Post-Traumatic Stress Disorder (PTSD) in Soldiers

A Pain Neuroscience Approach

U.S. Army Public Health Center
Technical Guide 378
May 2019

Approved for public release; distribution unlimited.

Post-Traumatic Stress Disorder (PTSD) in Soldiers
A Pain Neuroscience Approach

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US Army, 1970–1972

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The views expressed in this guide are those of the author and do not necessarily reflect the official policy of the Department of Defense, Department of the Amy, U.S. Army Medical Department, or the U.S. Government.

Note: This guide does not replace professional counseling or medical treatment. It may be helpful to discuss this guide with a therapist or other healthcare provider who understands Pain Neuroscience Education.

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It may be helpful to read only 1–2 sections at a time. At the end of each section, pay close attention to the key points and practical tips to help you with your pain and post-traumatic stress disorder (PTSD).

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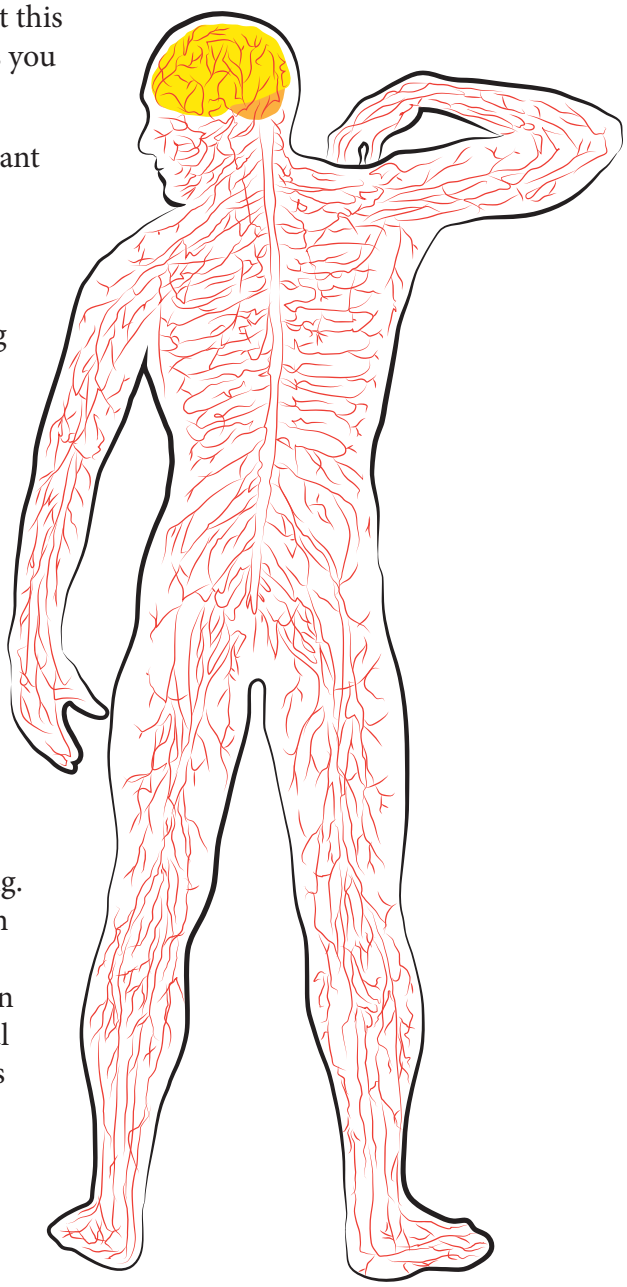
At the end of each section you will find a summary and strategies to help with your pain and PTSD.

References: Do you see the small raised numbers throughout this guide? Here you will find scientific support for the recommendations made in this guide.

You served your country. You are proud of your service. But if you have post-traumatic stress disorder (PTSD), you were wounded in a way that is just as real as a wound from a gunshot or shrapnel. These wounds may cause physical or emotional pain.[1] PTSD is a complex injury that results from a combination of your traumatic experiences, your family, your social support, and your biology[2] (how your body works).

When you read about emotions and PTSD, you might say, "Oh, they think the pain is just in my head." This is NOT the case at all. Your pain is real, and the purpose of this guide is to help you and your loved ones understand how PTSD affects your nervous system and increases your pain. If I punched you in the arm, the nerves in your arm would send an electrical signal to your brain, and you would probably say, "Ouch! You are a jerk!" You might have some strong emotions against me, but when we talk about pain throughout this guide, we are talking about physical pain, the kind that makes you say, "Ouch!"



Of course, with all pain, your nervous system plays an important part. Your nervous system uses pain and stress to respond to danger and to protect you.[3]

Consider this: what would happen if a Soldier ignored the possible danger following an enemy attack? Without changing routine behaviors, a Soldier might blindly re-enter a kill-zone. That would decrease the Soldier's chance of survival, wouldn't it? In the same way, when you experience trauma, your nervous system will make some changes to try and protect you. No matter what the cause of your trauma—combat, assault, or military sexual trauma—it will affect the way your nervous system handles danger.

Your nerves act as an **alarm** to help you survive dangerous situations. It makes sense that the nervous system stores trauma memories so you can be prepared for a similar threat in the future.

While detecting possible threats is a main job of the nervous system, sometimes this **alarm** becomes *too skilled* at protecting. The alarm becomes too sensitive. This can cause discomfort in social gatherings (*"there could be an enemy in this crowd"*) or decreased activities (*"movement might damage my body"*). Pain and anxiety following injuries or trauma are normal biological responses. Being disabled by too much protection, however, is not very helpful.

But there is hope!

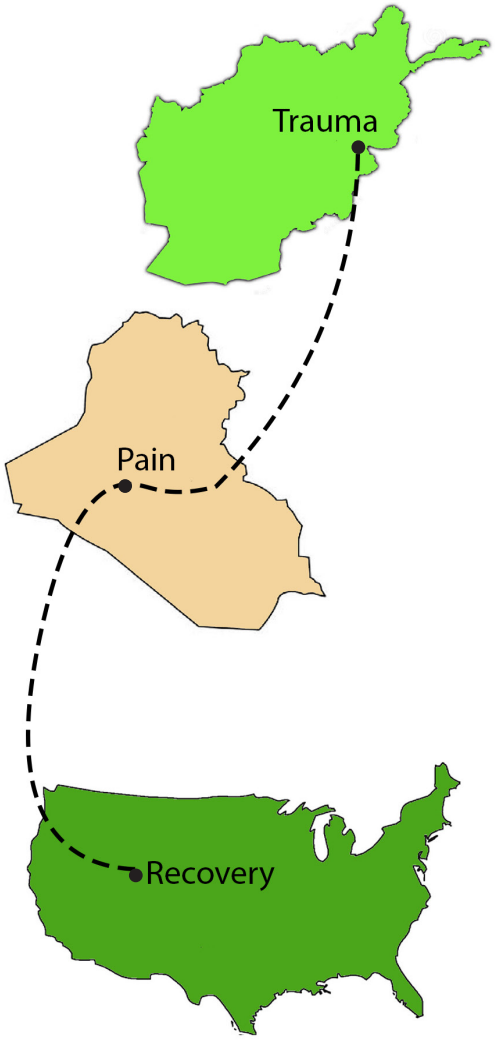
People who understand more about their pain have less pain and are more active.[4] When you are more active, you have less PTSD symptoms.[5] Anyone can learn about the nervous system, as complex as it may seem.[6] Your nervous system may be overly sensitive at detecting danger right now, but it *can* adapt and change. Although nothing can take away your trauma, you *can* change the way your nervous system responds to your experiences and help yourself become less sensitive. When your alarm is less sensitive, you can begin to enjoy more activities with less pain and worry.

Map to Recovery

Introduction to your nervous system:

Your body has billions of nerves. Many nerves have unique jobs, just like in the military. Since it might be hard to picture how a nerve works in your body, we will use military examples to give us a common language throughout this guide.

- First, you will learn how the nervous system acts like a radar to detect possible dangers.
- Next, you will see how stress hormones make you feel on edge when you have PTSD.
- Then, you will learn how the nervous system makes it so easy to quickly trigger PTSD or pain after trauma.
- Finally, you will find out how avoiding painful activities can keep the nervous system sensitive.



How do you make the nervous system less sensitive?

The end of each section and section 6 covers practical tips.

When you learn that pain does not always mean tissue damage, you can be confident in the practical tips in this guide—

- Exercise.
- Sleep.
- Eating well.
- And how to cope when you have a bad day.

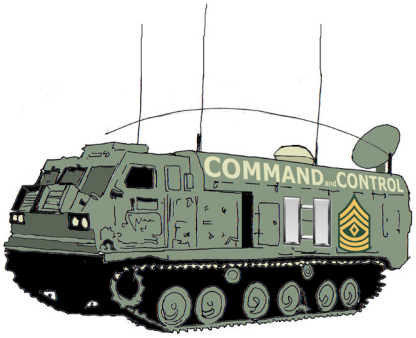
Note: Sometimes you may wonder if a strategy is for your pain or PTSD. There isn't always a clear boundary between the two. Pain and PTSD share many pathways in the nervous system. Most strategies in this guide can apply to either pain or PTSD.

To help you learn about your pain and PTSD, this guide compares the main parts of your nervous system with common military examples. Since it can be difficult to imagine a tiny nerve cell, these pictures will help you visualize the different parts of your nervous system.

Your Recon Team: These are the nerves throughout your tissues. They send messages up the chain of command when they sense danger, like if you stubbed your toe. If all of your nerves were connected end to end, they would stretch to a length of 45 miles.[7] That's a lot of reconnaissance!

Your Military Intelligence: These are special nerves in the spinal cord that filter through recon team messages. For example, do you notice the fabric of your socks right now? Probably not! Most nerve activity is inhibited, or blocked, by these special nerves. Your intelligence nerves can also turn UP the signal if there is danger, though.

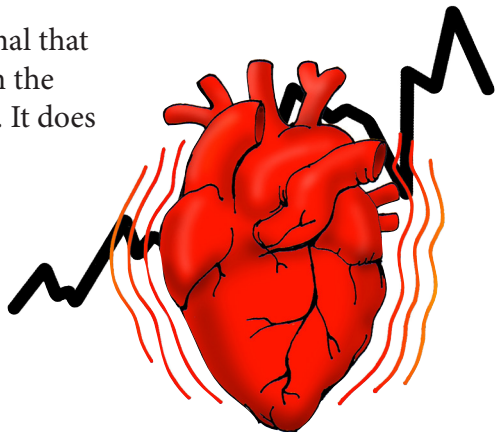
Your Radar Operator: This is part of the brain that is the quickest to detect danger. The scientific name for this part of the brain is the amygdala. It's a funny name, but it plays a major part in pain and in PTSD. For example, as you are driving you see a car swerve in front of you. You instinctively slam on your brakes thanks to your radar operator (your amygdala).



Your Command and Control Center: This is the executive center of your brain. Because the executive center thinks and evaluates, its decisions are made more slowly but are more complete than your radar operator (your amygdala). Any time you choose to act based on your values, instead of your fears, you are using your Command and Control Center.

Your brain: It is helpful to think of the brain as a **War Room**. This is where all the major decisions are made. The brain evaluates incoming information by talking to different staff members in the brain. Then it makes important decisions to make sure you survive. When the War Room believes it is safe, no action is taken. However, when the War Room believes there is danger, it will activate an alarm so you can take action.

Your Emergency Alarm: Having to stop and think about every nerve signal that comes to your brain, it would be way too slow to avoid danger! When the radar operator (your amygdala) senses danger, it needs to act quickly. It does this by activating the stress alarm or the pain alarm.



Stress alarm (PTSD symptoms): During a crisis, this response prepares the body for quick action. The brain causes stress hormones to release in the body.[8] This causes—

- Increased heart rate.
- Heightened alertness.
- Increased muscle tension.

Pain alarm (Ouch!): One of the best ways your nervous system tries to protect you is by producing pain. (Think about it: if a Marine punched your arm, you might say "Ouch!" and raise your fists. When the Marine sees your fists, the Marine runs away. Pain has protected you!).

Many times, these alarms are turned on automatically. That does not mean you *choose* to have stress or pain. However, the more you know about these alarms, you can turn the response *down*.

Introduction to Neuroscience

The more people know about their pain, the less they suffer from it. The journey begins with the nervous system, which has billions of nerves in the body and brain.[9] When most people hear about pain and the brain, they think doctors are saying "the pain is in your head."

This is not the case at all. Research shows that nerves in your tissues make real biological changes and contribute to pain. Even though your pain is very real, the level of pain you currently have does not always equal the amount of tissue damage in your body.[10] Most tissues and injuries heal after 3-6 months.[11]

Neuroscience!? Sounds complicated! Yes, it can seem that way.

But as Soldiers, you probably understand this better than most people—

- Many Soldiers experience severe wounds but have little or no pain in combat.[12]
- Ever heard of **phantom limb pain**? It is common that some amputees have severe pain in parts that are no longer attached to their body.[13]

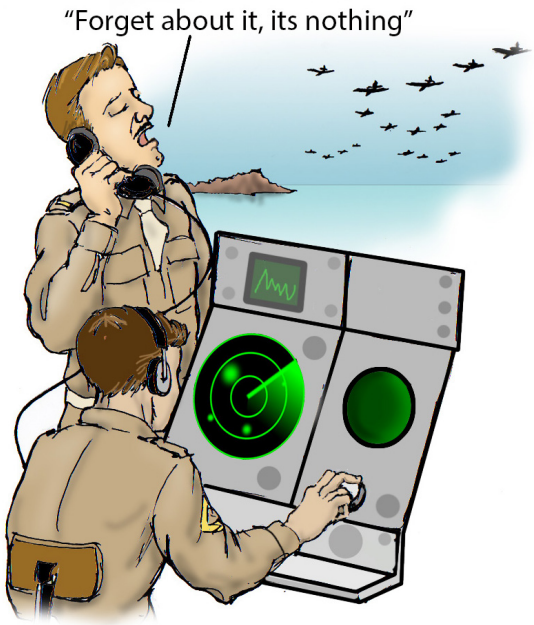
This is because the nervous system produces pain mostly based on *threat*, not on tissue damage.[14]

To summarize so far—

- Pain is real, but tissues heal.
- Traumatic memories from PTSD and pain act to protect you. But when they are combined, they can **amplify**, or **turn up**, unpleasant sensations.[15]

The next section explains more about your alarm system. The longer you are in pain, the more the alarm becomes sensitive. This makes your alarm system less accurate about your tissues.

