Roman Chair facing down. Secure the feet and hang. Extend the body to a neutral position. Then, extend the arms in line with the body and away from the shoulders. Bring the arms back, then let the body slowly come down.



McGill Sit-Up with Rotational Extension

Position the feet securely under an object, such as dumbbells or a partner's feet. Grab a plate. Straighten out the spine and lean back to approximately 45-60 degrees to get the abs engaged. Twist the body and extend the plate fully and rhythmically bring it back. Maintain a long neck.



Back Bridge

Position the body on the ground facing up. Place the arms above the head with the hands turned slightly out and knees bent. Push the hips up into a bridge. Swimmers that cannot get off the ground often try to drive too much from the lower back, not their arms and legs, and end up arching their backs far too much. In these situations, ask the swimmer to flatten the lower back and instead focus on pressing with the arms as hard as possible.

A full workout to improve streamline performance could look something like this:

Workout 1

Prep:

1. Glute Bridge
   x20
2. Dead Bug
   x20
3. Wall Angels
   x20
4. Close-Grip Hang
   x15-60s

5. Thoracic Hyperextension Foam Roll/Peanut – Arms Overhead
   x10

Block A

1. KB Swing
   3x10
2. Hanging MB
   3x5

Block B

1. Nordic Hip Hinge
   3x5
2. Terminal Knee Extension
   3x10

Block C

1. Reverse Hyper
   3x10
2. Kneeling Plate Overhead Side Raise
   3x10

Block D

1. Hanging Dolphin Kick Simulation
   3x5
2. Back Bridge
   3x5
3. L-Sit Variation
   3x5-10 seconds

Workout 2

Prep:

1. Glute Bridge
   x20
2. Dead Bug
   x20
3. Wall Angels
   x20
4. Close-Grip Hang
   x15-60s
5. Thoracic Hyperextension Foam Roll/Peanut – Arms Overhead
   x10

Block A

1. Hang Clean or Regression
   3x4

Block B

1. Hip Thrust or Regression
   3x5
2. Y-Lifts
   3x10

Block C

1. RNT Overhead Squat
   3x6
2. McGill Sit-Up with Rotational Extension

Block D

1. Hollow Rock/Hold
   3x20 or Hold 10 breaths
2. Back Extension + Reach
   3x5
3. Elbow Bridge Heel Kick
   3x

There Are Many Ways To Get Where You Want to Get

These workouts are about as swim -specific as I make them. I have borrowed some movements from gymnastics, but the majority are general strength and power exercises that build the body into one cohesive athletic unit. These exercises and workouts can be modified to fit everyone from a 13-year-old novice to an Olympic-level athlete.

Chapter 3

Explosive and Plyometric Training

Every Wednesday morning was the same. The team would gather outside the pool at Daytona State before dawn, stretching out, yawning. At 5.45 a.m. coach Steve Lochte would roll up in his golf cart, step on the pedal and take off on a mile-long loop around campus, with thirty swimmers running after him. He was not a slow driver, and the rivalry among the guys was fierce. Each week, the race was on. To this day I remain grateful to Steve and the athletic trainers who helped take care of my shin splints.

At Arizona State there were no mile-long morning treks. Instead, a small group of sprinters would gather on the track one morning per week during the spring and summer. We mainly worked on developing our plyometric abilities by doing variations of short sprints, hurdle jumps and broad jumps. This was far more technical and required rhythm and pure power. But just like with the running, the rivalry was fierce.

I was not a particularly talented swimmer. My body is nowhere near optimal. I am short, my knees do not hyperextend, my low back is naturally curved, my posture is relatively poor, my shoulder blades lack the range they need and my muscles tense up relatively easily. The training reminded me of my childhood when I would run around with friends after school, climb at the playground or play basketball. Over time, this kind of playing helped develop the tendons in my leg far more than if I had just been swimming.

Some body types are more receptive than others in developing so-called tendon stiffness, which helps release stored elastic energy in conjunction to muscle contractions. Even though my body type was not optimal for swimming, my natural stiffness and well-developed tendons helped me stay competitive with other swimmers whose bodies more had the stereotypical swimmer's build – tall and slender. Developing that stiffness takes time and requires patience. This is where the problem often starts: Swimmers jumping into aggressive plyometric training without being fully prepared.

The Problem

The terms "plyometric" and "explosive" training are often confused, which in itself is not surprising. But it is important to understand the difference to be able to structure workouts properly, because their impact on the body is rather complex.

Many swimmers are introduced to plyometric movements and exercises without a proper introduction to what they are, how they impact the body, how they translate to the water or how to best develop them. They are technically demanding, require a high degree of focus and can lead to injuries if done incorrectly. Some swimmers are prescribed movements that are too advanced, or opt for the heavier medicine ball, which may make their movements slower and less plyometric.

The Background

Plyometric and explosive training develop power and strength. Both aspects involve fast movements, but they are executed differently. For a movement to be considered plyometric, it must have a quick and noticeable lengthening contraction in the muscles before quickly shortening [66]. Explosive movements emphasize the muscle-shortening contraction – concentric –and are more frequently completed with heavier weight [41]. There is some overlap. Plyometric exercises can be categorized as explosive, but explosive movements are not by default equal to plyometric. The biggest distinction is that plyometric training involves a physiological phenomenon called stretch-shortening cycle (SSC).

The SSC is the primary component of plyometric movements with rapid transitions from eccentric to concentric actions. The transition time between is called

"amortization phase." The quicker the transition, the more elastic energy is released from the tendons to help the muscles propel you forward and boost power. This combination of a movement and countermovement and reliance on tendons being stiff form the basis of any plyometric movement. That is why a vertical jump is often called Countermovement Jump (CMJ). Some are born with stiff tendons and can easily develop their plyometric abilities. Others struggle to develop this stiffness in their ankles, making it more challenging for them to stay light on their feet during movements.

Plyometric exercises include sprints, jump rope, Squat Jumps and Medicine Ball Throws. But not all jumps and throws are plyometric, and the intensity of the movement depends on external loads and the length of the amortization phase. A shorter amortization phase indicates a more plyometric movement.

For instance, swimmers have much shorter contact times with the ground while sprinting and jumping rope than while doing Squat Jumps or, on the other end of the spectrum, Squats. As a result, they are more plyometric. Squat Jumps then arguably become more explosive than rope jumps.

Are swimming starts plyometric or explosive? As you may have guessed, the answer is explosive. Not all jumps are plyometric. A normal flat start is a jump without a countermovement, so there is no SSC. That puts the start into the "explosive" category. Developing explosiveness involves ballistic and dynamic training that can be performed with loads of up to 80% of 1RM, as long as the exercises are carried out with enough speed. However, doing plyometric movements at such high loads puts tremendous stress on the joints and tendons, so use caution.

How plyometric swimming truly is remains a subject of debate. The turns obviously fall into that category. The swimmer comes into the wall at high speed, plants their hands or feet on it and must quickly absorb and redirect the force as they prepare for the push-off. In the flip turn, where the legs are already bent with only the balls of the feet touching the wall, there is very little transition between the eccentric and concentric movements. In open turns, used in the breaststroke and butterfly, the arms absorb most force and the legs approach the wall while already bent. The upper body is a different story. Some swimmers extend their arms rapidly during the recovery before entering the catch, and the muscles and tendons in the shoulder arguably release elastic energy but certainly not to the same extent as traditional jumps. However, better plyometric abilities have been shownto enhance swimmers' explosiveness and overall power. Caeleb Dressel, for example, usually does one Tuck Jump the seconds before he steps up on the blocks to race – a plyometric primer before his explosive take-off. Few swimmers soar off the blocks like he does.

The Fix

Everything starts with learning how to land from jumps and catch things like medicine balls. These are low-impact plyometric exercises that make up a strong foundation for any swimmer. As long as adolescent swimmers are mature enough to be mindful of how their feet, legs and spine act when they land, and can understand and implement instructions, they are ready to learn these. The same thing goes for catches. A swimmer who can confidently catch a fast-moving medicine ball without losing balance will also be able to release the ball with conviction and power.

Medium- and low-impact plyometrics, such as variations of the Squat Jump and Box Jump are okay to introduce to swimmers after they have built a foundation of stability and strength. More advanced and high-impact plyometric movements and exercises with SSC should not be introduced until the swimmer can squat their own body weight with external loads, or hold a Split Squat for 90 seconds (see more in Chapter 10).

When it comes to explosiveness, swimmers of almost any age can start doing exercises using their own body weight. For example, instead of asking swimmers to simply do 10 Squats, they can focus on doing the eccentric downward phase slowly and controlled and the concentric upward phase as quickly as they can. Focusing on controlling the eccentric movement while maximizing the power in the concentric phase helps develop both explosiveness and power. I call these

"negative repetitions" because the first half is slower than the second half. Similarly, instead of doing 10 normal Push-Ups, try negative-tempo Push-Ups – slow down, fast up – and keep an RPE of about 8.

Older and more advanced swimmers can use external weights to boost the development of explosive fast-twitch muscle fibers. It is okay to use loads of up to 80% of 1RM, but the set ought to be terminated if the speed of execution of each repetition visibly slows down. At these loads, the number of reps should be kept between 2 and 4. The more advanced a swimmer is, the quicker they are able to move bigger loads. That provides a bit of wiggle room to experiment with what a swimmer's optimal load to develop power might be. If the swimmer feels heavy in the water and seeks to gain back some of their lightness, the maximum load should be reduced to 65% of 1RM, with 2-4 sets of 4-8 reps.

Explosiveness exercises can be modified to either simulate the characteristics of plyometrics by moving quickly between the eccentric and concentric components, or shorten the SSC. For instance, a Squat Jump is generally considered a moderately plyometric exercise as the duration of the SSC involves the body reversing its downward momentum and shooting back up, all while the feet are planted on the ground. (Compare that with the Tuck Jump, which is highly plyometric due to its far shorter SSC.) The Squat Jump can be made more explosive and start-specific if the eccentric component is cut out. The swimmer would hold the Squat position for a couple of seconds before taking off, resembling a start. The power will not be as high as during a regular countermovement jump because of the absence of elastic energy from the tendons. Still, both methods are useful.

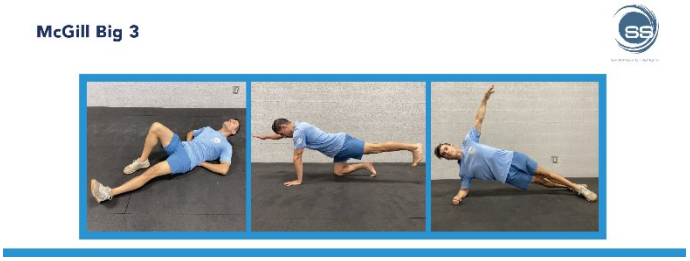
For the upper body, medicine balls are the best tools to develop plyometric abilities. But because these only play a small part for the upper body in swimming relative to other sports, there must be a mix between plyometric and explosive movements. For example, the Medicine Ball Chest Pass, done either against a wall or with a partner, is considered plyometric as long as the catch and the release are done in one quick and continuous movement. If the swimmer pauses at the chest before releasing the ball, the SSC is taken away and the movement goes from plyometric and explosive to solely explosive. Exercises such as Bench Press and Pull-Up can also be manipulated to be more geared towards plyometric movements by shortening the SSC.

No matter the speed of the movement, the technique always is the determinant as to whether a swimmer truly is ready for this type of training. That is why learning to master how to absorb forces – landing and catching – is more valuable for pre-pubescent swimmers than going straight to throws and jumps. If you can land and catch properly, it will be far easier to take that next step. Teenagers can start incorporating more variations of throws and jumps while maintaining the foundational principles from past progressions. No swimmer should be forced to do a movement they are uncomfortable with, because there are always substitute movements that can develop the same plyometric and explosive abilities.

Practical Takeaways

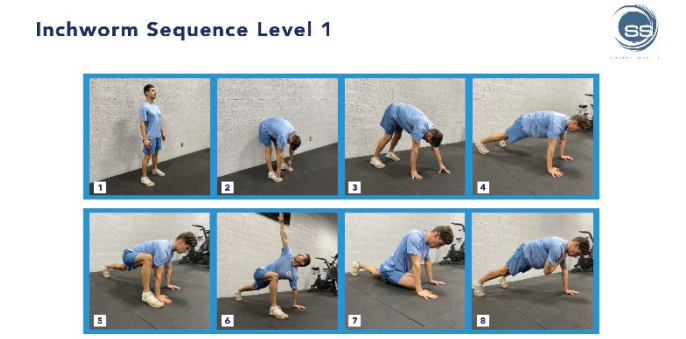
It is of utmost importance that swimmers are properly warmed up – both their muscles and minds – before taking these kinds of workouts. Completing movements that are this rapid requires the brain to make split-second decisions of how to best land on a surface or catch an object. Since the core transfers energy and coordinates movements, it must be properly prepared and ready to go. The warm-up must also include movements that will be carried out during the workout. For instance, if it will include Hurdle Jumps, the swimmers must prepare their ankles, knees and hips to be able to properly withstand and counter forces, and the brain must be ready to quickly signal to joints and muscles that they must generate enough forces.

<u>Sample Warm-Up: Light Plyometric Jumping</u>



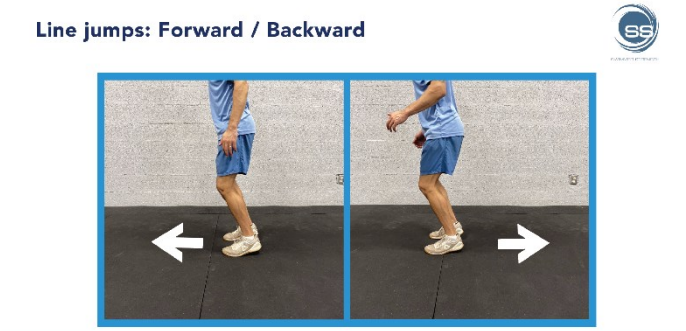
McGill Big

3 – 5-10 breaths per position



Inchworm Sequence

Level 1 – 3 rounds of: inchworm, spiderman stretch, thoracic rotation, pigeon stretch, shoulder tap, walk back.

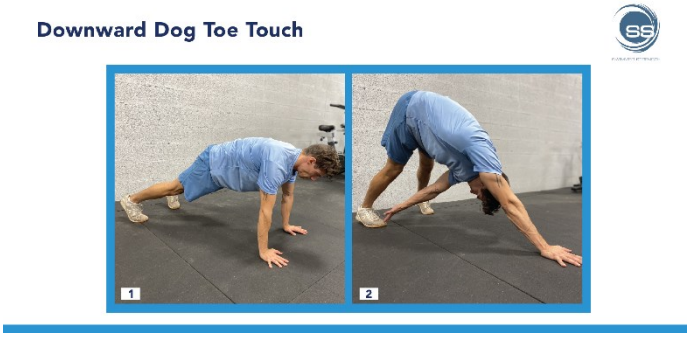


Line Jumps – forward/backward

Line Jumps – forward/backward 2x15s

Line Jumps – side-to-side

Line Jumps – side-to-side 2x15s

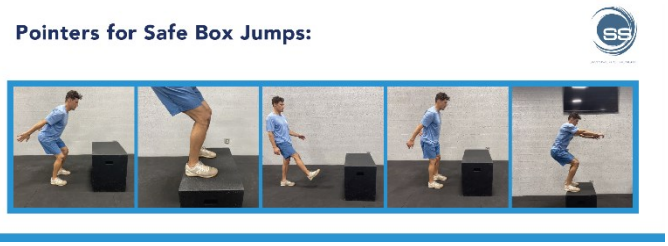


Downward Dog Toe Touch

Downward Dog Toe Touch – 3 on each side

Swimmers below 10 must learn the basics of skipping, landing and catching objects. I recommend spending 10-20 minutes per week, including warm-up, focusing on the fundamentals of low-impact plyometric movements with 1-3 sets of 5-10 reps. The core must learn to stay stable and the body remain stiff as external forces challenge it. They do not need to spend much time on explosiveness. Instructing swimmers to squat with negative tempo is enough, and it has the added benefit that it forces them to remain aware of what they are doing rather than just go through the motions. These types of movements become more relevant the last 2-4 weeks before the big meet of the season.

Pre-pubescent swimmers may progress into medium-impact movements and undergo instruction for how to carry out high-impact exercises. Between 20-30 minutes for 1-2 days per week is sufficient to cover both explosive and plyometric work. Learning how to sprint on land, for example, is a valuable skill, and it is okay to do as long as the swimmer feels just fine over the next few days. If not, sprint swimming is a better option. At this stage swimmers may also be introduced to movements with bands. Variations of jumping rope can also be good, focusing on being as light and rhythmic as possible. Learning how to properly do Box Jumps will also be valuable. Some fear jumping onto or over objects. The best way to get around this is to progress slowly and build the swimmer's confidence.

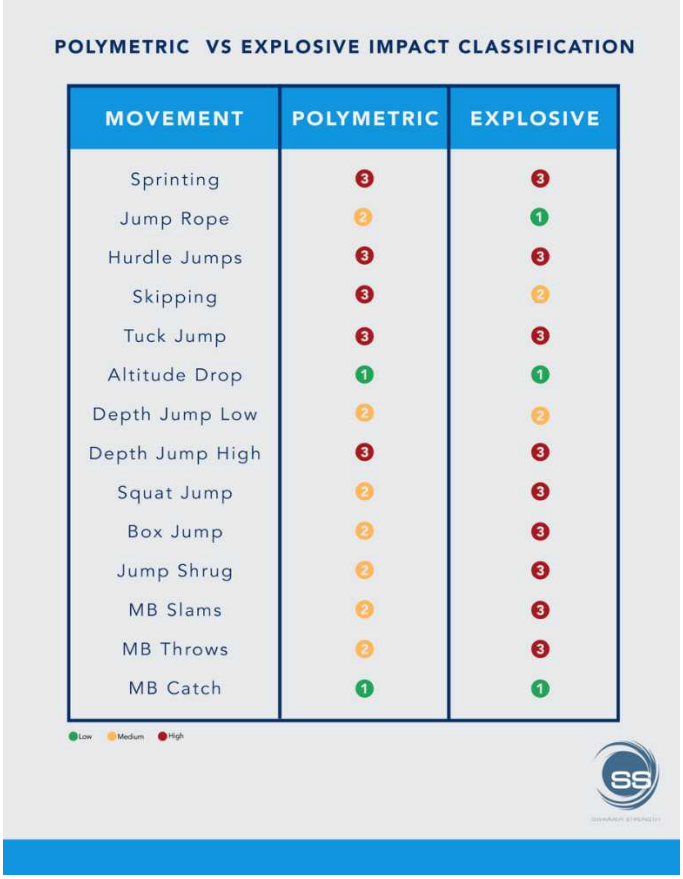


Pointerss for safe Box Jumps:

- Start with a lower box.
- Land with the whole foot on the box and try to keep the pressure at the middle of the foot.
- Land with the hips higher than the knees (the higher, the more power).
- When progressing to a higher box, approach the box with a step, similar to a relay exchange.
- Always maintain a stiff spine.

Teens can move on to mo re advanced plyometric exercises. They should master the Jump Rope, including so-called double-unders, meaning jumps during which the rope completes two full revolutions around the body. These are essentially continuous Tuck Jumps with arm motions. These s wimmers may also begin to develop explosiveness with external weights. Since they do not yet have a 1RM to base loads off of, the coach will have to make a judgement call based on how the swimmers look and their RPE. The RPE should range between 4-8 throughout the season, and it is okay to occasionally go above that threshold. The RPE, reps and weight should be reduced as the swimmer gets closer to a taper meet, but the speed of movements should increase.

With more advanced swimmers comes more freedom. Plyometric components can and should be included in any strength program. Combining heavy and strenuous exercises with lighter and quicker movements – like doing a Squat and immediately go into a Box Jump– has shown to increase power compared to a stand-alone Box Jump set. This is called post-activation potentiation and discussed further in Chapter 5. Add 1-3 plyometric movements to around 1 -2 strength workouts per week. Advanced swimmers can also add one workout that solely focuses on plyometric abilities, such as a jumping workout on the track.



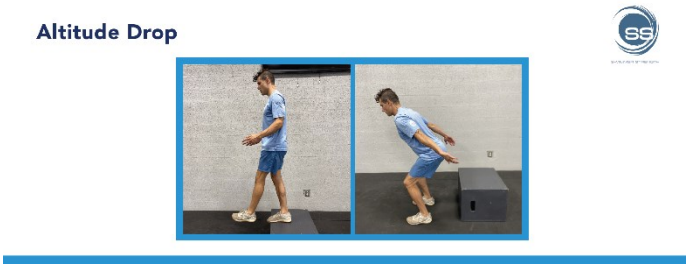
Below are a few examples of how to introduce, progress and differentiate explosive and plyometric movements for swimmers at different stages of development. More advanced swimmers can progress into more complex sequences of strength and power endurance.

Levels and exercise examples

Beginner

Plyometric: Landing and catching medicine balls

Explosive: Squat Jump, DB Split Squat, TRX Row



Altitude Drop

Step down from a box. Absorb the force of the body in the middle of the feet with slight bend in knees and hips. Higher boxes generate more force.

MB Catch

Stand in an "athletic" or "ready" stance: legs hip width or slightly wider with neutral spine. Body weight evenly distributed over feet. Catch a moving ball, ideally from a partner or coach. Focus on moving as little as possible and maintain stiffness in the arms and spine.

Moderate

Plyometric: Jump Rope, Low Depth Jump, MB Slams and Throws

Explosive: Jump Shrug, Box Jump, Push-Up

Depth Jump – Medium Drop

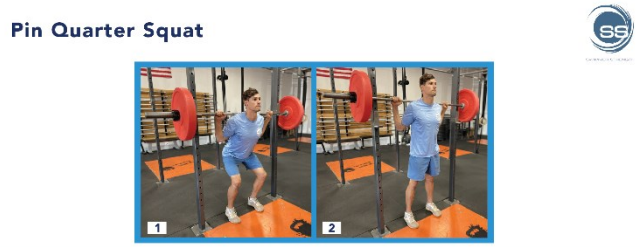
Step down from a box. Quickly absorb the force of the body on the balls of the feet – the two highest points of the tripod – with slight bend in knees and hips. Jump. Land with grace.

Higher boxes generate more force.

Advanced

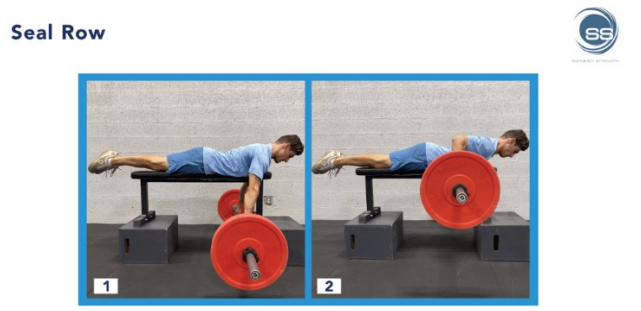
Plyometric: Sprinting, Tuck Jumps, Double-Under Jump Rope, One-Leg Box Jump, High Depth Jump, Clap Push-Up

Explosive: Pin Squat, Pull-Up, Seal Row



Pin Quarter Squat

Position a barbell on safety bars (this picture is showing an unsafe way of maneuvering this exercise). Place the body underneath the bar with a firm grip and a comfortable placement on the back with the bar. Get in to a squat stance. The legs should be in similar bend as they are on the blocks before a race. Take a deep breath and hold. Push through the ground to flow up into a standing position as quickly as possible. Body weight remains evenly distributed over the feet. Control the bar back on to the rack.



