Every individual who endures a **spinal cord injury** leaves the hospital thinking the same thing:

"Now what?"

There is no agreed-upon protocol, or even set of best practices, for how to reconnect a paralyzed body.

Drawing from movement disciplines not usually associated with paralysis recovery, the authors, Theo St. Francis and Stephanie Behrendt Comella, apply the anatomical science of full-body integration and the innate capacity of the brain to rewire itself to the challenge of neurological reconnection.

With fully illustrated exercise descriptions, this clinical perspective is written both for those recovering from spinal cord injury and for their movement trainers.

From the Ground Up **is an in-depth exploration of how to claim physical and mental ownership of the recovery journey.**

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From the Ground Up

St. Francis & Comella

From the Ground Up

A Human-Powered Framework for Spinal Cord Injury Recovery

Theo St. Francis
Stephanie Behrendt Comella

Contents

Now what?

This question is on the mind of every person who becomes paralyzed. Every patient and his or her family quickly realize medicine doesn't have a clear solution to paralysis like it does for broken bones and torn ligaments.

The patient is handed a prognosis with no mention that he or she has any power over the course of recovery. With paralysis, the medical system generally says, "What you get is what you get. You can't change your outcome much, so you should just get used to it."

This book is based on the opposite idea: **athletes, you have the power to change your outcome.** It doesn't matter how much function you have. It doesn't matter how complete or incomplete your injury may seem. And it doesn't matter whether you have a shoe-string budget, or all the resources in the world. We believe that your outcome is about more than just walking, and it begins and ends with *you*.

By working with the body the way it was designed, it is possible to awaken paralyzed areas without healing a damaged spinal cord. Of course, this takes your commitment during the session but it takes even more commitment to apply the movement concepts in those sessions to your life outside the clinic, gym, or studio. That is where the functional application is learned: on your own. Going about your daily life. Those are the moments when your life begins to improve.

Part I

The Groundwork

1

Opportunities for Optimization

What's ahead

- The two types of healing after SCI
- Creating environments to facilitate lasting change
- The five Opportunities for optimization in the current SCI recovery landscape

Paralysis rehab is an extreme challenge because the neural communication along the spinal cord has been blocked, and the body does not automatically repair it.

This would not be a problem if either the spinal neurons repaired and replaced themselves like skin cells, or the spinal cord could recover from damaged neural pathways like the brain. If we were zebrafish swimming in our native Ganges River in India, we would repair our severed cords fully within weeks (Mokalled, 2016, p. 630). Instead, the human spinal cord deploys various protective factors when it is damaged; these factors prevent it from further injury, but they also inhibit repair (Willette, 2015, p. 23-26). *So how can we work with a physiological response which prevents repair?*

Researchers in the fields of anatomy, physiology, and neuroscience continue to expose the complexity of body-to-nervous system coordination that makes movement happen.

Fig. 1.1: The name ***Zebrafish Neuro*** *comes from the namesake fish that is able to repair its own severed spinal cord within eight weeks (Mokalled, 2016, p. 630). While humans may be unable to regrow spinal tissue in the same way, we seek other ways of self-healing.*

Regaining even a few percent of these abilities would enable an SCI athlete to lean to the side and maintain balance, or to stand and take steps. Humans are over-engineered for the modern world: compared to the rugged wilderness in which we have developed for millennia, the built environment of cities alleviates many physical challenges so that the percent of total recovery needed to achieve our desired result is much less than we might expect.

In short, we choose to view the multifaceted-integration of the body and brain as an invitation to find alternative ways of communicating and creating movement. Where one route is blocked, others remain to be discovered.

Two kinds of healing

The paralysis rehab community has developed a heavy reliance on technology and modern medicine to compensate for the body's inability to heal itself: robots that help you walk, electrical stimulation implants that help your muscles contract, and transplanted stem cells that may regenerate communication cells. While researchers have made great progress toward 'healing paralysis' with these methods, this reliance on external development has shifted us away from exploring our innate mechanisms of healing.

What if it were possible for the body to heal itself (at least part-way), and we, as SCI athletes and trainers, need to simply optimize these processes?

The generally-accepted understanding has been that healing simply stops two years post-injury. We firmly believe this timeline is not true. Two years is not the end of recovery — it's just the time by which the majority of spinal cord inflammation dissipates. In fact, reconnection between the brain and the body is a separate process: one that begins — not ends — at two years and continues for life.

Without a doubt, there is recovery of function shortly after injury, especially for injuries assessed as "incomplete" (more on these labels in the Appendix). This recovery comes from the unmasking of neural connections that were undamaged, but covered up by swelling at the time of injury.

Create an environment

The Australian swim coach Forbes Carlile famously hung a sign above his team's locker-room door: "Our aim is not to produce champions, but to create an environment in which champions are inevitable" (Drane, 2009, para. 4).

We take this to our athletes: we create an environment where the body has the best possible opportunity for healing, reconnection, and recovery. This includes both the athlete's physical environment – his setups, progressions, and exercises – as well as his mental environment – stress level, self-confidence, and how he accepts responsibility for his recovery. This strategy of *creating a healing environment* runs throughout this book; it is one of the most important aspects of our approach.

Even with a blockage at the spinal cord, we find that supplying the body with the right inputs to create an environment for healing, such as correct biomechanical alignment and starting in evolutionarily regressed postures, guides the body to find new ways to activate muscles. The changes happen slowly, but compound into new functional capabilities, such as sitting unsupported and holding hips steady while standing. Over time these improvements give athletes access to muscles that have previously been unresponsive. As a result of these positive inputs, athletes have recovered functional movement patterns long after the two-year mark. It doesn't come easy, but it does seem to create neurological change which lasts far beyond the sessions of vigorous exercise. *Isn't that what recovery is about?*

We also asked ourselves if merely repeating a particular movement is the best way to relearn that movement. For example, runners can log miles, but adding a strength and mobility program will make them better athletes and less prone to injury. In the same way, 'doing the movement' is not the same as 'making neurological and muscular improvement.' We've found that this slow, steady, supported progress leads to a much different type of healing than the natural healing observed by the medical community within the first two years.

We have an opportunity

As part of the SCI recovery community, *you* have an opportunity to change the current paradigm of SCI recovery and rehabilitation. We need to recognize these opportunities in our own practices first and then teach others about them.

What follows are five Opportunities for optimization, which you can use to improve your current recovery process. Our hope is that by the end of this book, you are able to both recognize them and do something about them. As a collective group of determined athletes and forward-thinking trainers, we can redesign the SCI recovery process *from the ground up.*

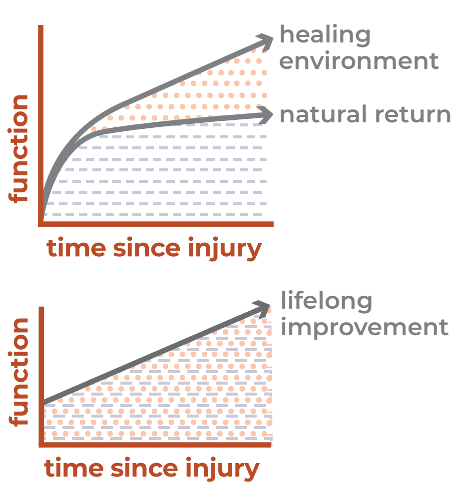


Fig. 1.2: A supportive environment and appropriate inputs facilitate lifelong improvement beyond the famed two-year mark.

Opportunity 1

Use natural development as a guide

Every athlete knows this frustration: *I'm doing a ton of rehab, so why isn't it working?* Perhaps what you're doing is fine, but how exactly you're going about it could improve.

Our first Opportunity proposes that we change the way we learn movement patterns based on clues from their natural development and operation. This concept is barely applied in current popular SCI recovery programs, or at least not well applied (we'll discuss more about popular SCI rehab protocols in Chapter 4). Perhaps all the other factors with SCI overwhelm us that we forget that we are still working with a human body.

Motor development has been studied by developmental psychologists since 1787 and by behaviorists since 1935. We can use two hundred years of published and reviewed science to guide our therapeutic process.

Foundations in infant development

It is not by accident that young children successfully develop motor skills in the first three years of their life. We all underwent a complex process of motor experimentation and signal consolidation in each position: lying helplessly on our backs; rolling sideways onto our stomachs; pushing ourselves into a seated position; rotating onto our hands and knees; crawling across the floor, and pulling ourselves upright into unsteady, supported standing **(Fig. 1.3)**.

The ability to perform human movements, such as standing and walking, is the result of a long process of development. Each stage of motor development depends on the stability and control developed in earlier postures to progressively build muscle strength, bone structure, neural coordination, and psychological connection. All of these elements integrate to form a fully functioning body.

However, it is not enough to visit the stages in a haphazard order. We need to investigate what each stage offers, so we can integrate this strength into the next foundational posture. The motor development progression (MDP) serves as a guide to restore fundamental postures and skills in a progression of integration after spinal cord injury.

Fig. 1.3: Infants transition through foundational positions in their development, with each position preparing the body for what comes next. We were able to watch our friend's son (modeling here) grow through this process during the development of this book.

The body is an integrated unit

Our muscular system operates best when functioning as an *integrated unit:* our muscles are meant to work together, firing at varying intensities and times to produce fluid movement for everything we do.

It is as if large movements, such as jumping, and even small ones, like raising an arm, are generated by one muscle with 600 parts, as opposed to 600 individual muscles. Movements are made possible not only by the large muscles which produce the movement, but also from hundreds of micro-contractions and stabilization throughout the rest of the body which support the movement. When the entire body produces the right balance of tension, we move with fluidity and ease.

We rob ourselves of the opportunity to learn how all these muscles work together in specific firing patterns when we train with muscle-isolating exercises and machines. Isolated training can lead to over-recruitment of a single muscle group. If the objective is to teach paralyzed and non-paralyzed muscles to work together again, then using the same isolationist training regime will only take you so far. Put simply, isolationist approaches seek to force healing on the body, whereas setting the body up for success allows healing to occur more organically.

So, how does this integration concept work in an athlete who is not yet able to create tension throughout the body? How do we integrate the system in a paralyzed body? This idea can be overwhelming and difficult to imagine and implement, so it is often neglected.