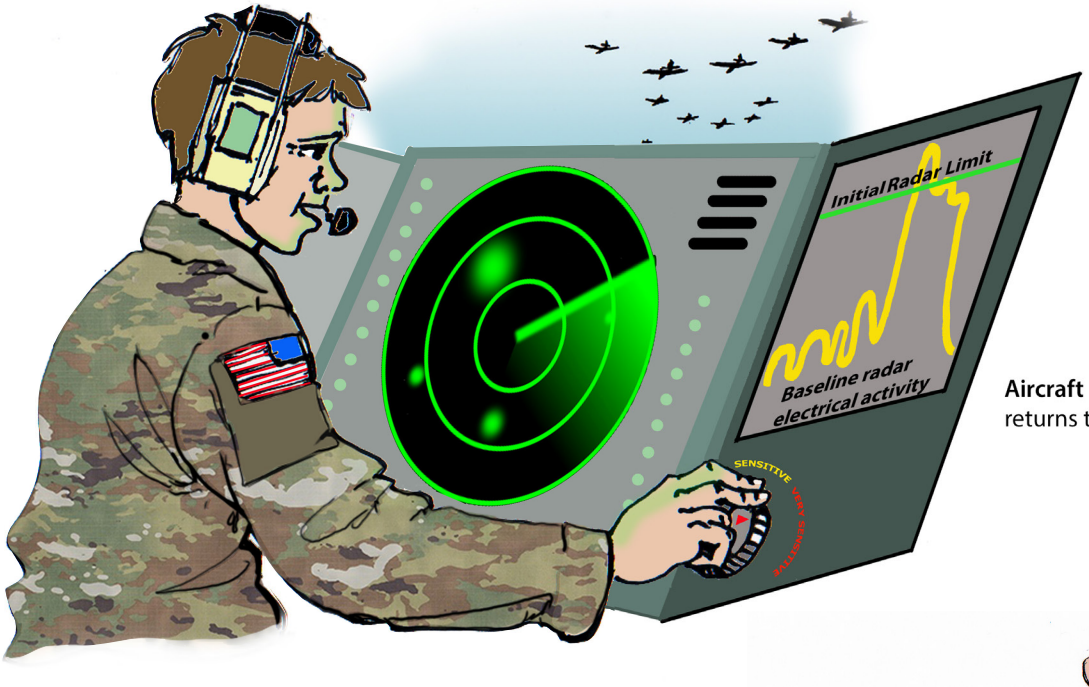
There are probably many times you have thought: I wish I never had any pain, and I wish I never had PTSD symptoms. But imagine if your brain *never produced* them: it would be disastrous!



It would be like the attack on Pearl Harbor. At 7am on December 7, 1941, Army radar operator PVT George Elliott spotted a large group of airplanes 100 miles north of Pearl Harbor on his radar screen.[16] When he called his headquarters to report this, he was told by the Lieutenant in charge to "forget about it." This decision had disastrous consequences.

What does that have to do with your PTSD and pain? Just like a radar, your nerves use electrical signals to pass along important information. When electrical activity goes higher than a limit in your nerves, a message is sent to the brain. In a radar, when a large object is detected, the radar produces a *blip* on the screen. The *blip* lets the War Room know there is a potential threat and further action may be needed.

The same is true of pain. If you were putting up concertina wire and you cut your hand, would you want to know about it? Of course you would!

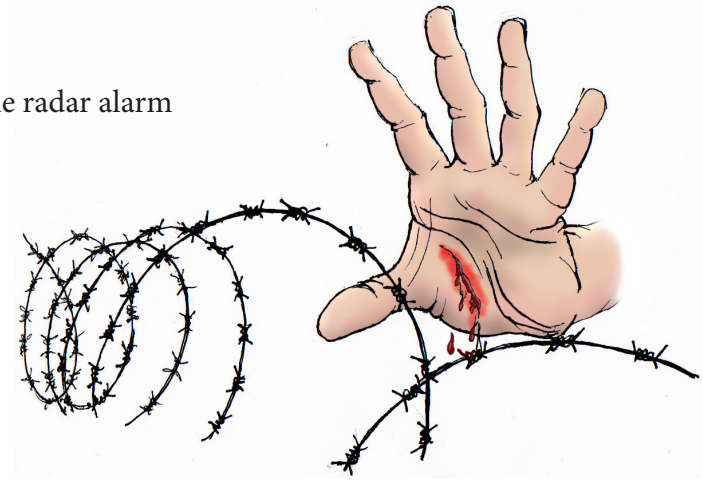


Enemy aircraft: Radar signal passes the alarm limit.

Aircraft leave: Radar signal returns to normal.

Pain is part of the built-in, natural alarm system.[7] After the radar alarm is turned on, your brain produces pain so you can—

- bandage your hand.
- put gloves on.
- see your medic.
- make sure your vaccines are up-to-date![7]



Your nerves—your recon team, radar operator, and War Room—have done their job!

After this, the radar slowly returns to normal and pain decreases. In a similar way, once the danger has passed the stress response also decreases.

Radar Operator Sensitivity

After a major trauma like Pearl Harbor, it makes sense that the nervous system might—

- increase the number of nerves that respond to danger.[32]
- pay closer attention to possible threats.[18]

Our nerves are on high alert now.[17]

These protective responses are caused by nervous system adaptation, or changes. **It is normal and helpful for the nervous system to make changes after trauma, wouldn't you agree?** But when these extra-sensitive changes do not return to normal and interfere with your life, the diagnosis of **PTSD** can be made.

When the alarm system adapts **too strongly or for too long**—

- The executive center of the brain tries to block memories related to trauma.[83]
- The executive center of the brain decreases its influence over the amygdala[3] (Figure 1).
- The amygdala becomes extra-responsive to danger. This speeds up the stress alarm. (Figure 2).
- This is what PTSD looks like in your nervous system: your radar operator cuts ties with the Command and Control Center and instead wires the commo lines straight to defense.

Now can you see why it is so easy to trigger a stress response after PTSD?

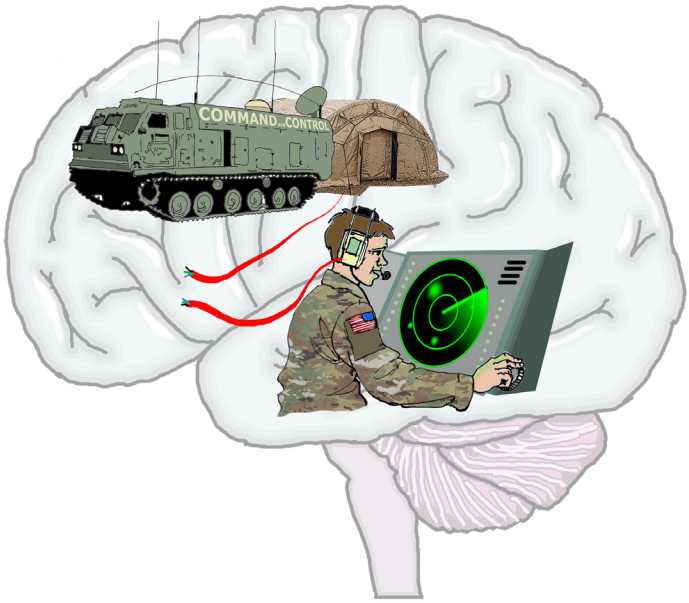


Figure 1

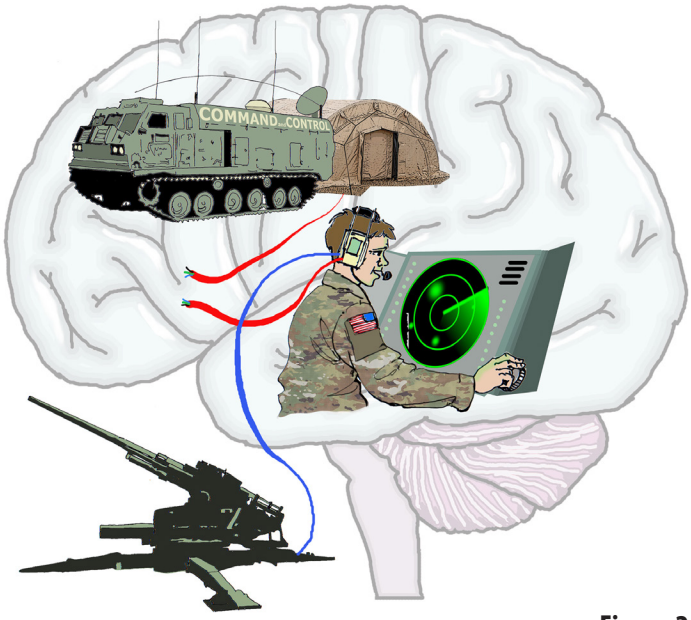
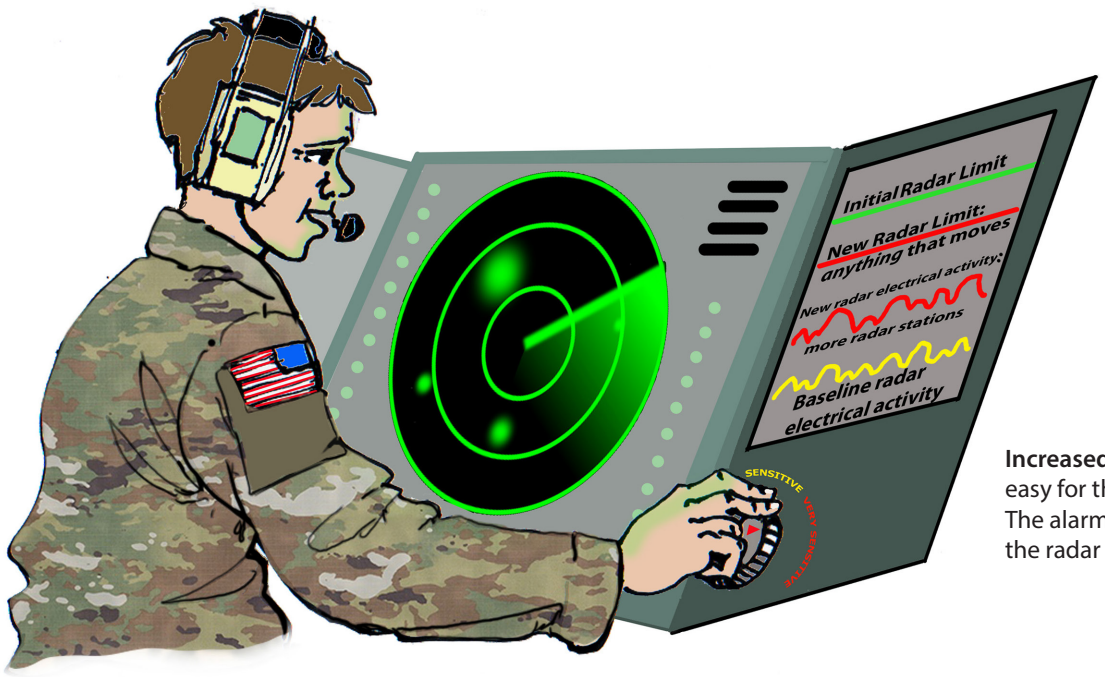


Figure 2

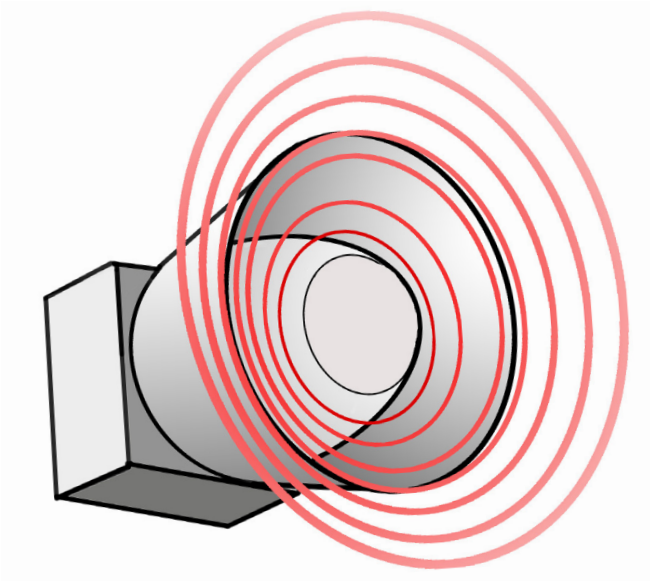


Increased Sensitivity: Now it is very easy for the radar to detect dangers. The alarm turns on quickly because the radar is extra sensitive.

As another example, what happens when a civilian airplane flies over Pearl Harbor now? Are the big-guns needed? Probably not, but the alarm system turns on because it can now detect the smallest movement. At this point, the radar alarm has become **a little too sensitive**; this is what a hypersensitive amygdala looks like in action.

Have you noticed it is very easy to turn on your own alarm?

How about at the end of the war? Under normal situations, radar sensitivity can decrease because the threat has decreased. Have you ever vacationed in Hawaii? I bet you're glad they turned down their radar alarm to let you land safely! In the same way, after an injury or stressful trauma, the nerves begin to return to resting levels.



Unfortunately, in approximately 10-25% of people after an injury or trauma, the alarm system fails to return to normal resting level.[19,20] Instead—

- The nerves fire just below the **alarm** limit.
- A reminder triggers the **stress alarm**.
- A small movement makes the radar operator turn on the **pain alarm**.
- The nerves are now extra-senstive.

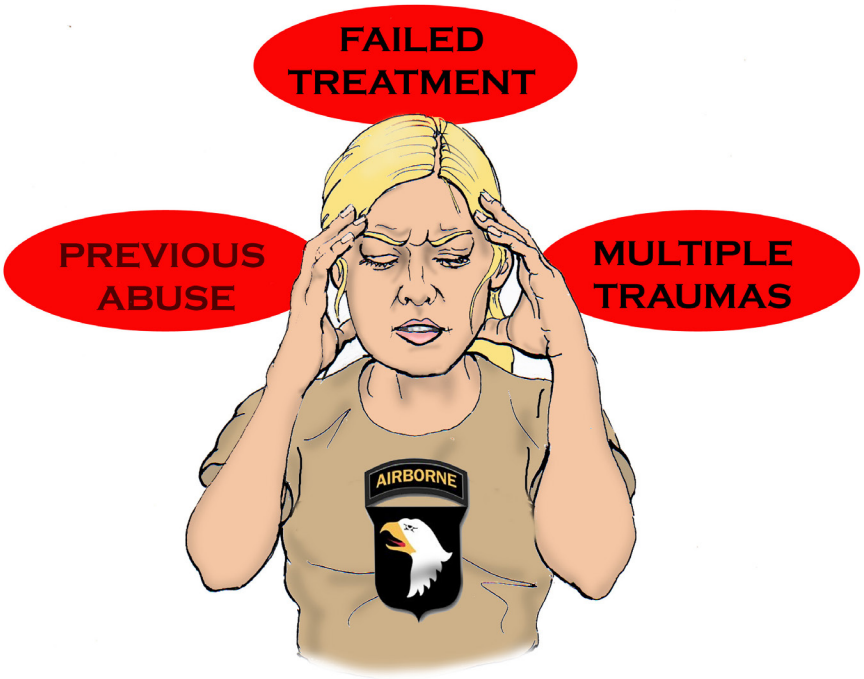
Why did my alarm system stay sensitive?

For many people, trauma makes the nervous system extra-sensitive. Let's look at the radar operator after the Pearl Harbor attack—

- He increased radar activity.
- He created alarms for specific threats: aerial radar and submarine patrols.

Your nervous system does the same thing after trauma or injury.[2]

Since you have learned that a purpose of the nervous system is to recognize dangerous situations, it should not be surprising that the alarm system gets sensitive after a severe trauma.[21]



Now, what can be done about this sensitive nervous system?

