Published by BODYworx Publishing
5 Abigail Court, Sudbury, ON CANADA

Care has been taken to confirm the accuracy of information presented in this manual. The author, editors, and the publisher, however, cannot accept any responsibility for errors or omissions in this manual, and make no warranty, express or implied, with respect to its contents.

The information in this manual is intended only for healthy men and women. People with health problems should not follow the suggestions without a physician's approval. Before beginning any exercise or dietary program, always consult with your doctor.

ISBN 0-9689972-0-1

Injury mechanics

The nature of an injury

An **injury** refers to trauma or damage to some part of the body. Trauma is the result of forces that exceed the integrity of the tissues, destroying connective tissue, muscle, nerve, and/or blood vessel cells. The cellular damage from an injury invokes a chemical signal that damage has taken place and that measures must be taken to remove the debris and for the tissue to be restructured. The damaged nerves send a pain signal to the brain, while broken blood vessels produce swelling and constrict with assistance from the clotting mechanism. The blood and cellular debris produced by the injury are known as a *hematoma*.

The formation of a hematoma exerts pressure on undamaged tissue, causing further pain and possible inhibition of surrounding tissues. This self-protection mechanism results in decreased muscular strength, range of motion, and altered biomechanics of the body in general, although these are usually noticeable in more acute injuries.

The next step is for the body to remove the hematoma. Blood vessels proliferate the injured area to allow white blood cells to move around the site and digest debris. Although a necessary part of healing, this process, unfortunately, affects the healthy, surrounding tissues. What occurs is a decrease in oxygen delivery to normal cells surrounding the trauma, a response which may result in secondary hypoxic (oxygen deficit) injury. If this happens, further tissue damage increases the amount of debris added to the original hematoma. Further fluid accumulates in the tissues (because of disruption of the normal fluid exchange), increasing swelling even more.

Injury Factors

There are several factors responsible for injury. They include:

- Energy Absorption, e.g., catching a weight, dramatic acceleration or quick deceleration require tissues to absorb the forces; see impact.
- Impact, e.g., dropping resistance on a muscle, such as catching a loaded barbell in a clean and jerk, can cause damage to the tissues.
- Inflexibility, e.g., lack of flexibility within a specific ROM also means lack of strength in that area of ROM; loading a muscle too heavily and working the area of poor flexibility can result in an injury.
- Muscle Imbalance, e.g., vulnerability of a joint resulting from some overly strong and some overly weak muscle groups; the rotator cuff group in the shoulder joint is a common example, since it often is weaker relative to the pectoral, shoulder, and upper back muscles.
- Overuse, e.g., exercising too often and not allowing for tissue remodeling viz., compensation and overcompensation.
- Rapid Growth, e.g., anabolic steroids accelerate tissue muscle strength and size to the point of the resistance exceeding remodeling (and strength capabilities) of other tissues.
- Structural Vulnerability, e.g., weakening of a muscle group or joint, possibly resulting in altered body positioning, limb favoring, etc. that could produce an overload in an unaccustomed plane of movement; structural vulnerability can be related to some of the above factors.
- Fatigue, e.g., as a person becomes fatigued, there is a reduction in skill performance; concentration and focus decline, reactions slow and judgement may become impaired as the individual makes faulty decisions; eventually this leads to an injury because of poor biomechanics, an alteration in normal movement, or the inability to avoid injury.[1]

[1] *Biomechanics of Musculoskeletal Injury*. Whiting, William C. and Zernicke, Ronald F. Human Kinetics. IL: 1998. p.114.

Exercise as a factor

The nature of the resistance, such as that presented by a barbell or a machine, has a strong bearing on whether or not it will produce an injury based on one or more of the above factors (barring more severe injuries such as broken bones, concussions, etc.). One must consider the magnitude of the resistance, or how heavy it is. Of course, a very heavy weight can be moved safely, whereas a light weight can result in an injury if moved too quickly; thus producing a greater net force and tissue absorption requirements than the heavier weight. Consequently, one must consider acceleration and velocity.

