STRONGER AFTER STROKE
YOUR ROADMAP TO RECOVERY
THIRD EDITION
Peter G. Levine

Now in its third edition, Stronger After Stroke puts the power of recovery in the reader’s hands by providing simple-to-follow instructions for reaching the highest possible level of recovery. The book’s neuroplastic recovery model stresses repetition of task-specific practice, proper scheduling of practice, setting goals, and measuring progress to achieve optimal results. Researcher Peter G. Levine breaks down the science and gives survivors evidence-based tools to retrain the brain and take charge of recovery.

In easy-to-read sections, Stronger After Stroke introduces readers to leading-edge stroke recovery information while simplifying the process to attain specific benchmarks. Also included is a sample recovery schedule, a helpful glossary of frequently used stroke recovery terms, and a list of resources for readers to research emerging stroke recovery options.

The new Third Edition of Stronger After Stroke features:
• Complete update of all chapters to reflect new knowledge about maximizing recovery
• The latest research insights applied to individual recovery programs
• Steps to cope with challenges at each stage of recovery and achieve success
• DIY strategies to save time and money
• New chapters on using electrical stimulation, reducing post-stroke pain, and understanding spasticity

Peter G. Levine is a researcher, author, clinician, and science communicator, dedicated to finding and reporting on the best systems for driving post-stroke brain plasticity. Since the late ‘90s, Peter has been at the forefront of testing many of the most innovative stroke neurorehabilitation options including EMG-based gaming, wearable robotics, mental practice, functional electrical stimulation, transcranial magnetic stimulation, and modified constraint-induced therapy (mCIT). He was the lab co-director at the University of Cincinnati Academic Medical Center and a Research Associate at Kessler Institute for Rehabilitation. He continues his clinical research with The Ohio State University B.R.A.I.N. lab. Peter communicates what he’s learned in research through his blog, dozens of magazine and journal articles, hundreds of talks on stroke recovery and this book, Stronger After Stroke.
Stronger After Stroke
Stronger After Stroke
Your Roadmap to Recovery

Third Edition

Peter G. Levine
Contents

Foreword by Michelle Ploughman, BSc.PT, MSc, PhD ix
Preface xi
Introduction xvii
Acknowledgments xxiii

1. Stroke Recovery Essentials 1
   - Plan Your Work and Work Your Plan 1
   - Say No to Plateau 3
   - Use Your Fantastic Plastic Brain 6
   - A Doctor Made for Stroke Survivors 11
   - Neuroscience: Your New Best Friend 12
   - Using the Wisdom of Athletes 20
   - The Ultimate Stroke Recovery Drug 23
   - Measuring Progress 27

2. Recovery Hints and Tricks 33
   - Challenge Equals Recovery 33
   - Use What You Have 35
   - Train Well on a Treadmill 38
   - Mirrors Reflect Recovery 41
   - The Mind, the Brain, and Sticking to the Task 43
   - Let Recovery Flow 47
   - The Recovery Calendar 49
Roadmap to Recovery 52
Tips for the Caregiver 56

3. Safeguarding the Recovery Investment 59
Reduce Pain to Increase Recovery 59
Stay Off the Killing Floor 63
Reduce the Risk of Another Stroke 67
Protect Your Bones 69
Don’t Shorten 70
Shoulder Care 101 76
Five Tests You Should Do 79

4. Cool Treatment Options 83
Constraint-Induced Therapy for the Arm and Hand 83
Get Your Hand Back 91
Imagine It! 95
Electrical Stimulation for Frugal Dummies 97
Stimulate Your Stride 102
Mirror Therapy (MT) 104
Recovery of Feeling 107
Speak Musically 113
Constraint-Induced Therapy for Speech 114
You Are Game—Virtual Reality 116
The Good Trains the Bad—Bilateral Training 118
Rhythm Rehab for the Arms and Hands 121
Walking in Rhythm 123
Shocking Subluxation 125
The Neuroplastic Model for “Pusher” Syndrome 127
5. **Elements of Exercise Essential to Recovery**  129
   - Horizontal Rehab: Good Sleep = Good Recovery  129
   - Get a Home Exercise Program  131
   - Space to Recover—The Home Gym  135
   - Space to Focus—The Community Gym  136
   - Weight Up!  138
   - Bank Energy and Watch Your Investment Grow  142

6. **Recovery Strategies**  145
   - The Four Phases of Stroke Recovery—And What to Do During Each  145
   - The Subacute Phase: Recovery’s Sweet Spot  160
   - Expanding the Therapeutic Footprint  166
   - Therapy Soup—Mix and Match  171
   - Lifestyle as Therapy  174
   - Your Work Schedule  175
   - Living Recovery  177
   - Keep the Core Values Close  179
   - Hard but Safe  180
   - Eat to Recover  182
   - Make Home Movies  186
   - Don’t Neglect the “Good” Side  188
   - Guide Your Doctor  190

7. **Spasticity Control and Elimination**  193
   - Spasticity—The Beast Unmasked  193
   - Neuroplastic Beats Spastic  196
   - Spasticity, Tone, and Contracture: Even Clinicians Get It Wrong  200
   - Spasticity—Jekyll and Hyde?  203
   - Give Spasticity the One–Two Punch  205
8. **Motivation: Recovery Fuel**  
   Meeting the Challenge of Recovery  
   Be a Caveman  
   When Help Hurts  
   Reconsider Medications  
   This Just Got Real: Psychological Adjustment After Stroke  
   Fight Fatigue  
   Walking Your Way to Better Walking  
   The Young Adult Stroke Survivor (YASS): Driven to Recover

9. **Recovery Machines**  
   Those Amazing Machines

**Resources**  
**Glossary**  
**Index**  
**About the Author**
You are likely reading this book because someone you love has had a stroke, or you are researching the topic of stroke on your own behalf. Either way, you have made an important first decision: to focus on recovery rather than compensation. How are these concepts different?

If you choose compensation, you choose to use the stronger side of your body and capitalize on what you are currently able to do. A focus on recovery means that the activities you do are directed toward restoration of your former abilities. Focusing on recovery is hard work and underpins the treatments outlined in this book. Directing your energies toward recovery means that you always try to use your weaker side first. Humans are optimizers; we are successful in the world because we use the abilities we have to their full potential. It is normal to use your stronger side after a stroke; however, consider that neuroplasticity is abundant especially in the first six months after a stroke. If you repeatedly use your stronger side to complete your activities of daily living, neuroplasticity will be used to make your stronger side stronger and more coordinated, while making your weaker side weaker (a process known as learned nonuse—explained fully in this book).

As a neurological physical therapist, neuroscientist, and stroke researcher, I appreciate the quality of the message and the scope of the research distilled in this third edition of Stronger After Stroke by Peter G. Levine. Pete has provided a field manual that outlines concrete steps you can take to foster better recovery. You are unique, your brain is unique, and your stroke is unique. Read the book, consider the advice of others, and try things out. Recognize that progress may be slow and some techniques will work better for you than other techniques.

This book is a good resource for extra therapy ideas so you can capitalize on neuroplasticity. As you read and re-read sections of this book, consider the high levels of practice required to gain plasticity-driven proficiency in the movements you are practicing. Remember “practice makes permanent,”
so when well-meaning family and friends offer to help, show them this book and encourage them to join you as rehabilitation partners and movement coaches.

*Michelle Ploughman, BSc.PT, MSc, PhD*

Canada Research Chair (Tier II); Rehabilitation, Neuroplasticity and Brain Recovery
Assistant Professor, Physical Medicine & Rehabilitation
Faculty of Medicine, Memorial University of Newfoundland
I wrote this book because I couldn’t figure out why it hadn’t already been written. So much has been discovered about recovery in the last two decades, but the information wasn’t getting to survivors. If you search magazines and the Internet you might get a smattering of related information, but there was no singular source. Stronger After Stroke is a “field manual” of information unifying and simplifying most of what is currently known about recovery. The word most is emphasized because one of the clear messages of this book is held within the proverb: “Give a man a fish, feed him for a day. Teach a man to fish and feed him for a lifetime.” Recovery requires knowing the latest and greatest research. The Resources section includes quick and easy ways of discovering what is new and effective in stroke recovery research.

Billions have been spent on stroke recovery research. You should benefit.

The first edition of Stronger After Stroke (2008) had a simple message: When it comes to recovery, stroke survivors are in control. Only survivors can leverage the power of brain plasticity for recovery. Stronger After Stroke wasn’t the first source to advocate a “neuroplastic model of stroke recovery.” It was, however, the first to pull the idea from scientific journals and books, explain it so everyone could understand it, and bundle it with tools survivors could use. The second edition expanded the same theme. This third, fully revised and updated new edition continues this tradition with new insights from psychology, psychiatry, rehabilitation science, exercise science, and, most importantly, neuroscience. But don’t blink. Scientists from around the world are adding their voices and expanding our understanding of how to rewire to recover. To catch a glimpse of this ever-expanding perspective, have a look at this book’s companion website (Google: Stronger After Stroke blog.)

Beyond the science, there is a very human aspect to the information in this book. I have done hundreds of talks across the United States, many at the most respected rehabilitation hospitals in the United States. Ideas are
exchanged with thousands of therapists during these talks. Many of the ideas in this book reflect those discussions—their best ideas for recovery, presented to you.

It is clear that stroke survivors have taken the message this book presents to heart. And the message is spreading—since the first edition it has been translated into several languages. *Stronger After Stroke* has also changed the way stroke is talked about, and it’s easy to track its influence. Prior to the publishing of the first edition, people who had a stroke were written about in the press (popular and scientific) as either patients or victims. When I wrote the first edition I knew many survivors who were neither patients nor victims, and reflected that by exclusively using the word survivors. Now survivors are almost always referred to as survivors. There have been other concepts from *Stronger* that have been generally accepted by both survivors and clinicians. Some examples are deemphasizing the plateau, focus on brain plasticity, the neuroplastic model of spasticity reduction, etc.