- You can decrease the threat of PTSD and pain.[22] When your amygdala (radar operator) over-reacts to every stressor or danger, your nerves will stay sensitive. When your nerves are sensitive, you have more pain and anxiety.
- You need your Command and Control Center—not your nerves—back in charge of your life!

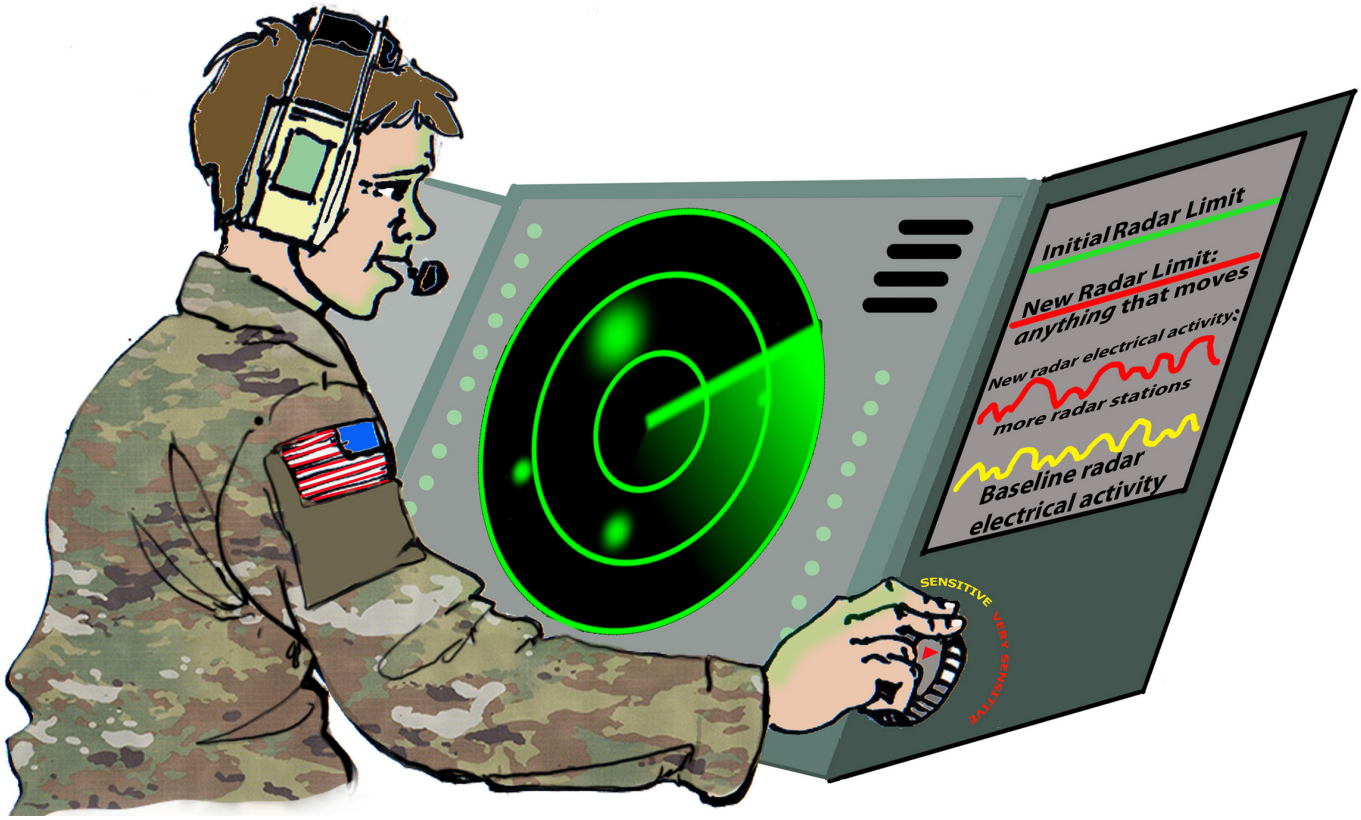
How can you do this?

Science has shown that the more you understand about pain and PTSD, the better your symptoms.[4,23] So, here's the strategy:

- **Knowledge** about pain and PTSD decreases the threat. You are already on your way!
- **Movement and exercise**. This gets your Command and Control Center back in charge of movement.
- **Nervous system desensitization**. The good news is that your nerves and brain constantly change and adapt. You can make new connections in your nerves by telling yourself: "I am safe. My tissues are safe." This can take time![24,25] The next page has an activity that will help you see where you are in the journey of becoming less sensitive:

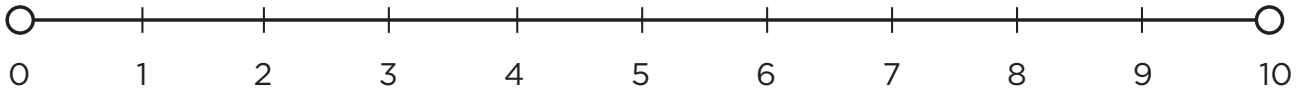
What activities and situations used to fly "under the radar?" Now that your radar is sensitive, do you notice how easy it is to trigger your PTSD or pain?

PTSD	Pain
New places or people: "I don't trust them."	Before, you could run for 30 minutes before you hurt. Now, you can only run 10 minutes before you have to stop.
Nighttime: "I have to check the locks over and over again."	Before, your pain was in a small area in your back. Now, it seems to spread across your entire back.
Emotions: "I get angry so quickly over small things that didn't bother me before."	You used to enjoy playing with your children. Now, you avoid this activity because it hurts.



Homework:

On a scale of 0-10, how sensitive is your alarm system? Zero is not sensitive at all; 10 is extra-sensitive.



Why did you pick that number? Why not higher? Why not lower? _____

_____

_____

_____

Write down three things you would do if your alarm system wasn't so sensitive:

1. _____

2. _____

3. _____

Section 2 Summary:

- Your nerves make adaptations, or changes, to respond to trauma and injury.
- The nervous system increases its electrical activity and sends out more patrols to detect danger.
- This alarm system can become too sensitive.
- Knowledge about the nervous system begins to give us the "All Clear" from pain: tissues heal!

Your nervous system in action

Your Radar Operator: The amygdala can become extra-sensitive. This is one of the main parts of the brain that detects danger and acts like an alarm.

Your War Room: Your brain ultimately decides to produce pain or a stress response to protect you.

Your Stress Alarm: When there is a threat, the body releases hormones.

Your Recon Team: These are the nerves in your tissues.

As a reminder, these are the parts of your nervous system in action in this section.

Why am I constantly on guard?

When you are on duty, you may be up all night, watching the phones on staff duty or watching the perimeter. How do you feel at the end of that shift? Do you feel alert? Sharp? Energized? Of course not! You feel exhausted. Your nerves feel fried. Why does this happen? Stress hormones help us during a crisis, but they are only meant to help for a short time before they need a break.[8] When you have PTSD, it is like your nerves are on guard duty all the time.

Imagine you were deployed when suddenly you hear your base sirens sounding the alarm.

How will your body prepare for this threat?

- First, your heart rate will speed up from *adrenaline* pumping through your body.[26]
- Next, *cortisol* is released so that your major muscles have the energy they need to defend you.[26]
- You need to grab your gear quickly and sprint to your defensive position. No need for small core muscles. Now it is time to move!
- Your stomach might start to rumble: is that nerves? Hunger? No time for eating now!

This is the "fight, flight"[27] or "freeze"[28] response. Stress hormones are released to try and help during a crisis.

After the attacks are over, imagine you still have to pull guard duty in case another attack comes. What if you had to keep an eye out for the enemy all day and all night?

How long do you think your body could stay in this heightened state? Two hours? One night? One week?

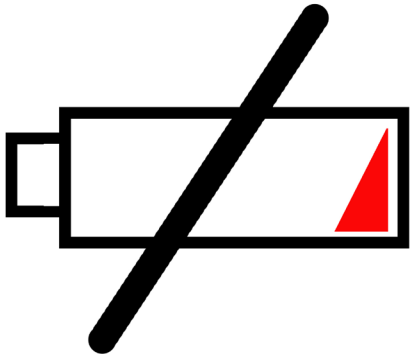
For many Soldiers with chronic pain and PTSD, the alarm system is almost always on high alert, ready for any danger.[15]

One of the key hormones that is released during stress is cortisol. Cortisol is a powerful drug that helps injured tissues heal and keeps you alert.[8] When your nervous system is always on guard, you run low on this important drug. It is like running out of ammunition after an all-night battle![8,29,30]

When your nervous system is running low on ammunition, your recon team (nerves) makes sure it sends danger messages all the way to the War Room (your brain). Since they don't have the ammo to fight inflammation in the tissues,[3] they call for back-up and recruit new nerve receptors to detect danger.[31]

- More danger messages means more sensitivity and more pain.[14]
- Your nerves become sensitive to stress, movement, blood flow, and temperature changes.[32]

This is how you feel when you run out of ammunition—



- Sore.
- Tired.
- Irritated.
- Stomach feels upset.
- It seems easy to get sick.

Does this sound familiar in your life? What can you do about it? Remember the scenario where you were pulling security after the base alarm sounds. What happens when the platoon sergeant comes to your position and lets you know, "The radar is All Clear! The attack is over!"?

Normally, the response would be—

- Your heart rate would start to slow.
- Your tense muscles would start to relax.
- Your stomach would start rumbling again, but this time it's not from stress; you realize you're hungry.
- After a nutritious meal, you would be tired. Your body could finally rest so that you can restore yourself.

How can I re-supply my stress hormones?

- **Give yourself "All Clear" messages**: "Tissues heal. Pain doesn't mean tissue damage." This decreases the threat of pain. Increased threat means increased pain. Increased threat also means the stress response stays on and stress hormones are released.
- **Knowledge**. Understanding how your pain works puts you back in charge, not your radar operator (amygdala). When your radar operator is in charge, your alarm system is always on high-alert.[18]
- **Sleep** is one of the most important ways to re-supply your stress-fighting hormones.
- **Regular exercise** produces more stress-fighting hormones in individuals with PTSD.[33]
- **Eat healthy foods.** (See Section 6).
- **Relax!** Try this breathing exercise:[34] breathe in while counting to 4. Next, release the air and exhale completely. Then, rest quietly while counting to 4 as you get ready for your next breath. Repeat. Make sure you let your stomach rise while air comes in. Relax your chest while breathing.
- See the final section of this guide for more details and practical tips for restoring yourself.

Homework:

Now that you have learned more about pain:

On a scale from 0-10, how confident are you that you can give yourself the "All Clear" from pain? Zero is not confident at all; 10 is completely confident that you can give yourself the "All Clear."

0 1 2 3 4 5 6 7 8 9 10

Why did you pick that number? Why not higher? Why not lower? _____

_____

_____

_____

Section 3 Summary:

- Living with chronic pain and PTSD can cause you to always be on guard: it's exhausting!
- Stress hormones that keep you healthy and give you energy can run out of ammunition.
- When you give yourself the "All Clear," your stress response can begin to return to normal. This helps your nerves and alarm system to become less sensitive.

Intelligence Update Brief: All Clear! A True Story.

One night in Iraq, gunfire erupted around our safe-house. My entire platoon rushed to the roof-top to our defensive positions. We thought we were under attack! Almost immediately after this I got a radio-call from my company commander that U.S. Forces had captured one of Saddam Hussein's top lieutenants. The residents of our city were shooting in the sky in celebration. Some fireworks, huh?! Once we learned this, we knew there was no threat: we were not under attack!

Learning about pain and PTSD can help us realize that the threat of pain is not as dangerous as we thought: pain doesn't mean tissue damage, it means the nervous system is paying closer attention to possible threat.

When the threat is decreased, we can get the "All Clear" and move on with our daily lives.

Your nervous system in action

Your Radar Operator: Your amygdala can become extra-sensitive. This is one of the main parts of the brain that detects danger and acts like an alarm.

Your War Room: Your brain ultimately decides to produce pain or a stress response to protect you.

Your Stress Alarm: When under threat, the body releases hormones.

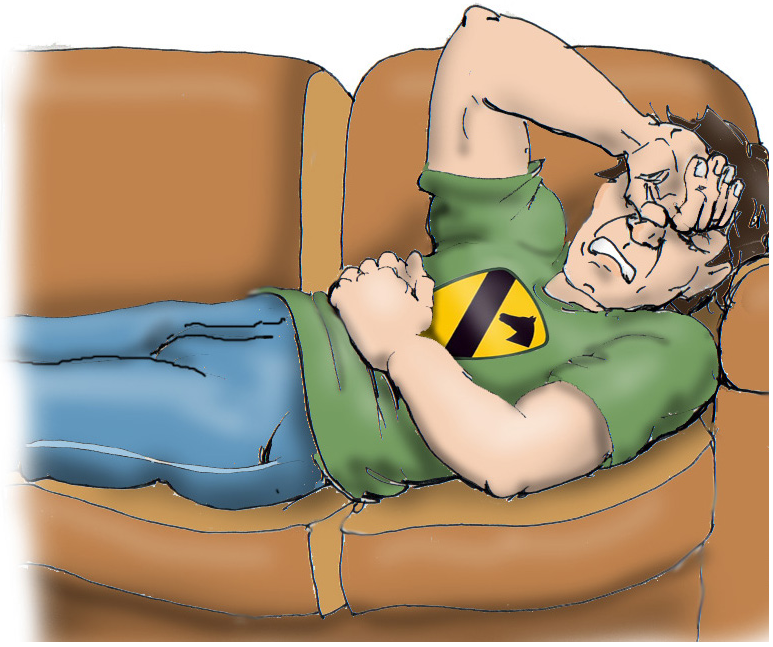
Your Recon Team: These are the nerves in your tissues.

Your Intelligence: Nerves in your spinal cord act as a filter for information headed to the brain.

As a reminder, these are the parts of your nervous system in action in this section.

Why do memories from my past invade my mind? Why does my pain come so easily now?