We've observed that full-body participation can happen even where the paralyzed muscles have been unresponsive to brain signals. When a muscle contracts, it influences the neighboring muscles and beyond through a chain reaction of tension and stimulation all the way down the body, even into paralyzed areas. We can communicate with, and therefore integrate, areas previously thought of as inaccessible by implementing exercise set-ups which challenge the body at an appropriate level and prioritize body positioning and alignment.

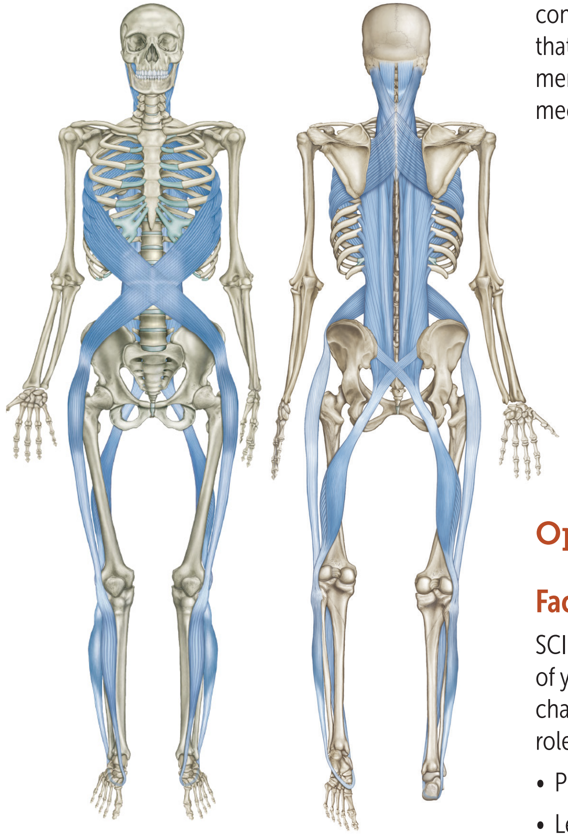


Fig. 1.4: Muscle and connective tissue communicate through neural and mechanical methods (Myers, 2014, p. 13). Observed patterns in this communication suggest distinct fascial chains that allow us to gain access to paralyzed parts of the body from unaffected areas.

This is why the common protocol of 'more reps, more time' oversimplifies an incredibly complex system. Observations of MDP illustrate that learning movement requires more than mere repetition: we must use the body's built-in mechanisms strategically.

Isolationist approaches seek to force healing on the body, whereas setting the body up for success allows healing to occur organically.

Opportunity 2

Facilitate kinesthetic understanding

SCI trainers have a hard job, and we applaud those of you who have taken it on! One of the many challenges is simply understanding the trainer's role, which includes a number of responsibilities:

- Physically move the athlete's body
- Lead a challenging workout
- Log movement repetitions
- Help reconnect the body
- Educate the athlete on movement concepts and anatomy
- Offer encouragement
- Facilitate *kinesthetic understanding* (what we believe is the trainer's primary job!)

Intelligence can be described as encoded patterns of neuronal firing, more of a conscious 'brain knowledge.' *Kinesthetic* intelligence, however, seems to be stored elsewhere: in our bones, connective tissues, and the peripheral nerves that run through them. It tells us what to do, when to do it, and with what speed and power. This type of body-knowledge is invaluable in learning how to

We spend about four years of our life trying, failing, and eventually figuring out how to move our bodies. An intact nervous system takes years to refine these patterns, and this is a natural process we must respect in SCI recovery.

Fig. 1.5: *Stephanie and Katie discuss a new movement strategy, demonstrating one of the ways a trainer can facilitate* ***kinesthetic understanding.***

Fig. 1.6: *Theo finds stability though his thighs and feet for stronger sitting.*

move reactively and spontaneously, which are both components of *functional movement*.

For example, when you are exhausted you may lean on a table to increase your stability. That's not a conscious decision – *I know I am having trouble standing upright, so I'm going to add a third point of contact* – but rather, it's something you feel. The information is contained somewhere between your body and subconscious brain. The ubiquitous action of arm-swinging-while-walking is another example. We do not do that consciously. We arrived at the kinesthetic realization that the arm-swing counteracts hip rotation and therefore makes gait more efficient. Kinesthetic understanding guides how we move, and leads to improved, and even new movement patterns. It also stays ingrained in the body long after a movement session.

A significant example in SCI rehab is understanding what it means to support the trunk with the legs while seated. An able-bodied individual automatically and unconsciously presses through his feet and the backs of his thighs in order to stabilize the pelvis and spine for upright posture. Athletes with lower-limb paralysis have likely deconditioned the voluntary involvement of their legs and rely solely on their torso for seated posture and balance. Using verbal instruction with physical experiences (described in Chapter 8), athletes learn to involve their legs, no matter how faintly at first. With this new kinesthetic understanding of what it means to integrate the entire body while seated, athletes can practice full-body participation throughout the day on their own, even outside of sessions.

These kinesthetic lessons tend to stay with athletes much longer than the fatigue of a good workout, or long bouts of repetitive motion, due to the nature of ingrained understanding. These lessons also spark curiosity – *what else can my body do?* – which triggers a mindset of ownership and exploration (more on this in a few pages).

Kinesthetic understanding guides how we move and leads us to both new and improved patterns.

The learning is in the struggle

Kinesthetic learning seems to happen best when properly executing exercises in the *Goldilocks Zone (GLZ)*: the place where the exercise is not too easy (and the athlete is not forced to learn), but also not too hard (where the athlete cannot execute without compensation). The GLZ is situated between complete ability and complete inability.

You know you're working in the GLZ when the athlete struggles to complete just two or three repetitions without compensation. He might say, *I'm doing it, but only just barely!* Postures are appropriately challenging for current level of ability, while stability and resistance challenges are almost out of reach.

Precision in execution is important here, because extremely small changes in angles, support or resistance can place athletes in or out of this desirable place for kinesthetic learning. It's the job of both the athlete and trainer to find this zone during movement sessions. You both need to actively search for it and communicate when you find it. These moments of realization look different for everyone, but they're usually clear when they happen.

Opportunity 3

Make conscious choices

When a paralyzing injury throws everything about your life into question, you are desperate for

answers. There is so much uncertainty that you are tempted to cling to anything that seems certain, whether it is good news or bad. This means that authority figures – such as doctors and physical therapists – have a lot of influence over self-expectations. It's critical to be aware of how this early period shapes mental posture throughout the course of recovery.

These authority figures present what they know about SCI outcomes in the most conservative way. It is done in good faith; they want to avoid any false hope. But this usually includes some reference to limited functional return (especially not after two years), which can be interpreted by the impressionable athlete as: *My fate is sealed. There is nothing I can do to change my outcome.*

All too often, athletes are implicitly and explicitly discouraged from believing that they have the opportunity to make recovery what they want it to be. *What could possibly disempower an athlete more?*

We are not advocating false hope, but we tend toward humility in our declarations for what the future holds. Many believe they are doing their best by patients to be as realistic as possible, but it has been our experience that this version of "realistic" is often overly conservative. While not everyone regains full voluntary movement below the level of injury, we cannot ignore increased muscular integration as a functional gain. We've seen too many athletes achieve what they were told would be impossible – like breathing or feeding independently, to sitting upright or standing on their own – to ignore the unknowable potential every athlete has for change.

Here is where the opportunity presents itself: athletes can choose to see their recovery as authority figures define it, or they can define their recovery for themselves. An athlete's conscious choices each day add up to a feeling of ownership over recovery, and toward a sense of control over life.

Opportunity 4

View recovery as a process

We have often observed how focusing on "finishing recovery" can, ironically, get in the way of making progress. Instead, focusing on the incremental process itself can get you where you need to be over time. This epitomizes a *process-centric* approach.

Take natural selection as an example: traits which improve an organism's chance of reproducing are passed down genetically through successive generations. If you are a gazelle, your ability to run away from lions faster than other gazelles helps you survive. Gazelles that survive reproduce and their run-fast genes will, over generations, be selected by the competitive environment of the savanna. Natural selection does not have an end goal; it optimizes through small, progressive changes.

As discussed earlier, a child's motor development

Fig. 1.7: *Janine maintains balance against resistance, working in her GLZ. With time and practice, her GLZ moves outward, and even more challenges are introduced.*

Anyone who has labored over a creative project is familiar with how the design process seems to have a mind of its own. You quickly learn that you must keep your end-goal simply as a guide while you optimize decisions at each stage in the process.

head back
open shoulders
upright pelvis
support from legs
tall spine

Sit → Kneel → Stand → Walk

Fig. 1.8: *Break down the end-goal into intermediate steps, then optimize each of these steps.*

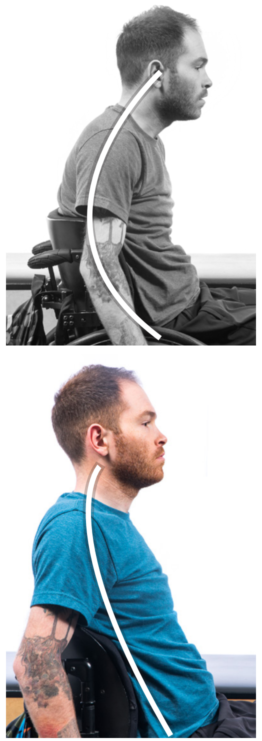


Fig. 1.9: *Corrections as small as head position can make a big difference when amplified through each intermediate stage.*

is another clear example of the power of small changes. Babies do not have a goal to walk, nor do they have a preconception of how they should move as they grow. Babies spend their energy accomplishing go-to-dad and avoid-painful-fall-to-the-ground. If toddlers can focus on anything, it is in improving what they do in the moment so that the movement happens with less effort, in less time, and with less pain. The one-foot-after-another method of moving through space, which we call walking, is the common result of 18 or 24 months of this optimization process.

The intermediate steps of sit, crawl, and stand **(Fig. 1.8)** are postural checkpoints for the body to master on its way to walking. This means you are better served working on the intermediate steps which make the sitting, crawling, or standing more successful, rather than exhaustively practicing the assisted walking motion itself. Simple changes, such as drawing your head in-line with the rest of the spine **(Fig. 1.9)** and correcting your pelvic position, offer a better biomechanical position for trunk and leg support and make a big difference in regaining neuromuscular connection over time.