There has been another phenomenon surrounding this book as well: plagiarism. Either word for word plagiarism, or as a sort of reverse engineering of the whole sections of the book. Even the title has been ripped off. Since the first edition the Journal of the American Academy of Neurology, University of Tennessee Medical Center, and Emerson Hospital, and many others have all called articles in print or on line “Stronger After Stroke.”

The fact that this book has a big footprint is a good thing because I have only one hope for this book.

I hope it helps.

**HOW FASCINATION WITH THE BRAIN HAS HELPED SURVIVORS**

Hippocrates was the first to define stroke—2,400 years ago. For most of the time since, rehabilitation was a patchwork of techniques based on clinical expertise and educated guesses. Within the last couple of decades, these techniques have been forced to give way to rigorous scientific consideration. Sheer curiosity has driven scientists to stroke recovery. Recovery from stroke provides a unique perspective on the capability of the brain. And that’s the hook: Science finds the brain a world of wonderment. At the same time,
a huge amount of other (non-stroke) brain science research is going on. This research, into the brain and into recovery from brain injury, will rapidly continue to provide new insights. In the meantime, the extent to which the brain is able to rewire is not yet known. What we do know is that every time the brain is asked to do extraordinary things, it responds. That’s the good news. The bad news is that the response takes a tremendous amount of hard work. This book celebrates and gives the scientific justification for that hard work.

THE SUPER-SURVIVOR

Every stroke survivor has a certain level of potential recovery. Few reach that potential. Stroke survivors who do reach their potential do so because they have no choice. This breed of “super-survivor” is so unwilling to let go of career independence, personal passions, family commitments, and so on, that they are compelled to recover. They intertwine recovery with what they love to do. Sometimes recovery is so much a part of what they love doing that they don’t even notice they’re recovering.

For the super-survivor, recovery is a vision quest. The challenge of recovery is no different from other challenges they’ve conquered in life. They get on with it. They put in the time. They fall in love with the process. It’s much the same reason athletes, dancers, and musicians are driven to always get better. Stroke survivors who recover the most see the process of recovery as an opportunity for growth.

This book is not for stroke survivors who are okay with where they are. This is a book for stroke survivors who want to get better.

If you are not a stroke survivor, this book may have meaning for you as well. The same thing that drives recovery from stroke can drive any form of learning. Learning involves the most important scientific discovery since fire: neuroplasticity. Humans have always used their plastic brain. But the discovery of how the brain changes allows us to wonder: How much more can we make it change? How plastic is it? Answering these questions will help develop the best ways to recover from stroke. It will also help anyone trying to learn any new skill.
NEUROPLASTICITY AND HOW SCIENCE GOT IT WRONG

In the mid-1800s, scientists began mapping the brain. Each portion of the brain was sectioned off. Each section was proclaimed as the only possible site for everything—from the ability to do math to wiggling your toes. One section, on the left side of the brain, always controls speech. Another section, near the top of the brain, controls the hand. The back of the brain processes vision; the front solves problems. These early attempts defined the brain as static. Sure, in our youth, perhaps before five years old, there were some changes in the brain. But after that initial wiring the brain was fixed, frozen, and locked. This was bad news for stroke survivors. What happened if the stroke killed the language portion of the brain? Because science thought the brain unchangeable, attempting to use different parts of the brain for language was, well … unthinkable. Once language, or limb movement, or sensation, or anything else was knocked out by the stroke, it was gone. Forever.

There is good news, however: These early attempts to define the brain were wrong.

Scientists had a “mechanistic view” of the brain. Galileo and Copernicus had mechanized the heavens and Leonardo da Vinci had mechanized pretty much everything else. Our fascination with machines profoundly influenced our study of the human body. Scientists viewed the body as a machine, with smaller machines inside. Muscles were pulleys, bones were levers, the kidneys were filters, the heart was a pump, and so on. Certainly the brain was some sort of machine as well. Scientists tended to compare the brain to whatever the latest technology was: “The brain is like a clock.” “The brain is like an engine.” “The brain is like a calculator.” Whatever the latest technology was, that’s what the brain was like.

And then, in the mid-1900s, scientists started to realize that the brain did not operate like any other machine. Consider computers. If you ask two identical computers to do the same thing, they’ll do the same thing in exactly the same way over and over and over again. But if you asked the same person the same question, once on Monday and once on Wednesday, they may very well give you different answers. They’ve “changed their mind.” That change was actually a physical, measurable change in the brain. Neurons change structure and/or function.
Most of the work challenging the idea that “the brain is just another machine” came from neuroscience. Neuroscience studies the entire nervous system but is fascinated with the brain. Neuroscientists are especially interested in developing and testing ways of rewiring the brain neuroplastically. And this is good for folks that have brain injury, including stroke. Neuroplasticity is at the core of recovery. Neuroscience will lead the way in developing systems to drive neuroplasticity.

The ability the brain has to change, the ability to learn, comes at a cost. Our brain is inconsistent. A computer might always express $A = B = C$. We might say “$A = C$ but I left out $B$ because I’m in the process of adding $D$.” As neuroscientists Sam Wang and Sandra Aamodt put it, the brain is less like machine and more like a busy Chinese restaurant. If you’ve ever been in a crowded Chinese restaurant, it’s chaos. Some people are getting their orders taken, other people are being seated, orders are being yelled, food is being eaten, and plates are clanging.

But everything gets done.

Your brain is less like a computer and more like a busy Chinese restaurant. As new connections between neurons are made in the brain, different answers, different perspectives, and different solutions to problems are created. What we lose in the linear ($A$ always $= B$, which always $= C$) we gain in the ability to do what other machines can’t: Learn. And that’s the point: Brains change, machines don’t. As you read this book you may associate exercise with neurons and neurons with recovery and recovery with your own personal story. The brain can associate anything with anything else. Machines can only associate what you tell them to associate. Simply, brains learn, machines don’t.

NEUROPLASTICITY: SIMPLICITY IN A BOX

The brain can be rewired and, under certain conditions, radically rearranged. It turns out that the brain, 100 billion neurons strong, can be changed into whatever kind of tool we want. And there is more good news: Some of the best tools needed for rewiring the brain after stroke are very simple. Although the brain is the most complex entity in the known universe, it responds and rewire according to simple instructions. All a person needs to change his or her brain is a whole lot of focused and dedicated practice. And it happens fast.
Large portions of our brains can be rewired in a matter of hours, days, or weeks. Understand: This is not some sort of vague “new-age” concept; this is an actual physical event, measurable by brain-scanning technology. From learning to control emotions to hitting a baseball, the core of change involves rewiring the brain.

You might suspect that there is a bit more to it, and there is. While the idea of “practice makes perfect” is simple, how to practice is more complicated. This book defines the elements needed to drive neuroplastic change.

Beyond focused and dedicated practice, rewiring the brain also involves another rather large pink elephant in the room: motivation. Neuroplasticity takes a tremendous amount of work. It does not necessarily involve a long period of time, just a lot of focused effort. Your hard work is the most essential aspect of successful recovery. Clearly, the most important person involved in the recovery from stroke is the survivor. Much of the work can be done at home with help from family and friends while under the guidance of doctors and therapists. While clinicians are essential to the recovery process, you and your caregivers should not wait for health professionals to chaperon you toward your highest level of potential recovery. There is no doctor, therapist, minister, guru, or shaman in a better position to run your master recovery plan. There is no one who cares as much. Accept the challenge, empower yourself, focus on recovery, work hard, don’t give up, and watch an upward spiral emerge that allows for the highest level of recovery.
Introduction

We are what we repeatedly do.

—Aristotle

In the last decade or so, stroke-recovery research has focused on a few basic core concepts. Understanding these building blocks of recovery will help you decide which of the growing number of treatment options is right for you. All of the following will provide insight into developing a great recovery plan.

ELEMENTS ESSENTIAL TO RECOVERY FROM STROKE

Mixing the following elements has been shown to the drive neuroplastic (brain rewiring) change necessary for recovery:

Repetitive. Pick options that use repetitive practice. Movements that you want to relearn should be performed over and over. For instance, if you want to lift your foot better, then you would concentrate on doing that movement repeatedly and with the highest possible quality of movement. Use of repetition requires “nipping at the edges” of your current ability. With each attempt, try to extend beyond your present ability a little bit more. Repetitive practice changes the part of the brain that controls movement. But how many repetitions are needed to change the brain? Let’s consider elbow extension (going from the elbow bent to the elbow straight). Approximately 1,200 repetitions are needed to make the brain better at controlling that movement. Not perfect, but better. And that’s for a single-joint movement.

Most of the movements we make involve many joints moving in a variety of directions. So how many repetitions are needed to do complex “every day” movements? The number of repetitions needed gets very large very quickly. Most practical everyday movements will require tens of
thousands, if not hundreds of thousands, of repetitions. This is one of the reasons that working only when a therapist is around is not practical. There is simply not enough time with therapists to accomplish the number of repetitions needed.

**New and Challenging.** Work on movements that are novel (new) to you. Of course, the movements are not really new. You may have been doing the movements for 50 years prior to your stroke, but it is considered novel if it has yet to be learned since your stroke. Researchers use the word “novel,” but a better word may be “challenging.” Focus on relearning challenging movements. Attempting movements that are too easy will not help you recover. As soon as you can perform a movement at a quality that reaches about 80 percent of your pre-stroke ability, move on to something new and challenging.

**Meaningful.** Neuroplastic (brain rewiring) change is much more likely to occur if the movement you are trying to relearn is part of a real-world task. The task has to be meaningful (important, essential, engaging) to you. The more important the task is to you, the more it will drive recovery. For instance, if you are trying to regain the ability to pick up objects, make it part of a real-world task that is meaningful to you.