Memories are tricky things! It seems easy to forget important to-do lists, but most Soldiers never forget painful memories like injury or trauma. Why is that? **Stress hormones!** Stress hormones amplify memories of dangerous events to protect you. Even if you are unable to remember all the details, your nervous system keeps track of trauma.[35]



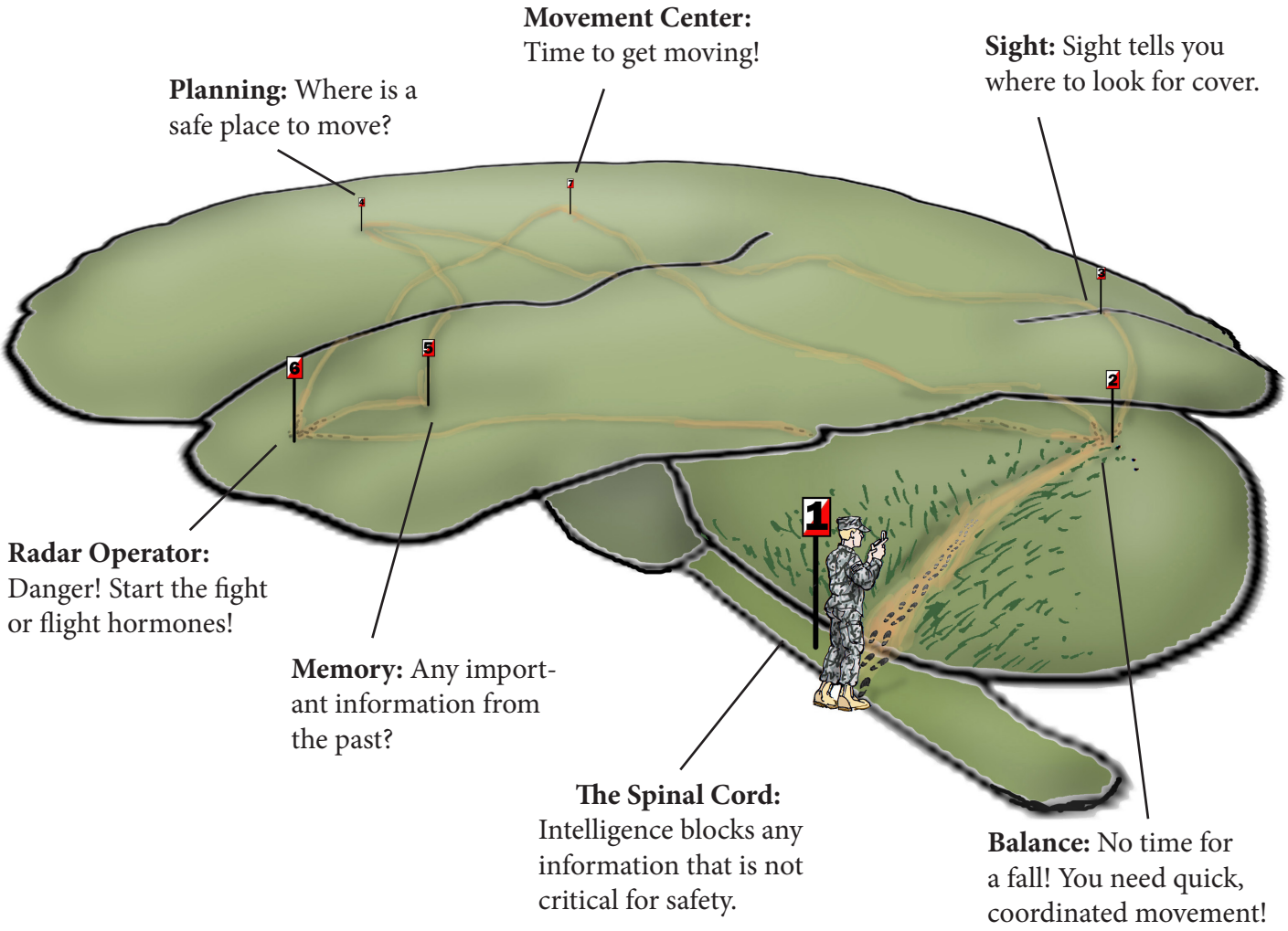
Not so sure? Do you remember the first Tuesday in September, 2001? Probably not, but but everyone remembers the second Tuesday, September 11, 2001. The brain is wired to remember important, dangerous events like "9/11".[36]

Your Trauma and Pain Memories

When it comes to physical danger, the radar operator (your amygdala) prepares your body for action before you can even think about it. This is smart. Could you imagine if you had to stop and think about diving for cover with incoming mortars? That would be way too slow and would increase the chance of injury.

Many parts of the brain are also at work. All of these parts make a **brain map**.[37] When a base alarm signals, "Battle-Stations" your brain focuses attention to the most important things for survival: find cover and seek safety!

Your Brain Map:



This response to danger creates a brain map.[37] The more you use brain maps, the quicker your response. Brain maps are very useful. In the military, when you train you are creating brain maps so you can respond to danger quickly. There are countless stories from combat where training and instinct from brain maps turned on and saved lives.

Take a look at your stress brain map. The stress brain map is frequently activated after PTSD—

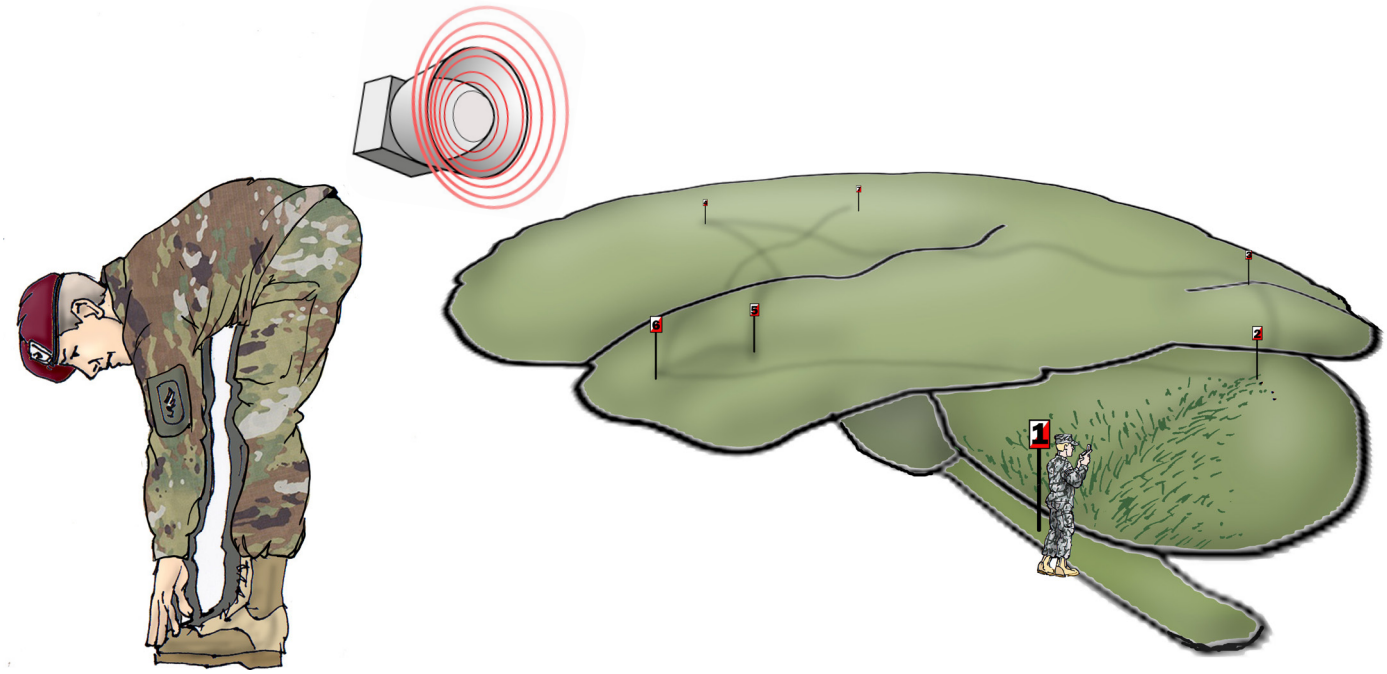
- You feel your major muscles tighten.
- Your heart rate goes up.
- The blood shifts to your muscles. This can give you an upset stomach.

Sound familiar? The stress brain map helps to protect you. But after PTSD this brain map activates often and easily. The stress brain map can be triggered by many things that remind your radar operator (amygdala) of your trauma.

A similar brain map happens with pain. After feeling sore after an activity enough times, you develop a pain brain map to protect you quickly. Nerves that fire together, wire together.[38] This means the more your nerves send danger messages together, your pain brain map gets stronger. Your pain brain map can become hard-wired!

Think about bending over to pick up an object:

In the beginning: A little discomfort bending down. Your War Room (brain) thinks, "This is not good. My battle buddy was discharged for back pain. Muscles: let's keep an eye on this and give a little extra protection." This is like walking through a land navigation course for the first time: the paths in your pain brain map are thin.



After walking the pain map hundreds of times: As soon as you bend over, the radar operator commands: "Battle-stations! You know what to do!" Your War Room knows what it is going to feel like without even needing to check in with the tissues. You may have used your brain map so much that the land navigation course now has wide paths that are easy to follow.

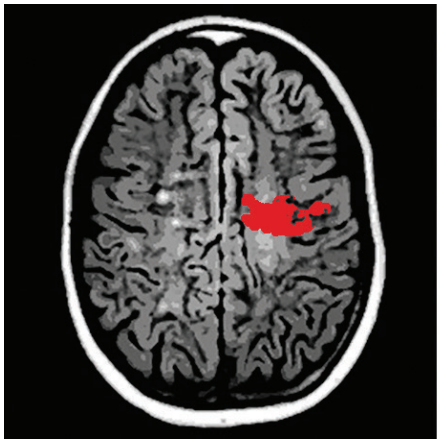
It may seem like the tissues in your back are getting worse since it takes less activity to activate the alarm. Really, though, your nervous system has become more sensitive and trained at producing a pain brain map. It is very easy to find your land navigation points on your brain map now because the paths are wide.

What can you do about the pain brain map? When you are armed with the knowledge of how the nervous system works, you can begin to make *new* maps. Brain maps change all the time.[38] You can help your brain map change by giving yourself a new intelligence report. Some activities may seem dangerous and sensitive, but your tissues are safe. These self-statements start to change your pain brain map.

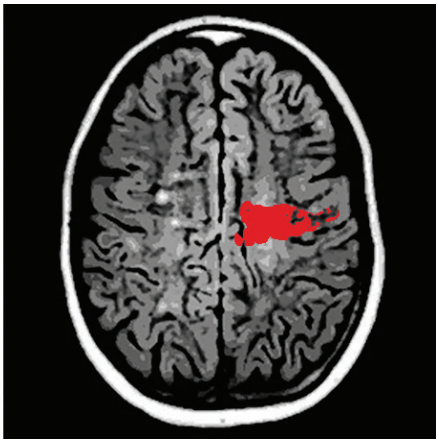
Other strategies to help—

- Practice new brain maps: just thinking about moving activates the same parts of the brain as real movements.[39] Visualizing movements in your mind is like exercising your brain. This is a great way to strengthen your brain (your Command and Control Center).
- Mental imagery really works the brain![38]

Imagined Movement:



Actual Movement:



The brain is incredibly resilient and can heal after trauma.[38]

Thinking about movements activates your brain, just like actually moving your body parts.[39]

- Identify something you used to do before your pain and PTSD brain maps became so strong. For example, imagine bending forward easily, without discomfort. Now, try bending forward 10 times. Gradually bend further each time. Remember to give yourself safety statements: it may feel sensitive, but bending forward is a normal and safe activity to perform. You are making a new brain map!

Intelligence Update Brief: Daily reports

In addition to brain maps, here is another reason why pain and anxiety seem to come so easily:

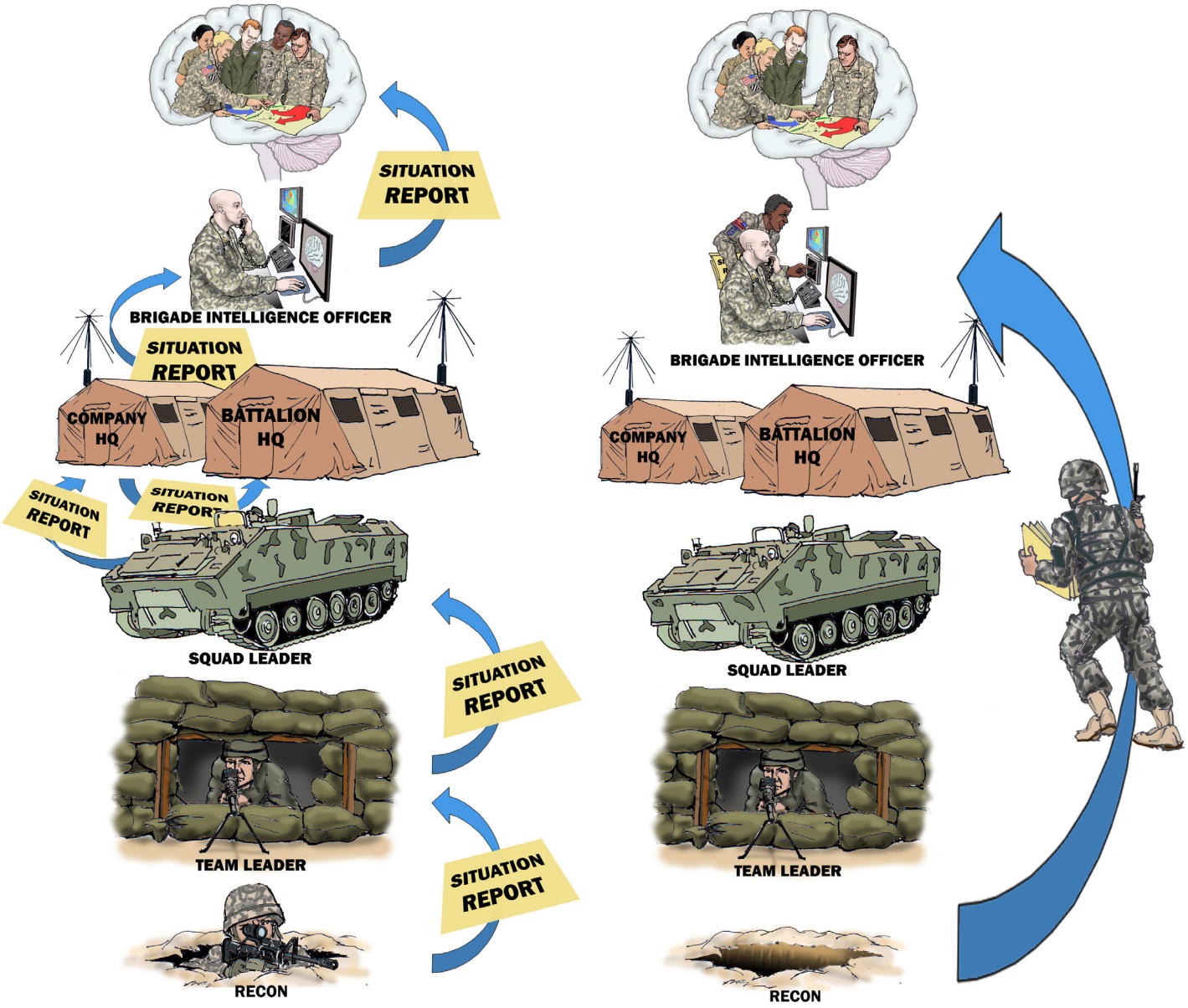
Your brain receives information from nerves in your tissues. These nerves (like your recon team) don't go straight to the brain, however. There are billions of helper nerves that filter and decide what information goes to the top, just like a chain of command.[40]

Imagine if the Brigade Sergeant Major decided to skip the normal process of receiving monthly situation reports from the Battalion. What if the Brigade Sergeant Major went straight to company squad leaders for hourly reports? What do you think he's going to find with these reports?

"This is a disaster! Three company arms rooms haven't opened yet. LT Brown hasn't finished his inventories. **We must be missing weapons!** Joe isn't at formation yet: **he must be AWOL! The Brigade has never been this bad!**"

Normally, the NCO chain filters these reports, sending up information only when there is a major problem; **but now, there is no filter**.