The location and direction of the resistance also will determine risk of injury. The "cheating" technique, for example, requires a trainee to heave or propel a weight up past the sticking point once he reaches muscular failure, a technique which necessitates contortion or alteration of body alignment. Cheating places strain on the muscles in a much different manner and neuromuscular pattern from lifting under strict conditions. The change in biomechanics may be sufficient to position tissues in a vulnerable state. Other considerations include both volume and frequency, both of which eventually can contribute to overuse (chronic) injuries.

> *An injury always will occur at the weakest link of the chain. Unfortunately, the weak link is not known or discovered always until too late.*

Cause and effect (This section expanded and adapted upon from Whiting and Zernicke, pp. 118-120)

When an injury occurs it is necessary to know how it happened so that one can determine what course of action to take; or at least have a better idea of what to do. Discovering the *cause and effect* relationship of an injury refers to the factors of an injury. A simple example is dropping a barbell plate on one's foot, resulting in swelling and possible bone fractures. If the injured trainee's physician asked what happened, and the trainee replied "I crushed my foot with a weight," then the mechanism of the injury would be indicated.

There are various contributing factors that determine the level of effect of the mechanism or the likelihood of occurrence. Many are interrelated and dependent on the anothers. They include:

Age. As we age beyond our 20s, tissues slowly degenerate. We then lose strength, flexibility, compliance, and energy-absorbing ability at a much faster pace once past age 50. These factors contribute to a greater likelihood of injury, necessitating careful execution of movement with sufficient warm-up and cool-down. Of course, an active 50- or 60-year old can have much better tolerance to both injury and exercise than a sedentary 30-year old, but with all factors remaining equal, age eventually catches up.

Anthropometrics. All humans are identical physiologically, but we differ in terms of measurement. In other words, we are of different heights, weights, and tolerances to exercise strain. An obese person who decides to begin jogging or pliometrics will be at a much greater risk for injury than a lean healthy athlete. The obese person is also at greater risk of a heart attack or stroke while exercising. Moreover, consider the mechanics of a machine that does not accommodate a very tall or short person and the additional strain possibly placed on his or her joints. This, too, increases the risk of injury. The same situation is apparent in some free weight exercises relative to the mechanics of the trainee; consider a tall person who perform the squat or deadlift, or someone with a long torso or legs relative to the remainder of his or her body.

Conditioning. The state of a person's physical condition has a major influence on the possibility of injury. Someone of poor condition will become fatigued and lose form progressively faster as he or she continue exercising. Conversely, although a well-conditioned person recovers faster, he or she is that much closer to a genetic limit, and that person will test his or her lmits more often and to greater extremes, resulting in a greater likelihood for injury.

Disease. Suffering from any disease, even if minor, increases the risk for injury. Gout (acute arthritis and joint inflammation) of the foot may force a trainee to hobble or shift more strain on the opposite leg. This could result in overuse injuries of the weight bearing leg. Training heavily while suffering from osteoporosis could result in bone fractures, a condition which necessitates that the trainee increase the load in small, manageable amounts while moving slowly until the condition is reversed.

Drugs. Pain medications sometimes can mask the discomfort of an injury produced from exercise or an old injury that worsens progressively from continued exercise. Anabolic steroids are known to stimulate muscle tears since the growth and strength of some tissues (muscle) can far exceed the strain capacity of other tissues (tendon). It is still unknown, however, if steroids produce this effect or if athletes tend to train more often and vigorously while on steroids, thus causing

overuse and eventual acute injuries. Other drugs, such as those with "speed" characteristics (e.g., ephedrine) increase blood pressure and heart rate, factors which can lead to cardiac arrest in some sensitive individuals. Obese individuals are twice at risk, especially if they undertake an exercise program while consuming ephedrine-based products for weight loss.