Use what you care about to drive recovery. Recover to do what you care about.

If you love to paint, practice picking up a paintbrush. But what if you can’t pick up a paintbrush? You only need to practice a portion of the task. It is not necessary to have the ability to accomplish the entire task to make it task specific. If the task is picking up a paintbrush, you may only be able to get the hand to the table but not be able to actually grasp the brush. As you bring the hand up to the table, have the paintbrush there to provide a meaningful goal.

**THE P.E.N.S. CONCEPT**

The P.E.N.S. concept provides an effective way to decide whether or not an option is worthy of consideration. It includes:
P is for *Patient driven*.

- Can you do the therapy by yourself, or does it require supervision?
- Is it intuitive, or does it require a lot of training? Is it expensive or is it affordable?
- Is it available in your area or do you have to travel to get to it?

Lean toward options that have the potential to be used at home, relatively easily, and with little cost and set-up.

*E* is for *Evidence based*. Has the option been researched? The amount of scientific testing of recovery options is highly variable. Some …

- Have never been tested
- Have been tested in small, poorly run studies
- Have been tested by people who will make money if the product sells
- Have done poorly in well-run studies
- Have done poorly in multiple well-run studies
- Have done well in well-run studies
- Have done well in multiple well-run studies

When researching the recovery option, ask the question: Did it shine or was it a lemon? In the Resources section of this book there are websites and other sources of information to help you pick and choose.

*N* is for *Neuroplastic*. Does the recovery option promote neuroplastic change? That is, will it rewire the brain in a way that helps recovery? The problem is, science may not have yet proven that the option you’ve chosen actually rewires the brain. There are few recovery options that have been tested this way. Try to determine if the therapy has all the earmarks of neuroplasticity included in Essential Elements of Recovery From Stroke, discussed previously.

*S* is for *Simulations* vectors. This is a fancy way of saying, “Consider multiple options as you plan your recovery.” There is no one magic bullet for stroke recovery. Therapists tend to use a small group of therapies that they know well. Researchers tend to focus on a small group of related treatment options. Both therapists and researchers bring important perspectives to stroke recovery.
But in some ways, both lack a sufficiently broad perspective. When stroke recovery is viewed globally, a hidden secret emerges: It’s not anything, it’s everything. Imagine stroke recovery as a picture puzzle. Solving the stroke-recovery puzzle involves using the puzzle pieces (recovery options) to build as complete a picture as possible (recovery). If the puzzle is done correctly, the highest possible level of recovery is achieved. The stroke-recovery puzzle has two added dimensions that picture puzzles don’t:

1. The number of pieces (treatment options) is continually changing. This is a result of increased research, including research of new technologies. At the same time, research is sifting out other, ineffective treatments.
2. The background picture (where you are in the recovery arc) changes.

Figuring out . . .
• what puzzle piece fits
• when it fits
• and how it fits

. . . is essential to an effective recovery plan.

GOOD NEWS AND BAD NEWS

Recovery takes hard work and commitment. It’s not easy. It will most likely be the hardest thing you’ve ever done. But the process is simple.

• The bad news: Recovery takes a lot of hard work.
  Note: If someone is telling you that they can help you recover without hard work, grab your wallet and leave!
• The good news: The process of recovering from stroke is both intuitive and simple.
  Note: If someone is telling you to do something to recover but they can’t explain why in simple language—it is cause for suspicion!

ONE LAST BIT OF HOUSEKEEPING . . .

While limbs on one side of the body are most impacted, research has found that all four limbs are affected by the brain damage caused by stroke.
Because all four limbs are affected, researchers use the terms “more affected” and “less affected” when describing the relative deficit in the limbs after stroke. Please note that for the sake of brevity and simplicity, this book sometimes uses the following terms:

- “Bad”—the limbs more affected by the stroke.
- “Good”—the limbs less affected by the stroke.

These terms are not meant to reflect the potential for recovery, nor the relative importance of the limb.
Acknowledgments

I would like to thank:

All the stroke survivors and caregivers I’ve communicated with over the past two decades. Successful survivors hold the key to recovery.

My wife, Aila Mella, who has had a profound influence on this book. Aila was one of my clinical instructors back in school and has continued to teach me through the many, many conversations we’ve had about stroke recovery and rehabilitation.

Dr. Stephen J. Page, my friend and colleague, who helped forge my perspective on stroke recovery and has provided the tools and support to everyone in our lab who has worked toward developing novel ways to help survivors recover. Steve has been our lab’s fearless leader from the early days at the Kessler Institute, through the early 2000s at University of Cincinnati, right up to the present at The Ohio State University.

The members of the Kessler Rehabilitation’s Human Performance Movement Analysis Lab, for teaching me the nuts and bolts of clinical research.

The scientists that helped all of us “connect the dots” between the many branches of science and stroke recovery, including Karl Lashley, Vilayanur S. Ramachandran, and Alvaro Pascual-Leone. Special thanks to Signe Brunnström, Edward Taub, Michelle Ploughman, and Jeffrey Klein, for laying bare the connection among neuroscience, psychology, and the therapeutic interventions that drive recovery.

Occupational therapist Aimee Fay for helping me understand the impact of psychosocial problems after stroke on physical recovery.

My mom, Rosemarye Massa Levine, and dad, Martin Levine, for encouraging and supporting me during all of my education.

My children, Emma Maria Levine and Jesse Martin Levine, because work is best done when it is balanced with what children bring: Fun!
Stronger After Stroke
Share

Stronger After Stroke: Your Roadmap to Recovery, Third Edition
1 Stroke Recovery Essentials

PLAN YOUR WORK AND WORK YOUR PLAN

Every great journey starts with a great plan. An ambitious recovery plan is vital to your recovery. The plan begins to evolve in the hospital, right after the stroke, and it continues to develop during your time in:

- Skilled nursing facilities
- Rehabilitation hospitals
- Outpatient clinics
- Home therapy

The early portion of the plan is easy because therapists are developing and implementing the plan. What do you do after occupational, physical, and speech therapies have ended? Stroke survivors typically face the rest of their lives, and the rest of the struggle toward recovery, with no formal recovery plan. Once the standard therapies have ended, the power of your plan becomes even more vital. This is a critical time in recovery. There are three options you can choose from:

1. You believe that, because your therapy has ended, your recovery has ended.
2. You are willing to continue your recovery, but you are not sure what to work on. You decide that you’ll join a gym and see what happens.
3. You develop a plan that takes you to the highest level of recovery possible. You know that your plan will change over time. Your plan has built-in goals. Achieving goals gives rise to new goals and new achievements. This forces an upward spiral of recovery.
How Is It Done?

A powerful and successful recovery plan will:

- **Be measurable:** The recovery plan includes specific goals and landmarks that represent breakthroughs in the recovery process. These breakthroughs are predicted by the plan. The same way coaches set goals for athletes, your plan should set goals that promote recovery. Examples of measurable goals include:
  - “I will be able to walk fifty yards at my daughter’s wedding in three months.”
  - “I will be able to use a fork and knife by Christmas.”
  - “I will be able to pull rope, hand over hand, on my sailboat by next summer.”

- **Be flexible:** Stroke recovery involves a constantly shifting set of opportunities. The choice of recovery options and exercises that you’ll use will change as you recover. A flexible recovery plan allows for quick adjustments to promote further recovery. For instance, consider the goal, “I will be able to pick up a cup with my bad hand.” Once you are able to do this, the plan is adjusted to provide a new challenge (e.g., “I will be able to pick up and drink from a cup”). The goal is made more difficult to promote even more recovery.

- **Encourage self-reliance:** Focus on recovery techniques that you understand and can carry out yourself. When you can perform the recovery technique without the aid of a clinician, you provide yourself with more opportunity to recover. Promoting self-reliance allows you to recover even after formal therapies have ended. This do-it-yourself spin on recovery allows you to take control of the process.

- **Include short- and long-term goals:** A short-term goal is to walk ten feet. A long-term goal is to walk without a limp. The long-term goal is made with the series of short-term goals in mind. As a metaphor, the long-term goals are the blueprints for a house made of brick. The short-term goals are bricks.

What Precautions Should Be Taken?

Any plan should be done within parameters of safety. Consider the examples, “I will be able to walk a quarter mile in ten minutes, and I will accomplish..."
this by Christmas.” Walking long distances has obvious inherent risks. On the other hand, a goal like, “I will be able to open my hand enough to grasp a cup handle within the next month” may rely simply on repetitions of opening and closing the hand, and so contains little risk. “Safety first” is essential to the recovery process, because nothing stops recovery like an injury.

**SAY NO TO PLATEAU**

Therapists will stop treating you when they can no longer measure improvement. This lack of progress toward recovery is commonly called a plateau. Plateau means “flattening out.” If you have “plateaued” it means that, according to clinicians, you are not getting any better. If it is determined that a survivor has plateaued, most insurance coverage ends. From the survivor’s point of view, the act of ending treatment too often says “That’s it. You won’t get any better.” In many stroke survivors, this has an unfortunate dual effect. First, the end of therapy means the end of the support, guidance, and expertise of therapists. Second, saying that a stroke survivor is no longer making progress often (but thankfully not always) becomes a self-fulfilling prophecy. The stroke survivor thinks, “The professionals who know the most about stroke recovery believe that I’m not going to get any better. I guess that’s all I can expect.” This assumption is not correct. There are several reasons for mistaken assumptions about when recovery has ended.