Normal Chain of Command: **Sensitive Nervous System: Skipping the Chain of Command**



The same thing happens with your tissues. Pain seems to be spreading and getting worse. Your sensitive nervous system decides all messages should be sent straight to your brain (War Room). The War Room sends the Sergeant Major to investigate the tissues. This is called up-regulation.[32] This breaks the chain of command that normally takes care of problems at lower levels. This information overload creates more pain and more vigilance!

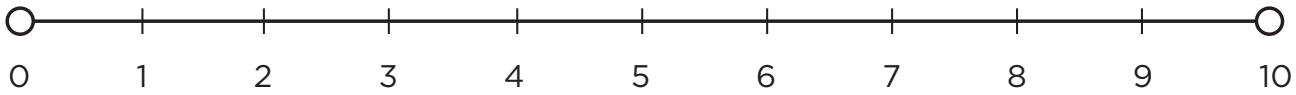
Strategies to help:

- Have you been taking a closer inventory on your life and body?
- Instead of taking closer inventories of all the problems in your body and life, try to find **acceptance**.
- People who have more **acceptance** about their pain have less pain and fewer PTSD symptoms.[41]
- **Acceptance** means recognizing
  - The things that you can control: taking steps to decrease nerve sensitivity, for example.
  - The things you cannot control: your past or what has happened to you.
- Give safety statements to yourself every day. Instead of worrying when you find a new ache or pain, remind yourself that your tissues are safe to move. This puts your chain of command back in control and filters out un-needed worries.

Homework:

On a scale from 0-10, how much do you accept the following statement? "Just because my pain and PTSD comes quicker and easier now, that does not mean my tissues are not safe. The path in my brain map is wider and easier to follow now. This is from extra-sensitive nerves."

Zero means you believe your tissues are not safe to move if you have pain. Ten means you believe your tissues are completely safe to move, even if you have pain.



Why did you pick that number? Why not higher? Why not lower? _____

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Section 4 Summary:

- After an injury, your brain produces pain to protect you.
- Pain and anxiety involve several parts of the brain.
- Nerves that fire together, wire together.
- This means every time you experience pain and anxiety, the nerves in your brain become better and more efficient at sending danger messages.
- This makes a map in your brain.
- This also means that you are not getting worse but you are using your pain and stress brain map much more now.

Your nervous system in action

Your Radar Operator: Your amygdala can become extra-sensitive. This is one of the main parts of the brain that detects danger and acts like an alarm.

Your War Room: Your brain ultimately decides to produce pain or a stress response to protect you.

Your Stress Alarm: When under threat, the body releases hormones.

Your Recon Team: These are the nerves in your tissues.

As a reminder, these are the parts of your nervous system in action in this section.

What is wrong with avoiding painful activites and memories?

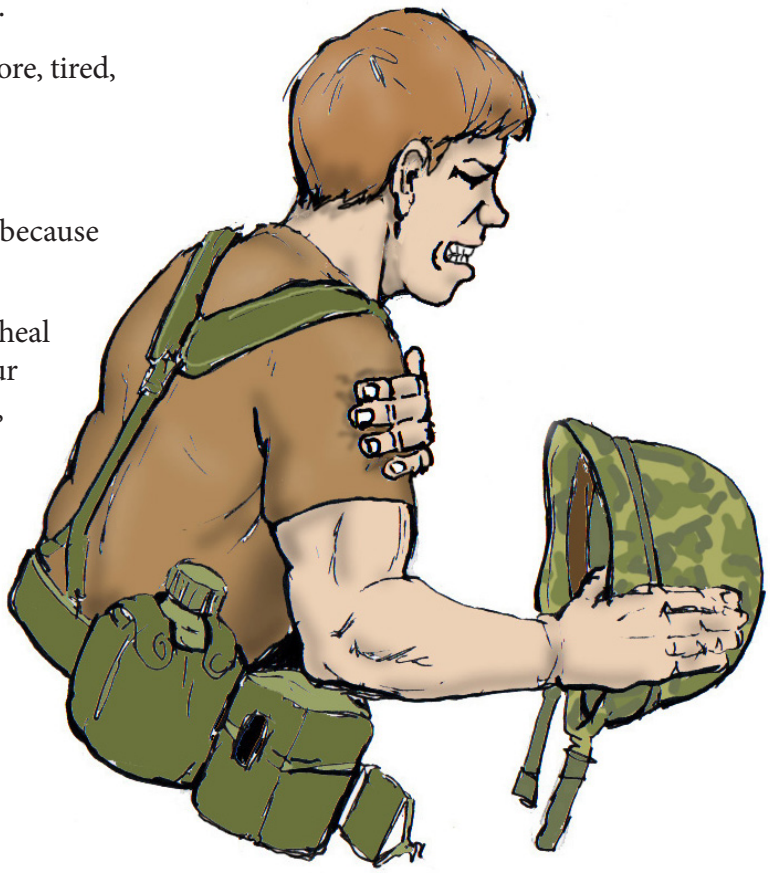
What if the military never left the wire to go on patrol? What if units just stayed bunkered down on the forward operating base to avoid the enemy? This strategy might be safe for the short term. In the long term, however, staying on defense does not always work. It can make sense to avoid situations that seem dangerous. However, this section shows how avoidance keeps your nerves sensitive.

Remember what happened to your muscles during a base alarm? Your body released hormones to increase your heart rate and supply big muscles with energy. When you are under attack, do you think that posture really matters that much? Of course not! You need to protect yourself!

During a crisis—

- Powerful "fight or flight" muscles are used.
  - Without a rest, these muscles become sore, tired, and over-worked.
- You also don't use core muscles as much.
  - These muscles become deconditioned because you must *"use it or lose it."*[38]

Most tissues heal within 3 to 6 months.[7] As tissues heal and you protect your injury, you may not stress your tissues in the way they are used to. Believe it or not, without *some* stress, tissues can become weak. Astronauts come back from outer space with bone and tissue problems because their bodies don't experience the stress of gravity.[42]



Soldiers understand the importance of conditioning. Do you remember how you felt during the first week of basic training?

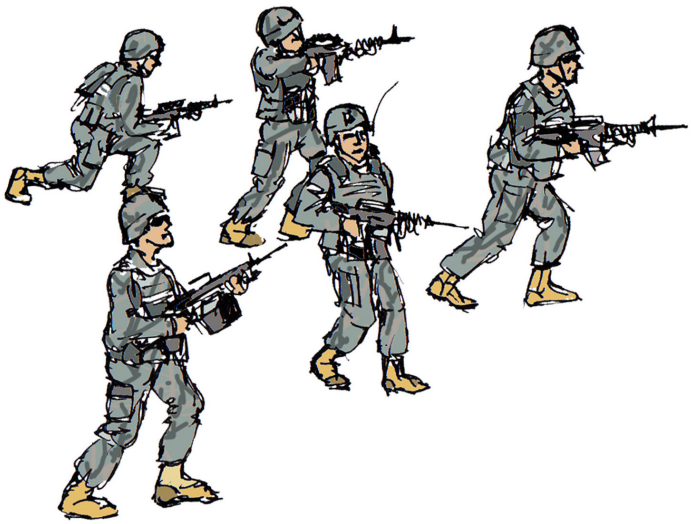
- Sore!
- Lots of blisters!

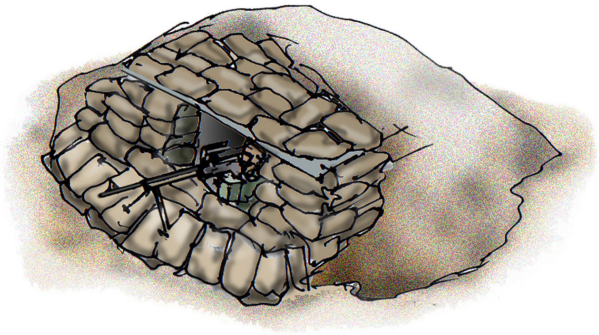
How did you feel at the end of basic training?

- Strong!
- 12-mile road march? No problem!

But after an injury, Soldiers usually respond in one of two extreme ways:

1. **"No pain, no gain."** A lot of Soldiers choose this first strategy. After all, you are professional at "driving on," and "accomplishing the mission." On top of that, Soldiers can learn to numb sensations after PTSD.[43] But when danger messages are ignored for too long, the nervous system will increase the alarm to get your attention.

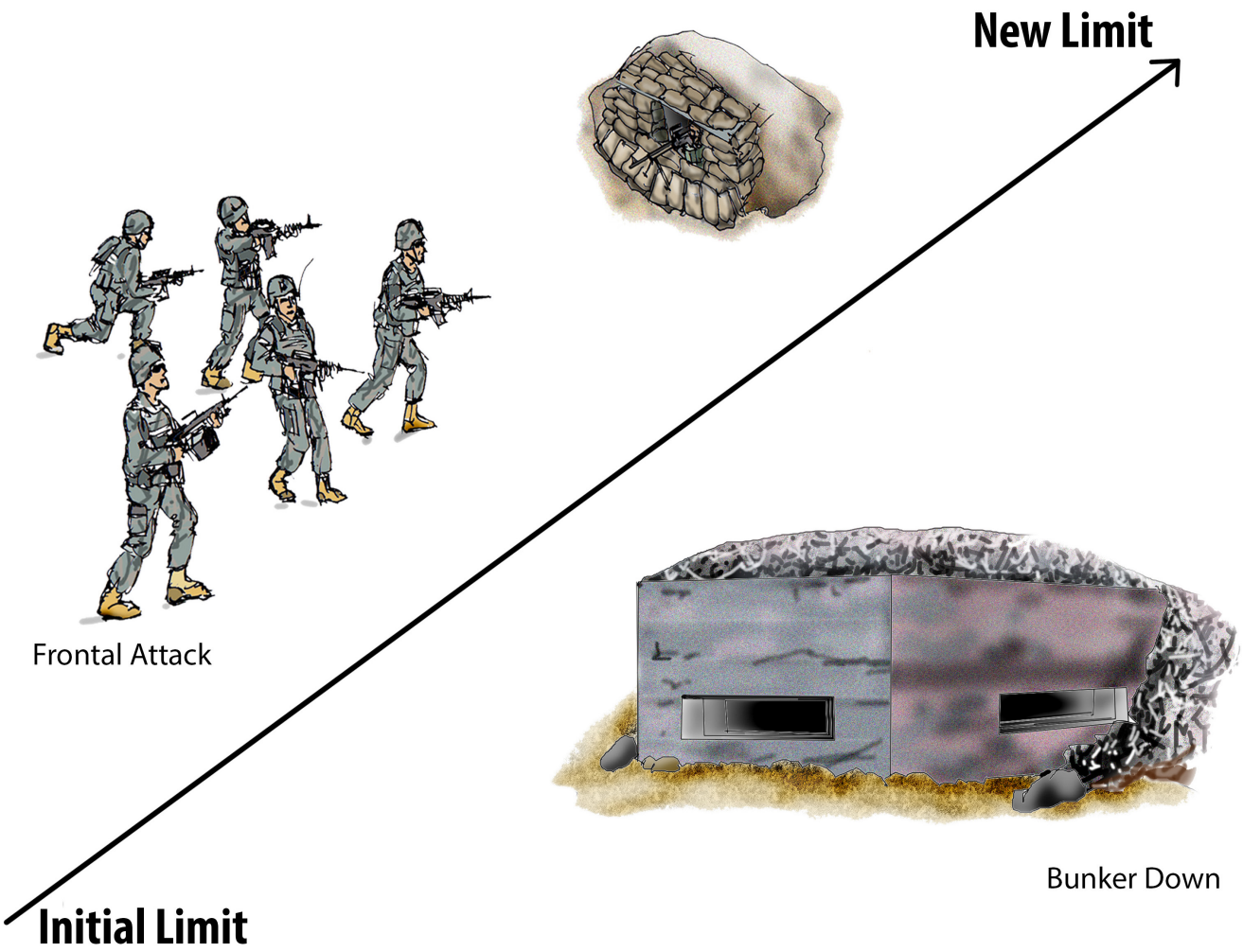




2. **Pull back to the bunkers and play it safe**. This strategy may be helpful for a very short time. But the bunker keeps you from enjoying life and doesn't help tissues get stronger. In the military, staying in a defensive position does not win wars. In the same way, too much rest keeps the tissues deconditioned and sensitive.

Since muscles become deconditioned quickly after an injury, one of the most important things you can do for your health and pain is to exercise regularly. Exercise has been shown to decrease pain,[44] depression,[45] and PTSD.[5] Exercise also helps increase the health of your brain.[46]

Remember: Exercising for as little as 15-25 minutes a day can give you many health benefits, including decreased nerve sensitivity[47,48] and decreased PTSD symptoms.[5]



Decreasing nerve sensitivity is a balance between "frontal attack" and "bunker down." Put another way, it's a balance between "no pain, no gain" and "avoid any activity that might cause pain." Remember how your radar became more sensitive after an injury? With gradual increases in activity, your radar limit raises and you can enjoy more activities.

You should NOT expect that these exercises will be completely pain-free. You may need to perform *modified* Physical Readiness Training (PRT) until you get used to the activities again. That doesn't mean push through sharp pains, though. "No pain, no gain" usually results in more pain in the long term. You can expect a little soreness as you begin your exercise program. **This is normal.**[49] Your nervous system is sensitive to movement. When your Command and Control Center (executive center of brain) tells your radar operator (amygdala) that exercise is safe, your nerves will start to communicate with each other in a new way. As the nerves in your tissues get used to new activities, your nerves become less sensitive. This can take time, but it works!

With repeated exercise, sensitivity decreases.[50]

Memory Avoidance: "Use it or lose it" applies to your brain as well. If you don't take the time to use your Command and Control Center, your radar operator stays sensitive and reacts to dangers automatically. Avoiding all triggers from your trauma keeps your radar operator in control. Believe it or not, avoiding all reminders of your trauma increases PTSD symptoms.[51] That is why your mental health provider may ask you to talk through some aspects of your trauma story. This mental routine is exercising your brain and training your radar operator (amygdala) to be less sensitive to trauma reminders. Gradually increasing your exercise activity works in a similar way.

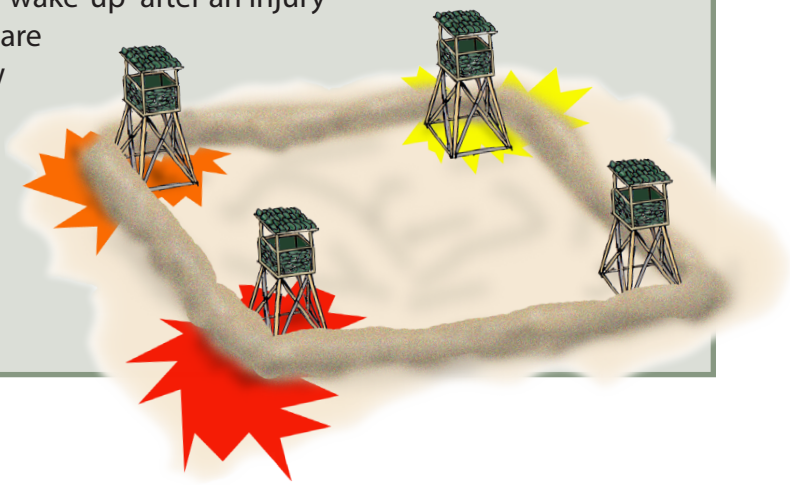
Intelligence Update Brief: Spreading Pain[7]

Many people **avoid** activities because they are worried they are dangerous. For example, what if your pain begins to spread? This must mean that the injury is getting worse, right? Spreading pain is usually due to increased sensitivity in your nerves, not from damaged tissues. Here is an example to explain this:

If you were pulling guard in the middle of the night, you might start to feel sleepy. What would happen if a nearby position was attacked? You would wake right up! You would pay extra-close attention to your sector. All the nearby guard towers would pay extra attention now.