Environment. A host of elements comprises the environmental contributing factors, such as altitude, noise, temperature, weather, training indoors or outdoors, the exercise facility's atmosphere, humidity, visibility (day or night), and terrain (slippery, rough). Consider the physiological challenges of jogging at night and not being able to see bumps in the road because of low visibility and shadows, or maintaining focus while training at a higher altitude that causes labored breathing.

Equipment. Equipment includes the tools used to train, clothing, footwear and other paraphernalia, such as gloves, joint wraps, and lifting belts. Squatting without a belt increases the risk of lower back injury. Jogging with improper footwear increases the risk of shin splints or arch problems. Free weights increase the risk of injury more than machines because of load balancing, a factor which is even more apparent if a Swiss exercise ball is used in exercise movements.

Experience and Skill Level. The more a person practices a skill, the more that person acquires the skills to execute movement with precision. Even when cheating a weight, a skilled lifter better understands how much the body needs to lean or shift to eke the weight up past the sticking point to completion. In all, the decision-making skills often are (or should be) more sound with the experienced trainee than the inexperienced trainee. It also should be evident that knowing proper technique in resistance training is vital.

Fatigue. Physical and mental fatigue increases the risk of losing form and focus while exercising. It takes only a moment for a joint or body part to become misaligned, resulting in an injury. Fatigue could be the result of performing too much exercise in a session, lack of sleep, or exercising too often. If an athlete is bordering on overtraining, for example, he may move sluggishly through a workout, not keep his spine in alignment, and produce a lower back injury. This, of course, is only one of several possibilities that may occur, but a real one. Sometimes chronic lower back injury is the result of compressive forces on the anterior portion of the disks because of a momentary lapse of muscular control (brief and sudden spinal flexion). This phenomenon is experiencedcommonly , wherein the lower back feels healthy and functional, only to experience a jolt of shooting pain while casually bending forward.

Gender. Men tend to be greater risk takers than women while they exercise, trying to outperform their last workout (adding weight before its time), or perhaps trying to impress peers. Women, on the other hand, are at greater risk of osteoporosis because of hormone changes. This condition affects strength levels and the ability to sustain energy absorption. Teenage girls are more at risk of an eating disorders than their male counterparts, and this may cause health problems during their developmental years and well into their later years.

Genetics. Often we are at the mercy of our DNA – of what our parents and their parents before them handed down through the lineage. Although we can improve our strength, endurance, and muscle mass, our risk for heart disease or to tear a biceps, or to injure a rotator cuff muscle can be at greater risk because of hereditary diseases and the fixed genetic architecture of the tissues.

Human Interaction. Social, competitive, or occupational interaction either can increase or decrease the risk of injury. Being trained by a skilled technical instructor reduces the risk of injury. Shifting one's focus to an attractive gym patron also increases that risk. Other examples that increase the risk of injury include contact sports or others walking carelessly by with equipment such as barbells and dumbbells.

Injuries. Exercising through or around an injury is an invitation for further trauma. An individual is at greater risk to reinjure the same muscle group (from additional forces) or other muscle groups when the body is realigned into planes or configurations to which it is not accustomed. Any exercise that cannot be performed comfortably should be terminated until the condition is nonexistent. Of course some rehabilitation is uncomfortable and even painful, and so it is important to differentiate between necessary and unnecessary discomfort.

Nutrition. Much can be said about the quality of a person's diet, from the raw materials to sustain energy, to the building blocks of muscle hypertrophy and recovery. Consequently, a good eating program can make a dramatic difference in avoiding injury or recovering quickly from minor injuries.

Psychological and Motivational Status. Being highly aware of one's surroundings and focusing intensely on a given task decreases the risk for injury. But if a trainee cannot focus properly on a task, or has no motivation to do it well, then the risk for injury increases. This can be due to high stress factors in one's life, training too long in a session (see fatigue), poor nutrition, distraction, and the inability to tolerate the discomfort of exercising hard.

Pain. Ironically, tolerance to pain can lead to pain and injury. This is true since some people are able to push themselves much harder and with more weight. The closer a trainee approaches an upper limit of tissue tolerance and capacity, the greater the risk for injury. Pain from injury will also affect movement and body alignment during exercise, possibly resulting in further damage to the same or other tissues. Most consequential is that pain is a reliable indicator of range of motion, modality, and need for the application of any required rehabilitation.