- Some healthcare professionals suggest that during the chronic phase of stroke (usually defined as starting three months after stroke), no further recovery can be made. The truth is that stroke survivors can continue to make progress years, even decades, after their stroke.
- A process known as learned nonuse (described fully in the section Constraint-Induced Therapy for the Arm and Hand in Chapter 4) may have taken place during the subacute phase. Learned nonuse is reversible, even during the chronic phase.
- To save money, payers (insurance, Medicare, etc.) put pressure on therapists to end therapy as soon as possible. Therapists would prefer to treat stroke survivors for longer periods, but they cannot. The result is that therapy is usually ended before the fullest possible recovery is realized.
- The tests that therapists use are often not sensitive enough to detect small but important changes in recovery. For instance, tests of spasticity
and reflexes can indicate progress toward recovery, but these two tests are rarely done in therapy settings. Other tests that are “stroke specific” (tests that are used only for stroke) are usually not done. These tests can detect small but important advances in recovery. So the question is: Is there really no progress, or are the wrong tests being used?

• Simply, your recovery could progress, but the most effective recovery options are not used. Clinically, these options may not be used for one of the following reasons:
  — Lack of therapist training in the new therapy
  — Lack of support for the therapy by the rehabilitation facility
  — Payers do not pay for the therapy
  — Clinicians are unaware of the therapy
  — The therapy does not make a profit

• Survivors and their families often push for release from the rehab facilities as soon as possible. Therapists are sensitive to this. Therapists work to help patients get as safe and as functional as quickly as possible. Rushing the survivor through the system means:
  — Less time is spent recovering
  — Less guidance is available
  — Less recovery is attained

• Therapists focus on helping you become functional and safe. **Functional** is defined as the ability to do useful or practical activities. For instance, if you can dress yourself, even if you don’t use your “bad” arm and hand, you are considered functional in dressing. Walking safely, even if it involves a cane and orthosis on your foot, is considered functional walking. Being functional will get you home and help you get on with your life. But being functional does not usually represent the highest possible level of recovery you can achieve.

  Achieving the highest possible level of recovery requires extending beyond functional ability.

  The word **plateau** has been used by clinicians to describe the point at which “no further recovery can be made.” But not everyone considers a plateau a negative thing. Athletes have used the word for decades. A plateau to an
athlete is different from the way plateau is used to describe the end of recovery after stroke. Athletes define a plateau as a point in their training where their present training techniques no longer help them get better, stronger, or faster. Athletes respond to a plateau by trying new strategies to improve their ability. Stroke survivors should view a plateau the same way athletes do—as an opportunity to re-evaluate and modify the recovery plan.

How Is It Done?

Many of the suggestions in this book can help you overcome temporary plateaus. But the most important suggestion is this: Assume that there will be no lasting plateau. Assuming no limits to recovery may be optimistic, but it allows for the largest opportunity for the highest level of recovery. If you want to get better, assume you will return to the same level of ability you enjoyed prior to the stroke. You may not achieve full recovery, but you’ll still have extended further than the supposed plateau.

If your recovery efforts are not producing results, a temporary plateau will follow. When this happens, and it will, do what athletes do and change your training techniques. Athletes look at it this way: “I’ve been using training technique ‘X’, and it’s been great. ‘X’ got me this far. But now I’ve plateaued. If I continue with ‘X’, the plateau will continue. But if I change my training, I may be able to achieve a new, higher plateau.” Survivors can look at it the same way. The same strategies will yield the same results. New strategies will yield new results. Challenge your physiatrist and therapists with suggestions of techniques, treatments, and technologies that you find during your research. If you see something that you think might work, ask these clinicians to use them. Remember: Therapy was most likely stopped because these health professionals believed that recovery ended. If therapists just continued to use the same techniques, then, indeed, you would not improve further. The same techniques will likely generate the same results.

In your own attempts toward recovery, look for new recovery options that might work.

There is another benefit to exceeding a plateau on your own: Progress can be used to justify more funding for therapy. Remember, discharge from therapy happened because no progress was being made. If you can show that progress has been made—on your own, since the discharge—insurance will view this change in status as a trigger for more therapy.
What Precautions Should Be Taken?

There are some instances where stroke survivors cannot achieve any more movement than they have at a given point in time. This is usually the case only when the stroke survivor does not have the mental capacity to try.

USE YOUR FANTASTIC PLASTIC BRAIN

Here are a couple of “mind blowers”: The human brain is the most complex structure in the universe. There are approximately 100 billion neurons (nerve cells) in the brain.

But that number is small compared to the number of connections between neurons in the brain. The present estimate of connections between neurons is an astounding quadrillion (a thousand trillion). But that vast number is not set in stone at birth; the number of connections can be radically increased. Anyone can increase connections at any time throughout their life, well into old age. This is usually done by learning something substantial and new.

Recovery from stroke often involves increasing the number and quality of these connections in the brain. Increasing the number of connections is determined by the hard work of the survivor. Forging new connections between the neurons that survive the stroke is the basis for much of the recovery from stroke.

Recovery will naturally follow from working with the one organ damaged by the stroke and from which all true recovery comes: the brain. In order to recover, stroke survivors have to rewire their brains. The technical term is neuroplasticity.

Neuroplasticity is a long word that, like so many medical words, can be broken down to determine the meaning. “Neuro” basically means having to do with nerves. The second half of the word is plasticity (from the Latin plasticus, which means molding). The root word is plastic. Plastic, when it is heated, becomes flexible and can be molded into almost any shape. Neuroplasticity allows the brain, within limits, to be quickly and massively remolded.

Neuroplastic change happens in all of us, all the time, and happens without us knowing a neuron from a necktie. Harnessing and directing the power of plasticity is the focus of most of modern stroke-specific rehabilitation research.
One of the proven ways to rewire the brain is called **repetitive practice**. Repetitive practice involves repeatedly practicing a movement, even if you can only do a small part of that movement.

One of the things that stroke survivors often ask is, “How many times do I have to attempt a movement before I see improvement?” Or, “How many repetitions do I have to do before I rewire my brain?” Survivors and therapists will often ask the “How many?” question of researchers that work in rehabilitation research. Therapists have a good reason for wanting to know this number: They have limited time with the survivor before they discharge the survivor from therapy. So knowing a specific number of repetitions helps the therapist know the number of repetitions—per session—that the survivor would have to do to recover.

For a long time, those of us in research didn’t know the answer. We would say things like “A lot,” and “As many as you can do.” The problem was, we only had good data for people who had learned how to move really well. Included would be professional musicians, cigar rollers in Cuba, carpet weavers in Iran, and college and professional athletes. How many repetitions do those people need? To become a high-level expert at something (e.g., a professional basketball player, carpet weaver, or musician), the number of repetitions needed are in the millions. You cannot tell a therapist that they should have survivors do millions of repetitions. The therapist will look at you cock-eyed and (sometimes politely) ask. “Do you know where I work? Sometimes I have problems getting survivors out of bed!”

But then we were saved! There is a certain breed of therapist that goes back to school and gets a PhD in neuroscience—the branch of science that studies the brain. These therapists have one foot back in the clinic (they are often therapists at heart). And because of their doctorate in neuroscience, they know a lot about the brain. And these therapists have done experiments to try to figure out the “How many repetitions are needed to recover?” question. These researchers will scan the brain and measure movement as the survivor adds more repetitions. So what did they find out? How many repetitions do survivors need?

Let’s put it this way: There is some good news and some bad news (and some more good news):

**Good news:**

The number of repetitions needed for a survivor to get better movement at one joint: approximately 1,200. Note that the actual number will be different for every survivor. The 1,200 number is the average,
Bad news:
The average number of repetitions a survivor does during an hour-long session with a therapist: is 25 to 35.

More good news:
Studies have shown that if the therapist and survivor focus only on repetitive movements during an hour-long session, the numbers can get real high real fast—in the 300 to 500 range. Survivors, working on their own, within the limits of safety, can reach very high numbers as well.

But there is a bit more bad news. Computing the number for stroke survivors is tricky. Let’s consider the “1,200” number. That number was found to be true for one movement at one joint. That is, in order to change the brain enough to make just one movement better, you would need 1,200 repetitions. Consider dorsiflexion (lifting the foot at the ankle). This movement is essential for walking. In order to gain more dorsiflexion, a survivor would need to do (approximately) at least 1,200 repetitions. But that’s just for that one movement at that one joint. Walking involves many movements at many joints (technically known as “multi-joint, multiplanar movement”). And all the other joints—besides dorsiflexion—in all the other planes (directions) would also have to be practiced repeatedly. This is why the number of repetitions for most functional movement (like walking, dressing, eating) is both large and difficult to estimate.

- **The number of repetitions is large** because many joints move in many directions in order to do common tasks.
- **The estimation of the number of repetitions is difficult** because the number of repetitions would be “survivor specific.” That is, every survivor, given their unique deficits, would require a different number of repetitions.

The number varies for each survivor depending on:

- The complexity of the movement to be relearned
- The amount of movement currently available
- The intensity and focus with which the repetitions are done
- The age of the survivor
- The health of the survivor besides the stroke
- And so on (the list of variables that can impact the number of repetitions needed is long)
How Is It Done?

You are the only person who can rewire your brain. The best therapist in the world can’t do it for you. Neuroplasticity, and the recovery that results, emerges from the inside out. The more focused repetitions of a movement the more the brain has a chance to rewire, reconfigure, and rebuild.

Neuroplasticity happens fast. There are classic scientific experiments that prove that large portions of the brain can be rewired with little more than four days of dedicated work. There is a catch, however. Rewiring the brain after stroke requires hard and focused work. Some stroke survivors may not have the cognitive ability or the mental focus required to rewire their brains using neuroplasticity. This is the case only if the stroke survivor has lost the ability to try.