In the same way, nerves in your tissues and brain "wake-up" after an injury or trauma.[21] Your nervous system is now more aware of the dangers.[18] Nerves in your tissues make new receptors to detect danger. Nerves that used to detect only movement or touch now also send danger messages. This is why pain "spreads".

When you understand that spreading symptoms are normal, you don't have to completely **avoid** activities because of pain or stress.



But wait, my pain is really bad. Shouldn't I get an MRI before I start a new activity?

Actually, magnetic resonance imaging, or MRI, does not show how much pain you are in. In fact, it is quite normal for individuals to have abnormal results on x-ray or MRI and yet have no pain at all.

Spine: 40-73% of healthy people have abnormal discs on x-ray or MRI; but they have NO pain.[74,75]

Shoulder: 96% of healthy people have abnormal structures in their shoulder.[76]

Arthritis: Some individuals with severe joint arthritis have little to no pain. Some individuals with minimal joint arthritis have severe pain. The amount of arthritis on x-rays or MRI does not match the level of pain.[77]

Mild Traumatic Brain Injury (mTBI, concussion): Many studies show that just because you may have had a mTBI, that does not mean you will always have cognitive problems.[78,79] Most people recover well after mTBI.[80]

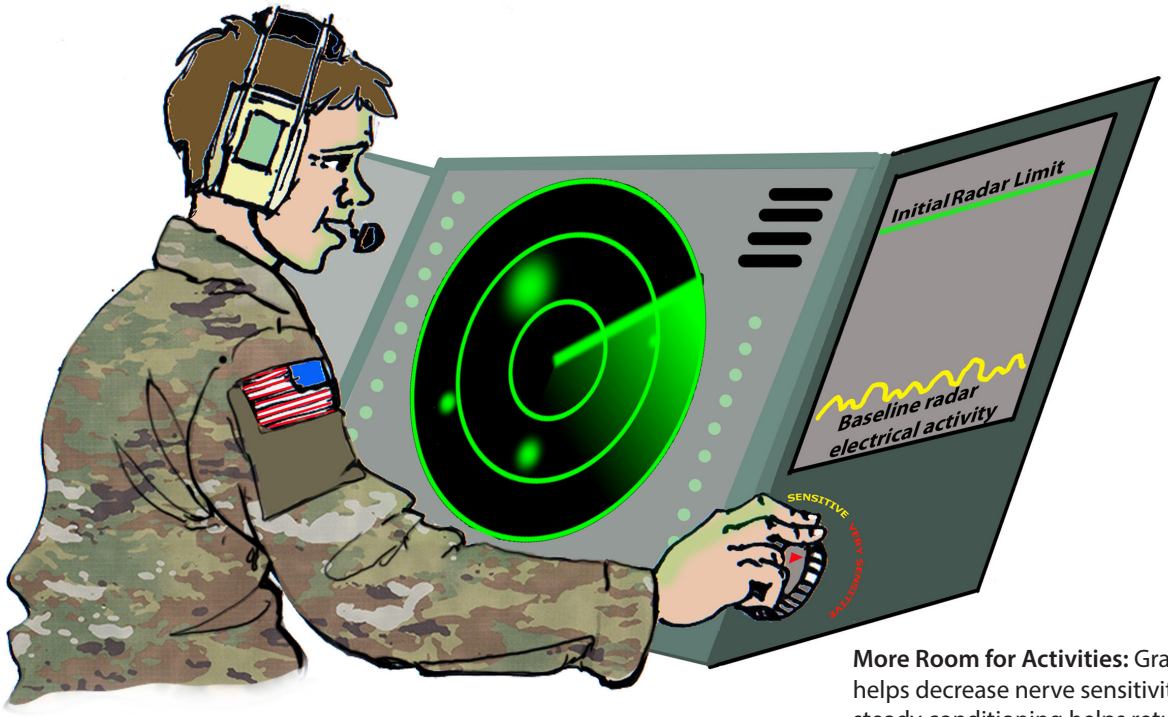
Herniated disc: *Even herniated discs in the spine heal.*[81] Many athletes are highly active, even with herniated discs in the spine.[74] In Veterans, tissue changes in the spine do not predict pain.[82]

Doctors now think that changes on x-rays and MRI as part of the normal aging process: much like gray hair or wrinkles.

Now that you know what is responsible for your pain (a sensitive nervous system), you can understand how MRI or x-rays have little to do with your pain levels.

Strategies to use if you have been avoiding pain or PTSD triggers—

- **Find enjoyable activities with friends and family.** This helps to make a new brain map. This helps condition your tissues for the activities you used to be able to do.
- **Talk to a counselor.** Your counselor can help you process your memories. This can help you put your Command and Control Center back in charge.
- **Pace yourself.** There is almost no limit to what you can do.[38,52] It is important to increase your activity levels gradually. It is also important to pace yourself. This means you don't over-do it, even if you are feeling good.
    - When you are feeling extra-sensitive, stick to your goal.
    - When you are feeling great, stick to your goal! One problem is that people over-do it when they are feeling good. After over-doing it, they feel extra-sensitive. When they feel extra-sensitive, they may avoid activities again.
    - Remember: no frontal attack is needed, but don't head to the bunkers.
    - Pacing yourself puts you in charge instead of reacting to your radar operator.



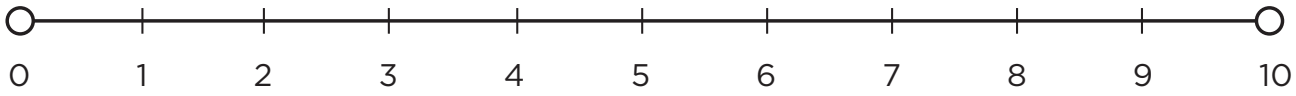
More Room for Activities: Gradual pacing helps decrease nerve sensitivity. Slow and steady conditioning helps return your radar to normal.

Homework:

Now that you have learned more about your nervous system:

On a scale from 0-10, how confident are you that you could begin exercising more, even if you have pain?

Zero means not confident at all. Ten means completely confident: you believe your tissues are safe to exercise, even if you have pain.



Why did you pick that number? Why not higher? Why not lower? _____

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Section 5 Summary:

- When faced with a severe threat, who has time to exercise? The body needs fast and strong muscles and so doesn't train your core muscles.
- If you only use these "fight or flight" muscles instead of also training your core, you can become sore and tired.
- Muscles become deconditioned quickly after an injury.
- It is important to realize that it is safe to increase physical activities gradually.
- You may be sensitive at first, but your tissues will adapt.
- You must use it, or lose it!

This guide has shown you how your nervous system can become extra-sensitive after a trauma and injury. This means that your radar operator (amygdala) is influencing your life more than your Command and Control Center. But there is hope! You can function in life after a trauma and injury. This section gives you a set of strategies to help you move forward.

We need a strategy that—

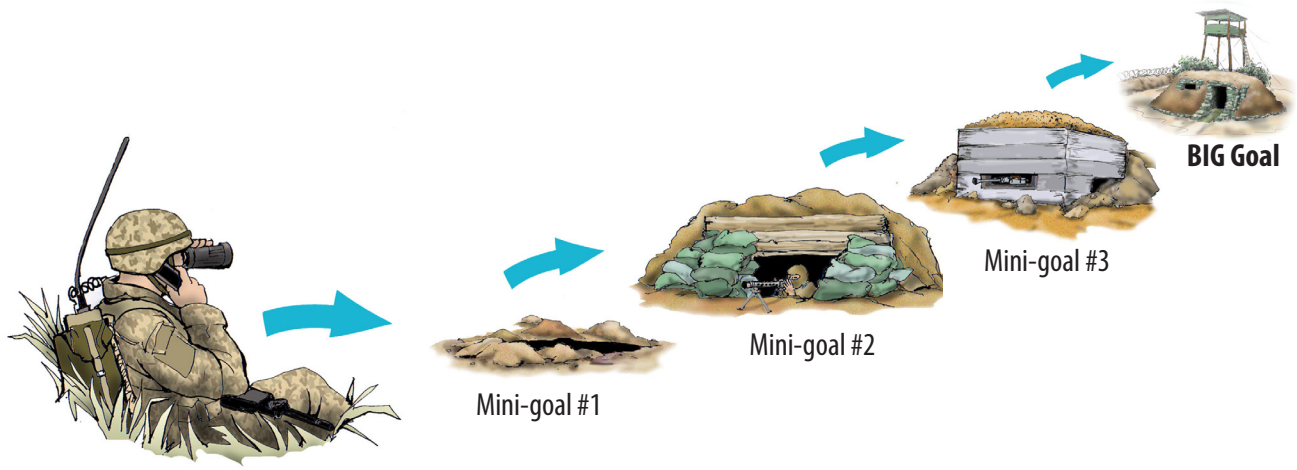
1. Helps make your nerves less sensitive.
2. Puts the Command and Control Center back in charge instead of your radar operator.

Goal Setting

In the military, you know the importance of having a **mission**. A mission, or a goal, helps make a map to recovery. Goals help you identify targets to aim for. At the beginning of this guide, you wrote down some things that you would do if your nervous system was not as sensitive. This is a good time to start thinking about what you want to achieve in the areas that matter to you.

Example Goals	Life Goal	Fitness Goal	YOUR Goal
BIG Goal	**Get promoted.**	**Run 2 miles.**	
Mini-Goal #1	Talk to your supervisor.	Walk 2 miles.	
Mini-Goal #2	Study for the board.	Run 1/2 mile.	
Mini-Goal #3	Take a class to improve your occupational skill.	Run 1 mile. Walk. Then run 1 mile again.	

Next, set smaller goals to help you achieve your bigger goals. The military does this all the time. The big goal might be to win the war, but small goals are necessary. **A good strategy takes one objective at a time.**



Make sure you set goals that are important **to you**. Here are some other tips for making goals:

- Write them down. You are more likely to accomplish your goals when you write them down.
- Be specific about what you want to achieve.
- Try to make your goals measurable. It is helpful if you can track your progress.
- Be realistic: don't make your goals *too easy*, but if you make your goals *too difficult* at first you may be discouraged.
- Share and discuss your goals with someone close to you.

Eat, sleep, and exercise!

These three things are very important in life. What you eat, how you sleep, and your amount of exercise has a big impact on your pain and PTSD.

Sleep:

When you don't sleep well, your alarm becomes extra-sensitive. So far, this guide has shown how people with PTSD and pain have an extra-sensitive alarm system. Unfortunately, alarms are great for waking you up, not for helping you sleep!

This is one way the alarm system works at night when we are trying to sleep:

- The War Room calls your recon team to check their sectors one final time.
- When all is quiet, the War Room starts to focus on danger messages. This happens even when your recon team—the nerves in your tissues—have nothing to report.
- Increased focus on danger messages turns up the pain alarm.[53]
- Activating the alarm can increase the release of stress hormones. Stress hormones can prevent good sleep.
- Lack of sleep makes the alarm system more sensitive.[54]
- What a tiring cycle!

One final check!

What can you do about this alarm system that keeps you up? First, it is important to know that good sleep starts with feeling safe. Military training can help here. In the military, you know how important Pre-Combat Checks are. You need to develop a Pre-Sleep Checklist.[55] When you have a specific checklist to follow, it can help you feel safe and confident.

Pre-Sleep Checklist

- ❑ Before trying to sleep, give yourself safety statements: "I am safe. I have done everything that I need to do to keep myself safe. My tissues are safe."
- ❑ Before trying to sleep, decrease over-stimulation:
  - No caffeine 8 hours before bedtime (no soft drinks, coffee, or tea).
  - Limit high-sugar snacks, alcohol, and tobacco products at night.
  - Try to unplug from electronics at least 1 hour before bedtime, and don't use electronics or television in your bedroom. The light from these types of devices makes your War Room extra-alert.
  - The bed is for romance and sleep. Don't use your room as a bunker when you are in pain during the day. Doing this will make your War Room extra-alert when you are in your bedroom.
  - Keep your room quiet, dark, cool, and comfortable.
- ❑ Keep a regular wake-up time.
- ❑ Keep a regular bedtime.
- ❑ Plan for around 7-8 hours of sleep each night.
- ❑ However, if you are having trouble sleeping:
  - Get out of bed if you cannot sleep.[56] Read something boring, like a military manual.
  - Go to bed when you are tired.
- ❑ Limit naps during the day. Try to limit naps to late morning, early afternoon for only 30 minutes.
- ❑ Stay active during the day. Make sure you are done with exercise by early evening.
- ❑ Move your bedroom clock to a place that you cannot see it.
- ❑ Park your ideas. Place a notepad and pen next to your bed. Write down anything on your mind. Doing this can clear your worries so you can go to sleep.

But what if this doesn't work? Don't give up! It can be very frustrating when you can't sleep the way that you want to. Try not to get too frustrated. When you are upset that you are unable to sleep, this may increase your waking hormones and cause your heart to beat faster, which will of course make it more difficult to sleep! Be patient with yourself as you work on building a new habit. Don't be afraid to seek professional help. Cognitive-behavioral sleep therapy has a very good track record for helping people sleep better.[57]

Have a sleep back-up plan: If pain keeps you up or wakes you from sleep, perform a few gentle movements or stretches to help decrease nerve sensitivity. Have your safety statements ready: A little sore, a little sensitive, but nothing dangerous to keep you awake. You may also want to practice the relaxation strategies on page 33.

Your War Room: It is important to realize that there is no "off button" for your War Room, or your brain. Don't try and turn your thoughts "off." Instead, learn to direct where your Command and Control Center focuses its attention—

- Your favorite memory.
- A poem.
- A verse.
- A prayer.

If negative thoughts keep you up, practice coping skills. See the coping section on the next page and try to focus on the things that you can control.

Eat:

Good foods can help decrease nerve sensitivity.[58] Good foods also help you sleep better.[59]

To improve your health and decrease your pain, follow these tips:

- Follow a healthy-fat diet.[60] Fats should come from plants (like olive oil) and fish.[58]
- Lots of vegetables and fruits.[58]
- Healthy whole grains like pasta and rice can help you with energy.[58]
- Nuts can be a great snack.[58]
- Avoid foods with a lot of added sugar, like soft-drinks.[61]

Here are some examples of specific foods and spices that have been shown to improve your ammunition levels to fight pain when taken at the right time—

- Chicken soup.
- Dark chocolate.[62,63] Now that is news that should make most of us happy! Remember, though: not too much chocolate before bedtime because chocolate has caffeine.
- Ginger.[64]
- Curry.[65]
- Pomegranate juice.[66]

Exercise:

Exercise has many health benefits—

- It decreases the sensitivity of your radar operator.
- It can help with PTSD symptoms.
- It puts your Command and Control Center in charge.