Rehabilitation. Rehabilitation refers to the process that people undertake to exercise and strengthen a weak and previously injured muscle group. Of course, the quality of technical experience and tools have a direct bearing on the situation. Consider a gym instructor who advertises his services for rehabilitation while using an unstable Swiss ball rather than someone who graduated from a MedX course and who uses a $40,000 lower back machine based on 90 million dollars in research (www.medxonline.com). The MedX technician would have greater success reestablishing past functional ability in a safe environment than a typical personal trainer with a quick weekend certification course involving general fitness. Moreover, sometimes it is unknown whether rehab will have an affect on the patient; whether the injured person will regain normal function (or the function once had) or above normal function. A reduction in what was once normal could have a bearing on future training. Unnatural alignment to favor a weak muscle group can produce an injury in a different muscle group. This can happen even if a person exceeds past functional ability, yet fears reinjuring the once injured body part.

Macrotrauma and microtrauma

Injuries are the result of either a macrotrauma (acute) injury or a microtrauma (chronic) injury. Macrotrauma injuries are usually the result of a single exposure of strain that exceeds tissue tolerances. Macrotrauma includes acute compartment syndrome, bruises and contusions, dislocations and subluxations, fractures, hemobursa, strains, sprains, and stress fractures. These will be discussed and described in the next section of this chapter.

Microtrauma injuries, also known as cumulative trauma disorders, are much less severe and come about from repetitive force application, slowly wearing and tearing away at tissues. Sometimes microtrauma can lead to macrotrauma as a result of weakening surrounding tissue and diminished strength levels. Microtrauma injuries include bursitis, cartilage wear and tear, neuritis, osteochondritis, overuse compartment syndrome, and tendinitis. These, too, will be discussed later.

The first step in injury prevention is to recommend a pre-activity physical with a medical doctor and, at the very least, complete a detailed questionnaire form (see Appendices). The goals of both are to:

- Assess overall health (a process which allows a fitness professional to make recommendations for an exercise program and to coordinate goals and ability); and
- Detect conditions that might cause injury or preclude the individual's participation in activity that may be too extreme.

Generally, a person can distinguish between mild and moderate injuries and more severe injuries, dependent on the degree of tissue damage experienced. Do note, however, that at times tissues can appear healthy, but are unable to accept a load or move through normal planes without discomfort.

Risk Factors for Microtrauma/Overuse Injuries (also see Cause & Effect, above)	
Extrinsic • Poor prescription in an exercise program, including sudden increases in overload, volume, frequency or set variables. • Improper or low quality equipment, including footwear and clothing • Bad mechanics (explosive or bouncing movement) while rehabilitating an injury.	Intrinsic • Previous or current injuries. • Lack of strength, flexibility, and endurance. • Improper lifting technique and biomechanics. • Strength or flexibility imbalances, anatomical abnormalities (e.g., bowlegs, legs of different lengths, flat arches), or diseases (e.g., arthritis). • Intrinsic factors can explain why some athletes incur overuse injuries while others using the same equipment and following the same training regimen do not.

SOMA

An overuse injury, from repetitive bouts of strain to the tissues, must take into account the following factors:

1. Insult to the tissues
2. Number of repetitions
3. Force of each repetition as a percent of maximum muscle strength
4. Amplitude or quality of motion of each repetition
5. Relaxation time between repetitions (lack of tension or pressure on the involved tissue)[2]