Neuroplastic change happens to all of us, all the time. The smallest event—from humming a tune to catching a set of keys—will cause neuroplastic change. However, if a skill is developed with the right intensity, it will promote lasting change in the brain. The saying among scientists who examine how the brain works is “neurons that fire together wire together.” Here is how this concept works. Imagine you are standing on the beach, ten feet from the water’s edge. You have a bucket of water, and you pour the water toward the ocean. You pour the first bucket of water. It flows a few inches and then becomes absorbed by the sand. The second bucket travels a foot or two. The third bucket extends even farther. After a few more buckets of water, you have formed a creek to the ocean. All the water that you pour then flows easily to the sea. Neurons (nerve cells) in the brain work much the same way. Every time you move, you forge new connections to make that movement easier and easier until you can perform the movement without thinking. Neuroplastic change is the result of the same set of neurons in the brain firing, over and over, in the same way.

The process needed to rewire your brain does not need to be fully understood to benefit from its power. Simply, the brain can be treated like a “black box.” If you put in the right kind of focused, repetitive effort, you get out better movement. It is the movement of different parts of your body that rewires the brain. That is, actively moving your limbs, mouth, trunk, and so forth, will rewire the brain. In this way, movement of the body rewires the brain, and rewiring the brain makes movement better. A virtuous circle!

How do you know your repetitive practice is working? Increased coordination will be the proof positive that your brain is being rewired. This
is why accurately measuring progress by testing the amount and quality of movement is so important. If there is neuroplastic change, that change will produce better movement. The better the movement, the more the brain has rewired.

Neuroplasticity is something that musicians and athletes use all the time. And the way musicians, athletes, and stroke survivors access neuroplasticity is exactly the same: focused practice. The same efforts that help athletes and musicians become the best they can be can help stroke survivors rewire their brains to navigate around the area of brain tissue killed by the stroke. If enough of this rewiring occurs, the stroke survivor can make progress, even when in the chronic phase (sometimes defined as more than three months after stroke) of recovery. Scientists, with the aid of brain scanning technology, have proven that the brain can rewire. Other tests including kinematics, kinetics, electromyography, and other outcome measures have been used as well. All of these tests have shown a direct link between brain rewiring and improved movement and function.

The trick to rewiring the brain after stroke is finding recovery options that promote neuroplastic change. The tools that rewire the brain range from highly sophisticated robots (i.e., recovery machines; see Chapter 9) to simple repetitive and demanding practice. Other brain rewiring strategies outlined in this book include:

- Bilateral training (see the section titled The Good Trains the Bad—Bilateral Training in Chapter 4)
- Constraint-induced therapy (CIT; see the section in Chapter 4 titled Constraint-Induced Therapy for the Arm and Hand)
- Mental practice (see Chapter 4, the Imagine It! section) will drive rewiring of the brain
- Electrical stimulation (see the section Get Your Hand Back in Chapter 4)
- Mirror therapy (see Chapter 4, the section on Mirror Therapy)

### What Precautions Should Be Taken?

The level of commitment needed to rewire your brain requires the guidance of your doctors, nurses, and therapists. Safety is essential. Many of the concepts in this book ask for an increased amount of time, effort, and repetitions of movements. These efforts, in turn, require increased muscle, heart, and
Neuroplasticity is fatiguing because it is a physical process in the brain. Bluntly, learning to move better after stroke—called motor learning—is fatiguing. But rewiring the brain also involves working weak muscles. So rewiring the brain involves fatigue from both building your muscles and changing your brain. Fatigue can lead to unsafe efforts and unsafe decision making. Be careful as you change your fantastic plastic brain.

A DOCTOR MADE FOR STROKE SURVIVORS

There are many types of doctors that can help folks that have had stroke—from neurologists to primary care physicians. But there is one kind of medical doctor who has specific training in stroke recovery: physiatrists (fizz-EYE-uh-trists). Their medical training and special knowledge of stroke recovery make physiatrists vital to the process of recovery.

Physiatrists are often called “stroke doctors” because they are the medical professionals that patients most often associate with treatment for impairments caused by stroke. Physiatrists:

- Know the latest stroke-related medical treatments and will be able to prescribe the most appropriate medications
- Do special testing that will help determine where you are in recovery
- Are able to design a recovery plan that focuses on the medical side of recovery, including spasticity reduction and pain control
- Have a large number of tools at their disposal to help foster the continuation of recovery from stroke

How Is It Done?

After their therapy ends, most stroke survivors never visit a physiatrist again. In fact, most stroke survivors don’t even remember what a physiatrist is a few years past their stroke. Because of this lost relationship, survivors are unaware of years of medical advancements that can impact their recovery. I even have a joke about it: When a stroke survivor is asked, a couple of years after his stroke, who his physiatrist is, he says, “There’s nothing wrong with my feet!”

Ask your primary care physician for a referral to a physiatrist. Get recommendations from other stroke survivors. Look for an aggressive
physiatrist who is willing to work with you as you actively strive toward full
recovery. Visiting a physiatrist can help set up an upward spiral in your recov-
ery. For instance:

- You visit a physiatrist.
- The physiatrist treats your spasticity.
- Since your spasticity has reduced, the physiatrist writes a prescription
  for therapy to help build on movements unmasked by your newly
  loosened muscles. A visit to a physiatrist will often trigger a prescrip-
tion for more therapy.
- The reduction in spasticity combined with therapy leads to recovery
  of lost movement.
- Recovery of lost movement allows you to challenge yourself with
  other new movements.

There are several other reasons to see a physiatrist that may or may not
be directly related to recovery from stroke. The following should automatic-
ally trigger a visit to a physiatrist:

- Pain that limits the ability to move or function
- Spasticity that makes a limb hard to move
- Falls
- Loss of normal bowel and bladder function

What Precautions Should Be Taken?

When talking to a physiatrist, listen to everything suggested, but also guide
the doctor toward what you specifically want to accomplish. For instance, say-
ing, “I want to be able to open my hand” is more effective than “I want to
move better.”

NEUROSCIENCE: YOUR NEW BEST FRIEND

The last couple of decades have produced an explosion in our understanding
of stroke recovery. Because of the overwhelming interest in the brain (stroke
is brain injury), many branches of science have lent their skill and energy to
the question of stroke recovery. From exercise physiology to psychology, from
electronics to genetics, interest in stroke recovery has radically broadened. But of all the branches of science that have lent their voices to this discussion, one has had the most impact: neuroscience. Neuroscience is very interested in brain plasticity. The ability for the brain to remake itself is the focus of much of neuroscience. Everyone has a brain, but we’re not sure of the best ways to change it. Finding the best ways to change it is what neuroscience aims to do. Neuroplasticity (the ability for the brain to rewire according to the will of its owner) can be defined in another, much simpler word: learning. So neuroscientists are interested in learning. And learning to move after stroke (called motor learning) is interesting to neuroscientists because it provides a unique window to all learning.

Stroke survivors often lose a part of the brain that controls movement. Stroke survivors can be tested to determine which recovery strategies help survivors move better. But there is a problem. Just because science says something works doesn’t mean that it will be used. Researchers call this “a lack of transition from benchside to bedside.” Researchers lament that what research reveals “benchside” (in laboratories) is not necessarily being used “bedside” (treatments that stroke survivors are actually receiving).

Science is still discovering the extent to which the brain can rewire. But there is one thing we’re sure of. *Given the right circumstances, the brain can radically rewire over a very short period of time.* What science has learned about the plasticity of the brain is good news for stroke survivors. Despite all we’ve learned, however, clinicians treating stroke survivors don’t necessarily view stroke recovery as having anything to do with the brain. Since clinicians can’t typically see the brain rewiring, they focus on what they can see. Clinicians usually look at stroke patients in terms of “functional ability” (ability to do everyday tasks). Typically, the goal of stroke rehabilitation is simple: Get survivors as functional as possible, and get them “home” as soon as possible. This focus on function is not just practical, it’s what managed care (insurance) is willing to pay for.

There is a downside to this focus on function, however. Function does not equal recovery. For instance, a survivor could put on his shirt and pants without moving his affected arm at all. Function does not necessarily reflect what’s going on in the brain.

Consider this thought experiment. “Tom,” a survivor, had his stroke six weeks ago. He is in a rehabilitation hospital getting therapy from great therapists. However, the therapists have noted a “stalling” of his progress. His occupational and physical therapists agree: Tom is making little progress.
Typically, if a patient has stalled in their recovery (called a **plateau**) the patient is discharged. Since Tom is no longer making progress, therapy must end. The thinking is, if no progress is being made, why should more money be spent?

Now, let’s say Tom’s brain is **right at the beginning** of the brain rewiring (neuroplastic) process. The beginning of the rewiring process reveals itself in small amounts of movement. In fact, the small increases may be real, but clinicians do not often measure these small changes. These small but important changes are not measured for two reasons:

1. Therapists do not have the tools (called outcome measures) that are sensitive enough to pick up these small but important changes.
2. Small amounts of movement are considered “nonfunctional”; that is, clinicians may observe new movement but since the movement does not lead to function (walking, dressing, eating) it is considered **unimportant**.

But small amounts of movement, while not yet providing function, are essential to the incremental process of recovery. Unfortunately, therapy may instead focus on using the “good side” to help the patient regain more function. Thus, the focus on function is really a focus on the “good side.” Because of this focus on function the part of the brain that controls the “good side” (ironically) rewires a lot. That’s where the focus is, so that’s what rewires. At the same time, the part of the brain that controls the “bad side” doesn’t rewire because nothing is being asked of it. This process is at the core of **learned nonuse** (described fully in the section in Chapter 4 titled Constraint-Induced Therapy for the Arm and Hand).

In the typical rehab setting, function is not only the goal, it’s what’s tested. Typically, these tests will focus on “activities of daily living” (ADLs) like walking, dressing, toileting. These tests are not very nuanced. The survivor can either walk, dress, or toilet, or they can’t. The only nuance is trying to determine the amount of assistance needed to do the task. The assistance needed involves four broad categories.