So why don't Soldiers exercise more? One reason is pain. Some military members who have pain avoid exercise because they think it is damaging their tissues.[67]

Now you know that pain during exercise is mostly due to sensitive nerves, not tissue damage.[49]

This is good news! This means it is safe to exercise, even if you have had pain for a long time.

The key is to start slowly and work your way to higher levels of activity. Progressive profiles can help with this. You may need to start with a low-impact profile as you progress to a self-paced profile. Leaders and medical providers will see you progressing from a low-impact to a self-paced profile and know you are working hard.

Here is a schedule that shows how you could do this:

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Week 1	Walk 15 min	Walk 15 min	Walk 15 min	Walk 20 min	Walk 15 min	Walk 15 min
Week 2	Walk 20 min	Walk 20 min	Walk 20 min	Walk 30 min	Walk 20 min	Walk 20 min
Week 3	Walk 4, jog 2 min, 5x	Modified PRT	Walk 4, jog 2 min, 5x	Modified PRT	Walk 4, jog 2 min, 5x	Walk 25 min
Week 4	Modified PRT	Walk 3, jog 3 min, 5x	Modified PRT	Walk 3, jog 3 min, 5x	Modified PRT	Walk 30 min
Long term goal[68]	Return to run	Unit PRT	Return to run	Unit PRT	Return to run	Walk 30 min

Note: Using this table is just one way to increase your exercise activity. The important thing is to make small increases.

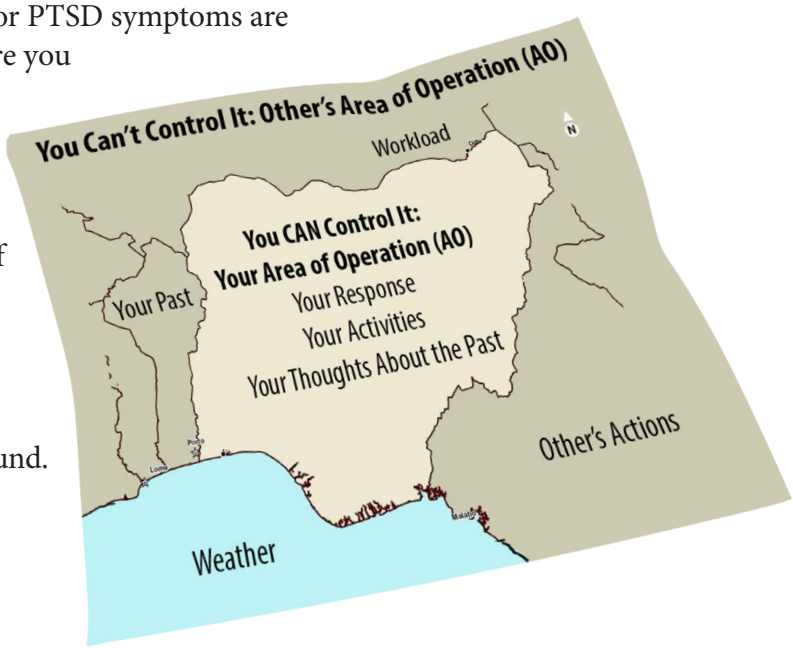
Remember your goals. When you have realistic goals and you gradually increase your exercise, almost no activity is off limits. For people who train, even running marathons is safe for tissues![52] With gradual increases, you know that your tissues are getting used to activity, even if you have some sensitivity at first.

Don't give up! Remember how you felt at the beginning of basic training? Your tissues will get used to it!

Reward yourself. After exercising, take a relaxing shower. Buy yourself comfortable workout shoes and clothes.

Coping

Here are some strategies to practice when your pain or PTSD symptoms are really bothering you. Just like in the military, the more you practice when you are having a good day, the more it will help you on the bad days.

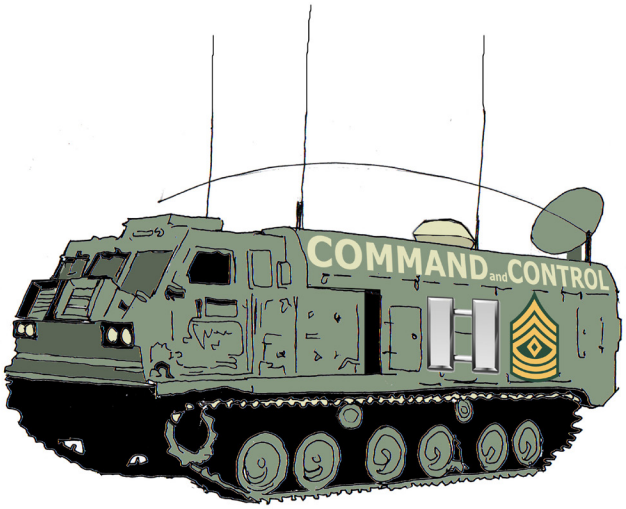


Acceptance

When something is really bothering you, ask yourself if it is inside your area of operation or outside your control.[69] For example—

- You can't control other people.
- You can't control your genes or family background.
- You can't control the past.

Command and Control Center:



Make a plan.

Focus on the positive.

Pick an activity that you can do.

Choose a response that supports your Command and Control Center.

Radar Operator:

Blame others or yourself.

Shame yourself.

Avoid thoughts or activities.

Think only of the worst-case scenario.

It is important to recognize and accept that you can't control some things in life.[70] But there are many things that you *can* control and put inside your area of operation—

- You can control how you respond to other people.
- You can control what you think about the past.
- You can control how you breathe and how you move your body.

It is important to focus on thoughts that are inside your Area of Operation, and then pick active responses that keep your Command and Control Center in charge. Focusing on areas outside of your control and worrying too much will keep your radar operator sensitive.

Here are other ways to get your Command and Control Center back in charge of your radar operator:

Practice relaxation.[71] Find a comfortable place to lie down. Take a few quiet breaths to start. Research has shown that relaxing in the 10 positions helps your Command and Control Center regulate your radar operator, or your stress response.[72] Try putting yourself in these 10 positions and resting for a few minutes. Remember there is no "off" button for your War Room. Practice focusing on the parts of your body that you are relaxing or a favorite poem, prayer, or verse.

1. Keep your **head** in line with the middle of your body. Your head should be supported.
2. Keep your **forehead** smooth.
3. Close your **eyes**. Keep your eyelids smooth.
4. Keep your **lips** and teeth apart. Make sure your tongue is not putting pressure against your teeth or the top of your mouth.
5. Let your **throat** and neck areas be still. Swallow if you need to. Otherwise, there should be no throat movement or sounds.
6. Allow your **shoulders** to slope gently. Keep them even.
7. Your **elbows** should be slightly bent, with your arms supported.
8. Rest your **hands** in your lap. Allow your fingers to curl gently. Keep your hands from closing tightly.
9. Keep your **knees** comfortably apart.
10. Let your **feet** point away from each other. Your feet should make a "V" shape.

Start practicing for 5 minutes at a time. As you get better at relaxing your tissues, add a minute to your next practice session. You can build up to 20 minutes a day. If you lose your focus, just start over at the top and notice how you feel at each body part.

Practice relaxed breathing. Remember the R's of breathing.

1. REST
   - Find a comfortable position.
   - Start your practice by taking a normal breath of air in, then letting it all out.
2. RISE
   - As you start to breathe in, let your abdomen rise.
   - Let your chest relax.
   - This is called breathing from your diaphragm.
   - Breathe in a normal breath while counting to 4: easy does it!

3. RELEASE
    - Exhale completely.
    - Don't try to control the release.
    - It is like a balloon collapsing. For most people this takes about 2 seconds.
4. REST
    - Count to 4.
    - This doesn't mean you must hold your breath. Just wait quietly until you are ready for your next breath.
5. REPEAT
    - **Rise**: let your stomach rise while counting to 4.
    - **Release**: exhale completely (around 2 seconds).
    - **Rest**: relax your body for a count of 4.
6. Your goal is around 3-7 breaths per minute.
7. Start practicing this for 5 minutes. Each time you practice, increase your time by 1 minute. Aim for 20-30 minutes each day.[34]
8. As you get better at this, try to breathe with your diaphragm throughout the day. You won't be breathing at the relaxed pace of 3-7 breaths per minute thorughout the day and that is OK. Breathing this way helps you stay more calm. If this activity makes you feel lightheaded or dizzy, please check in with your healthcare provider before continuting this practice.

Counseling

As important as these strategies are, sometimes everyone needs others to help. Camaraderie and support are a part of what makes military service so great! To seek help is a sign of strength, not weakness. Sharing your story can help your brain to re-wire and your body to heal. The great thing is treating PTSD symptoms also helps with pain![73] Find someone who connects with you!

If your trauma or your pain seems unbearable and if you feel you have no hope, give the Veteran's Crisis Line a call: **1-800-273-8255** (Press 1). Or, you can even TEXT the Crisis Line: just send a text message to: **838255**. There are people standing by who are ready to hear your story and be a part of your healing.

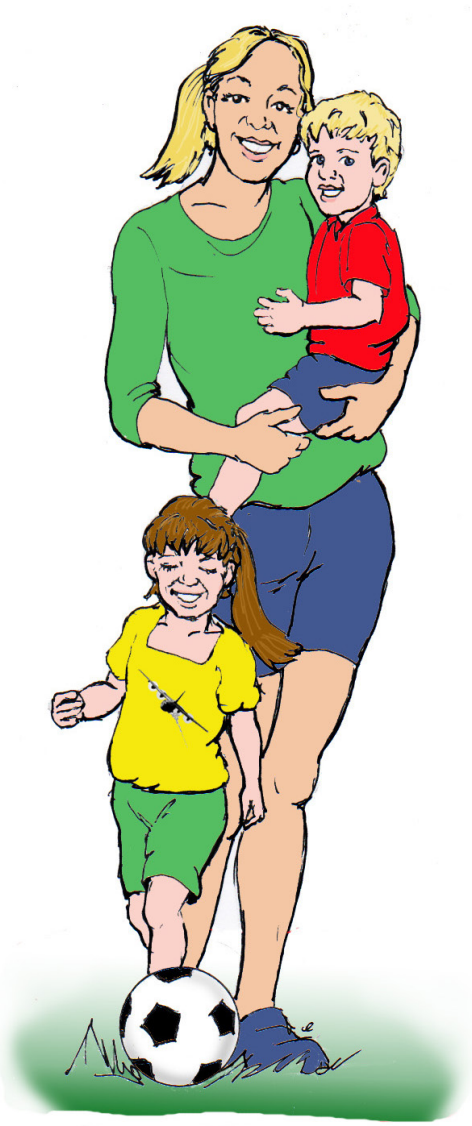
Section 6 Summary:

- The body uses pain and stress to protect you.
- The greater the threat, the more your radar operator will activate the alarm to protect you.
- After trauma, your radar operator becomes more sensitive and extra-alert.
- Stress hormones that help you fight sickness and inflammation in the short run can deplete yourself in the long run so that you "run out of ammunition".
- Getting the "All Clear" can help re-supply your ammunition and helps your nerves to become less sensitive.
- When you don't get the "All Clear," you make a stress and pain brain map.
- The more you use your map, the wider your path gets. You are not getting worse. Your path is just much easier to travel now.
- When it feels like you are getting worse, you avoid dangerous activities.
- Muscles become deconditioned quickly after an injury when you avoid activity.
- It is important to realize that it is safe to increase physical activities gradually.
- You may be sensitive at first, but your tissues will adapt.
- You must use it, or lose it!
- Give yourself realistic goals. Break them up into "mini-goals."
- Make sleep a top priority and goal.
- Eat healthy foods that help make your nervous system less sensitive.
- Exercise! Pace yourself.
    - No frontal attacks (don't think "no pain, no gain").
    - Don't head to the bunker, either.
- Focus your War Room on what you can control.
- Relax! Practice breathing with your diaphragm.
- These strategies make your radar operator and your nerves less sensitive.
- These strategies help get you, or your Command and Control Center, back in control of your life.

Conclusion

Remember, you are not alone! Your pain and trauma experience can be scary and worrisome. But now, you've learned that anyone can understand how the nervous system works. You have learned that your nerves have become more sensitive after your trauma. This can turn up your pain and stress response. Remember, this alarm system can be re-wired and turned down with persistence, patience, and knowledge about the nervous system. The more you know about pain, the less of a threat it is.

The choice is now yours! It is time to give yourself the "All Clear!" from tissue pain so that you can focus your efforts on healing and managing your trauma.