What do these process-centric approaches mean for SCI recovery? Nature's strategy teaches us to optimize intermediate steps, rather than focus on the end-goal. Through natural selection, nature chooses the most well-adapted; through constant trial and error, babies fine-tune their movement, scrapping failed moves, and refining successful ones. It serves us to approach rehab in the same way, using the end goal as merely a guide. View 'recovery' as an optimization of the process itself instead of the arrival at an end-point.

Opportunity 5

Reclaim ownership

Athletes, this final opportunity of recovery hinges on *you*. No matter how badly friends, family, and trainers want to shoulder the responsibility for you, this is your life and future, so it can be nobody's journey but yours. Your risk and your reward.

Think about people you admire who brought about significant change. They could be modern or historical figures, or strong-willed characters in your personal life. Which of their qualities make you look up to them? We can bet it isn't that they waited on others to do the hard work for them. Movers throughout history rarely asked permission before they changed the game. They made a conscious choice, acted, and took responsibility for what came next. That's why taking *ownership* of your recovery is the only option. If you don't, no one will.

Ownership comes in many forms. It not only includes getting yourself on a therapy program, but also dictates how you make decisions, how long you let yourself struggle before asking for help, and how well you accept consequences for things out of your control.

Through the development of our work, we realized that SCI athletes have a much bigger opportunity for personal impact than only improving movement function. By emphasizing self-reliance at every stage, we allow this sense of ownership to flow into all other aspects of life. How we approach recovery cannot stay separate from how we live our lives. They interweave and eventually merge to make each of us who we are as a result of our personal journeys. This is what gives recovery its richness: we have an opportunity not only to rebuild parts of ourselves, but to (re)discover who it is we want to be.

Fig. 1.10: *Ownership goes deeper than committing to a therapy schedule and doing homework exercises.*

Nature's strategy teaches us to optimize intermediate steps, rather than focus on the end-goal.

"Powerful beyond measure"

Writing in the early 90s about personal potential, author Marianne Williamson said, "Our deepest fear is not that we are inadequate. Our deepest fear is that we are powerful beyond measure" (Williamson, 1992, p. 165). This echoes a common, and often hidden, worry in SCI rehab: *what if I could be doing more to reconnect my body?*

It is daunting to think that we are our own biggest obstacle toward pursuing what we want. But it's empowering to know that we are able to make profound changes if we dare to commit to them. What's important is that change can happen on any scale: on a personal level, in an athlete-trainer partnership, within a medical program, or as the SCI community, all of us together as a recovery movement. Our goal with this book is to give you the exercise tools and fundamental physiological understanding to make those changes happen.

We hope you now see some of the uncertainties of recovery as opportunities for growth – and that you consider the rest of this book as a new perspective on a challenge to which no one actually has the answer. So, what's stopping you from figuring it out for yourself?

Moving More On My Own

What's ahead

- Seeking an inclusive definition of 'recovery'
- Visualizing an athlete's current movement status
- Bio-tensegrity as a model for body-wide integration

In two famous articles published in the *Journal of Neurotrauma* in 2004 and 2016, researchers polled hundreds of individuals with SCI and found that out of five possible categories – arm/hand use, walking, bladder/bowel control, sexual function, and relief of pain – arm/hand function had the highest priority for recovery **(Fig. 3.1)**. There was no significant difference in preferences among bladder/bowel function, pain alleviation, and even walking ability (Lo, 2016 p. 2; Anderson, 2004, p. 1374). This generally came as a surprise to the rehabilitation community, where the assumption had been that regaining the ability to walk was most important.

In the SCI community, the word *recovery* carries a variety of meanings. We often hear athletes say *When I'm recovered, I will finally be able to travel* or *I am taking a few years off from work to get recovered.* Everyone craves to know how long recovery takes, but what does it even mean to "be recovered"? With such variety in SCI athletes, is it even possible to define "recovery"?

This chapter explores these questions. We'll discuss how *integration* is critical to the process of recovery and how the structure of our myofascial tissue is evidence for the interdependence of all parts of our bodies. We encourage you to reflect on how our beliefs relate to your own model of recovery.

What is recovery?

Every individual has different priorities for his or her rehab process. Ask any SCI athlete what recovery means and you will likely hear a

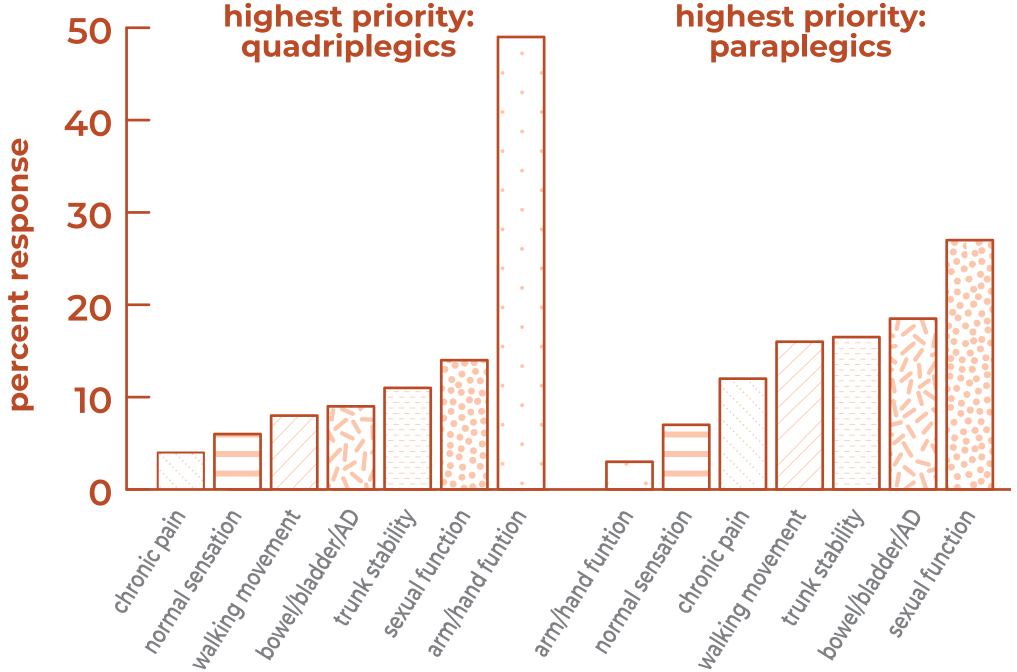


Fig. 3.1: Most SCI athletes place higher priority on recovering body functions than walking abilities (Lo, 2016 p. 2; Anderson, 2004, p. 1374).

combination of **functional** (standing, reaching, walking), **activity-based** (canoeing on a lake, tending a vegetable garden, cooking holiday meals) and **lifestyle** goals (providing for a spouse and young kids, feeling confident on the dance-floor, or managing a busy schedule). As a trainer, you must ask your athlete where he wants to go and what he wants to be able to do. It's not your role to decide in which direction to push recovery, but rather to help him go as far as possible along his chosen path.

Looking at the recovery goals in **Fig. 3.2**, we asked ourselves: what general outcome has a broad enough effect to encompass the vast landscape of recovery goals? The definition, if there could be one, had to be far-reaching yet flexible enough to encompass the root desires of everyone. Movement and independence are persistent themes, so we came up with this simple expression to describe recovery:

moving more on my own

You'll see us refer to this ideal as MMOMO from now on. There are three parts to this definition – "moving" / "more" / "on my own" – and each is important for understanding our Framework for Recovery in Part II.

"Moving"

The first thing that comes to mind is the conscious and voluntary kind of movement: decide to move an arm or leg, and it just happens. But that's not the only kind. Nervous jitters, a shoulder-shrug, and spontaneous dancing are all ways movement manifests. It can be subtle or emphatic, precise or chaotic, choreographed or explorative, active or passive, isolated to a single body part or integrated into the whole. The dexterity required to play violin is very different from the power required to kick a soccer ball down the field. And yet, our finely tuned neurology makes this broad spectrum possible.

Most athletes define recovery as accomplishing certain movements. We like to expand this to see movement an essential characteristic of our

Fig. 3.3: Seemingly insignificant tasks for an able-bodied individual, such as holding your own glass, can become goals with significant potential for life improvement for someone with paralysis.

Fig. 3.2: "Recovery" means something different for every athlete.

Own Your Journey

This chapter is by Theo, for athletes, on the topic of the *ownership mindset*. Trainers should also read through to better understand how this mental framework can improve an athlete's recovery process. After all, empowering athletes to take responsibility is part of the trainer's role.

Several months ago, I had dinner with another SCI athlete. He was a generation older, had been injured many years longer than I had been, and had regained little function after his injury.

We were talking about how getting enough exercise is a challenge with paralysis. There are many hurdles to staying active – time, energy, coordination of a helper, or planning ahead to do it yourself. I've found that the only *sustainable* approach is to get in a regular rhythm with an activity you enjoy.

"Find some activity which simply feels good and commit to it, even if it's only rolling around on the floor for ten minutes every morning to loosen up," I shared from my own experience. "I know how much better I feel afterwards, so I look forward to doing it every day. Because of that, I don't worry about staying motivated – it just happens, because I want to do it."

Bruce laughed in a sad way and responded with, "Yeah, staying motivated...is there a pill for that?"

Whoa. Not the response I expected. My message was lost. The goal is to develop intrinsic motivation; relying on a pill is exactly the opposite of cultivating an internal drive to exercise.

I simply responded as enthusiastically as I could, "But that's exactly the point...the motivation has to come from the inside, otherwise it will never work!"

Whether or not he asked the 'pill' question in a sarcastic way, it was clear that this conversation spoke to a much deeper truth about the powerlessness an SCI athlete can feel after injury. With an attitude of helplessness, it would be hard for anyone to make lasting changes in recovery.

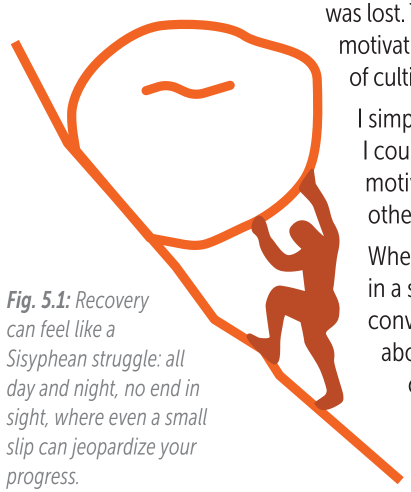


Fig. 5.1: *Recovery can feel like a Sisyphean struggle: all day and night, no end in sight, where even a small slip can jeopardize your progress.*

Powerlessness

It's obvious that with paralysis comes a loss of power to do *what* you want, *how* you want and *when* you want. Even if you are active in making decisions, you may not get the opportunity to actually make it happen, which can end up feeling like your life is being lived for you. This passive participation is one of the largest psychological challenges of recovery and, for many, it is a driving force toward achieving independence.