**Levels of Functional Ability**

- Independent: No assistance is needed.
- Minimum assistance needed: The survivor needs the caregiver to help with less than 25 percent of the effort needed to accomplish that function.
• Moderate assistance needed: The caregiver provides 25 to 50 percent of effort.

• Maximal assistance needed: The caregiver provides 50 to 75 percent of effort.

Once survivors have reached their highest level of functional ability they are discharged from therapy (therapy is ended). “The highest level of functional ability” is called the plateau, an assumed endpoint of recovery.

But neuroscience is challenging this concept by asking, “Are these really limitations imposed by the brain, or are these limits caused by the nature of rehabilitation treatment and tests?” Here’s another way of asking this question: “Are survivors treated according to convention or science?” These questions have become the foundation of a new perspective on stroke recovery, and, again, neuroscience is the vanguard of this new perspective. Neuroscientists view recovery not in terms of function, but in terms of the function of the brain. Because they focus on the brain, they tend to be much more optimistic about recovery from stroke than clinicians. In the average stroke (stress average), a small percentage of neurons (nerve cells) in the brain die. But because of the focus on function, that small number of neurons has a huge impact on the brain. Again, this process is known as learned nonuse. Stopping learned nonuse from asserting its influence on the brain is the most important goal of the subacute phase. Ideas for keeping the influence on learned nonuse to a minimum are discussed in Chapter 6 in the section The Subacute Phase: Recovery’s Sweet Spot.

How Is It Done?

Neuroscience has radically changed the way stroke recovery is understood. Traditionally, stroke recovery research had been done by clinicians with a lot of clinical experience (experience treating patients). In other words, researchers who study stroke recovery don’t start out as researchers. They start out as clinicians. Their experience in the clinic profoundly influences their research. Because they are typically “clinicians first” they often view survivors as vulnerable and frail patients. Their clinical experience tells them that most stroke survivors are older and have other diseases (heart problems, diabetes, orthopedic issues, etc.) as well as stroke. Their research is influenced by the perceived frailty of the body, not the plasticity of the brain.
Classic clinical research for stroke recovery has other problems as well. When you do research, you’re looking for (as much as you can) a “one-size-fits-all” treatment. Consider the following statements:

- “Aspirin reduces pain.”
- “Exercise reduces blood pressure.”
- “Caffeine makes people more alert.”

These statements have been proven true in healthy people. If you’re doing research on healthy people, you can choose any healthy person to participate in your study. But what if you are studying stroke survivors? How do you find “the average stroke survivor”? Every stroke is different. This statement is true in so many ways. For instance, each stroke . . .

- Is unique in its size and shape
- Affects different parts of the brain
- Causes different deficits

Also, each stroke survivor . . .

- Is a specific age
- Has a unique level of motivation
- Has a different level of overall health
- Has different goals
- Has a different amount of time since the stroke

Because of this, clinicians in rehab research find it difficult to develop “one-size-fits-all” treatments. This is where neuroscience has a great advantage. Neuroscientists often work with animals. The animals they usually work with are rats or mice. Rats and mice are good for stroke recovery research for a number of reasons. They . . .

- Are inexpensive
- Are easy to work with (compared to other animals)
- Have hands that move in a very human-like way

Neuroscientists can intentionally give rats a stroke. They give rats strokes in a number of ways. One way is to surgically block an artery that
feeds blood to the brain. Another way is to send a pulse of water into the rat’s brain. Researchers do this by using a specialized funnel that goes through the skull. A pulse of water is sent into the funnel, through the skull, killing a very specific part of the brain. Also, neuroscientists can use groups of rats that are very similar in terms of age, diet, health, environment, upbringing, and so on. The end result is that you have a lot of very similar “patients” who have had very similar strokes.

Beyond having access to an animal population with very similar strokes, rats provide another advantage. Consider this question: We know that intensity (a whole lot of hard work) helps survivors recover. We also know too much too early after stroke can reduce recovery (during the acute phase the brain is too vulnerable). So here’s the question: When should therapy get intensive, and how intensive should therapy get? In humans, this sort of research would be considered unethical for many reasons. Let’s say researchers wanted to test very intensive therapy early after the stroke. We know that the brain is very vulnerable immediately after the stroke, so any survivor you have doing intensive therapy could suffer. Research that has the potential to hurt humans is unethical and illegal. In fact, the rules to do any kind of study of humans are very strict, and permission to do a human study is difficult to get. So, a study that has any potential to harm humans in any way would never see the light of day.

But researchers can do just about anything (within reason) with rats. They could do very intensive therapy with the rats soon after they wake up from their stroke. Researchers might force them to swim or run for long distances (with their “good” paws) right after their stroke. Rat brains can be scanned in the same way the human brain can be scanned. Also, their limbs can be tested for any movement gains (or losses).

Researchers can test other things with rats that would be unethical in humans. Consider what is called “an enriched environment.” We’re pretty sure that an enriched environment (lots of social interactions, things to play with, etc.) help stroke survivors recover. But to test this, some survivors would have the enriched environment and other survivors would be to be isolated in a room with no social interaction. This is clearly unethical in humans. But this sort of research has been done with rats. One group of rats is put in separate cages in separate rooms with nothing but food. A second group of rats is put with a lot of other rats and with a lot of toys to play with. The rats who are in the enriched environments after stroke recover more. This information, that “enrichment = recovery” can be used by clinicians and caregivers to help survivors recover.
And it’s not just “enriched environments” that can be tested. Using a rat model, you could test just about any variable, including sleep, diet, exercise, environment, temperature, and so on.

**How Neuroscience Can Help Stroke Survivors**

What are the secrets that neuroscience has revealed? Here is a short list of some of the most remarkable insights neuroscience has provided.

- Behavior changes the brain. The brain rewires according to the survivor’s behavior.

- Although estimates vary, the average human brain has approximately 100 billion neurons. The average stroke destroys just over 1 percent of those neurons (1.2 billion). Neuroscientists are asking: Why, in the highly plastic human brain, does such a small amount of damage (less than 2 percent) have such a devastating effect on the average survivor?
  - Neuroscience is beginning to understand how learned nonuse, and not just the amount of damage to the brain, determines the impact of the stroke. Learned nonuse is something that’s controllable in the rehabilitation setting. That is, the way rehabilitation is provided may increase or decrease learned nonuse.

- Enriched environments (environments with a lot of social interactions and conversations, games, and things to “play” with) help the recovery of movement. Unfortunately, stroke decreases opportunities for social interaction.
  - In the first few weeks after stroke, survivors are alone approximately 60 percent of the time and they are inactive (resting or sitting) 75 percent of the time. Neuroscience research suggests that enriched environments during what is usually “downtime” promotes recovery.
  - Enriched environments are good for the brain after stroke. Enriched environments increase:
    - The number of branches (dendrites) produced by neurons (nerve cells in the brain)
    - The number of connections between neurons (synapses)
    - The number of cells that support neurons (called glial cells)
    - The number of blood vessels that deliver blood to the brain
— Enriched environments (interesting experiences, conversations, play, etc.) help recovery of movement. Unfortunately, stroke decreases opportunities to work within a complex environment.

• If done in the first ten days after stroke, focused training of the “good side” worsens future function of the “bad” side. Further, this negative effect extends to later efforts to rehabilitate the “good” side.

• Too much intensity of rehab in the first seven days after stroke can hurt function.

• When survivors exercise intensively (or “a lot”) and voluntarily during the first seven days of stroke, brain plasticity is decreased.

• When survivors exercise intensively and voluntarily starting 14 to 20 days after stroke, brain plasticity is increased.

• There are specific windows of opportunity after stroke in which the brain is highly plastic (moldable).

— In rat studies . . .

• Therapy started between 5 and 14 days after stroke had the most recovery

• Therapy started at 30 days after stroke had very little recovery

One more note about the neuroscience perspective on stroke recovery. There are many neuroscientists that are interested in the effect of a particular protein on brain rewiring. The protein is called brain-derived neurotrophic factor, or simply BDNF. BDNF has been called “Miracle Grow™ for the brain.” It is produced in the brain, and supports learning. BDNF “primes” the brain for motor learning—the sort of learning that helps survivors recover movement. BDNF is produced naturally right after birth, which makes sense, because the brain must massively wire right after birth. It also is produced right after brain injuries, including stroke. This is one of the reasons that the subacute phase after stroke is so important. During the subacute phase, the brain is awash in BDNF. This is one of the reasons the subacute phase provides such unique opportunities for recovery. You will find ideas for getting the most out of the subacute phase in The Subacute Phase: Recovery’s Sweet Spot section in Chapter 6.

If you were not just born, or haven’t just had a stroke, do you still have access to BDNF? Yes, stroke survivors can produce BDNF well after the subacute phase. In fact, everyone can produce BDNF at any point in their life. But it takes work. The way to pump the brain full of BDNF is with exercise.
Both cardiovascular (heart and lung) and resistance (muscle) training will bathe the brain in BDNF. So, along with all the other benefits to exercising after stroke (see Chapter 5: Elements of Exercise Essential to Recovery), you will also be helping your brain to more easily rewire.

What Precautions Should Be Taken?

The translation of these stroke recovery concepts from animals and humans has only begun. The “benchside (in the lab) to bedside (with the stroke survivor)” testing is ongoing. Researchers still have work to do, but it is not too soon for clinicians to study this basic animal research and think about how it might influence their clinical decisions.

USING THE WISDOM OF ATHLETES

One group of people knows the secrets of improving physical movement more than any other: athletes. The definition of athletes is broadened here to include anyone who uses the full range of physical movement in their career or as their passion. This may include dancers, martial artists, acrobats, yoga instructors, and many others. The secrets of recovery from stroke are hidden within the wisdom of these athletes. This wisdom comes from thousands of years of athletes pushing the boundaries of athletic performance.