Seal Row

Elevate a regular bench with help of objects, such as boxes. Place a barbell underneath. Position the body on the bench and with the head hovering outside the bench. Firmly grab the bar slightly wider than shoulder width apart. Maintain a neutral spine and legs straight. Initiate the movement with the shoulder blades and pull the bar into the bench and control the weight down.

See Chapter 10 for technical details and testing protocol.

Chapter 4

Strength Training Across Ages and Specialties

By now we have established that many swim coaches tend to rip a page from their rivals' playbooks when it comes to strength and dryland training. That also tends to bleed into when and how swimmers are introduced to those training regimens, and which exercises they are assigned depending on whether they are categorized as sprinters or distance swimmers.

For a long time, I was under the impression that all swimmers need vastly different training programs. Fortunately, it does not have to be that complicated. You can generally use fairly uniform training regimens. The key differentiators are a swimmer's age, gender, physical development and, to some extent, their mental maturity.

The Problem: Age; Gender; Sprint v. Distance; Strokes

There is a common misconception that haunts strength training: That swimmers who start lifting weights too early simply will stop growing, or will not grow as much. This is entirely false [(12)]. Same thing goes for the idea that strength and dryland training inevitably end up injuring swimmers.

The issue is simply that many adolescents who begin lifting weights or doing strenuous dryland workouts progress too quickly. They usually have not taken the time to understand how the body works or been taught the right technique before loading up the barbell with weights. They may also not yet have a fully developed core that can counter the forces put on the body during heavy lifting and efficiently transfer energy to the joints. A weak core cannot do this. Research also suggests that female swimmers get injured at a higher rate than their male peers [(71)]. And each of the different strokes require different mechanics, which adds to the challenge of adapting training for each swimmer.

A weak core or poor lifting technique are detrimental regardless of how old or fast a swimmer is. But they usually are particularly damaging for swimmers who are in the latter years of their careers. Someone in their early teens can go through rehab and recovery, learn from their mistake, correct their behavior and still have time to catch up to their peers. For someone in their 20s, however, an injury may cost them that last shot at standing atop the podium.

The Background

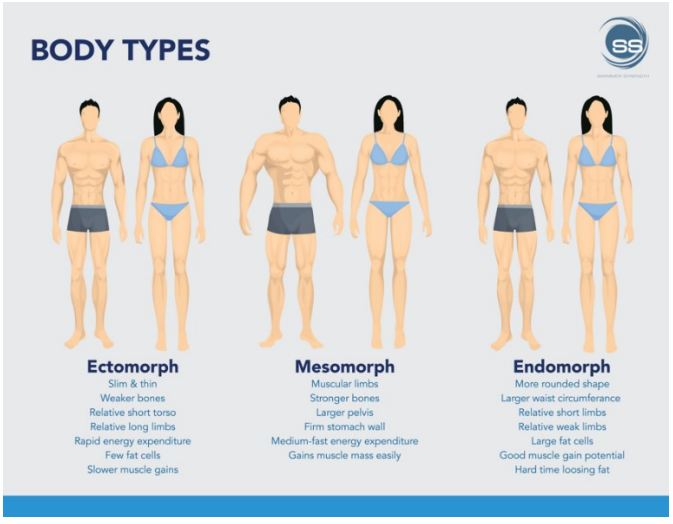
Distance swimmers and sprinters do not need vastly different strength workouts. Even milers need to develop a certain level of strength and power, not only lift light loads and emphasize muscle endurance. The longer the event is, the more turns the swimmer is exposed to. Each turn is a jump. To jump well, the core must be strong, legs and hips must have appropriate range of motion, the technique must be sound, and more available muscle mass will yield more force in each contraction, resulting in higher jumps. And it is foolish for sprinters to completely avoid the parts of lifting that are devoted to conditioning.

When I ran the strength program for the team at the University of Utah, I coached a senior named Bence Kiraly from Hungary. Bence had mostly hypermobile joints but also well-developed stability. He could take on serious strength and power challenges in the weight room. He is the only athlete I have ever coached who could do a flawless full-range 20 kg Barbell Overhead Pistol Squat, with his rear end almost touching the ground, on both legs, and would beat most if not all sprinters at box jumps. That year he swam the mile in 14:41.86, dropping a staggering 16 seconds – a 1.78% improvement – from the prior year and finished fourth at his last NCAA Championship.

Some coaches use strength and dryland training for conditioning purposes, even though the swimmers are

already well-conditioned. Some introduce workout regimens that resemble CrossFit. If the swimmers have not properly developed their joints and muscles to master the technical aspects of each lift, it is perilous to throw in that kind of training, especially since it tends to prioritize speed over proper form. Developing the energy systems should be predominantly done in the water. Muscles and movement quality should be developed mainly in the weight room. This distinction should be clear to everyone.

All bodies come in different shapes and sizes. Three distinct versions – called somatotypes – have been identified: ectomorphs, mesomorphs, and endomorphs [62]. Each person typically is a mix of all three with a general tendency towards one. The picture below illustrates the differences. Over the course of a season, the body should approach the ectomorphic shape as they gain more muscle and get leaner. In colleg iate swimmers, fat-free mass and height are the two strongest correlations with sprint performance [57]. Having an idea of where a swimmer falls on this spectrum helps both them and the coach become more aware of the impact of the training and can tweak th ings as necessary, because not all swimmers respond the same to training. Their somatotypes are partly the answer.



The Fix: Age

As previously said, there is no scientific evidence that lifting weights by default is harmful for a swimmer in their early te ens. Poor technique is the key culprit, and that holds true both for adolescents and adult high-performers. However, young swimmers cannot handle the same volume or weight because their muscles, tendons and joints are not yet fully developed. As a result, they should never attempt to do a 1RM lift. Instead the focus should be on developing maximum relative strength. That is a measure of how strong a person is relative to their body weight. For instance, the more flawless Push-Ups a swimmer can do, the highe r their relative strength.

Swimmers who have never done dryland or strength training must be briefed on etiquette and policies. All equipment must be respected and treated with care. Barbells, dumbbells and plates should not be taken for granted. If swimme rs lose focus, weights can drop on feet or hands or hit someone in the face. Unmindful movements and practices – a nice way of describing sloppiness and carelessness – tend to be one of the root causes of injuries.

In prior chapters we have established that it is necessary for any athlete to master stability before emphasizing strength and power. This does not mean swimmers should not be introduced to strength and power components, such as Push-Ups and jumping technique. A sound balance must exist and stability training should take precedence.

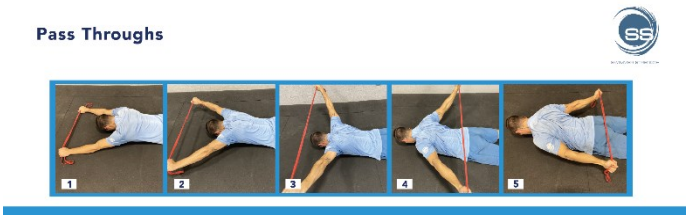
Submaximal Training Loads

Swimmers come in all shapes and sizes. The differences can be particularly stark for pre -teens and early teens, where some inevitably will have gone through growth spurts and have relatively well-developed musculature while others are late bloomers. That can make it tricky to determine which weight loads they should use for training, especially since coaches cannot put them through a 1RM session.

Here is my solution: The rate of perceived exertion (RPE). It is a highly effective method to determine training intensity [13, 46]. I have modified the scale to use a range of 1 to 10, with 10 being maximal effort for given sets and exercises. A relatively safe way of using this scale is to first determine the intensity goal of the workout; is it meant to be a more challenging workout or a session that focuses on recovery and movement awareness? If the swimmer cannot maintain the correct technique. Challenging workouts may gradually increase the RPE from 6 towards 8 or higher. If the swimmer cannot maintain proper technique at higher RPEs, back off and correct the form. Lighter workouts may stay at or under 5 RPE and should not be strenuous for the swimmers. This is a more appropriate option for example for a dryland workout that precedes a hard session in the pool. This method can be used to determine either repetitions, static hold times using the body as weight, or weight for any given number of repetitions.

10 and under

The priority for these swimmers should be to have fun, maintain range of motion, explore how their bodies move, start to develop core stability and work on coordination and balance. Exercises and movement patterns that challenge both their coordination and core are usually very good. And make sure to add versatility early on. Do not be afraid to introduce them to anything and everything they can do with their bodies, like skipping, tumbling, Burpees and Hip Hinges, as long as they are not at risk of injuring themselves. Also introduce movements that improve the range of motion, such as Pass Throughs and the Couch Stretch. And they should be encouraged to also explore other sports. Games are underestimated – these children love playing games that involve physical activity, such as Dodgeball or any form of tag. Testing these children is not necessary, but making sure that they are moving in all planes of movement and getting a versatile dryland experience is.



Pass Throughs

Position the body on the ground facing down. Grab a superband, towel, or a stick firmly and place the arms over the head with the forehead hovering on the ground. Lift the arms up by engaging the back and shoulder blades while maintaining tension on the band. Move the arm back to the hips symmetrically with only a mild discomfort. Control the motion back – stay symmetric and maintain tension in back and on band.

11-13 years

At this age, the body starts to lose some of its range of motion because of swimming demands and of how quickly the body grows, affecting hamstrings, hip flexors, quads, lats, chest and biceps tendons. Swimmers at this age tend to ramp up training intensity. They kick more intensely with straight legs and flail their arms excessively both in and out of the water. Be on the lookout for the swimmers who develop quickly and become immobile in vital joints, because most do not notice when their range of motion shrinks. (This holds true for swimmers of all ages, not just those near or in puberty.) The movements and exercises they do, and how they do them, also play a role.

To regain loss of mobility, swimmers need to spend more time outside the pool working on stability, strength and recovery. Stability and core training remain cornerstones. These swimmers can also be introduced to lighter weightlifting techniques with sticks to learn movements like the Clean and Overhead Jerk and Snatch, if the coach is qualified to teach them. The benefits are twofold. Most of those movements require good mobility, so it will push the swimmers into uncomfortable positions that require active muscle tension. Moving slowly and learning the technique will later teach them to do the movements quickly and explosively, which will be useful as they eventually

move on to lifting with weights. These exercises engage the entire body, just like swimming does. Training must still remain fun and engaging. Five to ten minutes of basic drills a few times per month is plenty and a great complement to their training in the water. It is also important to increase training that improves their relative strength during these years, such as Pull-Ups, Push-Ups and Split Squat Holds. They should be introduced to exercises using submaximal weights below RPE 8. Reminder: Swimmers at this age should not test for max loads or repetitions.

14-18 years

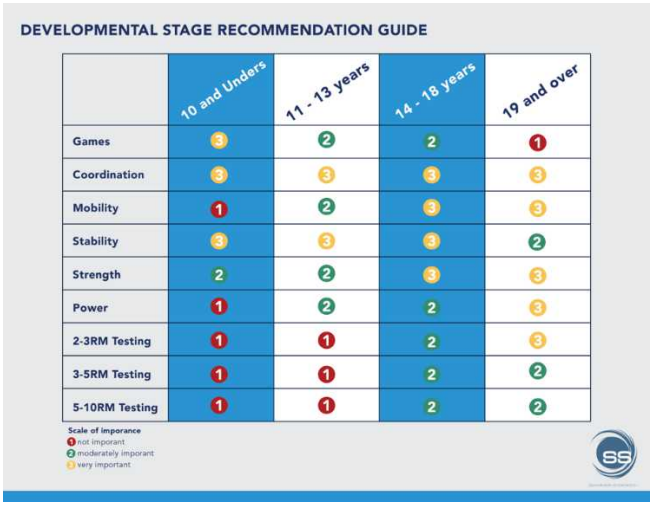
During this period coaches must help swimmers build a strong foundation of movements that are functional for swimming and require advanced coordination, meaning they have a greater transfer to swimming speed. The swimmers are able to absorb and implement technical instructions on how to perform a wide array of weight lifting and traditional strength training exercises. As always, the core must be the cornerstone of training. And if the range of motion is neglected, immobile swimmers will suffer greatly. At times, big physical changes that result in gains in the weight room may not immediately translate into speed in the water. This holds true both for boys and girls. The reason may be that the training loads have been too high or the exercises are performed poorly. If swimmers opt for heavier weights, the movement speed drops, making it less swim-specific. Improper technique leads to poor habits that result in the body compensating for movement quality.

On the contrary, hypermobile swimmers who are not given appropriate stability training may suffer from injuries later on because it takes time for joints, muscles and tendons to develop and be able to withstand higher forces than they are used to in the water. Maximal strength training and testing should not be a priority. At ages 16-18, swimmers are increasingly equipped to test for 3RM or 5RM once or twice per year. Swimmers aged 14-15 may test for 5RM or 10RM once per year for any exercise where they can master the technique for the given number of repetitions. Reminder: 1RM are not recommended also for swimmers at this age. It's simply too much risk over the reward and it's not cyclic.

19 and over

These are years during which swimmers generally try to reach peak performance. Training at that level always comes with increased risk. Developing maximal strength and power is exceptionally taxing on the muscles and joints. This type of training tends to make swimmers feel heavier and slower in the water. But it is a necessary component of success. As a result, the training regimens in the water and the weight room must be closely coordinated to ensure optimal results [9]. Typically, easier weeks in the water give room to push harder in the weight room. If training in the water is important, then back off the weights a bit.

Now, there is a wide range of athletes found from 19 and over. Surely, a 25-year-old swimmer will be more advanced and better equipped to handle the demands of more strenuous lifting sessions than a 19-year-old. Depending on their past training exposure, hypermobile swimmers still need a heavy emphasis on stability training, and immobile swimmer will need to continually develop their mobility. Since swimming is a cyclic sport with repetitive contractions, I recommend that swimmers test for 2RM or 3RM instead of just one rep.



The Fix: Sprint vs. Distance

Strength training aims to develop strength and power to help the body withstand forces in the water and achieve top speed. Starting with a foundation of stability, the

goal is to develop the musculature to help propel the body forward as fast as possible by increasing the amount and muscle fibers and improving their ability to contract.

Lots of research detail the benefits of lifting for sprinters, but lifting for distance swimmers has been studied far less. The faster the body moves in the water, the more forces it must overcome to maintain functional stability, or technique. This means sprinters must be stronger and more powerful than mid-distance and distance swimmers. Everyone must develop maximal strength and power, but sprinters need more of that type of training than a distance swimmer, who lives at submaximal training levels for far longer stretches of time.

The biggest difference in their training is in the water. Distance swimmers must maintain higher volumes and spend more hours in the water than sprinters. That means that they may need less time in the weight room – perhaps 2 or 3 sessions a week – to develop their horsepower, compared to 3 or 4 sessions for sprinters. As for the middle-distance swimmers, they tend to be either "sprintier" or more "distancy." Those that share racing strategies and body types with sprinters should lift more. Those whose swimming technique resembles distance swimmers and who hold up well at the end of races should lift less.

Regardless, their movements in the weight room need to be technically sound. Once the swimmers are familiar with the exercises and can execute them flawlessly, then designing workouts or circuits that resemble CrossFit is just fine. I have myself employed this strategy with successful results.

How?

By designing sets with a duration that matches the swimmer's best time or goal time in their No. 1 event. The exercises should only be fundamental ones, such as Hang Cleans, Squats, Jumps, Sprints, Pull-Ups and Push-Ups, and not be mimicking swimming.

For example: A sprinter has a goal of swimming below, say, one minute in the 100 meter freestyle in long course. First, pick one exercise and do it for 59 seconds at a submaximal weight of no more than 60% of 1RM. Count the number of repetitions and make sure the execution is flawless. Repeat that cycle 2-4 times, and keep track of the number of reps, for 3-4 weeks before mixing it up.

Another other option is to create a training block of 3-4 exercises the swimmer must complete: Hang Power Clean, Front Squat, Pull-Up, and a Sprint. The coach sets the number of repetitions and the swimmer adjusts weight and tempo to complete them in as close to 59 seconds as possible. The RPE at the end should fall between 8-10. These are examples of developing power endurance.

For mid-distance and distance swimmers, these blocks can be manipulated in length by adding repetitions or exercises. I have personally never made up a circuit that simulates the mile. But can it be done? Absolutely. However, I do not recommend going past the 5-minute mark, at the very most. Why? Because maintaining that level of an intensity for that long may result in poor technique, leading the swimmer to compensate movements, which in turn can lead to injuries. So be wise with the length of these sets.

The last distinction between sprinters and distance swimmers is the volume. In general, I prescribe fewer repetitions than strength-training literature recommends for swimmers. This holds true for sprinters too. I value movement execution and slower tempos, which are more strenuous than exercises executed in the traditional way. It is okay to add a few more reps for mid-distance and distance swimmers early in the season using submaximal loads. If a swimmer commits to strength training, eventually they will be training at loads above 90% of 1RM, regardless of whether they are a sprinter or not. At these loads, repetitions will not exceed 2. Prescribing more repetitions at heavy loads solely because they are distance swimmers will increase their chances of getting injured and compensating for technique.

The Fix: Genders

Several studies have shown that female swimmers report frequently more significant rates of injuries than male

swimmers [7, 27, 50]. One reason may be because they often undergo the same training volume and intensity as men do, even though they have lower muscle mass and fewer fast-twitch muscle fibers.

Because of this, it makes sense to take a more measured approach to progressing their training in terms of the number of sets, reps and weights, and add plenty of exercises meant to reduce the risk of injury such as stability and mobility training. This will require a thoughtful selection of exercises and management of workloads. Experience tells me that female swimmers tend to be a bit less keen on exercises with advanced movements than male swimmers. In those situations, just choose another movement that still is beneficial and will make the swimmers stronger and more powerful. Not all swimmers must do a Hang Clean or Box Jump. Find the right one for the swimmer.

The Fix: Strokes

The different strokes put different strain on joints and muscles. Breaststroke especially stands out relative to the other three given the complex combinations of movements in feet and hips. Swimmers specializing in breaststroke and IM will need to build more mobility in their hips and feet while strengthening and stabilizing their inner thighs and knees.

Compared to the other strokes, breaststroke utilizes more upper body strength from the biceps and chest. Substituting a few exercises for these swimmers to target these areas will make it more specific and personalized. Swimmers must also be made aware of how much strain is put on the lower back each time the upper body is raised up for the breath, which puts lots of stress on the lower spine. They can even this out by learning to engage the lower abs.

Freestyle and backstroke involve rhythmic, cyclic and powerful rotations coming from the trunk. Those swimmers must develop full rotational mobility and add exercises to ensure that the arms can move smoothly through the recovery and into a more powerful catch. These swimmers must also develop mobility in their ankles and hips. The difference from breaststroke is that the toes are pointed down – plantar flexion – and the legs remain fairly straight and must be able to maximally extend with the help of hamstrings and glutes.

The butterfly is the freakiest of all strokes. It requires the chest to press down once the arms start the catch phase of the stroke – hyperextending the upper spine – although the swimmer is actually also pushing forward. It is no secret that very young swimmers lack smoothness in their fly. The answer is to build overall upper body strength, stability and mobility. Some swimmers will need to emphasize mobility and others stability based on where they fall on the movement quality screen.

Chapter 5

Swim-Specific Movements

I was barely older than a toddler when I was introduced to swim-specific movements. I remember sitting on the cold pool deck with a group of other kids, attempting to do the breaststroke kick, carefully following my coach's instructions. Later on, we tried to replicate the butterfly rhythm and various hand movements. I am sure it was an amusing sight.

At the Mona Plummer Aquatic Center at Arizona State University I remember doing exercises on land using bands to replicate the hand's position in the water. Feeling out the different positions of the catch in the breaststroke helped me adjust my stroke in the water – small and subtle movements.

The idea behind swim-specific movements – movements done on land that mimic the motions done in the water – is to stress the muscles in the same manner as in the water. While novice age-group swimmers usually stick with simple kicks and arm movements, more advanced swimmers have lots of options, like simulated stroke band pulls, the breaststroke W-sit stretch and the Vasa Trainer. Swim-specific movements make swimmers faster in the water – at least in theory.

Little research has been done to evaluate whether swim-specific movements truly are beneficial for swimmers and translate into better speed in the water. As a result, the observations laid out in this chapter are mainly grounded in my own experience as a swimmer and a coach.

Why It Works

A few foundational principles may explain why swim-specific movements are effective, such as proprioception, imagery, post-activation potentiation and basic muscular adaptation via specific movements.

Proprioception encompasses the body's spatial awareness, meaning it helps the body receive information about a person's general understanding of where the body is positioned relative to everything around it, and how it moves [42]. Swimming involves complex movement patterns in a medium where the gravitational impact is radically different from that on land, so it is particularly important for swimmers to be attuned to how their body moves through and feels in the water. The same goes for exercises in the weight room. Every movement should be controlled – requiring a good base of stability – and well understood before the swimmer adds weight or speed.

Imagery is the rehearsal of a particular moment – like a race or an exercise – and comes in two distinct forms: visual and kinesthetic motor imagery. Visual imagery includes picturing oneself swimming, while kinesthetic imagery involves muscular sensation [39]. Each time you do this the brain sends neural signals to the muscles, strengthening the neurological connections between it and them, which in turn prepares you for next time you must be ready to perform. In effect, it helps develop proprioception.

Post-activation potentiation (PAP) is the improvement in the muscle force and power directly after the completion of an activity with certain levels of resistance [49]. For example, if the swimmer completes a heavy set of Squats and immediately goes into a few jumps, the swimmer should be able to jump higher than if they had done them without squatting beforehand. In the water, collegiate swimmers who performed 6 bouts of 10m sprints on one-minute intervals before a 100m freestyle trial did significantly better than swimmers who just completed a standard warm-up [20].

In sum, doing a certain movement will stress the muscles to adapt one way or the other way. But which movements most effectively increase speed in the water?

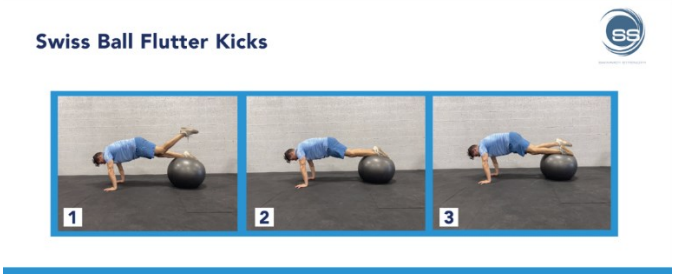
The Problem

Recreating actual swimming positions on land is very difficult. Because of the difference in gravitational impact, the body will have to do a whole host of different, unnatural contractions. In the water, on the other hand, excessive tension– commonly recognized as swimmers fighting the water – usually results in slower speed and a worse bodyline. My own experience tells me that repetitions on land are often rushed and may chip away at swimmers' natural feel in the water.