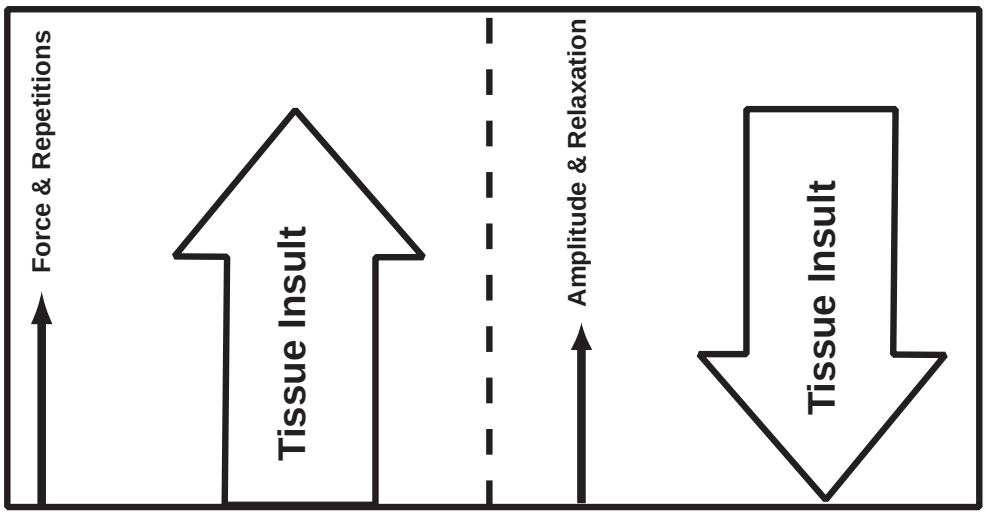
The insult to the tissue is directly proportionate to the number and force of the repetitions. The insult is indirectly proportionate to the amplitude and relaxation time (see diagram below).

Intense vibration, for example (i.e., using a jack hammer) results in a very high number of repetitions, high amplitude and short relaxation time between repetitions. Slouching over and placing strain on the lower back muscles produce a high force, but with near zero amplitude and relaxation time. Consequently, overuse trauma does not require many repetitions necessarily, but can transpire from a small number of instances.

It is vital to understand that the above five factors decrease circulation and compromise cell recovery. Hence, overuse injuries are the result of lack of remodeling time relative to the frequency of strain. This cumulative injury cycle involves several steps.

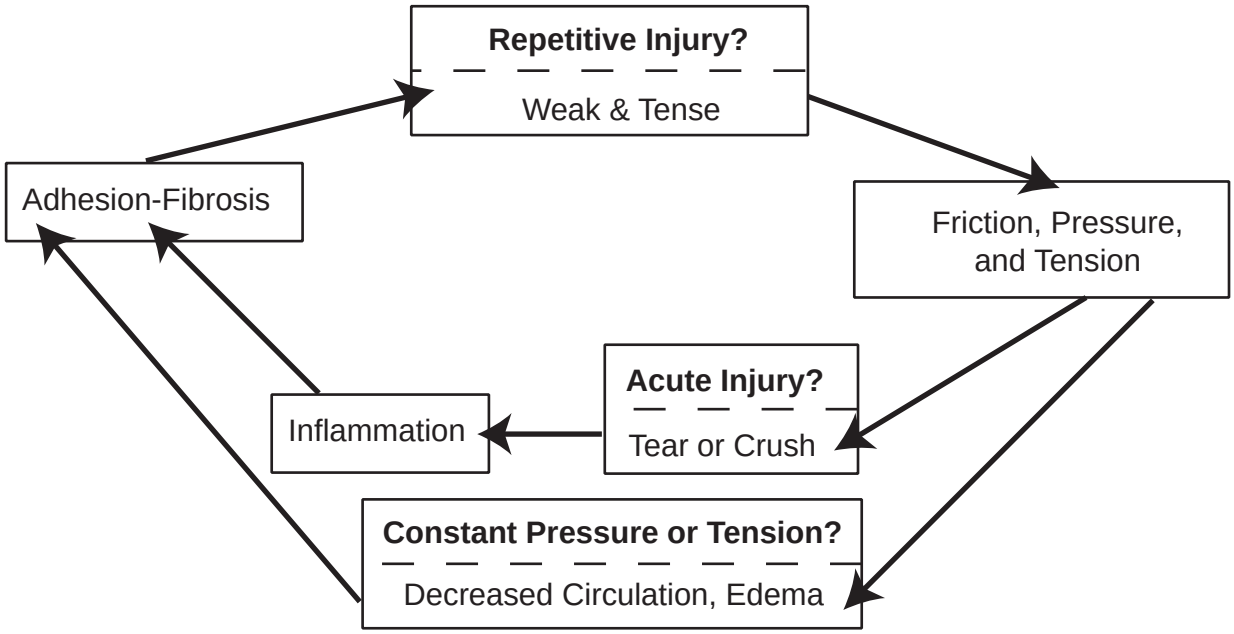
- Overuse injuries result in weak and tight muscles. Repetitive effort usually makes the tissues tighten, a condition which causes weakness and further tissue tightening; this causes the next problem.
- Friction, pressure or tension (or all three) increases because of the forces increasing around the weakened tissues in an attempt to support and stabilize the structure better. This, in turn, can result in an acute injury or simple inflammation.
- Decreased circulation and edma follow. The decreased circulation places pressure on the lymphatic system, causing edema. Other external forces or pressure, such as continued exercise, further decreases circulation and increases edema.
- Adhesion (scar tissue) formation occurs as the inflammation cycle initiates the fibrinogen process, resulting in further weakening and tightening of the tissues. A hypoxic (reduced oxygen) cycle also may result in adhesions.