For those who have not experienced paralysis, pause for a moment to imagine the implications from the perspective of an athlete who has limited use of his arms and must rely on a caretaker for basic needs:

One week I am living my life, making my own decisions, and the next week I feel as though I am no longer needed in my own life. In the hospital, all decisions are made for me. At home, everything is done for me. I eat and drink using someone else's hands to hold utensils. I am physically moved from place to place by a caretaker instead of moving myself. Medical professionals have declared what I can and cannot expect for the future, and everywhere I go people ask my caretaker in a soft tone if I need anything. Why don't they ask me? Am I no longer needed here?

This would be a huge shock for anyone, and it's important to register when we feel this powerlessness. By acknowledging this reaction when it happens, we can address specific triggers and gauge progress as it improves.

Reliance

Right after the injury, the degree of dependence we have on outside systems is at an all-time high. They are designed, and often required, to keep us alive. As our condition stabilizes, it's easy to forget how dependent we are on this support from others, even if we no longer need it. Without consciously assessing how we rely on **people**, **things**, and **situations**, we risk entering a vicious cycle of dependence which deprives us of responsibility and independence.

The goal with this chapter is to identify ways in which we are stuck in this cycle, so we can begin to reclaim control. We encourage you to reflect on your own reliance in each category.

People: Help on the basics, like washing, dressing, eating, cooking and cleaning. This is the most commonly cited form of dependence, and for many it is daunting to think about running a household without help. One essential part of incrementally reclaiming these responsibilities is accepting that tasks will take longer as you figure out how to do them on your own. Treat folding clothes (even if you complete just one item) as an exercise in arm, wrist, and finger coordination and pay close attention to where exactly the motion is difficult. This will help you find a different way or know what strength to work on. Just as in a workout, you need to enter the Goldilocks Zone of struggle to learn.

People: Trusting others to advise in your individual interest, or following a general protocol. Recommendations from professionals on what you need are one thing, but routine assistance for the same job prevents you from learning to fix it yourself. This is common in wheelchair adjustments, where the technician makes a guess about the proper backrest height or angle of seat "dump," but it's up to the athlete to analyze whether or not the changes are the right fit. The easiest way to take ownership of this is to investigate your specific needs and speak up about them.

People: Relying on trainers for routine movement. Maximize your time with those who have movement expertise by focusing on kinesthetic learning and challenging exercises while you satisfy basic 'maintenance' at home. This includes stretching shoulders and hips and using massage tools to hydrate tissues.

Thing: Reclining a seat to avoid falling forward. This strategy works really well, but it does not address the underlying postural problem of weak trunk muscles. Reclining is a temporary fix. Think about external supports you require to stay upright, like propping on an elbow while typing, or holding onto a steering wheel to lean and reach. Awareness is the first step to reclaiming the internal strength for yourself.

Thing: Spasm medication. Some athletes with severe spasticity take muscle suppressants with side effects such as decreased nerve conduction and short term memory loss. While medications are sometimes necessary to be functional, it's ultimately more satisfying to manage the needs of your body through movement.

Fig. 5.2: *Figure out simple things you can do at home to keep your therapy routine moving forward. Something as simple as self-release goes a long way.*

Passive participation is one of the largest psychological challenges of recovery and is a huge driving force toward achieving independence.

Fig. 7.5: Nicole's base of support is confined to her left foot. The force she exerts through the ball will either be counteracted by pressing through the ground, or by an opposite movement in her body (which can be observed in the bent-forward, arm-swing recoil after the kick).

your source of stability will be any stable surface you are sitting or laying on, and your *base of support* includes all of your body parts which touch this stable surface. For example, you have the largest base of support when you are lying on the floor (full body contact) and the smallest one when standing on two feet. You can extrapolate further to a ballerina on-point or a rock climber gripping a ledge. Take advantage of the ground while seated by pressing through your feet and down through the backs of your thighs to help anchor your pelvis. This stability from below is converted into tension above, allowing you to move freely without collapsing.

The goal is for both internal and external forces to be matched by internal stability.

Transmission of force leads to stability

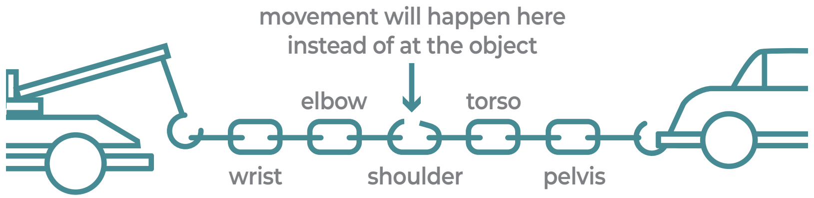
Anyone who has watched a Champion's League game has surely been impressed by the amount of power soccer (football) players create to kick a ball sometimes 80 meters down the field. Notice how different the roles are for each of Nicole's legs in **Fig. 7.5**. Her left leg (base of support) is responsible for holding her entire body steady as she transfers her momentum through her kicking leg and into the ball.

This is an example of creating stability in one Body-Half in order for the other to produce force. If any point along the pathway connecting the stability in Nicole's left foot to the movement in her right is impaired, then her kick will not be as powerful.

This example of stability for power in a soccer kick can easily be scaled back and applied to any movement in daily life for SCI athletes. No matter how simple a movement might be, pathways which "leak" stability create less force at the end of the chain. We aim to transmit as much force from the base of support as possible by stabilizing the joints in between. If just one of these joints is unable to handle the force, then movement occurs at the weakest point in the *force transmission chain*, rather than where it's intended **(Fig 7.6).**

A very clear example of this is in athletes with minimal to no strength in the triceps or forearms where stability is often compromised at the elbow and wrist joints. When such an athlete tries to push against a load applied through his hands, his elbows and wrists bend, unsupported, before creating movement against the load. It is best to apply this load at a place where efficient force transmission to and from the shoulder can occur, such as the upper arm **(Fig. 7.7)**.

Fig. 7.6: If the stability across any joint is not strong enough to communicate the force, then movement will happen at the weakest link in the ***force transmission chain****, instead of at the desired location.*



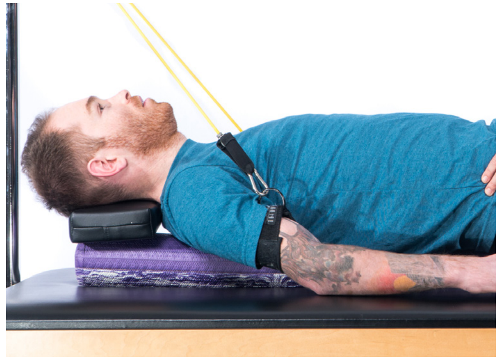


Fig 7.7: Jackson uses arms cuffs on the upper arm to appropriately challenge his shoulder joint without the issue of force transmission across the wrist or elbow joint. More on this application in Chapter 10.

Force transmission is strongest when bones are in good mechanical alignment. More specifically, the bone-alignment of your base – whether it is your pelvis (seated), your feet and ankles (standing), or your hands and knees (quadruped) – serves as a foundation that affects the alignment of everything "up the chain." How well your base interacts with the surface it touches has a disproportionately large impact on the stability in the rest of the system. Good mechanical alignment at the base will prepare the rest of the system to respond well; poor alignment will create a persistent challenge to overcome. We'll discuss more about "proper alignment" in Chapter 9.

Stability for power

After first establishing stability against gravitational and internal forces, such as sitting upright or being able to lift an arm without falling over, athletes can then train the stability which supports movement production against a load, such as pushing a door open or performing seated pulling exercises.

This concept is evident in wheelchair pushing. Remember the action-reaction law: the same amount of force you exert on the wheel rim will be felt in the opposite direction by your own body. If your torso is not stable enough to manage this reaction force, some of your efforts will push your body backward rather than the wheel forward.

Luckily for daily function, most wheelchairs have a backrest, providing another base of support. However, if you scoot your hips forward **(Fig. 7.9)**, your lower spine is now part of the force transmission chain (refer to **Fig 7.6**). You will need to stabilize here to not fall backwards and to create force to push the chair forward. This demonstrates the significance of achieving stability inwardly in order to generate force outwardly.

Try it yourself! For those athletes who use a manual wheelchair, try this drill to increase your awareness about your own internal stability (where the force is not transmitted through the chain) and how much you actually rely on the chair's backrest for stability. Those who are able to apply some pressure into the rims, or even push the chair forward, will feel the trunk muscles support this force transmission to avoid falling backwards.

How well your base interacts with the surface it touches has a disproportionately large impact on the stability in the rest of the system.

Viewpoints on stability in movement

The age-old debate in the movement community asks which comes first: *stability or mobility?*

Fig. 7.9: By sitting slightly forward and thus eliminating the backrest support on her low spine, Katie's torso must work significantly harder to maintain stability from her pelvis as she pushes the wheelchair.

Fig. 7.8: The addition of boxes under Theo's feet increases his base of support which he can use to create stability to sit tall. Tilting his pelvis (another base of support) into good mechanical alignment with a wedge makes it much easier to align the spine upright.

Anyone who has used a hammer or lifted a heavy cast-iron frying pan knows that the middle, ring, and pinky fingers are much stronger in gripping than the thumb and forefinger. The joints and musculature of the first and second fingers are optimized for dexterity, whereas the third, fourth, and fifth are better at strength applications. You can see this in the *arm lines:* the last three fingers connect to the slow-twitch muscles of the back via the *back arm line.* The first and second fingers connect to the fast-twitch muscles of the front of the body via the *front arm line.*

Shoulder

This group of bones is particularly fascinating because everyone knows where their shoulders are, but few know that the *shoulder complex* includes the shoulder blade *(scapula)*, upper arm bone *(humerus)* and collarbone *(clavicle)*. This group of bones essentially floats over the back of the ribcage with only one boney articulation with the rest of the body – where the clavicle meets the sternum! The integrity of this ribcage-shoulder "joint" is secured mostly through soft tissues.