Irrelevant muscle contractions

The unique forces experienced in the water can easily be illustrated by the freestyle pull. Swimmers arguably hold water rather than pull water when they do the stroke. The resistance should remain more or less constant throughout. If the hand is slipping through the water, the hand and forearm angles are off. Small hand movements may stir up water turbulence that alters the forces exerted on the arm, which may also impact the body and how the arm contracts [63]. (This is why stability is the cornerstone for swimmers.) These nuanced muscle contractions are nearly impossible to replicate on land.

There are several exercises that in theory resemble swimming motions but have lesser overlap in reality. For example, a freestyle pull done while holding a stroke band will be much harder towards the finish, when the cord is stretched out, while the water's resistance on the arm in a normal freestyle pull should remain more or less constant. Another commonly used exercise is to do flutter kicks on a stability ball with the arms in a Push-Up position. These movements may resemble the flutter kick visually, but the actual overlap is limited. The kicks cause tension in the ankles, quads and hip flexors, and they offer no resistance in the upbeat part of the movement. Bottom line: You think you train a certain thing, but may actually end up working different muscles and in different ways.



SB Flutter Kicks

These movements may resemble the flutter kick visually, but the actual overlap is limited. The kicks cause tension in the ankles, quads and hip flexors, and they offer no resistance in the upbeat part of the movement.

Irrelevant specificity

The goal of swim-specific movements is to help the swimmer get faster in the water, but the swimmer only has a limited number of options. For example, few sports involve the same continuous cyclic overhead shoulder rotations. A 100m freestyle alone requires roughly 60-100 overhead strokes and rotations. Compare that to a baseball pitcher who throws the ball at most 100 times over the course of a few hours, or the shot-putter who exerts maximal force on the ball six times. The only comparable may be professional canoeing. But there are not enough exercises that challenge the core muscles with the forces as are experienced during overhead rotations [2]. Band pulls, for example, resemble the underwater pull but do not include the element of continuous rotation.

Repetitive movements make the body prone to overuse injuries and inflammation in muscles, joints and tendons, resulting in what is known as swimmers' shoulder. It is important to let the body rest and to mix things up to ensure that the muscles are exposed to all-round training. Traditional swim-specific movements do not necessarily check either of these boxes, so they can increase the risk of injury if they become a large part of dryland or lifting programs.

The Fix

What makes a good swim-specific exercise? Well, we have established that simply picking a movement because it mimics a stroke can be ineffective, counterproductive or even risky. There are five criteria to evaluate the specificity of an exercise: Which muscles are used; what the muscles actually do; joint range of motion; planes of movement; and which energy systems are involved [6].

1. Primary Muscles Used

In swimming, nearly all muscles are working in harmony to generate speed. The legs kick, the hips rotate or undulate, the core remains engaged and sends energy into the shoulder blades and arms, engaging the forearms, hands and fingertips that hold the water. Therefore, movements that engage more or less the whole body, such as Power Cleans, Thrusters and Medicine Ball Power Slams count as swim-specific.

For other exercises that emphasize only a handful of muscles, ask yourself whether they match those used to propel the body forward in the water. For example, a Pull-Up is more specific to swimming than a Push-Up because it incorporates a pulling motion that engages the lats and also involves grip strength, which is crucial for sprint swimming speed [17]. A Bulgarian Squat may be more specific to developing the start compared to a regular Squat, because the exercise puts emphasis on one leg, recruits more muscle mass and better engages the glutes – muscles that help catapult the swimmer off of the block. The most integral muscles in developing swimming speed are the quads, hip flexors, hamstrings, glutes, core, lats, triceps and forearms.

2. Muscle Actions

Many movements in swimming are cyclic. For example, the pull in each of the strokes solely involve quick concentric contractions, meaning the muscles shorten. They have no true eccentric contractions. However, many strength and dryland exercises are paired, meaning they involve both concentric and eccentric contraction. The Pull-Up and the Squat are two examples. To make land exercises truly swim-specific, you have to find ways to only focus on concentric contractions in a repeat pattern

A Pull-Up can be made more swim-specific by simply doing the upward pull and then releasing the hands and dropping down. Other examples include jumps that eliminate the countermovement, such as Seated Squat Jump or a Hang Power Clean with a 2-second hold above the knees, simulating the position on the blocks.

This is essentially velocity-based training, meaning the speed at which a movement is completed with the given load is imperative to determine the overall power of the movement [11]. There are lots of fancy equipment designed to measure those things, but the bare eye and a stopwatch usually suffice.

The arms complete a full cycle (counting both arms in freestyle and backstroke) in somewhere between 0.5-1.0 seconds. The turnover is usually slightly quicker in breaststroke. Therefore, swimmers ought to have as a goal to complete upward pulls of the Pull-Up at least at the same speed that the arms move in the water. This kind of movement velocity arguably is more similar to swimming speed than band pulls because the muscles have to get more tense and there is greater force put on muscles and joints. A cheap and effective way of analyzing the swimmer's Pull-Up is to simply have them hanging with straight arms and explode into the upward movement. Granted, not everyone can do it. Many adolescent and female swimmers struggle to repeatedly pull themselves up from a hanging position in less than one second due to lacking stability, strength and power.

3. Joint Range of Motion

To be considered swim-specific, exercises must be executed through their full joint range of motion because each stroke in swimming requires a maximal reach with the arms. Mimicking these movements may help to improve the mind-body connection, particularly if they are done slowly. For strength training, a more concrete approach is to require that swimmers fully extend their limbs in whatever movements they make, like going all the way down when doing Pull-Ups and maximally push weights during overhead presses. Far too many swimmers get shorter and shorter for each rep they do of

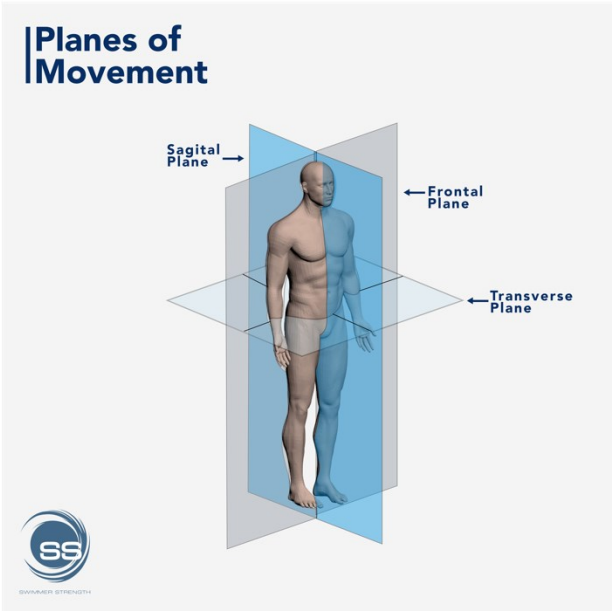
any given exercise, which indicates lacking strength and stability.

Overhead rotations help build the body's ability to stabilize in the catch position and are highly specific for swimming. But there are only a handful of few exercises that challenge the core muscles with the forces as are experienced during overhead rotations [2]. Examples included at the end of this Chapter.

The swimmer's bend in the legs while in the start position on the block more resembles a Quarter Pin Squat (shown in Chapter 3) than a normal Squat, both in terms of joint range, muscle actions and which muscles are actually used. Advanced swimmers should take note of this to develop their starts.

4. Planes of Movement

Three planes of movement exist: the sagittal, frontal, and transverse plane. Swimming mostly occurs in the sagittal plane moving forward. In the frontal plane, the breaststroke kick and pull go through a slight separation that is an important segment of generating speed. In freestyle and butterfly, the arms recover in the frontal plane, but do not generate swimming speed here. To an extent, all turns take place in the transverse plane as the body twists in to position, especially during each stroke in the rotation of the freestyle and the backstroke.



Slight changes to the body's positioning and how the feet are planted on the ground can make exercises more swim-specific. For instance, all strokes except for backstroke are done in a prone position. Not many exercises can mimic this horizontal plane to pull weight, unless there is a way to lay on an elevated bench and grab weights to pull, akin to the Seal Row. To make the Seal Row even more specific to the pull: The Seal Row Straight-Arm Pull. See end of Chapter 5 for explanation.

A submaximal split stance RDL is presumably more effective in developing swimming starts than traditional heavy RDL, because the feet positioning offers more tension on the front leg and the movement becomes faster than heavy weights. To mimic the swimming track start, more movements can be performed in a split stance position. The weight would be mainly distributed on the front leg with the back leg on the wedge acting as a stabilizer. Examples included at the end of this chapter.

5. Energy Systems

Three main energy systems exist: ATP-PC, glycolysis and fat oxidation. These systems work interchangeably at all times, but one is usually dominant depending on what the body is doing. The shorter and more intense the work is, the more active the ATP-PC system is. It generally stays active for 8-10 seconds on land and presumably longer in the water because the arms go through much slower cyclic repetitions than in running or cycling. This is the key system for strength training and things like starts, turns and underwaters that are rapid and do not last very long. Glycolysis is split up into slow and fast and ranges from 45 seconds to as much as 3 minutes on land, and perhaps longer in the water. The longer and more sustained the work is, the more dominant fat oxidation will be. Naturally, swimming will activate all of these systems but predominantly glycolysis and fat oxidation.

More advanced swimmers should use a latter part of the season to develop power endurance once they have gone through the phases focused on strength and power. Power endurance encompasses combining 2-6 movements into a circuit that will last for a duration that roughly equals the time the swimmer's main event takes to complete. For sprinters, that may be 20-60 seconds.

For middle distance swimmers it will range from 2 -5 minutes. These workouts generally are very strenuous and some swimmers will enjoy and respond to them much better than others.

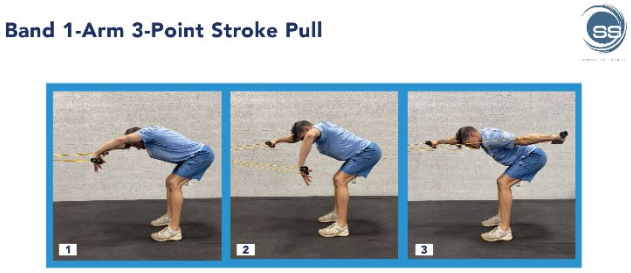
Swim-Specific Movements: The Traditional Way

Vasa Trainer

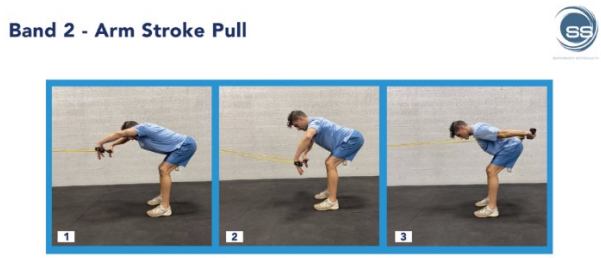
This tool is perhaps the best one available to replicate the underwater pull of freestyle, backstroke and butterfly, all without putting strain on the spine as is easily done when using bands in a bent -over position. The primary muscles used largely overlap with those used in the water, the resistance is constant and the swimmer gets to perform the full extent of the stroke, including the recovery. Depending on how much time is spent on it, all energy systems can be activated. Another major benefit is its versatility. The Vasa trainer comes equipped with a vertical board to simulate pushing off of the walls and other ways to strengthen opposing muscle groups.

Swim-Specific Band Pulls

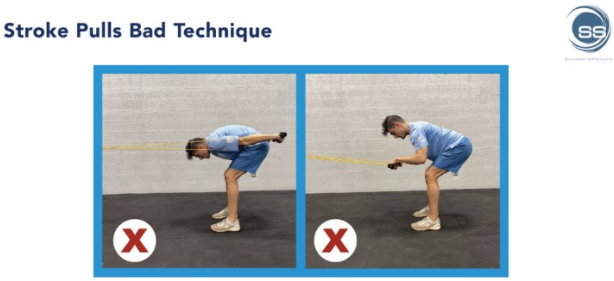
These exercises should only – and I repeat, only – be done by swimmers who have mast ered the hip hinge. This means the swimmer must be able to perform multiple variations of the RDL without bending the spine. Once that box is checked, there are plenty of ways to mix up this exercise to increase proprioception and stability that resemble movements in the water. One example is splitting up the stroke into three distinct phases – a catch, half-pull, and full pull. These movements should not be overdone, and that is for two reasons: They put certain muscle groups at risk of and also risking hi ndering swimming mechanics in the water. Novice swimmers may experience immediate changes of both their feel for the water and swimming speed.



Band 1-Arm 3-Point Stroke Pull



Band 2-Arm Stroke Pull



Stroke Pulls Bad Technique

The PAP-mechanism may be put to use with band pulls and swimming. There is no clear research on whether this works, but some coaches use a combination of stroke band pull progressions and swimming to enhance proprioception and also help increase the force of the stroke.

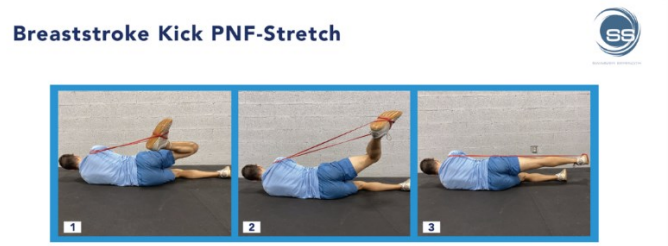
Swim-Specific Movements: The Evolution

What helps improve speed in the water the most: A traditional exercise that is modified to be more swim - specific, like a Pull-Up that is limited to the upward motion, or a traditional swim-specific exercise, like band pulls? No conclusive research has been done on this matter. The main physiological difference lies in the

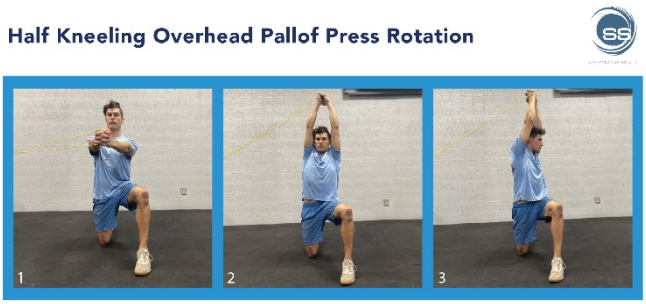
resistance. Presumably, swim-specific exercises recruit less muscle mass, particularly for the upper body movements, than traditional exercises like the Pull-Up. Nonetheless, movements that are inherently traditional and modified to be more swim-specific will put less stress on joints as long as the person's technique is sound.

Specificity: Joint Range of Motion

Any body part that is being targeted should be allowed to move through its full joint range of motion without pain. (Developing this range is particularly important for stiff swimmers, which is discussed further in Chapter 6.) The traditional breaststroke W-sit stretch should forever be scratched from the list of swimming exercises. They can be replaced with the superband breaststroke kick stretch.



Breaststroke Kick PNF-Stretch

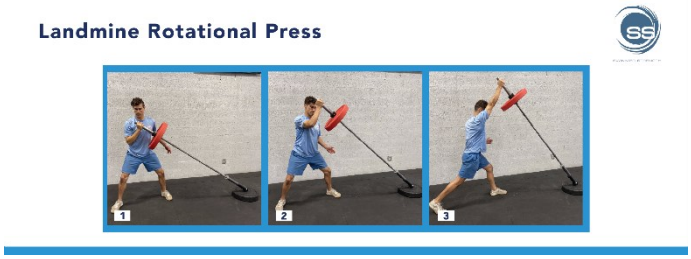


Half-Kneeling Overhead Pallof Press

From a half-kneeling position with the outside leg up and planted firmly on the ground. Grab a light band and hold it firmly by the chest. Press the band out and bring it up close to a streamline position, then rotate the torso away from the band anchor.

MB Overhead Walk

From a standing position grab a medicine ball. Bring the ball overhead and actively reach up while maintaining a neutral spine. Take a step forward and rotate the body towards the leg that takes the step - away from the straight leg. Come back from the rotation and flow in to the next step with the other leg, and rotate the other way. Keep the steps rhythmic.



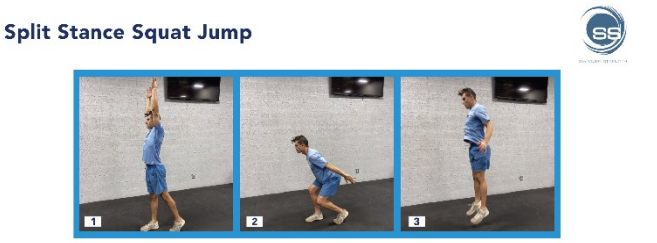
Landmine Rotational Press

Grab the bar firmly with one arm facing away from the landmine attachment. Place the outside foot slightly in front of the inside foot. Brace the core to stiffen the spine. Initiate the movement by pushing with the outside leg. Transfer the energy to the hips, then core, and finish with the shoulder blade to press the bar up while rotating, and quickly shift the feet to a split position. Slowly bring the bar back and rotate into the starting position.

Specificity: Planes of Movement

DB Split Stance RDL

Split the feet hip width apart, similar to a track start. Grab dumbbells and maintain a neutral spine. Rest 70% -80% of body weight in the middle of the front leg. Slowly lower the upper bodyand return, keeping the hands close to the legs.



Split Stance Squat Jump

Split the feet hip width apart, similar to a track start. Rest 70%-80% of body weight in the middle of the front leg. Reach the arms up. Quickly drop the body, similarly to going down into the start position on the block. Hold for 2 seconds. Jump and land softly.

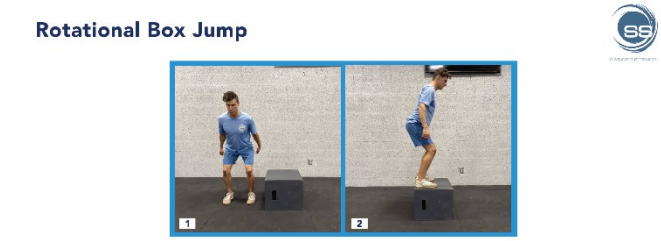
Note: To make it plyometric, flow through each jump.

Hang Power Clean – Split Catch

Advanced swimmers who can perform Hang Power Cleans can further develop their ability to absorb higher forces in a split-stance start position. Absorbing force is correlated to generating more power. Instead of catching the Clean in a regular stance, land in a split stance position like on the block, or even a little wider. Between 20%-50% of 1RM Hang Power Clean is an appropriate weight to work with.

Seal Row Straight-Arm Pull

With the same starting positions and cues as the Seal Row, maintain a long neck and an engagement through the core. With a slight bend in the elbows, pull the bar towards the hips. Touch the bar, and gently control the bar back.



Rotational Box Jump

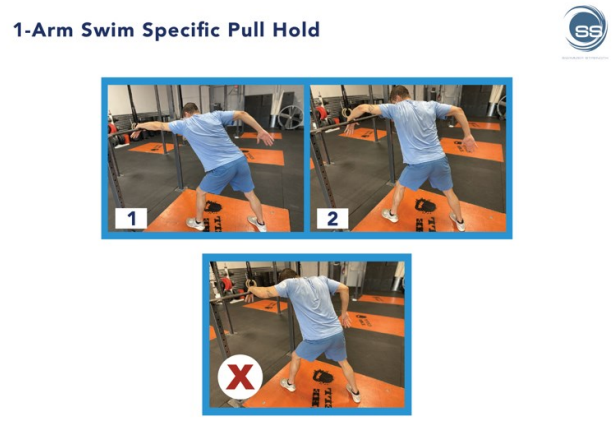
Stand next to a box. Jump and rotate in the air. Land firmly on both feet with the body weight evenly distributed.

As swimmers push off of each wall during the turns, the body twists and gets in to its swimming position, with exception for backstroke.

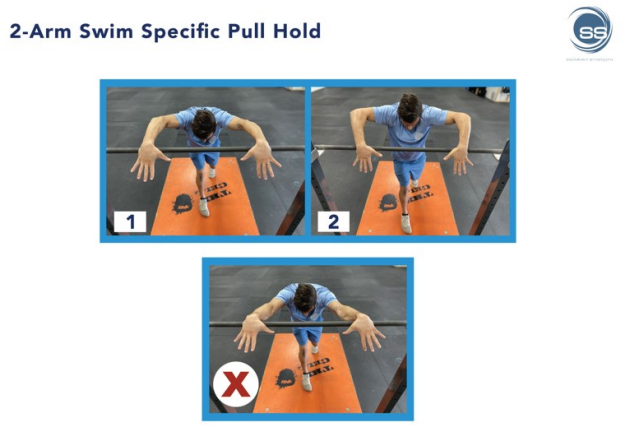
Isometric Swim-Specific Pull Hold

These exercises are meant to simulate positions in the freestyle, butterfly and breaststroke pull -out. These holds require that the muscles generate more force than during regular band pulls, and can also help develop feeling for the water during the pull. They can be good components of a super-set combining two exercises. For example, try adding 2 Swim-Specific Pull Holds for 2-4 seconds in 2-3 different positions after a Back Squat with a barbell. Make sure to maintain a rigid wrist, a long neck and a high -elbow catch position. If there is no barbell

handy, use anything else that is solid, such as a Suspension Trainer or a study table.



1-Arm Swim Specific Pull Hold



2-Arm Swim Specific Pull Hold

Swimmers also ought to do a wide range of movements and exercises on land that help develop and reinforce motor skills and coordination, and let the brain create new proprioceptive connections with the muscles. Arguably, many of the greatest swimmers can perform very well in other athletic events as well. Michael Phelps was a star lacrosse player as a kid and in 2016 sank the longest-ever televised golf putt, and Caeleb Dressel reportedly can dunk with relative ease.

As a championship meet drawscloser, I recommend that swimmers make strength and dryland movements more swim-specific: Move quicker and adjust the stance for jumps to resemble the positioning on the block. This can be done as far out as 16 weeks before the meet. Olympians who need more rest and recovery from strength training should start sooner than adolescents and teenagers.

Chapter 6

Hypermobile vs. Stiff Swimmers

I was, and still am, stiff by nature. My body is short and powerful, not tall and slender like the stereotypical swimmer's body. My muscles get tight and my knees do not hyperextend. I was often envious of other swimmers who effortlessly perfected streamlines and underwater kicks while I kept getting yelled at.

Little did I know the advantages that come with my body type. The stiffness may actually have helped protect my shoulders from severe injury even though my stroke length may have been compromised. And not everything is rosy for hypermobile swimmers. Their shoulders are usually more lax, which help them lengthen their strokes, but their joints may not be as durable or generate power as easily as stiff swimmers.

The Problem

Every swimmer has unique flexibility. Some have bodies seemingly made out of metal rods while others mostly resemble cooked noodles. Some can easily form a perfect streamline while others cannot. This creates challenges for coaches because those bodies adapt differently and at different rates to the same training. It is a mistake to treat everyone exactly the same.

Swimmers often do the same stretches and warm-ups even though these quite easily can be tailored to each person's needs. For example, a passive hamstring stretch will benefit a stiff swimmer far more than a hypermobile swimmer given their differences in range of motion and muscular tension. It is important to remain aware of these differences so that swimmers can adjust their movement habits and ensure that they keep progressing. Otherwise frustration may start to creep in.