Stroke survivors are low-level athletes playing a high-stakes game. Much of what is essential to the improvement of athletic ability is also essential to the process of recovery from stroke.

Here is a list of things athletes and stroke survivors have in common:

• Both want and need to move better. They do have that in common!

• Both benefit from cardiovascular (heart/lung) and weight (resistance) training.
  — Survivors need more energy because stroke often causes a lack of coordination. Less coordination means less efficient movement, which means more effort is needed to accomplish tasks.
  — Exercise stores energy. And survivors need energy because rehab is hard, physical work.
— Exercise releases **BDNF** into the brain that promotes brain plasticity. BDNF helps all forms of learning, including relearning how to move after stroke.

- Both use neuroplasticity (“rewiring” of the brain) to move better.
  — We don’t look at athletes and say, “Look at the size of that guy’s motor cortex! That thing is HUGE!” We don’t say it because the change is in the brain and we can’t see it. The brain is where the exquisite movement of athletes is stored. These areas of the brain that control movement can be made larger, in both survivors and athletes.

- Both learn to move by moving; no one else can learn the movement for them.

- Both benefit from working on the exact skill in which they’re interested.
  — The brain cares if you care. Do what you love to recover so you can recover what you love to do.

- Both benefit from “a lot” of focused and demanding practice.
  — The brain will turn into the tool you need. But to adequately change the brain requires a lot of practice. This work can be **massed practice** (many hours a day in a row), or **distributed practice** (many hours a day, but the hours of practice are broken up, or distributed, over the course of the day). Note that in both massed and distributed practice intermittent rest is required. Rest is essential to the recovery process.

- Both need to measure progress to improve. From tracking their speed to their batting average, athletes constantly measure progress. Athletes are looking for small but important advantages. Survivors also benefit from measuring small changes in ability. Small changes can be important by themselves and/or provide an opportunity to achieve larger changes.

- Both benefit from goal setting.

- Both benefit from **mental practice**.
  — Athletes mentally practice (imagine) specific movements in their sport. Survivors can benefit from mental practice, as well. (See the section titled Imagine It! in Chapter 4.)

- Both need coaching. Great coaches help athletes and survivors go way beyond expectations. Great therapists are great coaches.
Both know that the more they challenge themselves, the more progress they will see.

Both benefit from an upward spiral of success. Successful completion of one goal leads to new challenges and new successes.

Both benefit from training on the edge of their current ability.

Neither athletes nor survivors gain from belief in a plateau. What do you call an athlete who believes in a plateau? Retired. Athletes and survivors who accept a plateau create a self-fulfilling prophecy, limiting their potential.

How Is It Done?

Much of what applies to athletic training is useful to the recovery of stroke survivors. Survivors and athletes share the same goal: to get better. The stakes may be higher for stroke survivors but the quest is the same. Learn from athletes; learn from their training techniques and be inspired by their extraordinary level of commitment.

Here are some examples of the elements of athletic training covered in this book:

- **Cardiovascular** exercise (see The Ultimate Stroke Recovery Drug, later in this chapter)
- Weight training (see the section Weight Up! in Chapter 5)
- **Mental practice** (see Imagine It! in Chapter 4)
- Stretching (see the section Don’t Shorten in Chapter 3)
- Development of a training plan (see Plan Your Work and Work Your Plan, at the beginning of this chapter)
- Measurement of progress (see Measuring Progress, later in this chapter)
- Not accepting plateau as anything but temporary (see the section Say No to Plateau, earlier in this chapter)
- A healthy diet (see Eat to Recover in Chapter 6) and sleep (see Fight Fatigue in Chapter 8) to improve
- The use of the **neuroplastic** process to turn their brains into movement machines (see Use Your Fantastic Plastic Brain, earlier in this chapter)
It is important to understand the kinship between you and the training athlete. When you need direction, inspiration, or a window on how to train, look to athletes for guidance. Their trial-and-error experimentation over thousands of years provides vital insight. Much of what is known about the development of muscle, cardiovascular strength, coordination, balance, and every other aspect of human movement is based in athletic training.

Many of the magazine articles, research articles, and books on athletic achievement and training can be used to direct recovery from stroke. As the quest for recovery from stroke continues, you can use the essential elements of athletic training in your recovery. Also, athletes are role models of dedicated training. If an athlete were to focus on recovery, that athlete would dream about recovery and plan their days around therapy.

**What Precautions Should Be Taken?**

Athletes are athletes and stroke survivors are not. While the analogy is helpful to educate and motivate, it is not intended to encourage unhealthy risk taking. And that risk may halt progress. If an athlete pushes too hard and is injured they run the risk of slowing their progress toward their goals. If a survivor pushes too hard, the resultant injury could cause two things:

1. Halt recovery
2. Begin a cascade of events that leads to an overall decrease in health.
   For example, the injury requires rest, which reduces cardiovascular health, decreases muscle strength, and increases weight gain. All of this puts the survivor at risk for other comorbidities and could increase the risk of stroke.

As stated before in the chapter, *stroke survivors are low-level athletes playing a high-stakes game*. Injury for survivors comes with higher stakes as well. Consult your doctor and physical or occupational therapist prior to adding any athletic training concepts to your personal training regimen.

**THE ULTIMATE STROKE RECOVERY DRUG**

Doctors say it all the time: “If exercise were a pill, it would be the most prescribed drug in the world.” Being in shape is vital to recovery after stroke.
• Recovery takes a lot of energy.
• Neuroplasticity takes a lot of energy.
• Living your life takes a lot of energy.

Living Life After Stroke Takes a Lot of Energy

Stroke survivors take twice as much energy to live their life than before the stroke. There are many factors that contribute to the increased energy demand. These factors include:

• Moving when movement is uncoordinated (brain problem)
• Moving with a weak side (muscle strength problem)
• Medications prescribed after stroke that can sap energy

Many daily activities, most notably walking, take twice the amount of energy compared to people who’ve not had a stroke. Not only do survivors typically need twice as much energy to do most activities, they also tend to be much more out of shape after their stroke than before. Survivors have, on average, half the amount of cardiovascular strength as age-matched, healthy people who are out of shape. The same is true with muscle strength. Everything a stroke survivor does takes twice as much energy, but they possess half as much energy. So, survivors must exercise just to maintain enough strength to live their life. Survivors are also battling the natural decline of muscle and cardiovascular strength that comes with aging.

Recovery Takes a Lot of Energy

Research strongly indicates that exercise increases a stroke survivor’s chance of becoming more functional. Also, exercise is essential to storing enough energy to continue recovering.

Here are some reasons that that an exercise program should include both cardio and strength-training exercises:

• After stroke, survivors tend to get less of a natural cardio workout in their everyday life. Because walking, bicycling, jogging, and so on, are limited after the stroke, survivors do them less. Try to counteract this reduction in everyday cardio exercise by doing safe and challenging planned cardio exercises. Walking is usually the best choice. But if walking is limited or cannot be done, review other cardio options in the section Hard but Safe in Chapter 6.
• Stroke survivors need more cardiovascular strength than other folks their age, because a stroke causes many activities—especially walking—to require more energy because movement is less efficient.

• There is more chance of a stroke survivor having a second stroke than there is for people having a first stroke. Maintaining strong muscles and healthy heart and blood vessels is vital to reducing the risk of another stroke.

• Strength training, done correctly, can increase mobility (i.e., walking, wheelchair mobility) and make transfers easier (lying to sitting, sitting to standing, etc.).

• Rehabilitation efforts toward stroke recovery require stamina. Short-term bursts, as well as day-long amounts of energy, are required. Motivation means little when you’ve exhausted your energy and are too tired to try.

• Weight gain increases the risk of diabetes and blood vessel and heart disease. Muscles burn calories, even at rest. This is not true of other forms of tissue. For example, fat burns no energy (calories). Maintaining strong muscles and healthy heart and blood vessels is vital to maintaining optimal weight.

• As crazy as it may sound, exercise increases energy levels.

• Exercise can increase the amount and quality of sleep you get. The better the sleep, the more energy you can put toward recovery.

**Neuroplasticity Takes a Lot of Energy**

Learning how to move better involves the development of new connections between neurons (nerve cells) in the brain. Every time a neuron communicates with another neuron in the brain, it takes energy. It also takes energy to build the branches of neurons (called dendrites) as well as the connections between neurons (synapses). The amount of energy it takes to drive neuroplasticity is tremendous. Even when learning involves no movement, changing the brain is energy intensive. Consider how exhausting studying can be. And academic study doesn’t have the added burden of hard physical movement. The kind of learning that is done to recover movement after stroke is called **motor learning**. It happens in the same area of the brain as learning algebra or chemistry or any other academic subject: the cortex. The cortex is the very thin outer shell of the brain where most learning occurs. Survivors must not only change their cortex, they have to use very difficult movement to drive that change.
How Is It Done?

Have a physical or occupational therapist design a workout that will be challenging and safe. Let the therapist know, up front, that you want an exercise program that can (eventually) be done safely at home. A physical therapist can provide cardio and resistance exercises that will benefit your walking and overall fitness. Ask for an at-home exercise program that

- Is safe
- Has progression built in so that the workout remains challenging over the long haul
- Challenges your muscles and your cardiovascular system

Therapists should be able to develop an at-home program with one to three visits. The therapist calls this sort of at-home therapy a **home exercise program** (HEP; see Get a Home Exercise Program in Chapter 5).

Being in shape is essential to recovery and has been a lifestyle choice for many folks after their stroke. Going to the gym, doing physical work (e.g., gardening, housecleaning), and walking instead of driving are all choices that can get folks into better shape. The more strength that can be stored, the more energy can be directed toward recovery. This extra energy can propel an upward spiral of more energy and more strength, which can lead to more recovery, more effort toward exercise, and so on.