This inherent lack of stability is the price of movement freedom: humans have more shoulder range of motion than essentially all other vertebrate animals (except some brachiating tree-dwellers like monkeys). This shoulder mobility, combined with trunk rotation, gave our ancient ancestors the ability to throw and hunt – but it also put the joint at a greater risk of injury.

A closer look at the bones

Fig. 7.23 illustrates the large flat surfaces on the posterior and anterior scapula. Broad muscular attachments on these surfaces enable muscles to pull the scapula in any direction, an important characteristic for a bone whose function requires it to glide freely over the ribcage.

The *clavicle* wraps from the scapula to the *sternum*, making a stretched-out S shape. Just like the scapula, the clavicle depends on having balanced muscle-tension on all sides.

The head of the *humerus* rests in a shallow capsule on the scapula, called the *glenoid fossa*. This joint is supported by several *ligaments* (thick fascial connections between the bones), but the stability required for all the powerful movements we do with our arms is supplied by the muscles themselves.

We would like to point out that optimizing *gleno-humeral joint* congruency improves the efficiency of arm movements. In other words, humeral movement must be coupled with proper scapular movement.

Shoulders grant access

Besides standing on feet and sitting on pelvis, humans mostly interact with other people and objects through our upper extremities. This is particularly true for wheelchair users whose primary means of transport relies heavily on shoulder use.

Fortunately for most SCI athletes, the muscles of the shoulder are innervated by the cervical spine. This means that even an athlete with a cervical SCI will likely have some preserved function of the shoulder from the unaffected nerves above the injury.

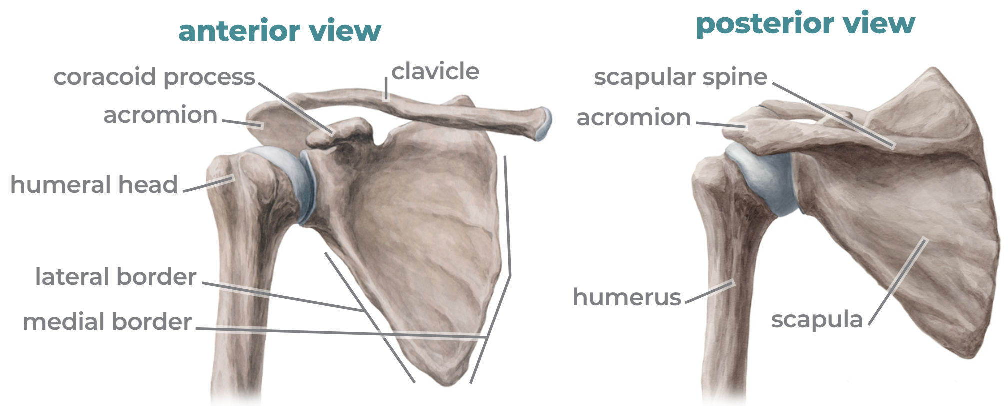


Fig. 7.23: The scapula has many unique prominences and ridges for muscle attachments. (KenHub.com)

Because the scapula falls within the paths of several fascial lines, the shoulder complex serves as a crucial access-point to the rest of the body. Proper placement of the scapula will "unlock" activation potential in the torso, hips, and legs through the spiral line, in particular. This means that all athletes, and especially cervical-level athletes, should focus on shoulder stabilization.

Recall the force transmission chain discussed at the beginning of this chapter, and recognize how scapular stability relates to forearm, wrist, and hand function. Any force applied to or exerted by the hand is supported by the scapula. The fascial *arm lines* illustrate how this force is communicated.

The shoulder complex is a crucial access-point to the rest of the body.

Muscle balance

With a wide range of motion available at the shoulder, and its support coming from soft tissue, tension balance among these tissues is critical. Cervical-level athletes likely experience disproportional innervation and strength in the shoulders. These athletes should focus on underdeveloped areas to balance the tension.

Although scapular movements are often referred to as very linear movements of *elevation, depression, protraction* and *retraction* **(Fig. 7.24)**, this is an over-simplified description of how our shoulder moves. Because our muscles co-contract with others, the scapula rarely moves solely in strict up, down, medial, and lateral directions. Instead, the scapula moves in more of an X pattern **(Fig. 7.25)**. As you read through the following list of shoulder movements and muscle groups responsible for each one, we encourage you to explore the movements in your own body.

Downward rotation. Actions from the *rhomboids*, *upper trapezius* and *levator scapulae* draw the medial border of the scapula up, and tip the acromion down (elevation + retraction). Since these two groups of muscles are generally spared after cervical SCI, the scapula tends to rest in this position when these muscles are not balanced by the ones introduced next.

Upward rotation. With the help of the *serratus anterior* and *lower trapezius*, the scapula moves down and out to the side of the ribcage (depression + protraction). This particular pathway makes room for the humerus during overhead movements. In addition, this action of the scapula draws the shoulders down without compressing nerves and blood vessels which run underneath the clavicle. These muscles are more commonly affected by cervical and some thoracic-level SCI, and therefore can be more challenging to activate.

Anterior tip. The *pectoralis minor* is a small muscle which attaches on the *coracoid process* on the front of the scapula and spans over the third, fourth, and fifth ribs. It draws the scapula up and forward over the top of the ribcage (elevation + protraction, also referred to as "winging scapula"). Through chronic pushing of a wheelchair or slouched postures, over-development of the anterior shoulder (with under-development of the posterior) tends to pull the scapula into anterior tip. Over time, this displacement can hinder overhead arm movements.

Posterior tip. Countering the *pectoralis minor*, the *mid-* and *lower-trapezius* pull the scapula down towards the lower thoracic spine (depression + retraction). Visualize this movement by gliding your shoulders to your middle-back.

A balance of all these muscle tensions allows the scapula to move freely in all directions. If just one

Fig. 7.24: Movements of the scapula. From top to bottom: elevation, depression, retraction, protraction.

The *sacrum,* introduced in the previous section, is the interface between the spine and the pelvis. The sacrum is capable of small movements relative to the four bones around it: L5 vertebra above, ilia on either side, and the coccyx below. But because the movement is so small at the sacro-iliac (SI) joint, the sacrum very closely follows movement of the pelvis, which then influences the rest of the spine.

The *femoral head* angles slightly to fit into the *acetabula* (a much deeper socket than the humerus's connection to the scapula at the gleno-humeral joint, which relies on myofascia for integrity). Our femurs have the potential to move relatively freely in this ball-in-socket joint: in rotation, flexion, extension, adduction, and abduction. However, a predominantly-sedentary posture deprives most people of the ranges the pelvis was designed to perform. Bartenieff said these changes result in a "dead seven inches" from navel to pubis (Hackney, 1998, p. 23). The pelvis becomes bound in place by unused and tight muscles, losing some of its 'switchboard' abilities that rely on its dynamic characteristics.

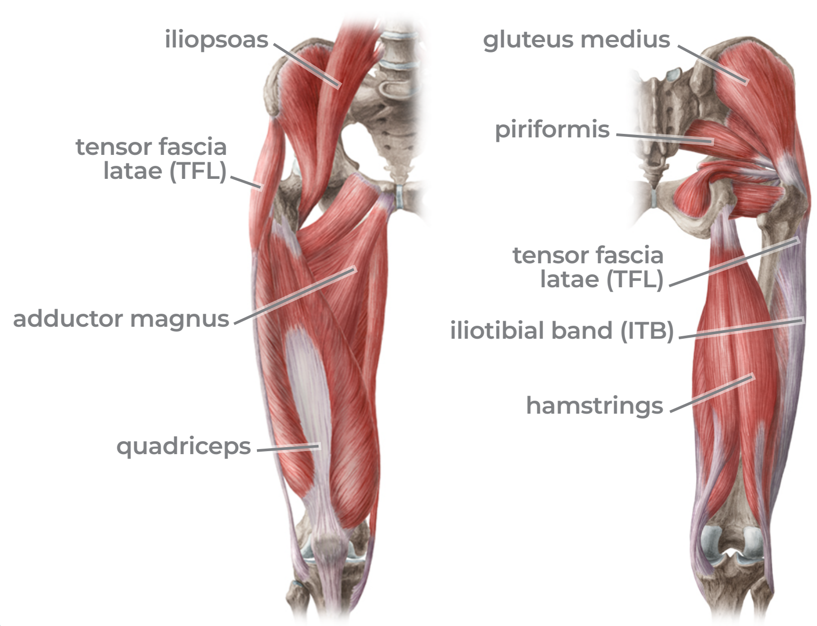


Fig. 7.35: *Anterior and posterior muscles of the hip. (KenHub.com)*

Muscle balance

As we've said before, it's useful to think of muscles both individually as well as myofascially – how does each muscle fit into the functioning of the larger whole?

Visualize standing for a moment: a top-heavy body balances on two legs several feet above the ground. It's like taping the ends of two pencils together and somehow balancing them perfectly vertically. The multi-directional muscular architecture which pulls on the pelvis from several directions maintains this balancing act, with both reflexive and voluntary control from the nervous system.

When discussing the muscles and actions of the hip **(Fig. 7.35)**, remember that one end acts as an anchor while the other end moves the bone. The body and limbs move depending on which end is fixed or stabilized. For example, if the pelvis is fixed, hip flexion will result in a marching motion. However, if the femur (or leg) is fixed, the same action manifests as a deep squat. You can apply the same idea with hip extension, abduction, adduction and rotation – it just takes some visualization!

Extension. Several gluteal muscles run from the *iliac crest* to the lateral anchor point on the femur, the *greater trochanter.* The posterior fibers of these muscles, especially the *gluteus maximus*, perform hip extension. The *hamstrings*, often thought of as only a knee flexor, connect the *ischial tuberosity* of the pelvis to the femur. With the pelvis fixed in place, hamstrings assist in extension of the hip (think kicking backwards). However, they can also bring a pelvis back upright after bowing forward, as in a deadlift or hip-hinge movement **(Fig 7.36)**. In an effort to get these hip extensor muscles activated, explore movements that fix either end in-place and see which ones lead to the best sensation of activation.