The Fix

Few things in life are binary and flexibility is no exception. Hypermobile swimmers can certainly suffer from muscle stiffness, and stiff swimmers can achieve full and functional range of motion in certain positions and, so to say, graduate from the stiff category to the normal category. And both stiff and loose swimmers must develop joint stability and keep that up during movements and exercises. But I argue that they still should take different approaches to warm-up, preparation work – movements done prior to the main block of work – and accessory work, meaning the blocks near the end of a workout that involve either individual muscle groups, swim-specific work or managing existing injuries and preventing future injuries. A stiff swimmer generally needs to focus more on mobility while a hypermobile swimmer needs to focus on stability.

The Stiff Swimmer

The stiff swimmer – also known to be relatively immobile – has visibly restricted active and passive range of motion in major areas, such as hips, spine, and shoulders.

Stiffness in certain muscles prevents them from properly controlling and fully utilizing their joint range of motion. This usually shows when the body gets into its natural active full range of motion, such as in a squat or a combined elevation with the arms (this will be addressed further in Chapter 10). The swimmer's level of range of motion and stiffness depends on their genetics and lifestyle. It is important for them to put emphasis on countermovements and active recovery both at practice and outside of practice to ensure the body does not become even less mobile.

But stiffness is not all bad. Tension in muscles and tendons is related with higher power output [71]. It typically takes a bit longer for stiff swimmers to look light and well-coordinated in the water. But as their physiology adapts – the core strengthening and stabilizing the body's line in the water, the person's

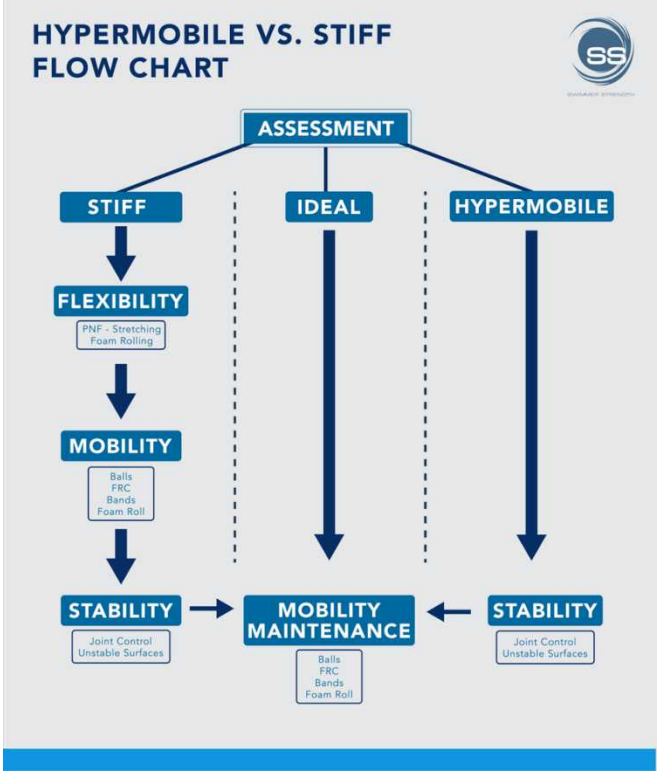
relative strength improving and letting them hold more water with each stroke – they will look better and better.

The Hypermobile Swimmer

Hypermobile swimmers are often described as having "double joints" in various parts of their bodies. In fact, the connective tissue that surrounds their joints are looser than normal resulting in a lack of stability to the area [29]. This gives them a greater range of motion but also makes them relatively weaker. This is not inherently bad and can even be advantageous in swimming, but it requires that the person is particularly diligent with stability training and movement awareness. Hypermobile swimmers are also particularly good at compensating movement patterns, which can pose big risks in the weight room.

How to Tell Them Apart

The swimmers at or near the extreme ends of the flexibility spectrum are easy to spot with the bare eye. But differences that are less distinct can be difficult to identify and evaluate. A visual estimate also does not quantify the person's movement quality or the degree of free movement that occurs in the joints. Australian physiotherapist Tom Barton has create d an assessment that measures a swimmer's ability to replicate key swimming positions on land [4]. These tests help to quantify the swimmer's movement quality, range of motion and imbalances in movement. The overall goal with this battery of tests is to ma ke the swimmer more aware of how their body operates and help coaches determine how to structure training plans. See Chapter 10 for all tests.



This flow chart shows how swimmers can be grouped and treated differently based on their physical characteristics. As mentioned, the stiff swimmer must prioritize developing flexibility – also known as the natural range of a joint – while the hypermobile swimmer should emphasize stability to control their joints in various positions. Flexibility for stiff swimmers is important because it will increase passive range of motion and will provide more availability to be active in deeper ranges. Both of them, and the swimmers that fall in the middle of the spectrum– the ideal swimmer– must work on developing and maintaining a baseline mobility for swimming – meaning joint function in desired ranges. It is important to not take any joint for granted, because different joints may have different characteristics with a general dominance to either side. This chart is based on a joint-by-joint basis.

Warm-Up

The idea of the warm-up is to increase the body's temperature and kickstart the chemical processes that are activated during intense exercise. It also aims to prepare

the mind and body for what is coming next. If Squats are on the agenda, the hips, knees and ankles must be ready to go. If Pull-Ups are up next, the shoulder blades, lats and the forearms should be readied. Regardless, the core must always be warmed up since all the energy is transferred through it. The warm-up should also include movements specifically targeting flexibility, stability or mobility depending on the swimmer's ability in each of those three areas. Warm-ups will look different depending on whether the swimmer has been in the pool before coming to the weight room.

Weight Room Warm-Up: Pre-swimming practice

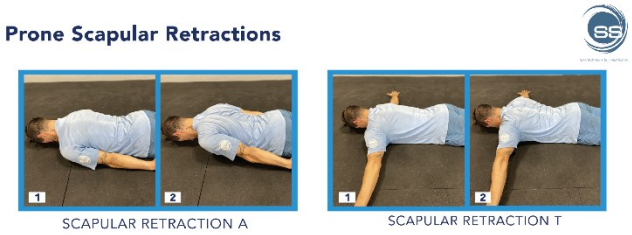
If lifting is the swimmer's first workout of the day, warm-up is even more important than usual. For starters, I recommend a general set of movements aiming to increase the swimmer's core temperature, including jogging, rowing, dynamic drills or in place movements using minimal equipment, such as bands.

Immobile swimmers may start with 5-10 minutes of PNF-stretching – a type of flexibility training that involves the contraction and stretching of muscles – of their worst areas, or a light full-body stretch aiming to gain more range of motion prior to workout. This can also be attained with the foam roller and recommended for swimmers who know how to properly use those to loosen tense muscles. Longer times can be spent here the closer taper is or during taper. Hypermobile swimmers do not need as much time to improve flexibility, but beware, even hypermobile swimmers start developing muscle stiffness at one point. If they want and need to spend a few minutes on a foam roller, that will be fine. Young and inexperienced swimmers should focus on technique and movement patterns of specific exercises, learning which muscles should work and when. Awareness and stability is best increased by pushing the body towards its full range of motion or using tools such as bands.

Weight Room Warm-Up: Post-swimming practice

Swimmers coming from the water do not need to raise their core temperature. They can cut that part and go straight to one of two options: Either address injuries or muscle fatigue, or immediately start the preparation block.

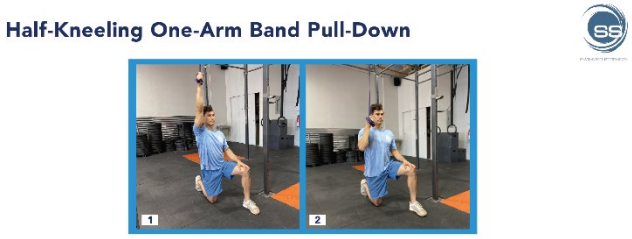
The preparation block is quite straightforward: It is the part of a warm-up that is meant to prepare the swimmer for the main workout block of the day. If Pull-Ups are on the agenda, the prep block should include movements that get the upper body ready for the demands of the sets. It helps maximize the strength and power output and can help limit the sense of fatigue that comes after the workout. An example of this particular block for swimmers who have not yet progressed into advanced weight room work can look like this:



Prone Scapular Retractions

Positioning on the ground facing down, the arms are placed comfortably beside the hips in an A-position and on the side and in a T-position. Always aim to maintain a long neck. Squeeze the shoulder blades together and keep them gently down and away from the neck. Relax and rhythmically repeat. Keep hands on the ground.

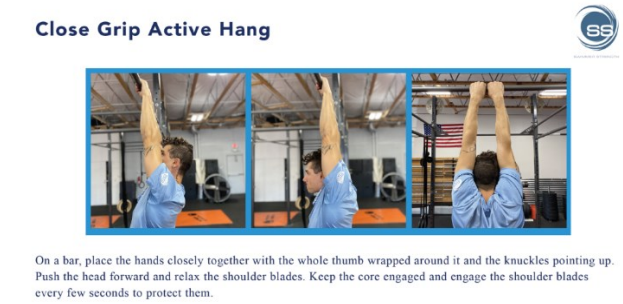
Note: these movement can be done with the arms overhead and hands on the ground.



Half-Kneeling One-Arm Band Pull-Down

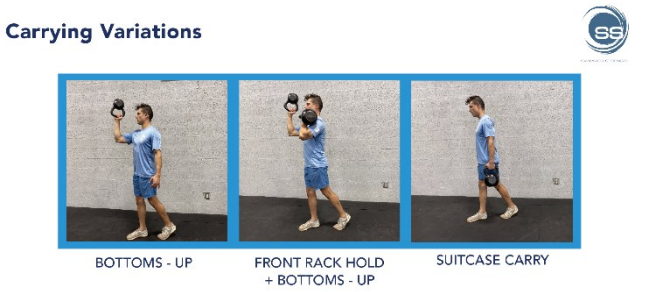
From a half-kneeling position, and firmly grab a band or cable from an above attachment. The hand holding the band is the same side knee that is on the ground. Initiate the movement from the shoulder blades and pull the

elbow in towards the rib cage in an approximately 45 degree angle. Control back and rhythmically repeat.



Close Grip Active Hang

As swimmers become more advanced advance, they may add carrying variations with kettlebells or eccentric Pull-Ups by jumping up and controlling the speed and posture on the way down.



Carrying Variations

- Suitcase Carry
- Bottoms-Up Carry
- Front Rack Offset + Bottoms-Up

Lifting Routines

Stiff and hypermobile swimmers generally do not need completely different lifting schedules. If the main exercises are, say, Hang Clean, Squat, Row, RDL and Push-Ups, the coach can modify some of them to fit the person's needs. If hypermobile swimmers experience shoulder pain, their Push-Ups should be swapped for, say, a Dumbbell Press on a stability ball, or an inclined Push-Up. The Hang Clean and Front Squat can be replaced with DB Jump Shrugs and KB Goblet Squat. Barbell Bent-Over Row can be replaced with a Suspension Trainer Row. It is important to be flexible and have a broad set of interchangeable exercises to choose from.

Remember, exercises per se are usually not the culprits – the road blocks usually are poor movement quality, poor technique, insufficient instruction or anatomical restrictions.

Accessory Blocks

Accessory blocks are weight room sets typically completed near the end of a session. These address single-joint movements, such as Calf Raises, Wrist Curls or core exercises. The ideal swimmer who falls in the middle of the flow chart will have more freedom to push the training here. Swimmers who visibly fall under the category of immobile or hypermobile may further address injuries and weaknesses in these blocks.

At the start of a season, swimmers can be prescribed more exercises to balance their bodies, such as developing their hamstrings and strengthening upper body pressing movement. As the season progresses, those should be swapped for exercises that target the main swimming muscles such as the quads and core.

Cool Down and Active Recovery

Cool downs and subsequent active recovery done at home help bring down the heart rate, clear out lactic acid from the muscles and speed up the recovery. Swimmers that experience more fatigue in certain body parts can add foam rolling or specific trigger point release with mobility balls (more about this in Chapter 9). The effectiveness of a swimmer's active recovery will determine how well their body restores and how well they are able to do well in practice the next day.

Chapter 7

The Taper

Go to any championship meet around the country, or the globe, for that matter, and you will find swimmers who swam poorly and chalk up their meager performance as a result of "missing their taper."

I have certainly been in their shoes many times. During my first three years of college I only modestly improved my best time in the 100 yard breaststroke, shaving off between 0.5% and 0.7% annually. But things changed in my senior year: I dropped a full 2% and finished my career with a 54.6. Both Scott Goodrich, who was my sprint coach, and Chris Desrosiers, who handled my strength training, deserve credit. But I also credit myself. By that time, I had spent countless hours in the classroom learning about the science behind strength and conditioning. In my last season I applied that knowledge on myself, partly by taking an unusual route during my taper.

While my teammates stopped lifting between two and four weeks before the big meet, I continued to go into the weight room twice a week. I would do a lengthy warm-up with lots of foam rolling, followed by no more than six exercises mixed with medicine ball slams and tosses, Box Jumps, Clap Push-Ups and sometimes even quick Pull-Ups. I kept the reps low. In essence, I was priming my muscle fibers to help me drop more time than the vast majority of my teammates, especially among the sprinters.

The Problem

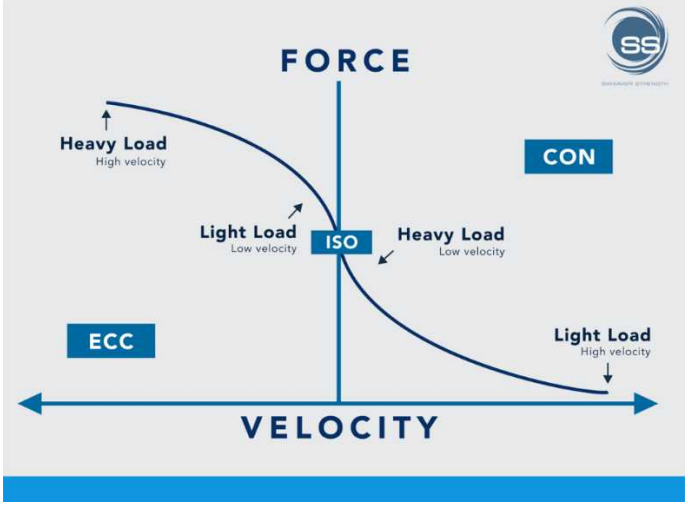
Strength training still carries a certain stigma in the swimming world. It is often blamed for slowing swimmers down, causing injuries or bungling a taper. In reality, the bad actors are poor technique, poor planning, poor execution and poor coaching. The weights will not hurt you – but you can certainly hurt yourself if you do not use them the right way.

But there are also many swimmers and coaches who pay attention to what the science says, seek out the right people to help them and find ways to tailor the training to their needs and capabilities – both in season and during a taper. A sound approach to strength training in the weeks before a championship meet is a key part of a successful taper. It will transfer strength into speed in the water and help prime both muscles and mind for fast swimming.

The Background

Simply speaking, strength is developed from repeated muscle contractions. Once the workout is complete and the swimmer recovers, the muscles repair themselves and evolve into incrementally better versions of themselves. This process is called supercompensation [72]. The rate of this improvement depends on the swimmer's training exposure and how well they recover. Research on how strength training effects swimming is relatively scarce, but is increasingly growing. It seems to have an overall positive impact mainly on sprint swimming performance and starts with more convincing data that lower body musculature has a stronger relation to speed, whereas there is conflicting research on the best or most effective upper body interventions for swimming speed [2, 3, 9, 14, 15, 17, 18, 25, 26, 68].

There are three distinct muscular actions that develop strength and power: concentric, isometric and eccentric. Movements that shorten muscles in length, such as standing up in a Squat, or Pulling up in a Pull-Up are concentric contractions. Isometric contractions are static, such as Wall-Sits and Bridges. Movements that lengthen the muscles as they contract are considered eccentric.



Unlike other sports, swimming almost exclusively relies on concentric muscle contractions to move the body forward. The eccentric portions generally come from shoulder external rotators. But while on land, almost all exercises that involve movement go through each type of contraction. The Squat, for example, begins with a downward eccentric motion and finishes with an upward concentric motion. Between the t wo, there will always be a transition that will be isometric, however brief. Improvements showcase themselves in the form of more and bigger muscle fibers that can produce more force. The training also improves the brain's ability to send signals to the mu scles. This neurological part explains why strength and power are not synonymous with the size of someone's muscles.

Muscle fibers are either slow -twitch, meaning they contract with lesser velocities and do not get fatigued as easily, or fast -twitch, which contract much quicker but also fatigue far sooner. Fast-twitch fibers generate more force per contraction and contract more quickly than slow-twitch fibers. The share of muscle fibers that are either fast- or slow-twitch partly depends on which training the swimmer is exposed to.

There are 7 different types of fibers, of which 2 are categorized as slow-twitch – labeled I and IC in the table below – while the remainder are fast-twitch [55]. The table shows the relationship between the fibers and different race durations. Based on the training exposure, muscles have the ability to shift between fibers [53].

Muscle Fiber Type Classifcation and Relation Sports Events

mATPase	I	IC	IIC	IICA	IIA	IIAX	IIX
Swim Events (LCM)	Open Water	1500 swim	400	200	100	50	
Other Olympic Events	Marathon	XC Running	1600-run	800-dash	400-dah	100-dash	Weightlifting
	XC Skiing	Olympic Cycling	Judo	Sprint Skiing	Alpine Skiing		Shot put

Inspired by Scott, Stevens, & Binder Macleod (2001)

Most competitive swims last somewhere between 25 seconds and 3 minutes, meaning swimmers predominantly use fast -twitch muscle fibers. The sport in gener al is not as reliant on slow -twitch muscles as many may think, with exceptions for the 1,500m, mile or open water. This is why all swimmers ought to maintain at least some degree of focus on lifts that stimulate fast-twitch muscle fibers.

Whereas swimming workouts are structured in sets, weight room workouts use the following terminology: A certain number of repetitions form a set, and a certain number of sets form a block.

Pripelin's should give coaches a good idea about the volume and load they should as sign their swimmers for optimal results. Since swimmers already undergo demanding workloads in the water, I recommend doing slightly fewer repetitions than what is listed as optimal, and always avoid pushing beyond the upper range.

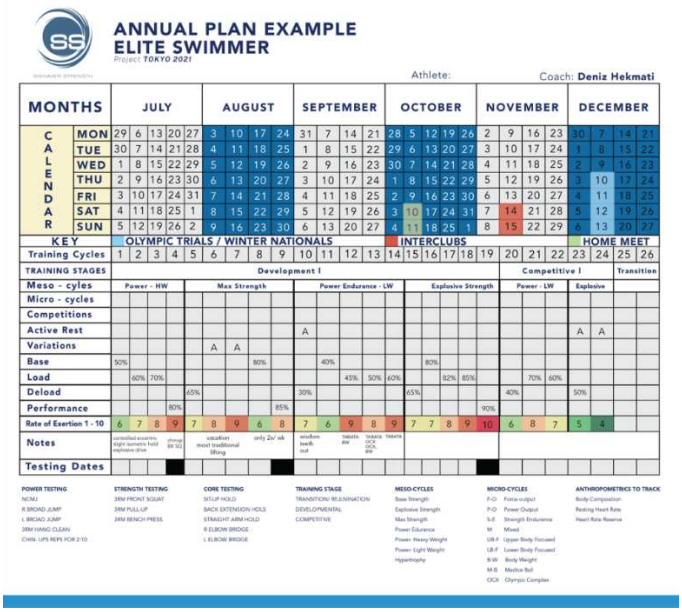
PRILEPIN'S CHART

Percent of 1RM	Reps per Set	Optimal Total Reps	Range of Reps
55% - 65%	3 - 6	24	18 - 30
70% - 80%	3 - 6	18	12 - 24
80% - 90%	2 - 4	15	10 - 20
90%	1 - 2	7	4 - 10

The Plan

Every swimmer needs a yearly training plan that aims to have them at peak performance at the big meet of the season [6]. This plan outlining the big picture is called a macro cycle, and it includes all forms of training a swimmer will undergo, both in the pool, for dryland and in the weight room. For the latter two, the idea is to go through a five-step progression: To first develop sound

stability, then strength, then progress to strength endurance, power and finally power endurance. This is the safest and most natural way to develop the muscles to become more powerful. Swimmers rarely need to spend time working on increasing the sheer size of their muscle mass – the process called hypertrophy – but in some instances it can be appropriate for elite athletes or teenagers who have fallen behind in their physical development. A few weeks – somewhere between 2 and 8 – out of the year suffices, because normal strength training will lead to muscle size gains, just not as quickly. Below is an example of what a yearly plan can look like:



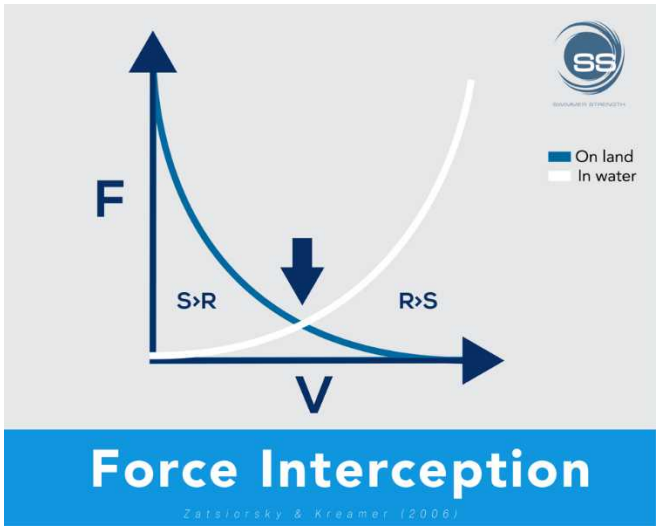
Within the macro cycle are multiple smaller training blocks – so-called meso cycles. In the weight room they commonly range from 3-5 weeks (in the water they can be as long as 12 weeks, depending on coaching style.) Each of these cycles shouldbe focused on one part of the five-step progression. Stability is closely linked to endurance but really has more to do with strength, control and ability to move gracefully, whereas endurance is often thought of as prolonged hard work. The meso cycles are usually broken into smaller week-long bits called micro cycles.

Throughout the season, swimmers will swing from feeling great to feeling awful at practices, both in the pool and the weight room. Strength training workouts that are high in volume or heavy in load often cause the sensation of feeling heavy in the water. A general rule of thumb is that if swimmers start feeling heavy in the water and affecting their training because of strength training it is a good idea to back off a little bit the upcoming workout or two.

Taper time is a high-stakes period of the macro cycle. The training volume in the water gradually comes down and more emphasis is put on top speed and technical sharpness. And the workouts in the weight room are typically sharply reduced several weeks out and cut out entirely anywhere from 2-4 weeks before the taper meet starts. During this period the body goes through its largest physiological changes throughout the whole season: The muscles grow in size as more muscle fibers are formed; the fibers begin contracting quicker; and they can become a bit more sensitive to lactic acid [8, 47, 64].

But I argue that abruptly ceasing strength training as long as a month before the taper meet is not an optimal approach. It may limit the body's ability to develop power. And it likely is not damaging in the way many tend to believe.