Exercise should not necessarily focus totally on the affected (“bad”) side. Stroke survivors can benefit from exercising all four limbs, developing cardiovascular endurance, balance, strength, and agility. Of course, involving the “bad” side is always a good idea. But exercise of the “good” side will help build strength and stamina so that the whole body can recover.

What Precautions Should Be Taken?

There are risk factors with every form of exercise, so consult your doctor prior to changing or starting a new exercise program. Your doctor and a therapist trained in stroke therapy will be able to direct you to the correct mix of exercises. These exercises will be designed to be safe and specifically designed to promote *your* recovery. Make sure that the exercises are stroke specific. Many “exercise professionals” are not qualified to develop an exercise program for
the specialized needs of survivors. Stroke survivors need therapists to develop an exercise program that will help with the specific needs required for stroke recovery. And, above all, therapists can design programs that are safe.

**MEASURING PROGRESS**

How do you know if you are recovering? How do you know if you’ve achieved one of your goals? Some aspects of recovery from stroke are easy to measure. The first time you walk, climb stairs, or write your name are all milestones that should be celebrated. These examples are easy to observe and identify. “I walked for the first time today!” Everyone understands what happened and is willing to give kudos for the accomplishment. Medical staff, therapists, family members, and friends are there to thrill at the gains made. As recovery continues, attaining goals will generally prove more subtle and harder for most folks to see. Walking a little bit faster may mean you can cross the street safely, but it may not be seen by the world as significant. This is one of the reasons that measuring progress is so important. Accurate measurement of progress will reveal small but important gains. Small incremental steps toward recovery may mean:

- The difference between independence and dependence
- The difference between progress toward recovery and ending progress completely
- The beginning of new skills, which allow for new challenges, which in turn allow for new gains, and so on

You may be progressing greatly, but you don’t see it. It is hard to accurately remember where you were a week, a month, or a year ago. There is a tendency to make judgments based on where you were yesterday. Maybe yesterday was a really good day and you made great progress. Maybe today is a really bad day and you actually got a little . . . worse. Many folks will give up after having had a bad day, or a series of bad days: “I’m not getting better, so why should I keep this up?” It may be that you are simply unable to see progress because the day-to-day changes are too small to detect. Relying on memory makes you unable to “see the forest through the trees.” Recovery should be judged by what happens over an extended arc of time. It’s like the stock market. You would put yourself through a lot of stress (and some people do!) with day-by-day details of how your stocks are doing. Investors in the stock market know that what is
important is the overall upward trend. Both stocks and stroke recovery involve collecting short-term information in order to see long-term trends.

Any person trying to learn any new skill has benchmarks that they feel they have to meet or exceed. Athletes use clocked speed, amount of weight lifted, batting average, and other measures to determine progress. Musicians have recitals as well as the ability to play new chords, songs, or pieces. The need to measure progress is just as great for stroke survivors. Here are some facts about measuring the progress of your recovery:

- Effective interventions can help you recover faster than you ever imagined. But determining the effectiveness of an intervention requires accurate measurement.
- If your measurements do show progress, you will be more motivated to continue.
- Honestly and accurately gauging lack of progress is an essential part of your recovery effort, as well. Interventions that are not effective are a waste of time, money, and effort.
- Measuring progress will reveal gains (or losses) that you might not otherwise see.
- Measuring progress will help you determine if your mix of techniques, exercises, modalities, and so forth, is working.
- In short, measuring progress will determine what is working—and what is not.

If a treatment, modality, exercise, or technique is working, keep it. If something is not working, it should be ruthlessly pitched. The key is accurately measuring the effectiveness of your overall recovery strategy. Because all interventions affect each other, you are not really evaluating individual interventions. Rather, you are measuring your current mix of interventions.

How Is It Done?

Without accurate data, assumptions about recovery are nothing more than guessing. Imagine a researcher scratching his head and saying, “Boy, I dunno. I think they’re getting better.” It would certainly lack merit!

You do not need complicated data collection tools and a lot of computing power to measure progress. There are easy ways of measuring progress that are
inexpensive and accurate. No matter what is measured or how it is measured, recording, either through notes (e.g., “I walked three blocks today in five minutes”) or by other methods (e.g., viewing a videotape of you walking), will allow you to accurately compare the past to the present. In short, measurement can be done efficiently, simply, and with modest expertise and little equipment.

Here are some ways to measure progress that take little training and equipment:

- **Timing how quickly something can be done:** From walking a specific distance, to saying a sentence, everything can be timed. Timing can be of two speeds; the fastest possible speed and/or “self-selected” speed. Self-selected speed is the speed that is comfortable and natural. Self-selected speeds have the advantage of more accurately assessing speed of an activity in a real-world, normal, and natural way. Timing the fastest possible speed has the advantage of determining the very edge of your ability.

- **Timing how long something can be done:** The length of time that an activity can be performed can reveal valuable information about endurance. For instance, the ability to propel a wheelchair for four consecutive minutes today is better than the two minutes you were able to do last week.

- **Observation as evaluation:** Using a mirror can provide valuable, real-time feedback as to the nature of the quality of movement. This sort of measurement is inherently subjective, but can provide valuable insight into strengths and deficits.

- **Videotaping different tasks:** Video can provide a viewable historical account of progress.

- **Audio- or videotaping speech:** Progress toward improving speech can be evaluated with an audio recording. Videotaping speech has the advantage of seeing the quality of movement of the mouth. Sometimes, however, it is better to not view the speech, but rather evaluate speech only by the quality of the sound. This is because while mouth movements may not be pretty, “ugly” movement may produce the best speech. This is true in expressive aphasia (difficulty speaking) that involves dysarthria. Dysarthria is when the muscles of the mouth don’t work well because of damage to the area of the brain that moves the mouth. People with dysarthria may use “ugly” mouth movement in order to produce the most understandable speech.
• **Counting repetitions:** The number of times a particular exercise is performed can indicate muscle strength and endurance.

• **Measuring distance:** Measuring the distance walked is the most obvious example, but there are other aspects of recovery that can be assessed by measuring distance. For instance, the distance reached across a table with the hand, the length of a single step, and measuring the number of inches the fingers can spread apart can all be used to measure progress.

• **“Task-specific” measurement:** You can measure whatever task you are doing, from painting to washing dishes. When attempting to measure how well you are doing in a specific task, ask yourself a simple question: *How would I have measured this on the playground as a ten-year-old?* Children are constantly measuring who is better at what, and if they are better than they were yesterday. How might you measure, say, painting? How long does it take to pick up the brush and load the brush full of paint? How many times can you accurately (as defined by a previously drawn border) “stay inside the lines” while painting a horizontal line? What about washing dishes? How many plates can you get in the washer rack accurately in 30 seconds? How long does it take to wash five dishes? Once you have that number, record it, and then try to beat it. Whatever you measure, make sure . . .

• **It is measurable.**
  
  — **Measurable:** How high can I reach my hand up while I’m standing?
  
  — **Not measurable:** Is my handwriting legible? Legibility is often in the eyes of the beholder—you may always be able to read your own writing, while to other people it looks like gibberish. However, even handwriting can be made quantifiable. For instance, using lined paper you can count the number of times you go “out of bounds” (i.e., above or below a set line) within a set amount of time.

• **It is repeatable.**
  
  — **Repeatable:** How fast can I walk around my quiet neighborhood block?
  
  — **Not repeatable:** How fast can I walk around a busy city block? There are too many variables from traffic lights to other pedestrians.

• **Take blood pressure and pulse:** Blood pressure and pulse are indicators of cardiovascular health. They are also important indicators of the progress of recovery. Decreases in blood pressure and resting heart
rate (pulse) are positive health indicators. For instance, let’s say a survivor is trying to build cardiovascular strength and measures their pulse in January as 75 beats per minute. In February she measures 68 beats per minute. This decrease in pulse rate would indicate that her hard work is paying off. Her heart can deliver the volume of blood needed to “feed” the body with less effort (fewer beats per minute).

Measuring pulse and blood pressure is important for two reasons:

1. Pulse and blood pressure can be used to measure progress toward recovery. Generally, a decrease in both are good.

2. Stroke, whether a bleed (hemorrhagic) or block (ischemic) stroke, is a very significant vascular event. Monitoring changes in pulse and blood pressure can give you and your doctor valuable information about your cardiovascular health.

See the section in Chapter 3 titled Five Tests You Should Do for more information about testing pulse and blood pressure.

When and how often should you measure progress? The more the better is the general rule. The important thing is to be consistent in measuring and recording the information you collect. Once you have collected your information, write it down in a logbook or calendar. For instance, you may write down the time it takes to walk around a quarter-mile track. Every time you make the walk, write down the time. Your measurement will show less and less time to make the quarter-mile walk. This decrease in time may continue for months. At some point, your times will not improve, unless you change the way you train.

Whatever you measure, and however you measure it, make sure the measurements are “apples to apples.” Take the example of timing how long it takes you to walk ten yards. You decide that you’re going to walk for ten yards twice, and then average the times. A week later you do the same test, twice, and again average the two times. Make sure that for all four measurements you are wearing the same shoes, walking over the same surface, using the same cane, at the same time of day, and so on.

Recovery options that involve a lot of practice per day should be evaluated in the short term (one to three weeks). Change should be measurable in the first couple of weeks. Other activities, like those that involve increasing stamina and muscle strength, take longer to show results.
What Precautions Should Be Taken?

Measurement works to modify behavior because most people try to beat their previous best. Measurement represents you competing against yourself. Any time there is a competition, there is going to be the tendency to reach for the edge of your ability. This striving can be very productive but can put you in danger. An example would be, “I’m going to beat my best time for walking around the block.” This aggressive attempt could lead to less safety awareness—which could lead to a fall. Be aware of your own limitations.