Fig 7.36: *Hip hinge to standing – the femur is fixed and the pelvis moves around it – is one effective way to work the hip extensors.*

Flexion. The *psoas* and *iliacus* attach to different places, the anterior aspect of the spine and iliac crest, and then converge onto the medial aspect of the femur. In addition to flexion, they also create external rotation and tilt the pelvis anteriorly, which is critical for maintaining an upright seated posture **(Fig. 7.37)**. The *rectus femoris* is the most superficial *quadriceps* muscle, which runs from the front of the pelvis across the knee to the *tibia*. Because it crosses two joints, it produces hip flexion and knee extension. If you want to train knee extension, you can begin with hip flexion and gradually coax that strength down to the knee – they're done, in part, by the same muscle!

Abduction. A smaller gluteal muscle, *gluteus medius*, and *tensor fascia lata (TFL)* connect the pelvis and femur along the *lateral line*. The action of abduction is usually represented as the leg moving out to the side, however, these muscles primarily work to prevent a lateral shift in the hips **(Fig. 7.38)**. Without this support, one side of the pelvis drops during weight shift or single leg stance. This lateral shift is common in athletes learning to walk again. With the pelvis out of alignment, the spine usually countershifts. When training lateral hip stability, it is equally important to train lateral stabilizers in the trunk as well.

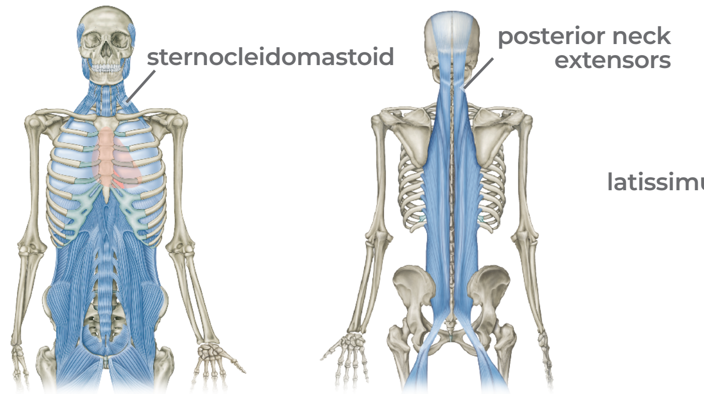
Adduction. Opposite to the abductors, this group of muscles brings the femur toward the midline. They run from the *pubic bone* and underneath the pelvis to the medial femur. They balance with the abductors to maintain pelvic position over the stance leg during gait. This group is part of the *deep line* and often operates as a deep stability system when other fascial lines are not effectively holding the body in a safe position. In addition, adductors can become over-tensioned from chronic sitting, with knees held together in a wheelchair. To ease this tension, try rocking the pelvis forward and backward in a straddle position.

Rotation. These are smaller muscles located deep inside the hip joint. While they are not designed to carry heavy loads like the quadriceps or glutes, they are no less important. Just like the rotator cuff in the shoulder, hip rotators orient the femur and pelvis into optimal positions for the big hip and leg muscles to operate efficiently. For example, external rotation during hip flexion will target the *psoas*, and holding the femur in neutral will emphasize *rectus femoris*. Even the smallest changes in rotation target completely different fascial lines. Don't forget that imbalances in these rotators can also alter the position of the pelvis when the feet and legs are aligned forward. You may need to address these tissues to help the pelvis and torso find alignment in standing.

When athletes spend a majority of their time seated, leg muscles adapt to this position: hamstrings, hip flexors, and calves get short and tight while the quads and hip extensors get long and tight. Beyond the difficulty of already less-responsive muscles, these tissue adaptations make standing even harder. Recall the idea of muscle pairing where each group of muscles is opposed (and supported) by another group. Tensioned hip

Fig. 7.37: *Hip flexors help Katie sit upright over her pelvis.*

Fig. 7.38: *Abductors are primarily responsible for holding the pelvis centered, preventing falling to the side. YouTube search "Trendelenberg gait" to observe what can happen when the lateral line does not adequately support lateral hip stability in forward movement.*



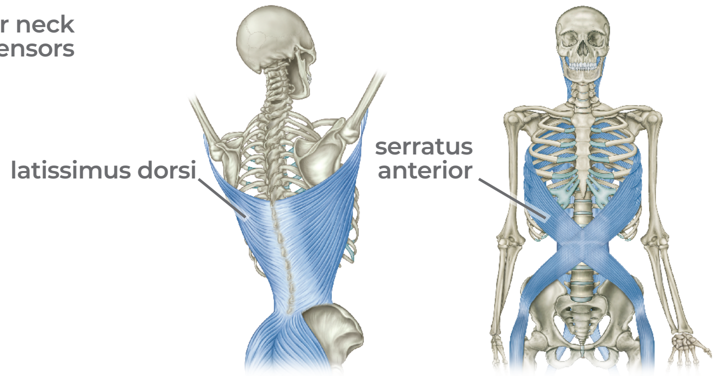


Fig. 8.8: Access the superficial front and back lines through this simple neck exercise.

With most of the fascial lines originating or passing through the shoulder girdle, we consider the shoulders as a gateway to our trunk muscles, both in SCI athletes and able-bodied athletes. Due to at least some preserved function in the shoulders, most athletes have some access there. **Scapulas are connection portals to the rest of the body through fascial lines.**

As a way to begin connecting via the myofascia, start with the following portals and exercises:

Neck muscles. Forming the top of the *superficial front line*, superficial neck flexors connect down to superficial abdominals. The deep neck flexors, which are close to the anterior spine, are also part of the *deep front line* and therefore create tension through the deepest layers of the *inner unit*. Posteriorly, neck extensors stimulate spinal extension through the *back line* **(Fig. 8.8)**.

Shoulders. The serratus anterior provides access to the *spiral line*. This connection travels from the shoulders into the trunk, including oblique muscles, before it crosses to the opposite hip. The latissimus dorsi connect the arms to the low back as part of the *functional line*, which also stimulates lower trapezius for increased *back line* activation. This lower trapezius connection also extends down through the *arms lines* to the forearms and even the hands **(Fig. 8.9)**.

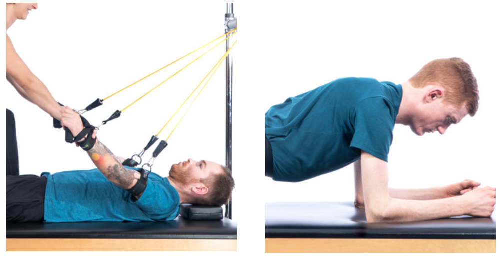


Fig. 8.9: Access the functional back line and spiral lines through the latissimus dorsi and serratus anterior.

Breath. Every inhale and exhale produces displacement in the bones of every fascial line. Rib expansion taps into the intercostals of the *lateral line*, while diaphragm and pelvic floor movement stimulate the *deep front line* **(Fig. 8.10)**.

Develop your connection at these access points before proceeding down each line. **By first establishing excellent rib, scapula, and neck control, you open portals to the rest of the body.** For athletes with *central cord syndrome* (more function or sensation in the legs and trunk than the arms) the direction of connection development is often reversed. These athletes can use their legs, hips and spine to create connection in the shoulders, arms and hands.

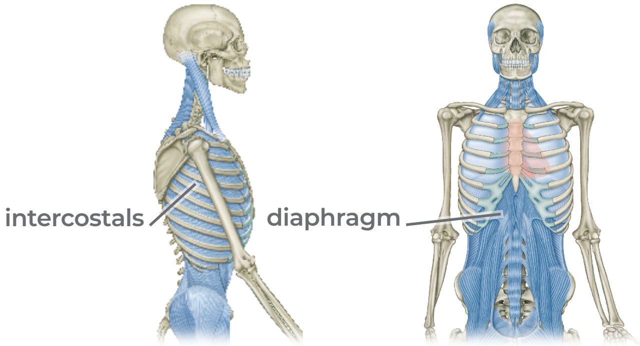


Fig. 8.10: Access the deep front line and lateral lines through breath and rib expansion. More discussion on breath as a significant rehab exercise in the next chapter.

Extend connection

Next, you can extend connection down these lines using intentional orientations, progressions, alignments while considering line interactions.

Orientation. Ask yourself: *in what position will the target line respond the most?* Position the body such that the target line must resist gravity. For example, supine exercises generally recruit the *superficial front line* (pulling the body into flexion), whereas prone exercises target the *back line* (lifting the head and chest in extension) **(Fig 8.11)**. Remember that the baby develops each of these in a specific orientation, because every movement in that orientation demands engagement. Nothing new here: we simply replicate this to execute the same developmental process!

Progression. We also use infant development to help us better understand the order for which the fascial lines best develop, where the establishment of one line supports the development of the next. Much like aligning the numbers on a combination lock, aligning torso rotation through balanced right and left *spiral line* activation allows other lines to connect. The *spiral line* is responsible for

Fig. 8.11: Prone exercises target the back line exactly like infant development during "tummy time."

Fascial connection feels different

Athletes, connection via fascial lines feels different than the voluntary connection you know from before the injury. Here's an analogy for how fascial connection takes a different form, based on shared experiences from our athletes: you want to ring the bell in the local bell tower, just as you have every morning for years. This time, however, the door is locked. You can't get inside, and it seems the bell simply cannot be rung. Then, someone tells you there's a new bell-keeper inside, and that if you knock on the door three times, he will ring the bell. You try it, and a moment later the bell rings. You knock again. Same result. Knock 1, 2, or 4 times, and you get nothing. You feel like you are not really ringing the bell yourself, because you are knocking, not ringing. And yet, you are indeed ringing the bell but by a different means...

You can see the parallels: you have always rung the bell (moved your body) but now you are locked out (paralysis). A specific stimulus of knocking (aligned body position and fascial connection) somehow makes the bell ring again. It's not the same as it used to be, but the bell rings (body moves) dependably, with your voluntary engagement. Part of the neuroplastic healing process is to get these new connections to be automatic, to be the primary pathways nerve signals take when you think about pressing to stand or leaning forward to reach with internal torso support.

By no means is the myofascial route the only way to connect. But it has worked for athletes when the standard healing stopped, and many agree that it works to integrate the body for long-term movement recovery toward MMOMO.

Fig. 9.19: This spring-loaded bar will push any athlete backwards without pelvic anchoring and spinal stability.

and try a few pushes without falling backwards into the seat. You can also practice this self-supported pushing pattern with Seated Straddle pushing exercises like the one in **Fig. 9.19**.