The training swimmers go through during the two months leading up to their big meet will have a significant impact on their performance. It is not uncommon that the final meso cycle before the usual three- or four-week weight room hiatus involves lifting weights at 80% or more of 1RM. The muscle contractions during those exercises are typically slow. Meanwhile at the final competition, swimmers need their muscles to contract rapidly. Mimicking this swiftness in the weight room without fatiguing the swimmers will be a far more appropriate use of the last meso cycle. It stimulates the fast-twitch muscle fibers without breaking them down as much as lifting heavier weights. Below is an illustration of how the force and velocity of movements on land compare to the forces in the water:



The intersection of the lines plotting force and velocity on land suggest that the best velocity to mimic swimming occurs when the swimmer lifts well below 50% of their 1RM [72]. The sweet spot is usually around 20%. Young swimmers and those who are physically weak fall even further to the right, given that the resistance of the water exceeds their level of strength.

The Fix

The taper in the weight room technically starts when the macro cycle shifts focus from maximal strength to power – doing similar exercise variations but progressively lighter and faster. This should happen quite a while before the taper meet. During this time, swimmers should start to feel lighter in the water and as if it offers less resistance than earlier in the season – what some like to call "downhill swimming." I like to say taper on land begins when the majority of exercises are done with weights at below 60% of 1RM or done only with one's own body weight, and starts to incorporate rapid-assisted exercises.

During those last few weeks leading up to the taper meet, I recommend swimmers follow three general guidelines: Faster movements, more recovery and less time spent on stability training. Cut down the long and fluffy ab circuits and replace it with self-recovery and mindfulness. Four weeks out from the taper meet, swimmers should pencil in two weekly weight room sessions of between 20 and 40 minutes each. The later the swimmer is in their career, the more preparation time they need.

An example of a workout is 2-4 quick blocks with either 2 or 3 rounds of 1-2 exercises per block, concluding with a core block. Alternatively, the coach can write out 5-10 explosive exercises, including the core, and the swimmers can either pick a handful of their favorites or do all of them. Distance swimmers may want to do a majority of them as they tend to need a bit less rest, while sprinters can be given the option to choose, which gives them the added benefit of a sense of autonomy.

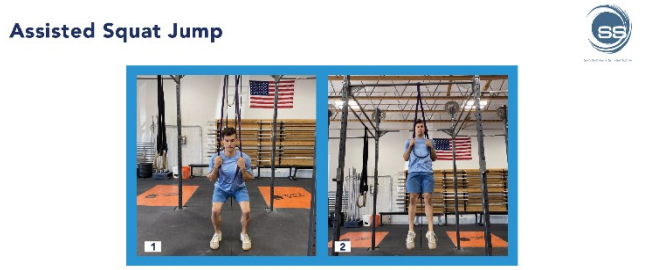
The exercises can include jumping variations, medicine ball variations, Hang Clean variations and rapid core movements. Assisted exercises, such as assisted Squat Jumps with bands, or explosive band Push-Ups, are often overlooked both in season and during the taper are assisted but can be excellent during these few weeks. The assistance of the bands help the muscles to contract quicker than they normally can, which helps them to get more primed by working on "overspeed", similarly to swimming with stretch cords. If the swimmer needs to emphasize straight-up power, each set should consist of most at most 8 reps. The power output and speed should be the focus.

Should the taper schedule include stability exercises? My advice: Do not overdo it. Stability training is generally more related to injury reduction and long-term performance than increasing short-term performance, and I have yet to find convincing research showing that proves the opposite[5, 59]. So I recommend that swimmers reduce the time spent on Bird Dogs, yoga movements and stability balls. If the swimmer has done their stability work throughout the season, they will be in a good place to swim fast.

Recommended Movements During Taper

Either one of these can be performed either as a plyometric or explosive variation.

To make it plyometric, flow through the repetitions continuously. To make it explosive, come down to a starting position and hold for 2seconds, then execute the movement.

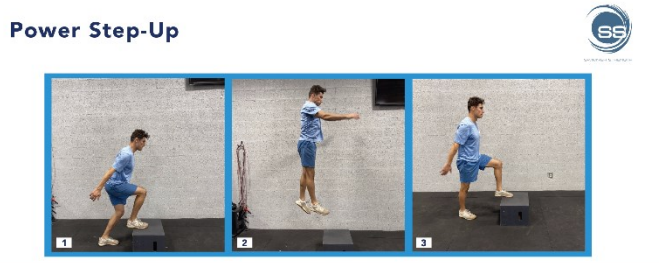


Assisted Squat Jump

Wrap a superband around a bar. Grab the band, and pull the elbows toward the ribcage. Squat down and jump. Maintain stiffness in the arms and the spine.

Assisted Power Push-Up

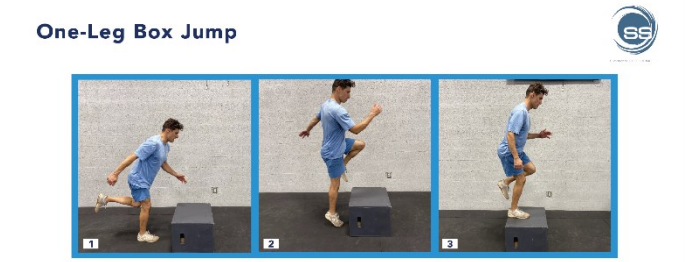
Wrap a superband around a bar. Place the band underneath the chest. Get into a Push -Up position with hands placed underneath the shoulders and slightly wider. Quickly bring the body down and forcefully push off the floor. Maintain tension in the core.



Power Step-Up

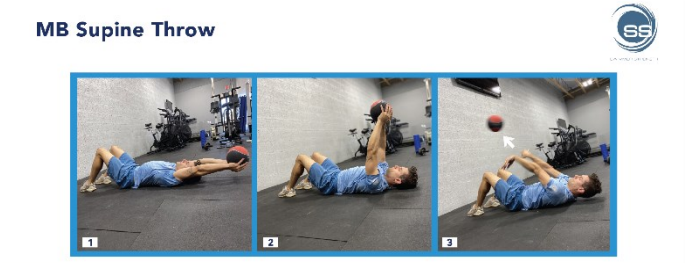
Grab a small box (10 -20 cm, or 4 -8 inches). Place the front half of one foot on the box with the other leg on the ground. Jump by pushing the foot “through the box.”

Shift the legs in the air and land with the opposing foot on the box and opposing leg on the ground.



One-Leg Box Jump

Grab a low - to medium-height box. Stand on one leg. Swing the other. Jump and land firmly with one foot on the box. The knee should be bent similarly to the bend on the blocks – hips high, knee slightly bent and the pressure focused in the middle of the foot.



MB Supine Throw

Lay on your back on the floor, holding a light - or medium-weight medicine ball at your chest. Bring the ball back overhead as far as possible without arching the lower back. Using arms and abs, throw the ball in the direction of your legs without crunching the spine. Either throw against a wall, or to a partner, and catch it again. Younger swimmers can keep their legs on the ground while advanced swimmers should keep their legs in the Hollow Hold position.

Chapter 8

Injuries

I have had my fair share of injuries. And as so often is the case, many of them have occurred under the most innocuous circumstances, like a pre-race stretch in front of the TV. That mundane activities can cause lingering damage is one of the most frustrating aspects of injuries.

My longest-lingering injury stems from a soccer match. I was a freshman at Daytona State College and me and my teammates would play between our pool sessions during winter break. It was at the peak of our tr aining cycle and we were all exhausted. Still, we would kick the ball around for hours. It was all fine- until I one morning up simply could not stand up straight. I felt like I had aged decades just overnight. I have endured a nagging irritation in my lower spine ever since.

As a result, I could not carry out a regular lifting schedule until my senior year. During those years, I could not do front squats or hang cleans. Instead, I would do modified squats and various power movements, afraid of doing anything that could further aggravate my injury. And I became fascinated by the impact strength and conditioning programming has on swimming performance and overall quality of life.

Bottom line: Injuries are dreadful and both physically and emotionally draining. Sometimes they even end careers. Still, if you are a competitive swimmer, chances are you will have to work through at least a handful of injuries over your career. That is why it is important to create a game plan, be disciplined, stay optimistic and learn from the past.

The Problem

Swimming is a demanding sport with grueling pool sessions that put enormous strain on the body and wears it down over time [58, 61]. Trying to do weights and dryland workouts while already fatigued often results in poor technique. One day they might just push a little too hard and boom, something goes wrong.

Injuries that occur in the weight room typically stem from exercises done either too quickly and without proper body awareness and movement control, or heavier than what the body is able to muster. Some athletes put too much pressure on muscles and joints by adding too much weight too quickly. For instance, shoulder injuries often occur if the phase of lowering the weights in the direction of gravity is performed too quickly and without proper tension. Shoulder injuries caused by Push-Ups are one example. They often happen because the swimmer drops their body too quickly, lets the hips sag and drops the neck right before commencing the upward push. Another example are squats . Letting the body drop during the downward phase instead of lowering it in a controlled way will cause the chest to fall forward and the knees to cave. That will position the body in a bad spot.

It is important that swimmers learn the difference between " good" pain and "bad" pain. They must distinguish between the burning sensation that is concentrated in the muscles and disappears relatively quickly with a bit of rest, and the sharp or dull joint - centric pain that lingers, signaling that something is wrong.

It is crucial to communicate these matters to the coach, but doing so is not always a cakewalk. Many swimmers avoid mentioning their pain to coaches because they are afraid of being judged, mistreated or simply not believed. Perhaps they have had a simi lar experience in the past.

Then there is injury management, which is difficult to understand but crucial to carry out correctly to ensure a speedy return to the pool. And it is important to remember that injuries not only affect muscles, joints and tendons, but also a swimmer's mind and self - confidence. If they are not nurtured and coached through this adversity, the swimmer may land in a downward spiral of hopelessness and negative self-talk.

The Background

An injury is some kind of mechanical failure that affects either a muscle, tendon or joint, or all of them. But it does not stop there. An injury can impact the brain's relationship with the body part and sometimes the former ends up rewiring itself slightly. This may cause more or less movement dysfunction or pain.

Injuries generally fall into two categories: Acute or chronic. Acute injuries result from immediate trauma to muscles, joints or tendons. It can be a swimmer hitting their hand on the wall at the wrong angle, spraining a few fingers, or a swimmer rolling their ankle while jumping rope on the pool deck. Acute injuries typically result in a jolt of pain and swelling. It may take as long as two weeks to recover from such injuries. If they are not addressed quickly, they may turn into chronic injuries such as inflammation in muscles and tendons. No manageable acute injury should turn into a chronic one as long as the swimmer seeks out adequate help.

Chronic injuries last for longer than two weeks – in some instances throughout an entire lifetime. These include overuse injuries resulting from incorrect movement patterns both in or out of the water, excessive volume and intensity without adequate recovery. They include serious strains, sprains, tendonitis and nerve impingements. For instance, a month before the Pac-12 conference championships during my senior year of college I injured my shoulder. I had just finished a lactate set and dove back into the pool for a recovery swim. Typically, I would keep my arms locked in a streamline and during a dive. But in this instance, I kept them relaxed. When my hands broke the surface, my left hand sliced inward and the thumb instantly rotated down, straining some of the muscles around my rotator cuff, like the subscapularis and teres minor. I immediately went to the team's athletic trainer who helped me rehab for two weeks. I completed the meet without pain. But once the season was done, I did not keep up my rehabilitation. It has lingered ever since, turning into a chronic injury.

Diagnosing injuries is far from a straight-forward process. The cause of an injury – the so-called pathology – can vary depending on a swimmer's anatomy and coordination. For instance, the lower back is the third-most prevalent area of injury for swimmers, trailing shoulder and knees [64]. But lower-back pain experienced by two swimmers may have completely different root causes [16, 36]. For some, the injury pathology may be weak and tense hamstrings, while others have weak and tense hip flexors, or issues with their actual spinal discs. Recent research also suggests that lower back pain may stem from excessively tense and weak oblique muscles – the side-abs supporting flexion and rotation of the lateral trunk [48].

There is lots of research suggesting that athletes should not specialize too soon [28, 31]. It is important that they are exposed to a variety of training stimuli at a young age. That holds true both for different strokes and exercises, but also with respect to volume. Having a 14-year-old repeatedly do 50,000 yards a week, for example, could arguably fall in the category of training that is too specific. And most likely, tendinopathy – inflammation in tendons – may in some cases follow [23].

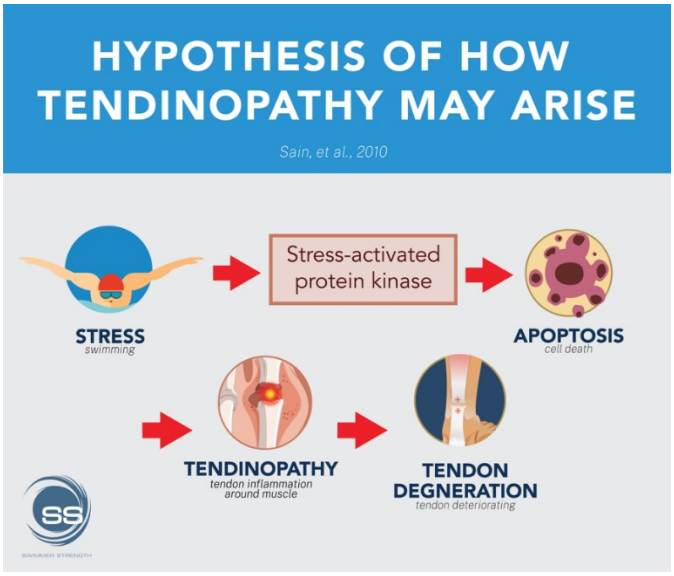
Research also suggests that female athletes get injured at a greater degree than males [7, 27, 50]. There is no clear reason why. One hypothesis is that both male and female swimmers tend to do the same practices, but males have greater muscle mass to withstand the forces exerted by the water resistance. It is also important to stay safe outside the pool. Research suggests that swimming is the main cause of injury among college swimmers (60%), however, activities outside practice hours, including the weight room, account for as much as 38% of team injuries [71]. These findings are not conclusive and may vary depending on myriad factors.

Common Types of Injuries in Swimming

Microtrauma

Microtraumas are injuries that stem from overuse of a body part, which in a way is a natural part of elite-level swimming. Excessive microtrauma causes inflammation that disrupts the body's ability to repair and restore itself. They are very common in swimming, particularly in the shoulders, lower back and knees. An Australian study

involving elite swimmers ranging from 13 to 25 years of age found that two variables were strongly correlated to pain and inflammation in shoulders: The number of hours spent in the pool and the training volume [56].



Strains

Strains happen when muscle fibers are stretched or torn. They can range from relatively limited– mild damage to only a small percentage of fibers that results in temporary and limited loss of strength and range of motion – to severe, in which a muscle or tendon snaps completely. Fixing that c an in some cases require surgery. Strains happen more often when the body is fatigued, or the swimmer is unfocused or inexperienced. Imagine a novice swimmer in the weight room trying to lift too heavy or without proper technique and you get the idea.

Impingements

Impingements refer to the painful pinching of the muscles, tendons or other soft tissues between the bones or ligaments – sensations commonly experienced by swimmers [16, 47]. They occur when tendons are pinched between bones, which is painful. If not treated, they might result in tendinitis or inflammation. Heavy strength training and high volume in the pool can cause certain structural changes to a person's tissues and ligaments, which can cause impingements. Recent research suggests that shoulder impingement injuries instead should be labeled "rotator cuff disease" [35]. Consistent foam rolling and aggressive treatment on the mobility balls help ease this tension in the fascia – the sub-skin tissue that keeps everything in place inside the body – and help modify body shapes to allow for more efficient movement patterns. It is also highly recommended that swimmers regularly seek treatment from a sports massage therapist or physical therapist.

Shoulder & Biceps Tendon Inflammation

The supraspinatus tendon and subscapularis tendon – responsible for lifting the arm over the head and rotating the arm inward, like in the high -elbow catch position – are both at high risk for swimmers [56, 65]. Additionally, biceps tendinitis is also reported among swimme rs [65]. While biceps are not main contributors to forward propulsion in swimming, they help during the catch phase of a stroke and remain more or less isometrically contracted until the stroke finishes. As the arm breaks the surface, the front part of the shoulder hyperextends while it is internally rotated. The same goes for butterfly – but the difference is that the butterfly recovery requires both arms to break the surface. This requires more strength, power and stability than in the freestyle motion because the body does not have another arm in the water to help anchor and stabilize the body while the other arm recovers.

Tears of the labrum in the shoulder – the cartilage that acts as grease for the shoulder joint as it moves around– are less common than inflammation of the biceps tendon. This is mainly because the trauma sufficing to elicit a labrum tear is often associated with much higher forces

Muscle Knots

Muscle knots can best be described as stiffness in a muscle that has been too tense for too long, which causes pain. The specific area of a muscle where the pain originates is called a myofascial trigger points (MTrP). These are either latent – meaning they are sensitive only upon touch – or active, which means they actively radiate pain [10]. The root cause of muscle knots is usually repetitive motions. Less is known of how the quality of movement affects muscle knots, but presumably with

poor technique, and a lack of countermovements, the frequency and intensity will be different.

Knots may be an inevitable part of hard training and racing. Swimmers often feel so-called muscle knots in their upper trapezius, triceps, pectoralis minor, lats, hip flexors and calves. A mindful swimmer will notice when knots occur. For the less mindful swimmer, I recommend using foam rollers and massage balls to help find them and treat them.

Lower Back

The lower back is a complex area that swimming unfortunately can damage in several different ways given the many different motions required to do the different strokes. It is hypothesized that high-level competitive swimming may amplify degeneration of the lumbar disc [24]. For example, freestylers and backstrokers constantly rotate their hips, which can eventually cause structural damage to the lower discs in the spine [16]. Butterfly and underwater swimming require rapid and aggressive undulations that involve pretty radical pelvic tilts and spinal bends. And breaststrokers must hyperextend their spines and hips when the arms have finished the pull and the head is above water. These motions turn dangerous on the discs if the tension and engagement from the abs are lacking and the thoracic spine is lacking mobility. Then there are anatomical differences: Some lower back injuries stem from how the swimmer's pelvis is positioned in relation to certain musculature that is excessively tense. Pain in the lower back is often sharp and intense if felt during certain motions. And some swimmers experience achy sensations in their lower back once they start to lift. Because the lower back muscles are endurance muscles in nature, they will go through the process of becoming stronger and withstanding higher forces. This can leave swimmers feeling tender, especially if they have a naturally curved lower back that may add more pressure when swimming in the horizontal position.

Some swimmers use foam rolls to treat tension in their lower backs, but I advise caution. Always keep the abs and glutes activated to alleviate pressure on the back by the roll, and press the lower back down without arching it.

Knees

It is commonly believed that breaststrokers are the only swimmers suffering from knee pain. It is true in the sense that breaststrokers' knees typically become sensitive due to the kicking motion. Once the legs are in their fully flexed position, ready to push water back, the feet rotate out, hips in, and then they aggressively snap together in a split second. That can put a lot of stress on the knees.

But swimmers specializing in other strokes obviously can incur knee pain as well. The other strokes require hard pushes off the walls and highly rapid and aggressive cyclic contractions to fully extend the legs both during the flutter kick and dolphin kick. These movements, over time, will affect the internal structure of the knee joints, which may cause pain [58]. And tightness in calf muscles, resulting from swimmers constantly pointing their toes, can sometimes cause irritations in the knee. As a result, it is important that all swimmers continuously work on knee stability. The muscles below and above the knees ought to get some love from the foam roll, and use mobility balls while working on stabilizing the feet and hips.

Ankles

Swimmers must repeatedly point their toes. Over time, this can cause instability in the ankles. That shows when swimmers try to balance on one foot but seemingly cannot find the tripod of the foot, meaning the heel, the big toe and little toe, to stabilize themselves. This puts the swimmer at greater risk of rolling their ankle on the pool deck, in the weight room or during hikes.

Why Swimming Injuries Happen

I like to use the analogy of supply and demand when it comes to injuries in swimming. The sport comes with high demands on the body. If the body does not get the appropriate supply in terms of nutrition, rest and care, the scale will tip and the body breaks. Reality is of course a bit more complex. Below is a rundown of some of the most common causes of injuries I have witnessed during my time as a strength coach for swimmers.

Lack of Awareness

Swimmers must be mindful of how their bodies operate on land. It begins by minding how a movement is supposed to be performed and feeling which muscles are involved in exercises. A lack of such awareness creates poor movement habits, which over time increase the risk of injury. For instance, swimmers who aggressively chop their hands into the water during the butterfly or cannot maintain tension in their ankles and feet during the breaststroke kick likely lack both strength and awareness.

The body is exceptional at findin g ways to get things done, so poor movement habits can easily linger with a person for a lifetime. When this happens, the body compensates for these movement patterns, leading the swimmer to believe that everything works the way it should. When pain appears, the swimmer might believe it originated from another place. Poor movement patterns can be particularly detrimental when the training intensity is turned up, or when the swimmer starts lifting heavily.

Kinetic Chain Imbalance

The simplest example of an imbalance in the kinetic chain is a swimmer who has a slight gallop in their freestyle and is either unaware that it needs fixing or unable to fix it. The gallop indicates that energy is not rhythmically being transferred through the legs and core to maintain the stability in either the catch, pull, recovery or a combination of all three. In fact, the swimmer may be much stronger on one side of the body than the other. This can be tested with the Split Squat Hold and Elbow Side Bridge (see Chapter 10 for testing).

Imbalance Between Training and Recovery

Training swimming is a balancing act between exhausting the body and letting it recover. It needs sleep, food and active recovery, such as stretching, to maintain that balance. Needless to say, if the balance is off, the swimmer puts themself at an increased risk of injury.

Prevention, Reduction and Management of Injuries

Injuries seem more or less inevitable for highly competitive swimmers. Consistent reports exist on elite-level swimmers competing at World Championships and either are, or have gone through injuries leading up to the competition [32, 33]. A sound and clearly thought-out plan for how to efficiently manage and treat those can drastically shorten the recovery period. But it is equally important to prepare the body ahead of time and try to minimize the risk of incurring an injury in the first place. There are a number of movements and exercises swimmers can do to reduce that risk, and training programs can be designed for that purpose as well. These measures all fall under the concept of injury prevention.

Many coaches like to prescribe their swimmers certain exercises solely aimed at reducing the risk of injury. If you have hung around enough pool decks you have likely seen a wide array of examples: Small, specific exercises that resemble what you might see at a physical therapist. It can appear very sophisticated and advanced. But in reality, it may just be a waste of time. Many of those exercises are not functional, meaning the effect they purport to have does not transfer to the water particularly well. And they can take focus away from what is actually import ant: Movement quality and technique.

Keenan Robinson, who is director of sports medicine and science at USA Swimming and for years was Michael Phelps' athletic trainer and strength coach, has said that any movement could be considered preventative if done correctly. Yes, this means that performing 40 body weight Squats, 10 Push-Ups, and 3 Pull-Ups can be both safe, healthy and preventative if done properly.

Steps to Reduce Risk of Injury

Warm-Up and Cool Down

Stick to the basics. Everyone has heard this tune before, but it deserves to run on repeat: Warm-up increases the body temperature, engages joints and muscles, and prepares the swimmer for what is ahead. And a cool-down helps release and clear out lactic acid from the muscles, speeds up the recovery and reduces muscle soreness.