1. Brage S, Sandanger I, Nygard JF. Emotional distress as a predictor for low back disability: a prospective 12-year population-based study. *Spine*. 2007;32(2):269-274.
2. Pierce ME, Pritchard LM. Lower stress-reactive cortisol in female veterans associated with military status but not PTSD. *Stress* (Amsterdam, Netherlands). 2016;19(5):486-491.
3. Scioli-Salter ER, Forman DE, Otis JD, Gregor K, Valovski I, Rasmusson AM. The shared neuroanatomy and neurobiology of comorbid chronic pain and PTSD: therapeutic implications. *Clinical Journal of Pain.* 2015;31(4):363-374.
4. Louw A, Diener I, Butler DS, Puentedura EJ. The effect of neuroscience education on pain, disability, anxiety, and stress in chronic musculoskeletal pain. *Archives of Physical Medicine and Rehabilitatio*n. 2011;92(12):2041-2056.
5. Rosenbaum S, Sherrington C, Tiedemann A. Exercise augmentation compared with usual care for post-traumatic stress disorder: a randomized controlled trial. *Acta Psychiatrica Scandinavica.* 2015;131(5):350-359.
6. Moseley L. Unraveling the barriers to reconceptualization of the problem in chronic pain: the actual and perceived ability of patients and health professionals to understand the neurophysiology. *The Journal of Pain.* 2003;4(4):184-189.
7. Louw A, Puentedura E. Therapeutic Neuroscience Education: *Teaching Patients about Pain: a Guide for Clinicians.* International Spine and Pain Institute; 2013.
8. Hannibal KE, Bishop MD. Chronic stress, cortisol dysfunction, and pain: a psychoneuroendocrine rationale for stress management in pain rehabilitation. *Physical Therapy.* 2014;94(12):1816-1825.
9. Bianconi E, Piovesan A, Facchin F, et al. An estimation of the number of cells in the human body. *Annals of Human Biology*. 2013;40(6):463-471.
10. Woolf CJ. Central sensitization: implications for the diagnosis and treatment of pain. *Pain*. 2011;152(3):S2-S15.
11. Liu SH, Yang RS, al-Shaikh R, Lane JM. Collagen in tendon, ligament, and bone healing. A current review. *Clinical Orthopaedics and Related Research*. 1995(318):265-278.
12. Beecher HK. Pain in men wounded in battle. *Annals of Surgery*. 1946;123(1):96.
13. Flor H, Nikolajsen L, Staehelin Jensen T. Phantom limb pain: a case of maladaptive CNS plasticity? *Nature Reviews: Neuroscience.* 2006;7(11):873-881.
14. Moseley GL. A pain neuromatrix approach to patients with chronic pain. *Manual Therapy.* 2003;8(3):130-140.
15. McFarlane AC. Stress-related musculoskeletal pain. Best practice & research *Clinical Rheumatology.* 2007;21(3):549-565.
16. AP. George Elliott, 85; Warned of Planes Nearing Pearl Harbor. *The New York Times*. 2003(25 December 2003).
17. Shvil E, Rusch HL, Sullivan GM, Neria Y. Neural, psychophysiological, and behavioral markers of fear processing in PTSD: a review of the literature. *Current Psychiatry Report*s. 2013;15(5):358.
18. van Marle HJ, Hermans EJ, Qin S, Fernandez G. From specificity to sensitivity: how acute stress affects amygdala processing of biologically salient stimuli. *Biological Psychiatry.* 2009;66(7):649-655.
19. Smart KM, Blake C, Staines A, Thacker M, Doody C. Mechanisms-based classifications of musculoskeletal pain: part 1 of 3: symptoms and signs of central sensitisation in patients with low back (+/- leg) pain. *Manual Therapy.* 2012;17(4):336-344.
20. Horn SR, Charney DS, Feder A. Understanding resilience: New approaches for preventing and treating PTSD. *Experimental Neurology.* 2016;284(Pt B):119-132.
21. Asmundson GJ, Katz J. Understanding the co-occurrence of anxiety disorders and chronic pain: state-of-the-art. *Depression and Anxiety.* 2009;26(10):888-901.
22. Jackson T, Pope L, Nagasaka T, Fritch A, Iezzi T, Chen H. The impact of threatening information about pain on coping and pain tolerance. *British Journal of Health Psychology.* 2005;10(3):441-451.
23. Gray MJ, Elhai JD, Frueh BC. Enhancing patient satisfaction and increasing treatment compliance: patient education as a fundamental component of PTSD treatment. *The Psychiatric Quarterly.* 2004;75(4):321-332.
24. Craske MG, Kircanski K, Zelikowsky M, Mystkowski J, Chowdhury N, Baker A. Optimizing inhibitory learning during exposure therapy. *Behaviour Research and Therapy*. 2008;46(1):5-27.
25. Cooke SF, Bliss TV. Plasticity in the human central nervous system. *Brain*. 2006;129(Pt 7):1659-1673.
26. Morris MC, Rao U. Psychobiology of PTSD in the acute aftermath of trauma: Integrating research on coping, HPA function and sympathetic nervous system activity. *Asian Journal of Psychiatry*. 2013;6(1):3-21.
27. Osorio C, Probert T, Jones E, Young AH, Robbins I. Adapting to Stress: Understanding the Neurobiology of Resilience. *Behavioral Medicine* (Washington, DC). 2016:1-16.
28. Kozlowska K, Walker P, McLean L, Carrive P. Fear and the Defense Cascade: Clinical Implications and Management. *Harvard Review of Psychiatr*y. 2015;23(4):263-287.
29. McEwen BS, Seeman T. Protective and Damaging Effects of Mediators of Stress: Elaborating and Testing the Concepts of Allostasis and Allostatic Load. *Annals of the New York Academy of Sciences*. 1999;896(1):30-47.
30. Morris MC, Compas BE, Garber J. Relations among posttraumatic stress disorder, comorbid major depression, and HPA function: a systematic review and meta-analysis. *Clinical Psychology Review*. 2012;32(4):301-315.
31. Latremoliere A, Woolf CJ. Central sensitization: a generator of pain hypersensitivity by central neural plasticity. *The Journal of Pain*. 2009;10(9):895-926.
32. McMahaon S, Koltzenburg M, Tracy I, Turk DC. *Wall and Melzack's textbook of pain*. 6th ed. Philadelphia, PA: Elsevier/Saunders; 2013.
33. Scioli-Salter E, Forman DE, Otis JD, et al. Potential neurobiological benefits of exercise in chronic pain and posttraumatic stress disorder: Pilot study. *Journal of Rehabilitation Research and Developmen*t. 2016;53(1):95-106 112p.
34. Schmidt JE, Joyner MJ, Carlson CR, Hooten WM. Cardiac autonomic function associated with treatment adherence after a brief intervention in patients with chronic pain. *Applied Psychophysiology and Biofeedback*. 2013;38(3):193-201.
35. Van Der Kolk B. *The body keeps the score: Brain, mind, and body in the healing of trauma*. New York, NY: Penguin; 2015.

36. Fivush, Robyn, Valerie J. Edwards, and Jean Mennuti-Washburn. "Narratives of 9/11: Relations among personal involvement, narrative content and memory of the emotional impact over time." *Applied Cognitive Psychology* 17.9 (2003): 1099-1111.

37. Melzack R. Pain and the neuromatrix in the brain. *Journal of Dental Education.* 2001;65(12):1378-1382.

38. Doidge N. *The brain that changes itself: Stories of personal triumph from the frontiers of brain science.* New York, NY: Penguin; 2007.

39. Hanakawa T, Dimyan MA, Hallett M. Motor planning, imagery, and execution in the distributed motor network: a time-course study with functional MRI. *Cerebral Cortex*. 2008;18(12):2775-2788.

40. McBain CJ, Fisahn A. Interneurons unbound. *Nature Reviews: Neuroscience*. 2001;2(1):11-23.

41. Cook AJ, Meyer EC, Evans LD, et al. Chronic pain acceptance incrementally predicts disability in polytrauma-exposed veterans at baseline and 1-year follow-up. *Behaviour Research and Therapy*. 2015;73:25-32.

42. Vandenburgh H, Chromiak J, Shansky J, Del Tatto M, Lemaire J. Space travel directly induces skeletal muscle atrophy. *The FASEB Journal.* 1999;13(9):1031-1038.

43. Geuze E, Westenberg HG, Jochims A, et al. Altered pain processing in veterans with posttraumatic stress disorder. *Archives of Geneneral Psychiatry.* 2007;64(1):76-85.

44. Chen YW, Li YT, Chen YC, Li ZY, Hung CH. Exercise training attenuates neuropathic pain and cytokine expression after chronic constriction injury of rat sciatic nerve. *Anesthesia and Analgesia*. 2012;114(6):1330-1337.

45. Cooney G, Dwan K, Mead G. Exercise for depression. *Journal of the American Medical Association*. 2014;311(23):2432-2433.

46. Hillman CH, Erickson KI, Kramer AF. Be smart, exercise your heart: exercise effects on brain and cognition. *Nature Reviews: Neuroscience*. 2008;9(1):58-65.

47. Hoffman MD, Shepanski MA, Mackenzie SP, Clifford PS. Experimentally induced pain perception is acutely reduced by aerobic exercise in people with chronic low back pain. *Journal of Rehabilitation Research and Development*. 2005;42(2):183-190.

48. Yu SH, Park SD. The effects of a neck musculoskeletal intervention on neck pain levels and depression in post-traumatic stress disorder patients. *Journal of Physical Therapy Science.* 2015;27(6):1975-1978.

49. Meeus M, Nijs J, Van Wilgen P, Noten S, Goubert D, Huijnen I. Moving on to Movement in Patients with Chronic Joint Pain. *Pain*. 2016;1.

50. Andersen LL, Kjaer M, Sogaard K, Hansen L, Kryger AI, Sjogaard G. Effect of two contrasting types of physical exercise on chronic neck muscle pain. *Arthritis and Rheumatis*m. 2008;59(1):84-91.

51. Ruiz-Párraga GT, López-Martínez AE. The role of experiential avoidance, resilience and pain acceptance in the adjustment of chronic back pain patients who have experienced a traumatic event: A path analysis. *Annals of Behavioral Medicine*. 2015;49(2):247-257.

52. Hohmann E, Wortler K, Imhoff AB. MR imaging of the hip and knee before and after marathon running. *American Journal of Sports Medicine*. 2004;32(1):55-59.

53. Bantick SJ, Wise RG, Ploghaus A, Clare S, Smith SM, Tracey I. Imaging how attention modulates pain in humans using functional MRI. *Brain*. 2002;125(2):310-319.

54. Irwin MR, Olmstead R, Carrillo C, et al. Sleep loss exacerbates fatigue, depression, and pain in rheumatoid arthritis. *Sleep*. 2012;35(4):537-543.

55. Rahimi A, Ahmadpanah M, Shamsaei F, et al. Effect of adjuvant sleep hygiene psychoeducation and lorazepam on depression and sleep quality in patients with major depressive disorders: results from a randomized three-arm intervention. *Neuropsychiatric Disease and Treatment*. 2016;12:1507-1515.

56. Seyffert M, Lagisetty P, Landgraf J, et al. Internet-Delivered Cognitive Behavioral Therapy to Treat Insomnia: A Systematic Review and Meta-Analysis. *PLoS One*. 2016;11(2):e0149139.

57. Mitchell MD, Gehrman P, Perlis M, Umscheid CA. Comparative effectiveness of cognitive behavioral therapy for insomnia: a systematic review. *BMC Family Practice*. 2012;13:40.

58. Oliviero F, Spinella P, Fiocco U, Ramonda R, Sfriso P, Punzi L. How the Mediterranean diet and some of its components modulate inflammatory pathways in arthritis. *Swiss Medical Weekly*. 2015;145:w14190.

59. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Dietary nutrients associated with short and long sleep duration. Data from a nationally representative sample. *Appetite*. 2013;64:71-80.

60. Cooper MA, Ryals JM, Wu PY, Wright KD, Walter KR, Wright DE. Modulation of diet-induced mechanical allodynia by metabolic parameters and inflammation. *Journal of the Peripheral Nervous System*. 2017;22(1):39-46.

61. Johnson RK, Appel LJ, Brands M, et al. Dietary sugars intake and cardiovascular health a scientific statement from the american heart association. *Circulation*. 2009;120(11):1011-1020.

62. Kuebler U, Arpagaus A, Meister RE, et al. Dark chocolate attenuates intracellular pro-inflammatory reactivity to acute psychosocial stress in men: A randomized controlled trial. *Brain, Behavior, and Immunity*. 2016;57:200-208.

63. Cady RJ, Denson JE, Durham PL. Inclusion of cocoa as a dietary supplement represses expression of inflammatory proteins in spinal trigeminal nucleus in response to chronic trigeminal nerve stimulation. *Molecular Nutrition & Food Research*. 2013;57(6):996-1006.

64. Mozaffari-Khosravi H, Naderi Z, Dehghan A, Nadjarzadeh A, Fallah Huseini H. Effect of Ginger Supplementation on Proinflammatory Cytokines in Older Patients with Osteoarthritis: Outcomes of a Randomized Controlled Clinical Trial. *Journal of Nutrition in Gerontology and Geriatrics*. 2016;35(3):209-218.

65. Sahbaie P, Sun Y, Liang DY, Shi XY, Clark JD. Curcumin treatment attenuates pain and enhances functional recovery after incision. *Anesthesia and Analgesia*. 2014;118(6):1336-1344.

66. Ghoochani N, Karandish M, Mowla K, Haghighizadeh MH, Jalali MT. The effect of pomegranate juice on clinical signs, matrix metalloproteinases and antioxidant status in patients with knee osteoarthritis. *Journal of the Science of Food and Agriculture*. 2016;96(13):4377-4381.

67. Dobscha SK, Corson K, Leibowitz RQ, Sullivan MD, Gerrity MS. Rationale, design, and baseline findings from a randomized trial of collaborative care for chronic musculoskeletal pain in primary care. *Pain medicine* (Malden, MA). 2008;9(8):1050-1064.

68. Garber CE, Blissmer B, Deschenes MR, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine and Science in Sports Exercise*. 2011;43(7):1334-1359.

69. Covey SR. *The 7 habits of highly effective people: Powerful lessons in personal change*. New York, NY: Fireside. 1989.

70. Steinhardt M, Dolbier C. Evaluation of a resilience intervention to enhance coping strategies and protective factors and decrease symptomatology. *Journal of American College Health*. 2008;56(4):445-453.

71. Kwekkeboom KL, Gretarsdottir E. Systematic review of relaxation interventions for pain. *Journal of Nursing Scholarship*. 2006;38(3):269-277.

72. Schilling DJ, Poppen R. Behavioral relaxation training and assessment. *Journal of Behavior Therapy and Experimental Psychiatry*. 1983;14(2):99-107.

73. Church D. Reductions in pain, depression, and anxiety symptoms after PTSD remediation in veterans. *Explore* (New York, NY). 2014;10(3):162-169.

74. Alyas F, Turner M, Connell D. MRI findings in the lumbar spines of asymptomatic, adolescent, elite tennis players. *British Journal of Sports Medicine*. 2007;41(11):836-841.

75. Boos N, Semmer N, Elfering A, et al. Natural history of individuals with asymptomatic disc abnormalities in magnetic resonance imaging: predictors of low back pain-related medical consultation and work incapacity. *Spine* (Philadelphia PA 1976). 2000;25(12):1484-1492.

76. Girish G, Lobo LG, Jacobson JA, Morag Y, Miller B, Jamadar DA. Ultrasound of the shoulder: asymptomatic findings in men. *American Journal of Roentgenology*. 2011;197(4):W713-W719.

77. Finan PH, Buenaver LF, Bounds SC, et al. Discordance between pain and radiographic severity in knee osteoarthritis: findings from quantitative sensory testing of central sensitization. *Arthritis and Rheumatism*. 2013;65(2):363-372.

78. Verfaellie M, Lafleche G, Spiro III A, Bousquet K. Neuropsychological outcomes in OEF/OIF veterans with self-report of blast exposure: Associations with mental health, but not MTBI. *Neuropsychology*. 2014;28(3):337.

79. Vasterling JJ, Brailey K, Proctor SP, Kane R, Heeren T, Franz M. Neuropsychological outcomes of mild traumatic brain injury, post-traumatic stress disorder and depression in Iraq-deployed US Army soldiers. *The British Journal of Psychiatry: The Journal of Mental Science*. 2012;201(3):186-192.

80. Ruff R. Two decades of advances in understanding of mild traumatic brain injury. *The Journal of Head Trauma Rehabilitation*. 2005;20(1):5-18.

81. Macki M, Hernandez-Hermann M, Bydon M, Gokaslan A, McGovern K, Bydon A. Spontaneous regression of sequestrated lumbar disc herniations: Literature review. *Clinical Neurology and Neurosurgery*. 2014;120:136-141.

82. Jarvik JG, Hollingworth W, Heagerty PJ, Haynor DR, Boyko EJ, Deyo RA. Three-year incidence of low back pain in an initially asymptomatic cohort: clinical and imaging risk factors. *Spine*. 2005;30(13):1541-1548.

83. Frewen PA, Dozois DJ, Neufeld RW, et al. Emotional numbing in posttraumatic stress disorder: a functional magnetic resonance imaging study. *Journal of Clinical Psychiatry*, 2012. 73(4):431-436.

Many of the analogies and methods for explaining the neurobiology of pain were adapted from:

Louw A, Puentedura E. *Therapeutic Neuroscience Education: Teaching Patients about Pain: a Guide for Clinicians*. International Spine and Pain Institute; 2013.

Louw A. *Why Do I Hurt? A Patient Book About the Neuroscience of Pain*. International Spine and Pain Institute; 2013.