Standing

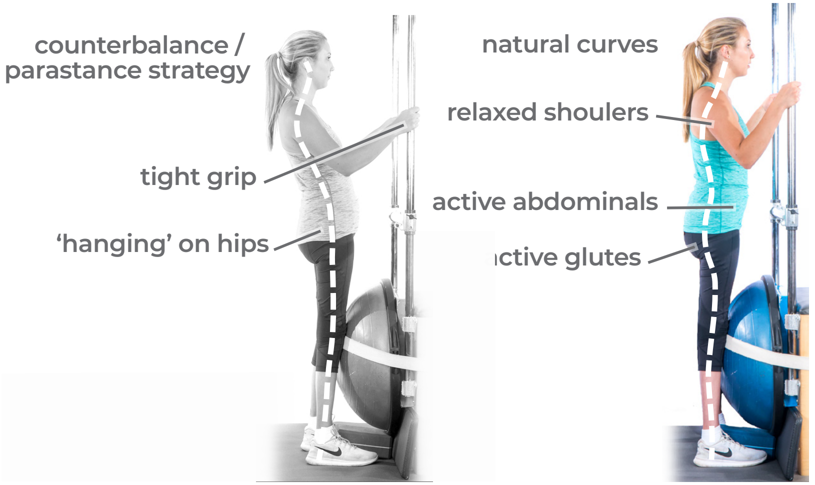
Even more so than in sitting, the orientation and activation of the feet and degree of ankle dorsiflexion available can greatly impact standing alignment. Here, again: better aligned bones means better engaged muscles. Bone congruency is important for joint health and carryover to standing and gait.

Common standing patterns

Parastance describes a standing posture which relies on a passive stacking of bones held by ligaments and connective tissue, rather than muscular support. It is characterized by alignments shown in **Fig. 9.20** with the hips pressed forward and the torso resting backwards. Limited ankle dorsiflexion will lead to hyperextended knees in this posture.

Athletes rely on their arms to hold the body upright with limited contribution from the legs and hips (and learned non-use of the lower extremities).

Fig. 9.20: Drawing the pelvis back over the heels and under the shoulders places the body in a mechanically efficient position for standing and walking.



Assess the level of upper-body support by having the athlete remove one hand and maintain uprightness. The shifts in the body will show how much the arms are used for support.

Improve your stance

Standing postures during sessions should be held through athlete self-support, but some areas may need to be supplemented with equipment or trainer support. It's best to work with *variable supports*, such as springs and resistance bands, to give athletes the opportunity to feel weight-shifting and find their center by "pinballing" within their kinesphere while still feeling safe.

Start at the base of support and address any misalignments. As you work from the bottom up, neutral posture takes form in the body: lift arches to prevent ankle eversion, separate thighs (with a block), and tilt the pelvis into a neutral position (with a sling or trainer support). Most athletes find that holding a neutral pelvis and maintaining upper-thoracic extension are challenging when the hips are positioned over the ankles. Break down these components in regressed postures, then integrate them in standing.

Be aware that some athletes become less connected to their bodies with too much support. In these cases, get creative with variable supports using springs and resistance bands around the shoulders or hips.

Hip flexion and extension

During gait, the entire body must balance on one leg during the stepping phase. This requires a large degree of stability in the single stance leg before the body "feels safe" enough to lift the other leg to step. When the body determines it is *unsafe*, perhaps some degree of unconscious neurological inhibition is working against the conscious desire to take a step. Recall that with every pull/reach (hip flexion), there must also be a push (stability in

the other leg). It is no wonder that even SCI athletes with strong hip flexors who can stand still have a hard time combining these skills to take steps.

Common hip flexion patterns

Athletes usually induce what looks like hip flexion through excessive spinal movement **(Fig. 9.21)**. The oscillation of lumbar flexion and extension can create motion at the hip due to the passive pulling on the hip tissues. However, this pattern strengthens the spine, not hip. This is frustrating to unlearn because the athletes go from "moving their legs" (with heavy compensation) to holding steady in the spine but relying on assistance for movement. Yet, addressing this compensation makes crawling and walking much more efficient and healthier for the spine in the long term.

Improve your hip movements

For optimal training of hip movements, develop intellectual and kinesthetic understanding of lumbo-pelvic stability in a neutral position during leg movements **(Fig. 9.22)**. In the beginning, especially for athletes working to change old habits, we encourage a slight over-correction: *extend the low spine during hip flexion* and *flexion during extension*. If this new intention is too challenging for the athlete to coordinate, cue these intentions with breath: *inhale during hip flexion* and *exhale during extension*.

Keep in mind that hip flexion is a fundamental part of the gait pattern; it is supposed to be rhythmic. While the psoas, iliacus, and rectus femoris muscles create the motion, the hip flexion that occurs in walking is primarily the result of the myofascial stretch on the front of the hip. As the hip extends in the gait cycle, the *front* and *deep*

Fig. 9.21: Katie demonstrates a common compensation strategy to produce steps during gait training (left) by leaning back into the hip-belt and leveraging a stretch reflex in the hip flexors. On the right, she maintains spinal alignment for true hip flexion and supports herself over the stance leg.

front lines are stretched, and release this tension through flexion.

If possible, practice single leg or alternating hip flexion and extension while the other leg supports the body. This left-right differentiation is critical. Try this in quadruped, kneeling, or standing postures.

"How" is important

Our goal with this chapter has been threefold: to show how important the motor development is for connection, patterning, and generally outlining a recovery trajectory; to illustrate that improving *how* you move is a worthwhile quest that should be guided by supported, controlled, and functional patterning; and to demonstrate by example that you can – and must! – analyze your own postures in order to improve them.

We hope you're primed to pay attention to the nitty-gritty now, because you'll need it: coming next is efficient strength training. It is dependent on both connection and patterning. So, let's add some load...

Fig. 9.22: In Seated Scooter, the trunk is upright just as it will be in standing. The athlete connects to his hip flexors through the flowing rhythm of unilateral hip flexion and extension, with stability coming from the stance leg (and arms, if needed).

Seated

Sitting on the floor is surprisingly challenging for most athletes without the support of a cushion and backrest. It is an important skill for MMOMO, and is the first position that requires stability in all directions in order to maintain vertical.

1 Cross-legged

Pull on thighs to sit upright if needed, relaxing shoulders. Focus on lumbar extension to create natural lower-back lordosis. **Back prop (1b):** press through hands for chest-opening spinal extension.

2 Z-sit 90/90

This position opens the hips and allows you to integrate firing in the low back, glutes, and legs. Focus on pressing into the floor with both knees to create stability up into the spine. Challenge yourself by reaching one hand while maintaining hip position (2c). Explore different transitions from this position (see opposite page).

1a

1b

2a

2b

2c

Transition: Prone to Quadruped

This requires a push from the upper body with a pull from the lower body. The transition develops coordination between these halves to stabilize in all-fours position. As always, there are many ways to do this, so play around to find what works for you.

1 Prone press back

Start prone, with hands under shoulders. Press through elbows and draw in abdominals to push hips back. Trainer can support the hips as shown. Transition to hands and continue to press back over knees. Feel how *lateral lines* connect hand through torso to knee to control motion side to side.

2 Seated roll over

Start seated, and focus on pressing with both hand and knee to lift the hips.

3 Z-sit bridge

Start in a Z-sit (as shown on opposite page) and press hands into the floor while pressing hips up. Adjust ankles by yourself or with help to achieve quadruped or begin crawling. Use your *front line* to keep pelvis neutral, instead of anteriorly tilted with an arched back.

1a

1b

2a

2b

3a

3b

Prone: Chest Lift II

Objectives

- Strengthen spinal extensors through concentric and isometric exercises
- Feel how pelvic anchoring into table helps spinal extension
- Prepare spine for extension required in seated postures

Set-up

Make sure athlete is forward on table (hips towards the edge) to avoid excess pressure on the ribcage. Try **2x light springs on the #2 setting** on the Chair.

Trainer spotting: *Apply pressure on hips to anchor the movement.*

Modification: *Add box or arc to lift hips for a larger range of motion in extension. This lift is better for tall athletes with long arms and torso.*

Use roller to support ankle alignment.

Avoid excessive neck extension or scapular elevation.

Create length in spine, reaching head forward instead of up.

Intentions

Recall connections practiced in *Prone: Chest Lifts* (previous page). Use abdominals to support effort in spinal extensors, shoulders and neck muscles:

Reach the head out, not up

Pull the pedal into the Chair for a stronger lift

Initiate the movement from a lift in abdominals underneath

Anchor pelvis by drawing pubic bone in (slight lumbar flexion) and reach tail towards feet

Variations

1 Extension

Engage abdominals while lifting pedals. Raise a few inches to verify that *front line* supports the *back line*. Another variation: maintain isometric spinal extension while protracting and retracting shoulder blades.

2 Tricep press

Maintain isometric spinal extension while raising and pushing pedals. Avoid lifting or dropping the chest during movement to direct efforts into the arms.

3 Rotations

Keeping elbows straight, hover one pedal. Lift the other, open chest to that side, then push pedal back down to switch sides.

Side Lying: Legs

Objectives

- Transmit lateral trunk support and lumbo-pelvic stability down into leg movements
- Connect to lateral and medial hip stabilizers through abduction and adduction
- Maintain isometric trunk control in lateral flexion and rotation even with leg movement
- Prepare the body for lateral stability required in kneeling and standing

Set-up

Trainer supports knee in extension and ankle in dorsiflexion. Try **1x long yellow spring** attached to the ankle and **1x short yellow spring** to knee, both anchored directly above the cuffs. Some athletes prefer a roller, towel or small lift under ribs to press into for low oblique connection.

Ground out stabilizing leg with yoga block.

***Trainer spotting:** Hold foot in neutral while supporting knee.*

***Modification:** Pilates Arc or other large support better aligns spine with sacrum, but reduces leg range of motion.*

Avoid looking down at the foot, or positioning leg forward of midline.

Keep spine and leg aligned with hip, or slightly behind, to activate lateral and back lines.

Intentions

Recall the lateral trunk support practiced in Side Lying Rib Lift. Maintain engagement in trunk, especially through *spiral line,* to provide a source of connection for hip muscles to draw upon:

Lift the rib cage by drawing shoulder down to hip

Press down with the bottom leg for stability

Reach leg out to create length

Draw abdominals in and keep hips stacked to maintain neutral pelvis

Variations

1 Abduction

Lift and lower leg.