Develop the Core Before Extremities

The core is the key to transferring energy and coordinating movements. Naturally, it should be developed before the arms or legs. The tests outlined in this book may help coaches determine when it is appropriate to start putting emphasis on extremities.

Develop Awareness

Awareness involves carefully paying attention to how the body moves and feels during certain positions or movements. Performing movements at an overly slow speed helps develop that awareness and also boosts stability and strength. A swimmer that is aware will be able to feel when the joints are unable to move further in any given position, or when pain in a muscle is more than just pure fatigue.

Progressive Overload

This is theprocess of successively increasing the training load to ensure the muscles get the biggest bang for the buck during the toughest periods. It is important to do this in a gradual manner to minimize the risk of injuries stemming from overuse.

Movements > Muscles

This should not be news to anyone: The quality of a swimmer's movements during a lifting routine must take precedence over weight or number of repetitions. A swimmer with a well-rounded movement quality is generally ready to target and develop movements that predominantly involve the specific swimming muscles.

Stability Before Strength before Power

Stability encompasses the body's ability to synchronize movements and ensure they are coherent and controlled. Stability ensures the joints and muscles are more durable and that the swimmer can learn and adopt good technique. So, again, work on controlling movements before working on strength.

Improve Relative Strength and Power

Relative strength – meaning how strong a person is in relation to their height and weight – is an important measurement because swimmers who score higher are able to stay more stable during fast swimming, when the forces on the body are higher.

Relative power can easily be measured by timing how quickly the swimmer can pull themselves up from a hanging, straight-arm position. The same method can be used for Push-Ups and exercises using weights. The quicker the swimmer is, the stronger on a relative basis they are. See Chapter 10 for a detailed outline of how to safely assess relative strength and jumping power in adolescent swimmers.

Relative strength is often expressed as a number. A higher number indicates better relative strength. Most swimmers have better relative strength in their lower body compared to their upper body. High relative strength will help swimmers unlock greater capabilities in their swimming. Comparing two swimmers' raw strength to relative becomes more relevant with advanced swimmers.

Power is the body's ability to quickly move, lift or push objects with maximal force. A strong foundation of stability and strength training is essential before starting to focus on improving power. Otherwise the muscles, joints and tendons may not be able to handle those forces and could end up damaged.

Be Careful with Swim Specific Movements

Swim-specific movements encompass exercises on land that mimic movements done in the water. Band pulls mimicking the freestyle and butterfly underwater pull are one example, or newbie age-group swimmers who practice the breaststroke kick while sitting on land. These exercises might seem like a logical part of any

strength or dryland program, and I agree that they can be good for beginner swimmers who need to carve the motions into their muscle memory. For the remainder, I urge caution.

To start, many people do not perform these movements particularly well while on land. The impact of gravity is entirely different on land, which will add tension and put pressure on muscles in a way that hardly resembles what is going on when the swimmer is in the water. Performing these movements on land usually becomes more difficult, which can result in bad technique.

Secondly, it adds even more repetitions of the same movements that the swimmer repeatedly does in the water. Part of the idea with a thoughtful strength and dryland program is versatility and countermovements, both with the ambition to give the body well-rounded exposure to exercise and prevent injuries.

Thirdly, there's the question of transferability to speed in the water, which we covered in Chapter 7.

Controlling Breathing

This should not be confused with hypoxic capacity, or so-called breath control in the pool. This is simply about how a swimmer breathes in their everyday life and in the weight room. A rhythmic and regular breathing pattern that goes through the belly with the help of the diaphragm helps the body stay relaxed. During movement, especially heavier loads, it is important for the core to maintain intraabdominal pressure. This is achieved by stiffening up the spine and bracing the belly. In this position, athletes should still be able to take small breaths while maintaining the pressure.

A version of this technique – holding the breath to lock the spine and create pressure and stability around the core – is known as the Valsalva maneuver, which is frequently used in weight lifting. The breath is held before the movement is initiated, typically during the lowering (eccentric) phase of the motion, and is held during the ascending (concentric) phase of the motion through the "sticky point," meaning the most challenging portion of any lift. The breath is then sharply exhaled. The Valsalva maneuver helps keep athletes safer in the weight room. This becomes increasingly important during lifts with loads at or near maximal effort.

Injury Management Tips

Active Recovery

This encompasses anything a swimmer does outside their training to speed up their recovery beyond just doing the basics – eating and sleeping. Examples include tools like foam rollers, mobility balls and massage guns, or professional help like a massage therapist or physical therapist. These all fall under two categories called secondary and tertiary recovery modes (more on these in Chapter 9). All those forms of active recovery may increase the output the swimmer may see from their training.

For injury-prone swimmers, morning and evening routines of active recovery can be a deciding factor in whether injuries persist. It can be something as simple as just 5 minutes before bedtime and after waking up. I myself either do a full-body stretch with bands or a full-body foam roll for 15-30 minutes in the mornings and evenings, which helps me sleep better and recover quicker from long work days that sometimes include my own workouts. Pay attention to the body type you are and experiment with routines and adjust along the way. Over time, it can have a big impact on how fast you swim and how resilient your body is.

Dr. Kelly Starrett – a physical therapist who wrote the book *Becoming a Supple Leopard* – recommends using mobility balls to improve joint and muscle function.

When a muscle is injured, the tissue surrounding it sometimes grows stiffer as a kind of protective measure. These muscles may lose some of their range of motion and also exert pain in certain situations. Mobility balls are a good tool to put pressure on small areas of the body to improve the blood flow and range of motion, and give the muscles a bit of respite.

The painful sensation that sometimes follows the pressure created by the mobility balls and foam rolls come from the MTrP – the muscle knots. Swimmers should try to address those areas.

Train With No Pain

Pain is the body telling us that something is going on. Anything beyond muscular soreness and achiness from training, or the occasional growing pain for teenagers, should quickly be evaluated by an expert. Respect what the body is telling you. If there is a slight pinch during certain movements, address it. Form new habits. Train with no pain, and the gains will be both bigger and more long-lasting.

Develop End-Range Strength

Muscle strength is often developed in a certain range of the body part's full range of motion. At one point in a swimmer's career she may see minimal improvements while lifting weights. The strength and power gains are just not being seen. The answer can sometimes be found in the swimmer's poor relative strength in the outer ranges of the movement. Changes in strength, muscular structure and fatigue resistance is dependent on the length in which they are being worked [(1)].

Physiotherapist Dr. Andrea Spina is known for his training method *Functional Range Conditioning* (FRC). It involves muscles voluntarily contracting to, or near, maximal levels to move the joints to a place where they are restricted, while the non-moving parts are kept static. These methods essentially help bridge the gap between passive and active range of motion at end-ranges. They may also have the ability to be a self-assessment tool for movement quality that may expose underlying movement dysfunctions.

Stay Consistent

Without consistency, you will not see results. I would be lying if I said I stretch and roll *every single* morning and night, but I do some form of focused movement quality, using only my body, every day. Otherwise my old injuries flare up again. Consistency requires discipline and devotion, and is a necessary component for long-term success.

Chapter 9

Recovery

In my late teens I hit a roadblock and came close to quitting swimming. I had plateaued. All the hours spent staring at the black line at the bottom of the pool seemed to be all for nothing. That fire that once had burned deep within me had vanished. I was ready to be done.

But I did not quit altogether. Instead I just took a three-month break. I reassessed my ambitions and settled on one concrete goal: Making it across the Atlantic Ocean. Two months after I got back into the water, I went a best time in the 100m breaststroke. And some time later I secured a scholarship at Daytona State College, which would become my home for two years. That fire within me had been rekindled. All I needed was some time away – some recovery.

It hit another roadblock at the end of my junior year, after three years of meager improvements. I was at Arizona State University at that point, and realized that I needed to change things to break my unimpressive streak. As a senior, recovery became a focal point. I found a brand of post-workout recovery drinks that worked well for me. I started going to sports massage once or twice each month. And I ended up having the best season of my career.

Swimming is among the most demanding sports out there. The seasons are never-ending and the workouts tend to be lengthy and grueling regardless of whether you are a sprinter or distance swimmer. It can overwhelm both the mind and body of any athlete, which is why recovery is such an integral part of success in the pool. Only a sliver of the week is spent in the pool or the weight room. What swimmers do with the remainder of their time will have a huge impact on their performance.

The Problem

There are no shortcuts to success in the pool. It is not uncommon for young teenagers to train well over 12 hours per week both on land and in the pool. College swimmers usually must manage a weekly workout load of a bit over 20 hours. Some professional swimmers may fall closer to 30 hours. And the seasons are year-round. That results in an astounding amount of time spent putting stress on muscles, joints and limbs, not to talk about the mind. If swimmers do not spend sufficient time on recovery, they are at an increased risk of plateauing, getting injured or simply burning out. Despite this, the idea of recovery carries a certain stigma. Some coaches and swimmers err on the side of working too much rather than working too little, and either forget or neglect to incorporate recovery days or weeks to let the body catch up.

A few decades ago, the prevailing method to produce top-level swimmers was to drive them so hard in the pool that only the handful who could sustain the workload remained. That notion of you-must-crack-a-few-eggs-to-make-an-omelet still lingers in some corners of the swimming community. And sure, it works for some. But it drives countless others out of the sport at a young age, depriving them of what perhaps could have turned into a long and successful career. Things are different today, but the heart of the matter persists: Without recovery, success will be elusive. That is especially true for swimmers that also incorporate dryland and strength training.

And although coaches bear a huge responsibility, they can only do so much. Even athletes who train 20 hours per week spend 85% of their time elsewhere. Using this time efficiently and properly requires discipline and consistency. Life is filled with endless distractions – smartphones play no small role – that can capture a swimmer's attention and impede their sleep and capacity to recharge mentally. An overloaded mind can result in all kinds of issues, from poor sleep to anxiety and eating disorders.

The Fix

Intense training for long durations pushes the body in a sometimes extreme way. During a tough pool session, the cardiorespiratory system is pushed hard, the muscles

near maximal fatigue and the lungs ventilate at their full capacity. Prolonged hard tra ining makes the neural connections from the brain to the muscles fire slower. In the weight room, the muscles and joints take the largest impact of forces that are much higher than those they are exposed to in the water, which may lead to muscle knots and neural fatigue. The time it takes for muscles to recover will greatly depend on the muscle damage and inflammation caused by the training [43].

It takes two to tango. The coach is responsible for the physiological recovery to optimize the output from swimming and strength training. The swimmer is responsible for doing their part when it comes to eating, sleeping, paying attention to signs of pain and taking additional time at home to do active recovery. The swimmer must understand and respect the interconnectedness of all the aspects of their life on how they perform in the pool. Champions, in my mind, are made outside practice hours.

Recovery does not mean the swimmer has to stay away from the weight room or the pool. There is plenty of work that can be don e even at a slower pace or lower weight, such as technique. And while at home, the swimmer can use foam rollers or mobility balls as active recovery. The recovery process can be broken up into three major steps: primary, secondary, and tertiary recovery.

Primary

Sleep, nutrition and hydration are the primary pillars of recovery. Athletes who sleep 8 hours per night are at *significantly* reduced risk of getting injured or ill, and also maximize their muscular recovery [67]. Research suggests that good habits in and around the bed, such as eliminating blue light from cell phones or computers around 30 minutes before going to sleep, can markedly increase your sleep quality.

Dietary habits will dictate how well the muscles repair and develop, and how quickly ene rgy deposits are replenished. It will also dictate the quality of sleep [19]. Treat your body as if it is a high -performance car that needs the best fuel to drive at its top speed. Proper hydration makes sure that all the body's processes are working efficiently. For example, if the body lacks fluids, the blood volume drops, forcing the heart to work harder to pump nutrients and oxygen to the muscles and brain, and rid them of rest products like carbon dioxide.

Then there is mental wellness, which I argue a lso ought to be a component of primary recovery. Meaningful friendships both with teammates and others, and activities or hobbies outside the pool that lets the swimmer take their mind off of things, are very important.

Secondary

This part of recovery inv olves professionals whose sole job it is to help you treat and heal your body and mind. That includes physical therapists, athletic trainers, massage therapists, sport psychologists and therapists. In short, anyone that can legally put their hands on you. Mental recovery is often overlooked, in part because it's harder for an outsider to survey and quantify. With mental health issues among young Americans on the rise, it is extremely important that coaches, swimmers and others pay attention to this.

Tertiary

This incorporates anything a swimmer manually can do to him or herself to aid in the recovery, such as foam rolling, stretching, self-massage techniques or meditation and mindfulness. Breathing techniques and meditation can help a person clear their mind and feel more energized. I tell my swimmers that 30 minutes of active recovery at home each day adds 2% of training to their week.

It's important to remember that recovery, just like a session in the pool or the weight room, requires work. It starts by be coming aware of what the body tells you it needs, and then choosing the best measures to take, and take them with perfection.

Active Recovery Techniques

Diaphragmatic Breathing

This is a technique aiming to fill the lungs with air using the diaphragm rathe r than expanding the rib cage. It is

often used in mediation. The more stress the body is under, the less it tends to use the diaphragm to breathe. Hyperventilation, for example, is on the extreme side of that spectrum. Studies involving athletes have shown that diaphragmatic breathing decreases secretion of cortisol, a stress hormone that tenses up the muscles, and increases melatonin, the hormone that helps regulate a person's sleep [34].

Mobility

Mobility involves actions to improve joint and muscle function, including range of motion. The best way to improve joint function is to go through the options listed under the secondary and tertiary recovery steps while the body is slightly warmed up. I recommend between 5-20 minutes of mobility or stability work prior to practice.

Self-Myofascial Release

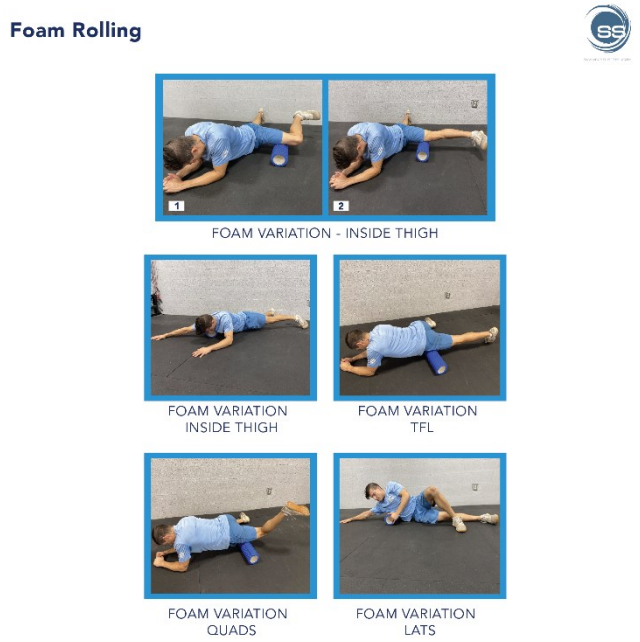
The fascia is a sheet-like tissue structure underneath the skin that covers the whole body and holds everything – muscles, organs and so on– separate but together. When an injury occurs, or when muscles are sore, or when the body is growing, the fascia tends to get tight and immobile. If the sheet is overly tense, muscles won't develop or recover as well as they could.

One of my college professors gave me this analogy: "Picture a bag of bread – the bag is the fascia, and the muscles are the bread. At one point, there will be no more room to put bread in. The same can be said about muscular growth. If the fascia is loose, then there will be more room for the muscle to grow." Self-myofascial release techniques help expand the bag.

Foam Rolling

Foam rolling is a manual treatment method that involves rolling out the fascia and certain muscles with the help of a rubbery cylinder. The more tender the area, the more tense the fascia and the muscles are. Foam rolling can shorten the recovery time, help alleviate muscle soreness and increase the swimmer's range of motion [54]. It also stimulates heightened awareness between the mind and body, called proprioception. However, spending 5 minutes using a foam roll before a demanding power exercise has been shown to decrease performance, whereas shorter stints of about 1 minute improves performance [44]. So, it is crucial to know when to use the foam roll to recover, and when to use it for preparation.

Avoid trying to roll out the bony parts of the body. Spend more time on tender areas. And make sure to contract and relax the muscles opposing those that are being worked on. When rolling out the quads, flex the knee and bring the heel as close to the rear end as possible. Use similar techniques throughout the body. Keep moving the legs and arms when you find tender areas until the tension subsides. Differentiate between the "good" pain and "bad" pain. If you feel a pinchy or burning sensation, stop immediately.

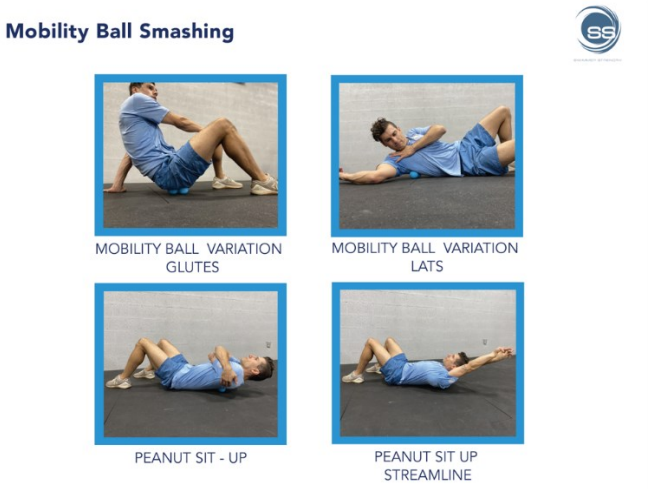


Foam Rolling

Mobility Balls

These are dense rubber balls. They come in different shapes and sizes, just like the foam rolls, but are smaller and more precise. They will dig deeper into the muscle tissue. Once tender areas are found, the aim is to contract the targeted muscle as maximally as possible and gently release until the pain and tension subsides [60]. One

effective method to ease muscle tension is to find the tender area and then add 5 -10 short and quick "mini - contractions" before exhaling and then relaxing, letting the balls sink deeper into the body. The more you use these, the more you will get to know your body and muscles, and the more effective you will be in managing current and unforeseen injuries. Before a training session, after a warm-up, 5-10 minutes on areas that either are injured, or on areas the workout will be focusing on is sufficient. At home, after practice, dinner and homework, lay down on the ground, turn on Netflix and smash muscles to amplify recovery time.



Mobility Ball Smashing

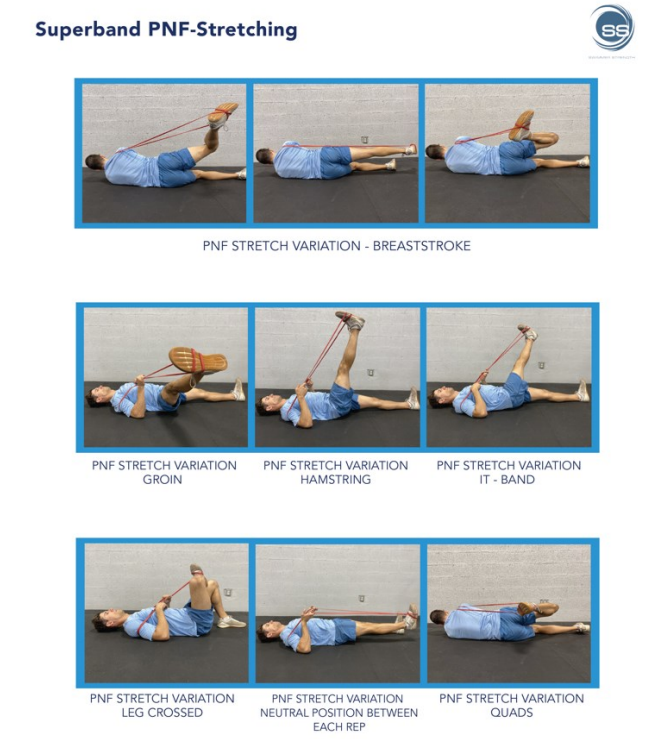
Stretching

Stretching is an active or a passive attempt to increase flexibility in the joints. This is done by extending muscles and tendons to manipulate joint angles and create adaptive stress. Passive stretching simply pushes a joint near the end of its range and usually evokes a mild feeling of discomfort. The rest of the body stays relaxed. Active stretching, such as proprioceptive neuromuscular facilitation (PNF) techniques, also involves muscles.

Stretching has been shown to decrease blood flow [52]. This may be due to all of the muscle fibers being forcefully stretched out. Imagine holding a stack of rubber bands in your hand. When they are not stretched out, you can split through your fingers easily. If you stretch them out, it will be more difficult to get through them. Stretching may therefore not be particularly well-suited for recovery immediately after a hard swim practice. Foam rolling would be a better option.

Next, the most effective way of stretching is PNF, the active version. It involves pushing the joint near the end of its range and then adding muscular contractions, which helps extend a swimmer's range of motion more efficiently than a passive stretch. Stretching becomes dangerous when the muscles are rapidly extended beyond their usual range.

Static stretching done shortly before a race or a hard practice may decrease the swimmer's performance[45]. It is better to stretch at different times of the day. To stretch my legs, every other morning I go through a short routine that involves a red superband that I wrap around my foot, pull the leg to the edge of its range and hold it there for 3-5 breaths. Then I contract my hamstrings and glutes to move the leg down, then back up into a deeper stretch. Here, I move into every angle my body is asking me to: Keeping the leg straight emphasizes the hamstrings, crossing the body stretches the IT-band and outside leg, opening up the leg gets the inner thigh and groin, and the quads and hip flexors are targeted on the side.



Superband PNF-Stretching

Not all swimmers stretch. César Cielo told me it makes him slower in the water. The explanation may lay in the power that is produced by stiffness in muscles and tendons. If the stiffness declines, the power output will suffer.

Mindfulness

Mindfulness is synonymous with awareness. Awareness of one's surroundings, thoughts, emotions, and physical preparedness. This way, the swimmer and coach will be more effectively communicating any internal issues that may arise within a season. Meditation, breathing techniques, yoga or Pilates may help swimmers become more aware of how their bodies operate and how their muscles feel, and to reduce the pressure from stress and anxiety.

Physical Therapy and Athletic Training

This includes diagnosing and rehabilitating injuries – key components of performance for high-level swimmers. They use hands-on tools including scraping the muscles, cupping, ultra-sound and laser radiation as treatments.

Sports Massage

These types of treatments include soft-tissue recovery and give swimmers time to relax. They help flush out byproducts lingering in the muscles, release endorphins and decrease the amount of stress hormone in the body [(21)]. Swimmers who get massages during the season may feel lighter and quicker in the water the next day. Massages near or during a swimmer's championship meet may help to increase their top performance and help sustain energy levels throughout the days-long meet.

Chapter 10

Testing

The clock had just struck 6 a.m. when I stepped into the weight room at Arizona State University together with my two dozen teammates. It was in August of my junior year. I had recently moved to Tempe and joined the Sun Devil swim team. On the agenda that day: Testing. I was the new kid on the block and both nervous and intimidated. Seconds later, the coach blew the whistle and we were off.

It was not a pretty sight. There were no strict rules or standards for how we had to perform our tests. Our Pull-Ups were sloppy. We were allowed to rest at will. One of my teammates held an Elbow Bridge for over 5 minutes. Another did 100 Push-Ups in 60 seconds. As you can imagine, both of them were shaking almost uncontrollably towards the end, having lost almost all of their form. We also got tested on vertical and horizontal jumps. The best attempt out of two was recorded.

Testing gives coaches crucial information about the state of their swimmers, rates of progression and possible weaknesses. And the results should help inform coaches about how to plan out the season.

The Problem

In recent years there has been an explosion of different digital devices to test everything from how quickly swimmers can move a barbell to how long they remain on the ground during jumps. This poses two problems for coaches. Many swim clubs cannot afford the tools they need and must instead rely on less precise methods. But even if they can afford fancy equipment, it can be tricky to choose and leave coaches second-guessing themselves. And even the costliest and most advanced testing equipment is a waste of money if not used consistently or the results are not put to use. Arbitrary testing without clear standards and periodic follow-up will yield unreliable results that are largely useless. Some swimmers may feel uncomfortable or scared when testing is on the agenda, worrying about getting injured or being judged by teammates. Coaches ought to see it as an opportunity to boost their swimmers' self-confidence.

The Fix

The best way to produce reliable and useful test results is entirely intuitive. Figure out what you need to test swimmers on, and why. Settle on a battery of tests that meets your needs. Create a set of written standards and methods to ensure consistency. Stick to the schedule and analyze the results. Pick equipment and tests that can easily be repeated, or the results will not be particularly reliable. And if a swimmer experiences discomfort or pain during any tests, stop immediately.

Bear in mind that swimming is a technically complex endurance sport. While a mix of tests including movement quality, strength and power will help show a swimmer's physical blueprint, there is no conclusive research that tells us how much improvements in these areas result in faster swimming. And there are times when swimmers may improve in all categories but still fail to swim faster. Lots of other factors play into swimming performance. The tests should therefore be viewed and used as a tool to mold the swimmer's training program.

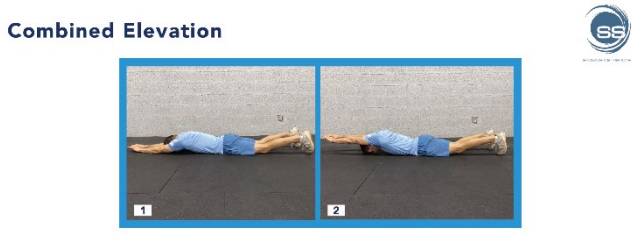
Movement

These assessments examine joint and muscle mobility and give the coach a blueprint of each swimmer's technical abilities both in the weight room and the pool. Below are a set of movement protocols that I recommend using.

Many strength coaches, myself included, do not always fully assess and track joint flexibility. Some have enough experience that they can measure this with the bare eye, but for most it is better to put the swimmer through an actual test. I make my judgement based on how well I can coach a swimmer into an Overhead Squat with a

stick. Once the swimmer is in their absolute best position, I am a ble to tell what the next few weeks and months may look like. This works both for hypermobile and immobile swimmers.

Tom Barton is a physiotherapist and yoga instructor who has worked with elite swimmers in Australia and Singapore. He is also the founder of "Q Swim" – an app designed to guide the layman swim -enthusiast through tests of the most important movements [4]. Below are Barton's tests and a few others I have selected.



Combined Elevation

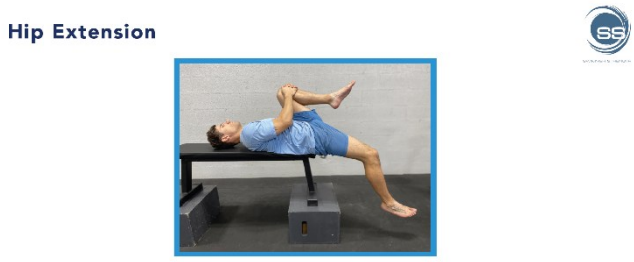
Tests the swimmer's ability to raise their arms overhead. Indicates a swimmer's stroke length, hand entry position, arm recovery and ability to carry out overhead movements in the weight room.

Starting position: Assume a prone position. Arms are overhead with thumbs interlocked.

Set-up position: Engage the core to limit movement in the pelvis and ribcage. Keep the elbows straight.

Test: Lift the arms up to the end of their range. Keep the head down.

Signs: The higher the swimmer is able to lift the arms, the more easily they can form a streamline. A swimmer who must arch their low back, or visibly struggle to lift the arms above the head has significant immobility in their lower trapezius muscles.



Hip Extension

Tests the range of motion for the swimmer's passive hip flexor and quadriceps. Indicates a swimmer's aptitude for starts and underwater kicks.

Starting position: Assume a supine position on the edge of a table.

Set-up position: Slide to the edge of the table.

Test: Hug one leg and let the other hang down. Keep the lower back on the table.

Signs: How far down the hanging leg drops will indicate how well the swimmer can kick, especially underwater dolphin kick and flutter kick. A leg that cannot fall particularly far indicates that the swimmer has tense hip flexors and quads.

Hight Elbow Catch

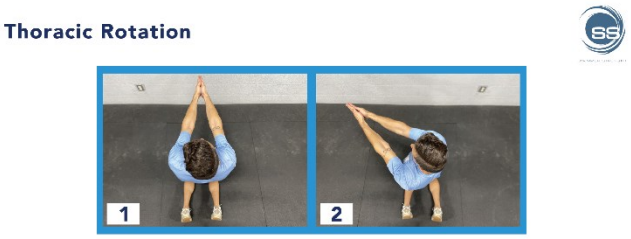
Tests the swimmer's ability to actively control the shoulder blades in the upward rotation and shoulders in the abduction. Indicates a swimmer's stroke length and smoothness in the freestyle and butterfly recovery.

Starting position: Assume a kneeling sit with thumbs touching the front of the shoulders.

Set-up position: Maintain an upright posture with neutral spine. Engage the core to keep the ribs from elevating.

Test: Float the elbows up and out to the end of their range.

Signs: The height of the elbows will indicate how easily and smoothly the swimmer can carry out the recovery parts of the strokes in freestyle and butterfly.



Thoracic Rotation

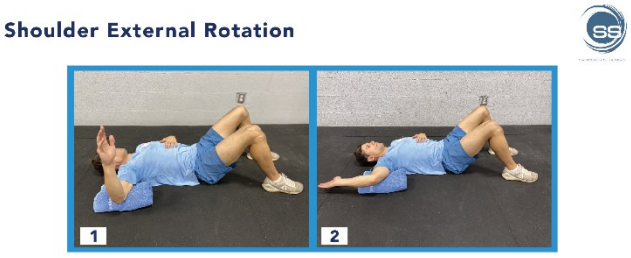
Tests how well the core rotates. Indicates a swimmer's aptitude for freestyle and backstroke rotations.

Starting position: Assume a kneeling sit with palms brought together by the chest.

Set-up position: Maintain upright posture and keep the spine neutral. Engage the core and avoid lifting the rib cage.

Test: Rotate the core and move the hands to end of their range. Let the head follow.

Signs: The further the swimmer can rotate, the more easily they will be able to do so in the water.



Shoulder External Rotation

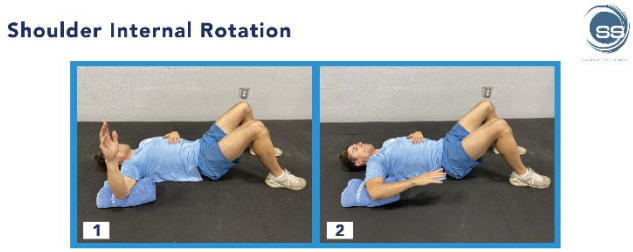
Tests the shoulder's external rotation mobility. Indicates a swimmer's overall shoulder health, ability to carry out overhead exercises in the weight room and to decelerate the arm when it enters the water.

Starting position: Assume a supine position on the ground.

Set-up position: Bring one arm away from the body at a 90-degree angle. Align the elbow and shoulder with the fingers. Let the palm face up. Place a rolled-up towel or yoga block underneath the elbow to help elevate it.

Test: Rotate the shoulder back by moving the back of the hand toward the floor. Keep the wrist straight.

Signs: The further the swimmer can rotate, the safer they will be to carry out overhead movements in the weight room. They may also have better stroke length in the water.



Shoulder Internal Rotation

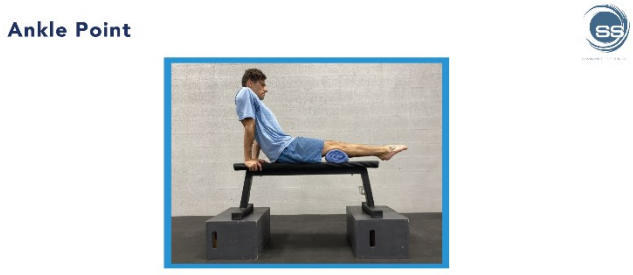
Tests the shoulder's internal rotation mobility. Indicates a swimmer's ability to catch water, exert strength during pulls, and overall shoulder health.

Starting position: Assume a supine position on the back, on the ground.

Set-up position: Bring one arm away from the body at a 90-degree angle. Align the elbow and shoulder with the fingers. Let the palm face down. Place a rolled-up towel or yoga block underneath the elbow to help elevate it.

Test: Rotate the shoulder down by moving the palm toward the floor. Keep the wrist straight.

Signs: The further the swimmer can rotate, the more effective they will be able to catch water in the freestyle and butterfly. They will also be able to do upper body strength exercises more safely.



Ankle Point

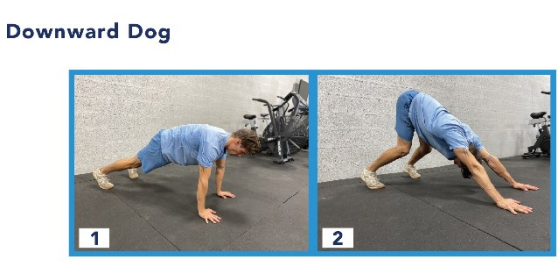
Tests ankle mobility. Indicates a swimmer's aptitude for the flutter kick and dolphin kick.

Starting position: Assume a supine position on a table.

Set-up position: Place a small rolled up towel underneath the calves.

Test: Point the toes towards the floor.

Signs: The further the swimmer can bend their ankles, the better they will be at kicking.



Downward Dog

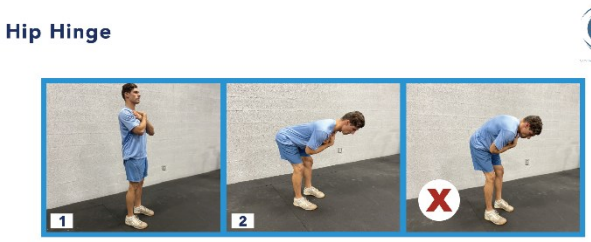
Tests relative strength, and stability and mobility in shoulders, core and legs. Indicates a swimmer's stroke length, catch strength and overall health in shoulders, hips and spine.

Starting position: Assume a 4 -point kneeling position with hands beneath the shoulders, knees beneath the hips, and the toes flat on the ground.

Set-up position: Pretend a string is being pulled through the spine. Keep the core engaged.

Test: Lift the hips up and back. Push the ground away from the body. Maintain a long neck and neutral spine, and keep ankles and knees soft.

Signs: Swimmers with more range are able to perform this test more easily. They are also stronger and more mobile relative to others. Pain in the shoulders, hips or the back may reveal underlying issues that could become bigger problems if not addressed.



Hip Hinge

Tests core stability, which is relevant for more or less all exercises in the weight room, the bodyline in the water and overall spinal health.

Starting position: Assume a standing position with the feet hip-width apart and the toes pointing forward.

Set-up position: Engage the core by keeping the shoulder blades gently together and down, while maintaining a neutral spine. The legs should have a slight bend.

Test: Lean forward towards the ground by hinging from the hips. The hips may slightly shift back. Keep the pressure in the middle of the feet and keep the spine neutral. Swimmers who bend their backs should do the test with a stick along the spine.

Signs: Swimmers with a bigger range have better mobility in their hips and spine. Swimmers who cannot drop down very far likely have tense hamstrings.

Internal Hip Rotation

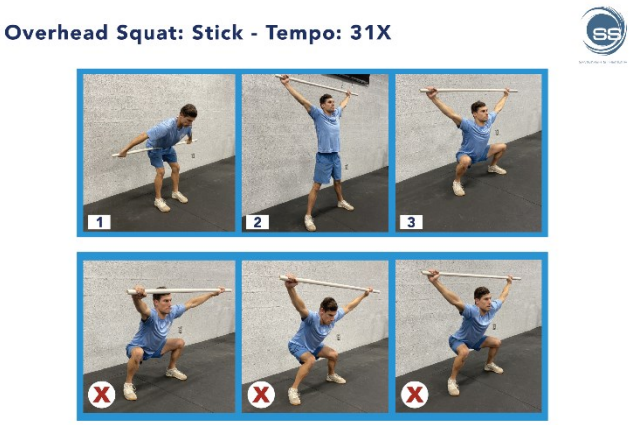
Tests the hip's internal rotation mobility. Indicates a swimmer's range of motion and power in the breaststroke kick.

Starting position: The swimmer is seated on a table with the feet off the ground. The knees should be in line with the hips.

Set-up position: Place the hands on the side of the table. Press through the table to lengthen the spine. Maintain stiffness.

Test: Move the one leg out and away from the body maximally. Keep the knee in line with the hip and maintain the posture.

Signs: Swimmers must strive to turn their feet outward. This will yield more efficient breaststroke kicks and be better for the hips when going through lower body movements in the weight room.



Overhead Squat: Stick - Tempo: 31X

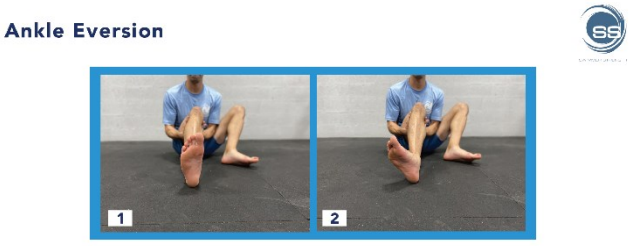
Tests stability and mobility in the ankles, knees, hips, shoulders and spine. These are relevant for movement efficiency in the weight room and the streamline.

Starting position: Standing in a natural squat position with the feed about hip-width apart and the toes pointing forward and no more than 30 degrees away from the body.

Set-up position: Grab the stick as widely as the arms allow while bent forward. Keep the stick above the head.

Test: Squat down for 3 seconds, hold the position for 1 second, explode up quickly. Repeat thrice.

Signs: The stick must remain in line with the knees and toes throughout the movement together with a neutral spine. The body weight should be on the middle of the feet and the knees move the same way as the toes. The arms shoulder remain straight.



Ankle Eversion

Tests the ability of the foot to turn outward. This measures the efficiency of the breaststroke kick.

Starting position: Assume a seated position on the ground or on a table. Grab onto the back side of the knee to relax the leg.

Set-up position: Keep the knee in line with the heel and maintain an upright posture. Point the toes towards the face, called dorsiflexion.

Test: Maximally turn the foot out and away from the body without moving the knee or the hip.

Signs: Swimmers must strive to turn their feet out as far as possible.

Core

These tests should be preceded by a proper 5-10 minute full-body warm-up.

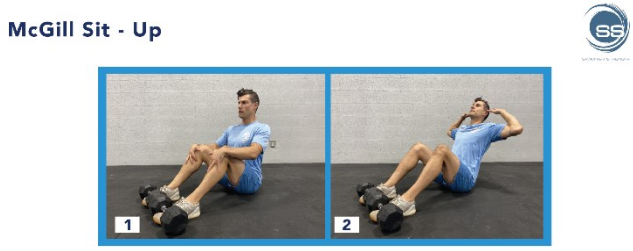
The swimmer should do each movement at least once or twice during the warm-up.

If the swimmer experiences sensations of pain beyond muscle fatigue, end the test immediately.

The spine must be kept still and straight relative to the head, back, hips and legs.

Swimmers who fail to maintain proper form should get no more than 3 chances to correct it before the test is terminated.

Remind the swimmer to keep breathing even while contracting the core muscles.



McGill Sit-Up

Tests isometric strength endurance in abs, hip flexors and to some extent postural muscles.

Starting position: Sit with the knees bent and feet planted on the ground. Hook the feet unde rneath a weight or

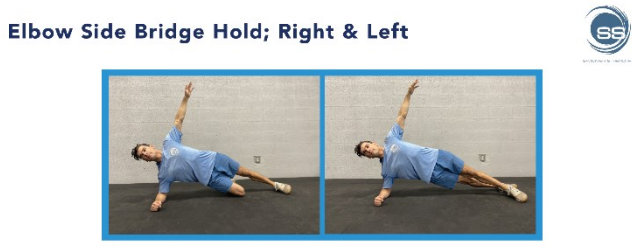
another static object. A partner can assist by standing on the feet.

Set-up position: Grab the knees with the hands and pull the chest forward, ensuring that the spine is straight from hips to neck. Place fingertips right above the ears. Squeeze shoulder blades together to move elbows away from each other.

Test: Lean back 45-60 degrees. Hold until failure.

Faults:

- Alignment changes; body moves higher or lower than starting position.
- Elbows forward.
- Rounding of back.
- Intense lower back pressure.



Elbow Side Bridge Hold; Right & Left

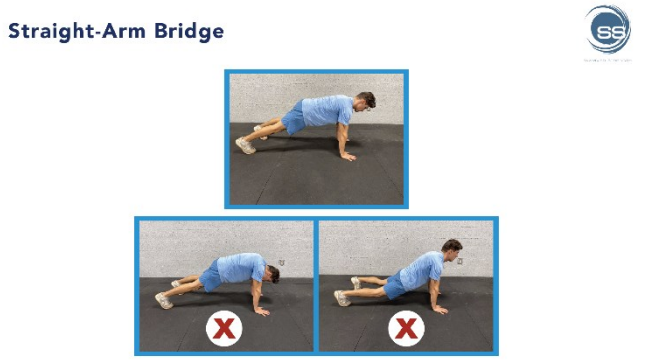
Starting position: Lie on the side with the elbow positioned right beneath the shoulder.

Set-up position: Push through the ground with the elbow and bring the shoulder blade down. This helps you attain a long neck. The sides of both feet should touch the ground, with the top leg in front of the other.

Test: Lift the hips up by evenly creating pressure from the arms, side abs, hips and feet. Both shoulders and the elbow should be aligned. The body, from neck to ankles, should be straight. Very young swimmers may place the bottom leg down on the ground as a regression.

Faults:

- Alignment changes; hips drop or shoulders roll forward.
- Neck drops or moves excessively.



Straight-Arm Bridge

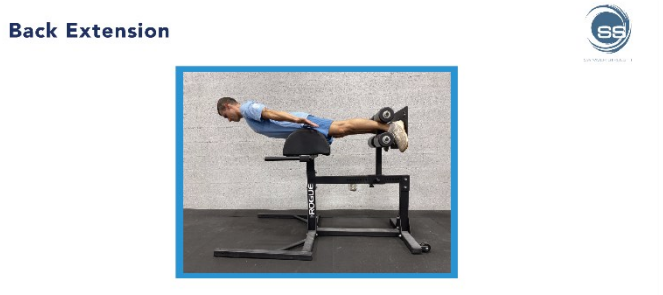
Starting position: Assume a 4 -point kneeling position with the hands beneath the shoulders, knees beneath the hips, and toes flat on the ground.

Set-up position: Push through the ground with the hands and bring the shoulder blades down to attain a long neck. The fingers should point out slightly. The heels should point straight up and the weight should rest on the toes.

Test: Lift the knees off the ground while keeping the spine straight. The body, from head to hips, should be aligned. Keeping the hips slightly higher is okay, but not lower. The elbows should be slightly bent and not locked. This is especially important for swimmers whose elbows are hypermobile when extended.

Faults:

- Alignment changes; the hips move higher or lower than starting position.
- Excessive movement of the head.
- The shoulders fall behind or in front of hands.



Back Extension

Starting position: Assume a prone position using a GHD machine or a table. If using a table, an assistant must help

the swimmer to hold down the lower body. The top of the swimmer's pelvic bone should be at the edge of the table, with the upper body hanging freely in the air.

Set-up position: Keep the hands on the ground or the table or connected to the GHD machine for stability. Straighten the spine by engaging the hamstrings and glutes.

Test: Bring the upper body up so that the head and back are aligned with the hips and knees. Keep the hands by the hips, off the table or GHD. The palms should face up, while the shoulder blades should be squeezed together and down, resembling the back position of a butterfly stroke.

Faults:

- Alignment changes; the body moves higher or lower than starting position.
- The shoulder blades separate or the swimmer loses their long neck, i.e. starts shrugging.

Strength

These tests assess the swimmer's ability to create and withstand forces. Conveniently, they should also be part of any well-rounded strength program. Muscular strength can be measured and trained in two ways: Intermuscular or intramuscular [6]. The first refers to using just one's body weight and loads below 80% of 1RM – Pull-Ups or light barbell exercises – while the second refers to using external loads over 80% of 1RM. Any swimmer who is healthy overall is generally fine to undergo intermuscular testing. Intramuscular testing should be reserved for older and more experienced swimmers as they generate a bigger impact on the body.

Intermuscular Tests

There are two main ways to manipulate the body's ability to maximally generate force: Holding until failure or max repetitions.

Elevated Split Squat Hold

Evaluates the swimmer's isometric leg strength. It indicates relative strength and whether the body is fit to withstand heavier training. I recommend capping the maximum time at 2 minutes. A teenage swimmer able to hold the position for that long with proper form is ready to progress with weight loads that exceed 80% of 1RM. Young swimmers often start to struggle after 20 seconds. This test will also lay bare if one leg is stronger than the other, which may be the result of an imbalance in the kinetic link.

The idea is simply to hold until failure. The testing supervisor should allow at most 3 technical reminders before calling off the test. The swimmer should rest 2 minutes before swapping the positions of the legs and commencing the second part.

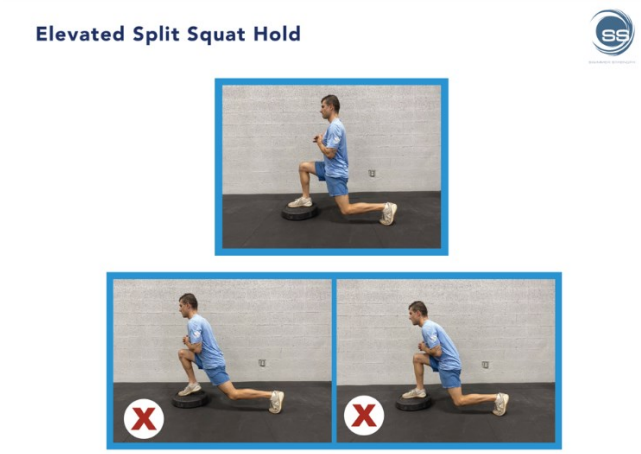
Set-up position: The front foot should stand on an object that is between 1.5-3 inches (4-8cm) tall, such as a plate. Place the back knee on a soft pad.

Starting position: Assume a half-kneeling position with legs hip width apart. Maintain neutral spine.

Test: Lift the back knee from the pad by pressing the front leg through the plate. Keep the front knee in line with the hips.