2 Leg circles

Circle the thigh, keeping leg straight.

3 Hip flexion

Keep the knee and ankle level with the hip with bent knee hip flexion and extension. *Other variation:* guide leg through gait cycle while maintaining lateral stability.

Spinal Rotation

Objectives

- Increase rotational mobility, awareness, and connection at each vertebra
- Prepare *spiral* and *functional lines* to support the spine through asymmetrical movements

Intentions

Spinal rotation requires the connections developed in all previous spinal movements. Push the right rib cage forward, draw the left rib cage backward, and maintain extension of the spine. Look in the same direction as rotation and push off opposite leg for a full spinal rotation.

Wind up the spine like a coiling wire

Feel your left hip and leg pulling your right shoulder closer

For pure axial rotation, avoid lateral deviation (translation to the side).

Trainer feedback might be necessary initially to maintain axial rotation.

1

2

3a

3b

4a

4b

4c

Variations

Rotations can be performed in a variety of positions, each providing a different challenge.

1 Transition elbows to hands

Rotate the spine to lift elbows off box. This small yet crucial movement requires *functional line* recruitment.

2 Rotator discs

Explore small and large rotations; upright or hinged forward.

3 Side bend + rotation

Add rotation to any side bending exercises, maintaining *lateral line* engagement through the rotation.

4 PTB rotation

Press bar forward with obliques while reaching behind. Explore different rotational movements on the PTB with the bar down, or pressed up overhead.

Standing: Scooter & Lunge

Objectives

- Practice torso and lumbo-pelvic stability with hip extension
- Stabilize from stance leg while freeing movement in opposite leg
- Connect and strengthen glutes and hamstrings for posterior push-off during gait

Set-up

Be sure to work with a sturdy piece of equipment. Use a prop (a foam block shown here) to support one knee in extension. Use torso belt and/or hip belt, if needed. Try **light to medium bands** on the CoreAlign cart.

Use bench over base with knee blocks to stand. Remove one block to make room for the knee to swing forward.

Trainer spotting: *Place one foot on the cart to guide movement, one hand on the knee and the other on the ankle for tracking and support.*

Avoid lateral shift of hips and torso by engaging spiral and lateral lines.

Maintain weight over stance leg and upright torso.

Intentions

Recall the connections developed in Seated Scooter. Focus on supporting the body through the stance leg and hip while maintaining neutral pelvis during hip extension:

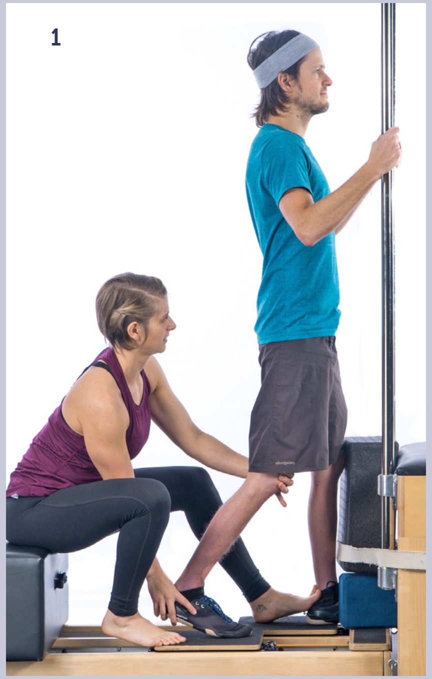
Use lateral abdominal support to keep torso stacked over level pelvis

Engage the stance leg to support and power the movement on the other side

Kick leg back like riding a scooter

Press into cart with ball of foot, point toes

1



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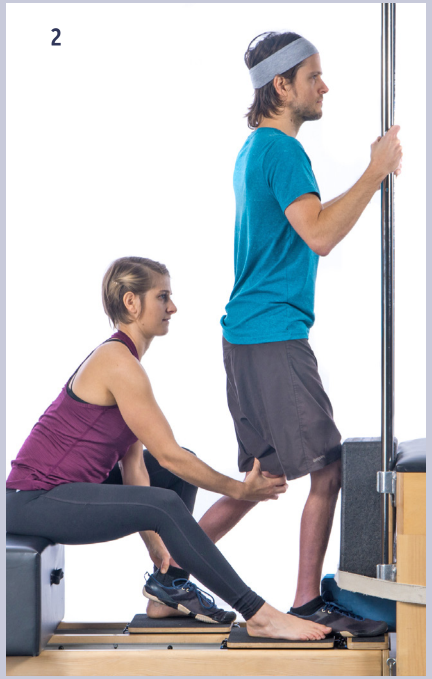

Variations

1 Scooter: straight stance

Keep stance leg straight while straightening the other. Control the cart eccentrically as it returns. This recruits all fascial lines, with particular emphasis on *back* and *functional lines*.

2 Scooter: lunge stance

Hold a lunge position in the stance leg. Progress to holding the stance knee off the block. The partial squat recruits *front line*, which may help with abdominal engagement.

Explore different orientations of the leg in extension, as well as opening the hips out to the side during the kick, as if the athlete were turning around. This requires significantly more balance and lateral line stability.

Assessment & Programming

What's ahead

- Working with four interweaving systems
- Recommendations and best practices for the first session with an athlete
- Intake, sensory, postural, and dynamic assessment tools
- Program pools and training block cycles
- Establishing an at-home exercise regimen

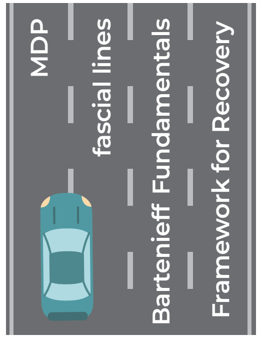

Fig. 14.1: *Be intentional in using multiple systems throughout recovery.*

Now that we have a library of exercises to draw from, the question is no longer *what* to do or *how* to set it up, but rather *when* to do it. This is the domain of programming, which has less to do with knowledge and more to do with craft. You may choose to focus on any of a variety of disconnected elements, and inevitably you will reach the complex truth that each is dependent on the others.

Programming for any population is one of the more challenging parts of a movement practitioner's role, and SCI athletes and trainers have the increased challenge of all the other variables to consider: tightness, pain, spasticity, and tone, overall mental and physical state, as well as time and resources available for rehab.

The SCI rehab community has successfully adapted many kinds of able-bodied workouts (ABT is one example of this). However, we must look beyond simply making known progressions work for those with paralysis and instead consider what will maximize carryover of movement skills from the session to the athlete's life. This involves movement analysis, curated exercises, and methodical progression.

Because SCI athletes have a far greater variability in what resonates from a 'connection' perspective, it can be hard to generalize answers to fundamental programming questions: *Where do you start? How do you sequence exercises into a 'movement arc' over a session? When should you advance positions? What happens when the connection of one region lags, but all others are ready to progress? How long should you wait before determining a program isn't working?*

This chapter will guide you in creating uniquely-effective programs to keep your sessions organized, relevant, and progressive for each athlete.

Interweaving systems

Neuro-rehab is messy and there are no defined rules about progression, but the systems we discussed throughout Part II do offer clues. Notice how each one presents a different perspective on the same process:

Motor development. Progress through positional, postural advancement.

Fascial lines. Progress through connection in each line, and improved integration among them.

Bartenieff Fundamentals. Progress through regional body relationships.

Framework. Progress through the stages, each building to support an athlete's ability to understand, connect to, and use his body.

Every system has its own performance indicator for progress, and while it is not guaranteed that every system will work for everyone, we have found the four above reliably effective for SCI training. We encourage you to consider what progress means in other disciplines and systems you know.

Casting a broad net with respect to movement systems is crucial given how fickle athletes' bodies can be. If you're not making progress in one system, shift context to another and decide how to progress in that frame of reference. For example, an athlete with *central cord syndrome* (see Appendix) has greater connection to his lower body than his upper. When we consider the strategies to better connect an overhead reach movement, each system offers a different avenue to get to the same place:

Motor development perspective. Prone work on elbows provides weight-bearing through shoulders, which cues serratus anterior activation and deltoids. These muscle groups contribute to the scapular and humoral movement of the arm when reaching overhead.

Fascial-line perspective. If the athlete has more connection to the lower body than upper, consider which fascial lines connect hip to shoulder, particularly in an overhead reach (*functional lines*). **Fig. 14.2** shows how sliding one elbow while prone demands spinal extension with cross lateral support through the *functional line*.

Bartenieff Fundamentals perspective. The Upper-Lower connectivity pattern suggests that a lower-body push pairs with an upper-body reach. **Fig. 14.3** demonstrates this relationship using a hip bridge (push) to facilitate an overhead reach with the PTB.

Framework perspective. Understanding bone relationships within the shoulder (how the humerus relies on scapula movement and thoracic spinal mobility) helps the athlete visualize what is going on within the joint. Using tactile cues or actively moving the arm, the trainer can show the athlete the path of movement.

Scan Chapter 13 and visualize how each movement can be implemented through the lens of each system described. Individual athletes may resonate better with a particular system but should consider using the other systems as a way to enhance a program, or push through a plateau. This mental flexibility is a critical tool for individualizing workouts and trouble-shooting exercises.

Fascial lines, the MDP, Bartenieff Fundamentals, and the Framework all offer different perspectives on the same process.

Fig. 14.2: *This exercise helps athletes understand the need to recruit spinal extensions to off-weight the shoulders enough to slide the towel forward. Meanwhile, the opposite hip helps stabilize through the functional line.*

Assessment overview

The intake assessment is as much about getting to know your athlete and his movement patterns, as it is for him to get to know you and your training style, and to understand his own baseline in the context of your methods. You will also determine the athlete's current abilities, where he wishes to be in three months and in three years. Show the effectiveness of your techniques for his goals in the hope that he "buys in" to your methods and continues his recovery with you.

The same broad approach that gives this kind of programming its wide effectiveness also makes it difficult to teach, as these strategies are best demonstrated via an in-person, hands-on context.

Fig. 14.3: *The lower-body push in the form of a bridge supports the upper-body reach overhead. You can leverage this relationship in other positions, such as quadruped rocking or pairing an overhead reach with a leg press.*