Faults:

- Alignment changes; the body moves higher or lower than starting position; the body leans forward; the lower back arches.
- The plate, or object is sliding forward; a sign of pushing away, rather than pressing down.



This is one of the most fundamental bodyweight movements and a highly effecti ve exercise for swimmers. The regular Overhand Grip Pull-Up puts more strain on the shoulder than a Neutral Grip Pull-Up where the palms face each other, but it also activates the lats far better. Some female swimmers reportedly are less prone to doing Pul l-Ups during training than their male teammates [25]. This sample, which is from a Division I setting, is admittedly small. But my own experience tells me there is at least some truth to the notion that females shy away from Pull -Ups to a large extent than men. High-performing male swimmers should be able to complete between 15 and 20 repetitions without issues. Elite swimmers should be closer to, or above, 30 decent reps. High-performing females should range between 5 and 15 reps. Research shows that both Pull-Up speed and maximal Pull-Ups have a strong correlation with water speed for sprinters [3,25].

Many swimmers are unable to make even a single Pull -Up. Pull -Up Holds can be a good substitute until the swimmer has gained enough strength. Experience has taught me that swimmers must be able to hold the position for between 40 and 50 seconds to muster their first full Pull-Up. Some swimmers, particularly those on the heavier side or others recovering from injuries, may not be able to perform a hold. These s wimmers should work on strengthening their grip and shoulders. It is crucial to ensure that they are engaged and encouraged to keep working toward being able to perform a full Pull Up.

Anyone who can complete at least 3 Pull -Ups can generally begin working with additional weights. Sets with more than 5 reps go from strength to strength endurance. Both play a role in achieving maximum speed in the water but also being able to maintain that speed for an entire race.

Set-up position: Place a box or other objec t underneath the bar to easily reach it.

Starting position: For Overhand Pull -Ups, grab the bar with the hands slightly wider than the shoulders. Keep the hands in line with the shoulders for Neutral -Grip Pull-Ups. Wrap the thumbs around the bar. Step off of the box and hold. Engage the core to prevent the pelvis and rib cage from opening up. Maintain a long neck.

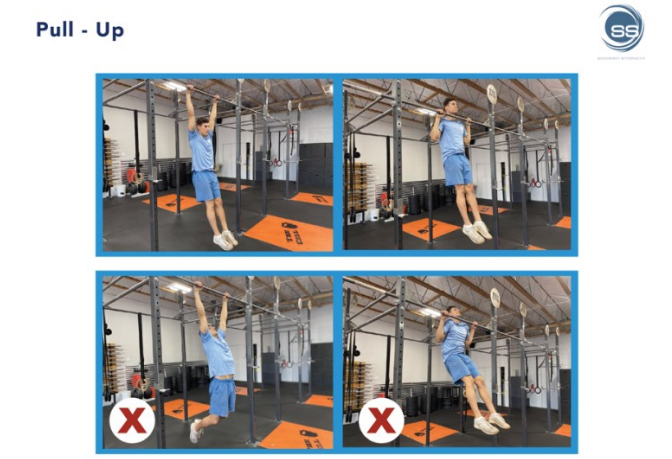
Test (Pull-Up): Initiate the pull from the shoulder blades. Pull the chin over the bar. Lower the body, extend the arms fully and immediately repeat the motion. Maintain straight legs and a neutral spine.

Test (Pull-Up Hold): Jump up and hold the chin over the bar for as long as possible while remaining still and straight.

Test (Weighted Pull-Up):

Faults:

- Body excessively swinging or crunching up.
- Stopping at the bottom. The Pull-Up should simulate the butterfly stroke, and swimmers do not get a break between strokes.
- Shoulders shrugging
- Elbows rolling out and away from the body.
- Jerking the body during the upward motion.



Push-Ups

The Push-Up is not necessary to test for swimming but it is a great foundational exercise and generally safe to do. A general rule of thumb is that swimmers should be able to do 3 Push-Ups for every Pull-Up they can do.

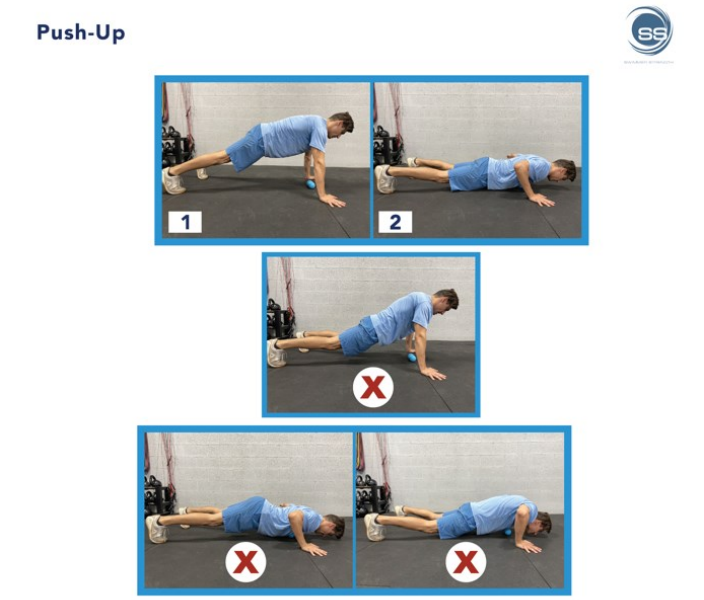
Set-up position: Place a ball equivalent to a te nnis ball size on the ground underneath the chest. Set a metronome for 60 beats per minute.

Starting position: Keep the hands underneath shoulders and slightly wider. Feet should be hip -width apart and the spine remain neutral.

Test: The swimmer should follow the rhythm of the metronome beat, coming down on one beat,touching the chest to the ball, and pushing up on the next. When the beat becomes too fast for the swimmer, or if the swimmer no longer can maintain proper form, the test is terminated.

Faults:

- Excessive movement of the head or hips.
- Elbows flare out.
- Shoulders shrug to neck.
- Full range of motion is not maintained.



Intramuscular Tests

These tests are more strenuous and taxing on the muscles and joints. The swimmer must have a soundfoundational physique before embarking on any of these. Because swimming is a cyclic sport that requires a large number of repetitions, I advocate testing that involves at least a handful of repetitions.

19 or over: 1-3RM

14-18: 5-10RM

13 or younger: no need to test.

Some teenagers may be developed enough to test a 3RM. But there are also many swimmers above 19 that need more foundational work before attempting a 3RM. Again, actual age is less relevant than a swimmer's biological age – meaning the body's developmental stage that is dependent on genetics and environmental exposure, such as sleep and diet – and training history.

Squat

There are several different options. I usually recommend either the Back Squat or the Front Squat for high -performing swimmers, with a preference for the latter because it is far more demanding in terms of keeping the right posture. It also overlaps with the movement pattern

for Hang Cleans. Many breaststrokers tend to prefer the Back Squat, but will not be a deciding factor to w in a Championship. Adolescent swimmers should begin with Kettlebell Goblet Squats until they are ready to try Front Squats.

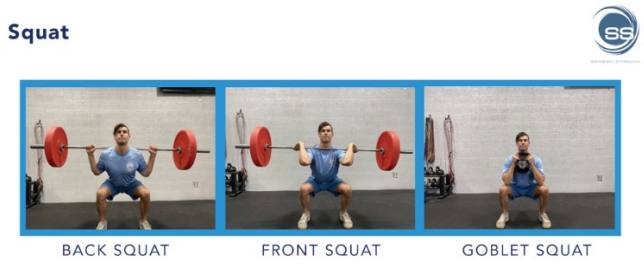
Starting position: Grab the given barbell, dumbbell or kettlebell.

Set-up position: Standing in a natural squat position with the feed about hip-width apart and the toes pointing forward and no more than 30 degrees away from the body.

Test: Squat down until the hips at least are horizontally in line with the knees. Keep the pressure in the middle of the feet. If the swimmer does not ex perience pain, they can go lower. Then push through the ground and stand up, maintaining a neutral spine throughout the entire movement.

Faults:

- Hips do not reach the knee-level.
- Knees cave in.
- Head starts moving.
- Posture failure, spine excessively hunched forward.
- The weight resting on the toes.



Seal Row

Tests a swimmer's pulling abilities from a horizontal position. This movement serves as an excellent supplement to the Pull -Up. It is one of the only movements where swimmers generate maximal muscular contractions while placed horizontally, akin to the body's position in the water. Keep the body still while performing the pulls– do not kick the legs or move the head. Another version of this exercise that is even more swim-specific is the Straight-Arm Pull, but I do not recommend using this for testing as it puts lots of strain on the shoulders without any help from the elbows.

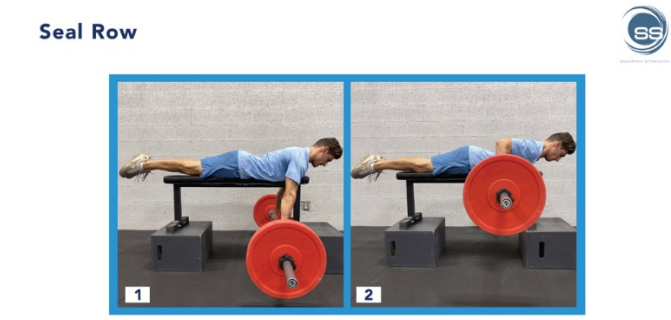
Set-up position: Place a bench on an elevation to allow the swimmer to keep arms fully extended.

Starting position: Grab the barbell or dumbbells with the thumbs wrapped around. Maintain a long neck, neutral spine and engaged core.

Test: Initiate the pull from the shoulder blades and aggressively row up to full range. Lower the weight in one controlled motion.

Faults:

- Body excessively flopping of body; head and legs.
- Shoulders shrug to neck.
- Full range of motion is not maintained.



Floor Press

Tests the swimmer's ability to push weight from a horizontal position. Swimming is a back-dominant sport, but it is important that swimmers maintain equal strength and stability in muscles both in the front and the back of the body. Perform the test either with a barbell or dumbbells. Less experienced swimmers should first get comfortable with the latter before trying out the former. The floor helps protect the shoulders and still allow the swimmer to reach full muscular activation. Experienced swimmers may elect to do a regular Bench Press.

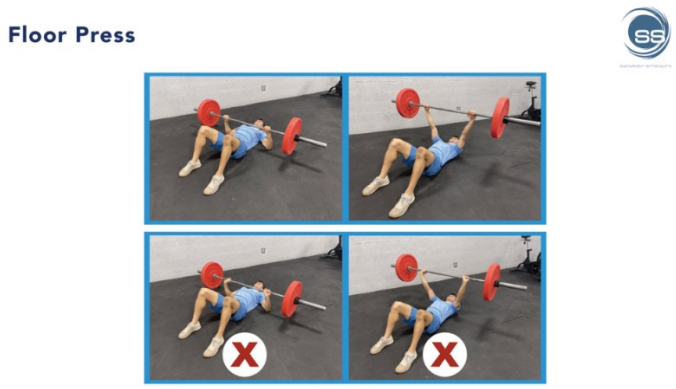
Set-up position: Place a barbell low on a rack or two sets of boxes.

Starting position: Assume a supine position on the ground. Grab the barbell or dumbbells with the knuckles pointing up. Bring the weight right above the shoulders.

Test: Initiate the movement from the shoulder blades and bring the weight down so that the elbows come down to a dead stop position on the ground. The elbows and wrists should be aligned. Then press the weight up to the same starting position in one controlled motion. The Elbows should be approximately 45 degrees away from the body.

Faults:

- Elbows flare out and away from the body.
- Arms are asymmetric during the press.
- Shoulder blades elevate to the neck during press.
- Elbows and wrists are not in line at the bottom position.



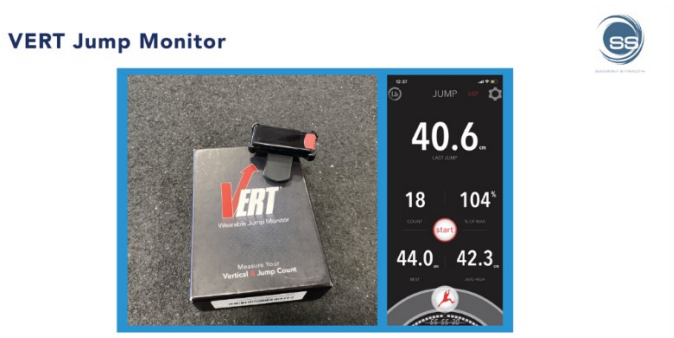
Power

These tests assess how quickly the body can generate force and can help gauge the efficacy of a strength training program.

Improvements here can be good predictors of potential drops in swimming times, and also as a training check - points to see the effectiveness of a strength training program.

For the lower body I recommend various jumps, which strongly correlate with the person's top speed and speed off the blocks. I long struggled to pick tests for the upper body because it is challenging to f ind a movement that can assess pulling or rowing power. I eventually settled on a Medicine Ball Chest Throw with a hip extension – a full-body test with emphasis on upper body pressing. For full-body testing I employ weightlifting variations because they yield high power output and are relatively safe if performed with proper technique.

I use the VERT Jump System for jump testing. It involves a device attached to the swimmer's hip that is synced with a smartphone. It is an efficient and relatively cheap, making it a good alternative for anyone who cannot afford jump mats or the OptoJump system.



VERT Jump Monitor

Non-Countermovement Jump (NCMJ)

Tests a swimmer's explosivity from a dead stop position – meaning the swimmer's stance on the blocks. The swimmer should bend the knees to roughly one -quarter of a normal squat, similar to the bend in the front leg on the blocks.

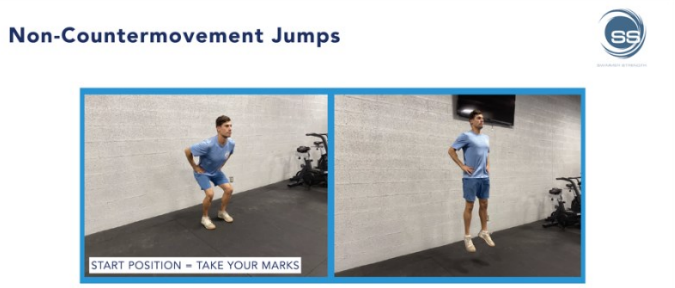
Starting position: Assume a standing position with legs hip-width apart. Keep the hands on the hips.

Set-up position: On command by the adm inistration – "Take your marks" – the swimmer drops to the quarter-squat stance and holds it. The weight should rest on the middle of the feet.

Test: Upon hearing the start signal, the swimmer should jump as high as they can without moving the arms.

Faults:

- Hand positioning changes during the jump.
- The swimmer puts their weight on the toes or heels prior to jumping.
- Excessive head movements.
- Knees cave in excessively as the swimmer jumps.



Non-Countermovement Jumps

Countermovement Jump (CMJ)

Tests low-impact plyometric jumping ability. The swimmer jumps at their will. The legs remain straight and the arms loaded overhead.

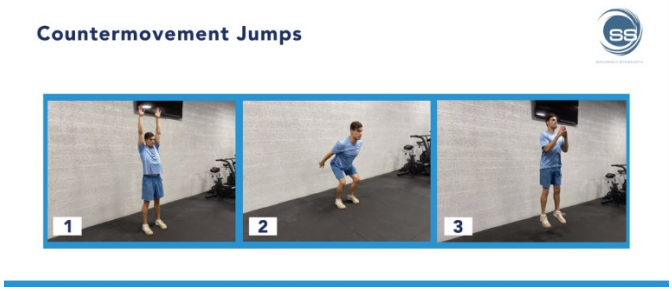
Set-up position: Assume a standing position with legs hip-width apart.

Starting position: Load the arms overhead.

Test: Quickly drop down to a quarter-squat and jump. As the body drops, the arms come down by the hips; the weight shifts from the middle of the feet to the balls as the swimmer pushes off the ground.

Faults:

- Hand positioning changes during jump.
- The swimmer puts thei r weight on the toes or heels prior to jumping.
- Excessive head movements.
- Knees cave in excessively as the swimmer jumps or lands.



Countermovement Jumps

One-Leg Broad Jump

The start is not only a vertical jump but also a jump forward – a broad jump. Th is test will also show differences in strength and plyometric abilities between the swimmers' legs. At least 25% of swimmers in the average adolescent swimming group are at least 5% less powerful in one leg than the other. Most of those put their strongest leg at the back-end of the block during the start. A deficiency bigger than 10% should raise flags for any coach. If not addressed, they can eventually cement imbalances that may affect the swimmer's health in ankles, knees, hips and back.

Set-up position: Place a jumping mat and measuring tape on the ground.

Starting position: Place one foot firmly on the ground. Keep the core engaged.

Test: Swing the opposing leg and rapidly explode off the ground. Land firmly on both feet and quickly decelerate the bo dy by crouching into a squat position and concentrate pressure on the middle of the foot while keeping the spine neutral. Measure the distance from the back of the heel.

Faults:

Swimmer loses balance.

Bending the spine during the landing.

Knees caving during landing.

Weight is put on the toes during the landing, rather than the middle of the feet.

Broad Jump One-Leg

Kneeling Medicine Ball Chest Pass

Tests full-body pushing power. This is not just a test of the chest– the hips and core both helptransfer the energy to the arms and ultimately the medicine ball. Weight recommendations:

Pre-teenage swimmers: 1-2kg

Teenage swimmers: 3-4kg

Elite swimmers: 4-6kg

Set-up position: Place measuring tape on the ground.

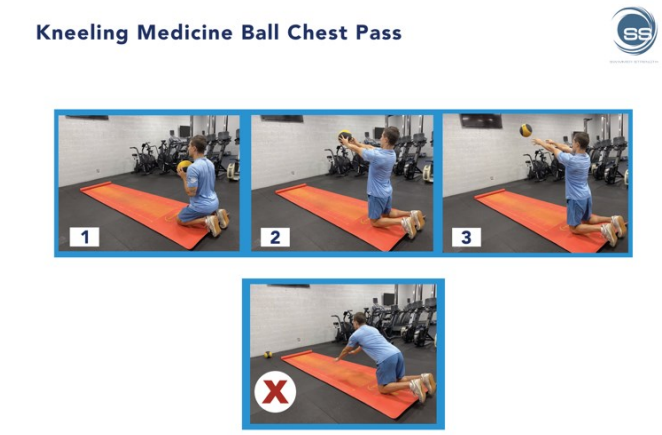
Starting position: Assume a sitting kneel with the toes on the ground and the weight planted at the back of the body. Holding a medicine ball and keep the core engaged and the spine neutral.

Test: Spring the hips away from the heels and throw the ball in a rainbow-shaped trajectory.

Faults:

The spine and core lose tension; the body continues to fling forward after releasing the ball.

The throwing motion is uneven.



Kneeling Medicine Ball Chest Pass

One Exclusion: Deadlift

I no longer include the Deadlift in my battery of tests. It is a phenomenal exercise if done correctly, but too many swimmers with too -big ambitions – or egos – end up injuring themselves when trying to reach new personal bests. And there's no need to test both Deadlift and Squats – pick either or. The main difference isthat while a Deadlift is hip-driven full-body pulling motion, a Squat is a knee-driven lower-body pushing motion. I also recommend experimenting with functional variations, such as Split -Stance Deadlifts and Split Squats, which will have greater transfer to start performance.

Power Testing Protocols

To ensure that the tests remain highly reliable, let the swimmers have at least two attempts for each power test, and ideally as many as five. Take the average of the highest two values and record that number [22].

How Strength & Power on Land Transfer to Water Speed

There is no easy way to track how improvements in the weight room result in faster swimming. No major research has been devoted to this matter, in part probably because it is challenging to measure and must be done over a long period of time. Experience tells me that a 20% improvement in vertical jump will result in a 1% -

4% improvement in the water, as long as the swimmer maintains the same level of mobility.

But that of course does not mean that it is impossible. It can be done by simply applying basic sports science to test results that are collected over time. Ideally, all of the swimmer's test results have been recorded, not just the average of the two best attempts, or it will not be possible to derive the standard deviation [72]. (I will not take it to that extent.) This progression must be compared to a similar battery of results from tests done in the water. This poses a challenge, because in-water testing is not as clear-cut.

Strength and power in the lower body is known to positively correlate with starts and turns[14, 15, 26, 69]. Jump height is known to correlate with starts and speed in the water during sprints [18]. Things are less conclusive with upper-body strength. Swimmers must presumably aim for higher-speed movements with the upper body to have stronger relation to swimming speed. Even though there is a strong relation between sprint freestyle and the person's aggregate performance on squat velocity, non-countermovement jumps and 1RM Pull-Up, especially for females, the same study showed lesser correlation with swimming and 1RM Pull-Up [25].

Time drops in personal bests should be judged based on percentage improvements rather than absolute time, because the latter varies widely depending on the swimmer's age and development. Highly competitive swimmers should be able to drop between 1% and 5% per year. For world-class swimmers, the range is between 0% and 1% every 1-2 years.

Movement Quality Transfer to Speed

It is even more challenging to determine how water speed relates to movement quality on land. But what I do know is that uncoordinated swimmers on land who gradually improve to become more coordinated, lighter on their feet, more confident in their movements and more durable, eventually start looking better in the water as well. And without these skills, the swimmer will not be able to move on to developing strength and power.

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About the Author

Deniz Hekmati is the founder and head performance coach of Swimmer Strength and the Arizona High-Performance Swimming Academy. He served as a graduate assistant for the men's and women's swim teams at University of Utah from 2014 to 2017, responsible for strength training. He helped coach Cesar Cielo in 2013. Through Swimmer Strength he has worked with dozens of teams around the world including the U.S., Europe, South America and Asia. Under his oversight, hundreds of swimmers have successfully gone through the Swimmer Strength regimen with positive outcomes and faster swimming. For more information, visit www.swimmerstrength.com.

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"This book is a great opportunity to continue to learn. It's for coaches who seek advice from experts, and for swimmers to ensure their training is balanced and safe. Well done to Deniz in producing this book".

COACH JOHN ATKINSON
Co-author of Championship Swim Training

"Deniz gives insight into the training process through his experience as a swimmer, coach and researcher. The lessons of this book can be applied to athletes of any level, which is why any coach will benefit from reading *Foundations of Strength Training for Swimming*".

COACH HERBERT BEHM
Division I Sprint Swimming Coach, USA Swimming Coach

"This book is for anyone looking for a competitive edge on strength and conditioning for swimmers. Deniz explains how strength development on land translates to healthier and better performing-swimmers".

COACH DAN DALY
CSCS | Former collegiate All-American and swimming strength and conditioning coach

Swimming is among the most physically demanding sports on the planet, involving endless hours of grueling training. Intensity and volume often overrule other critical aspects of performance, like preparing the body to withstand such taxing work. As a result, swimmers suffer from more overuse injuries than almost all other athletes.

It does not have to be this way. Success in the pool means taking into account all aspects of training. With this book, Deniz Hekmati takes a deep dive into how strength training and recovery impact performance for swimmers of all ages, ranging from complete novices to Olympians. His science-based solutions will challenge your views on the relationship between strength training and fast swimming.

This book is for all the swimming enthusiasts who realize that they themselves hold the keys to their own success. It is for the coaches who are passionate about making swimmers faster and addressing their injuries. And it is for the devoted swimmer parent looking to understand the sport and set their child up for success and good health.

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