Overuse trauma is a self-perpetuating cycle. The more times the cycle is completed, or the more severe the factors, the more severe the resulting syndrome. All this syndrome needs is a constant supply of the original injury to accelerate the cycle, thereby causing diminished strength and ROM, as well as neurological symptoms such as pain, numbness, and tingling.



[2]*Introductory ART for Weight-Training Spinal Injuries.* Third Annual International Weight-Training Injury Symposium, 2001. Dr. Mike Leahy, D.C.

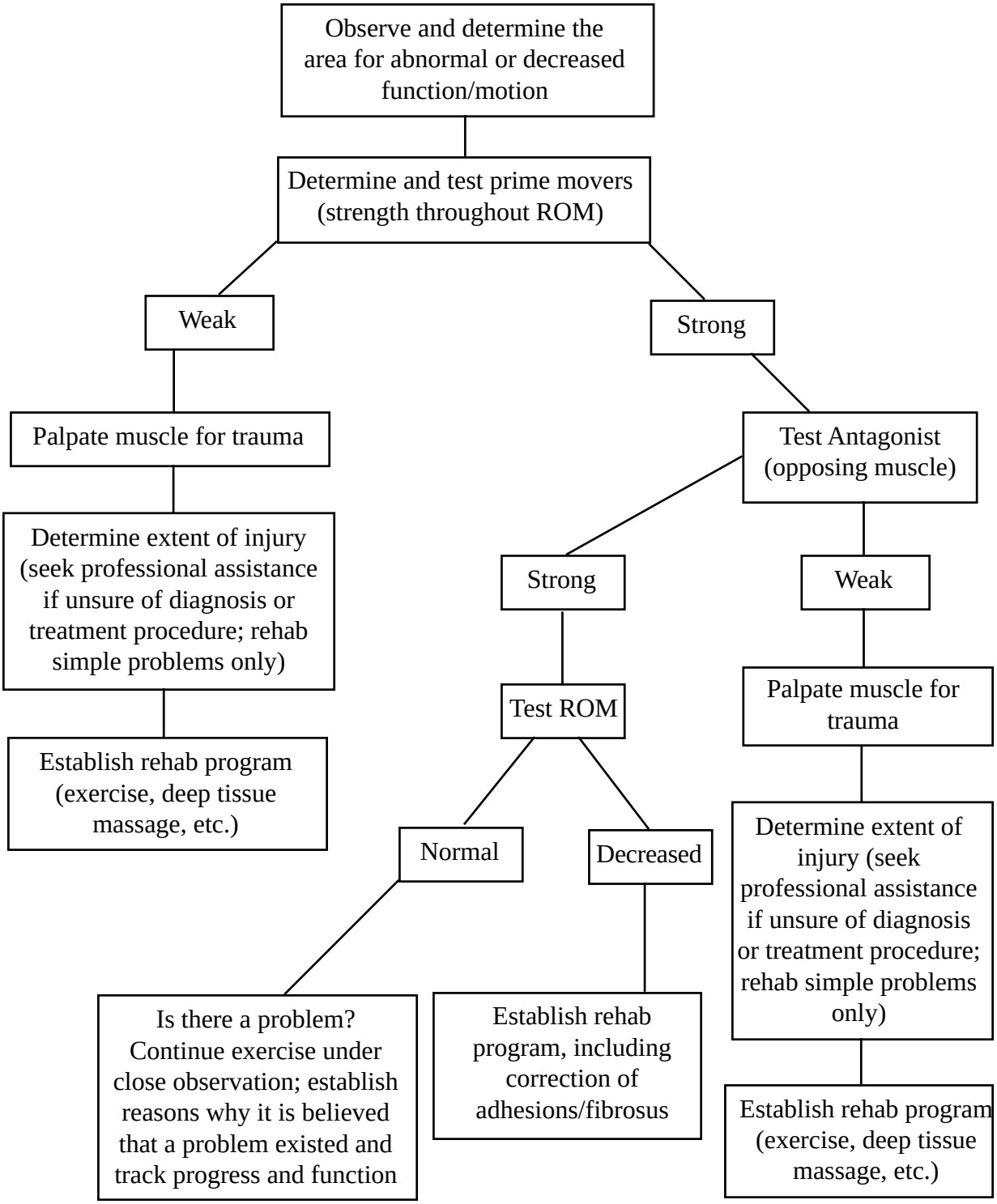
Overuse Injury Cycle



Minor Injuries	Moderate Injuries	Major Injuries
• Mild pain or discomfort after exercise • No deformity • Mild (or no) swelling • Minimal (or no) discoloration • Function intact with no loss in performance	• Moderate pain or discomfort before and after exercise • No deformity • Mild to moderate swelling, but often only when in use • Minimal (or no) discoloration • Function intact, although loads must be lighter than usual; performance may be mildly affected	• Persistent pain before, during and after exercise, often accompanied by severe discomfort • Possible deformity; tender to the touch • Swelling • Discoloration • Loss of Function; performance affected during exercise and activities of daily living; inability to handle loads
Action • Reduce training schedule • Alter exercise program to eliminate or reduce strain on the injured part • RICE and OTC meds (chpt. 5) • Gradually reimplement original exercise if desired or as required	Action • Rest the injury as required • Alter exercise program to eliminate or reduce strain on the injured part • RICE and OTC meds (chpt. 5) • Gradually reimplement original exercise if desired or as required	Action • Terminate any exercise activities • See a physician immediately

Injuries also can be divided into *Primary* and *Secondary* classifications. Primary injury refers to that which is a direct, immediate consequence of trauma, such as dropping a barbell plate on one's foot. A secondary injury can happen in two ways: One, it can be a delayed result of the injury, such as brain damage from a previous head impact. Two, it can develop as an accommodation to the primary injury. For example, in regard to structural vulnerability, altering a walking or running gait or weight training technique shifts strain (perhaps too much strain) onto various muscles in an unaccustomed plane of movement.

Discovering Soft Tissue Trauma



Instructing an Injured Client

Client Cooperation

The cooperation of the client is vital. This is best achieved by letting the client know exactly what will be taking place in simple terms and without creating confusion with technical talk. This helps to calm and relax the client, making him or her more receptive to instruction. It also provides the client confidence in the therapist's ability and what must be done, allowing for maximal volitional concentration and work.

Cooperation is necessary for both passive and active exercise. During passive movement, the result is relaxation, allowing the therapist to work the joints efficaciously. If it is explained that the client will experience some pain or discomfort, but that he or she should relax as much as possible and not tighten the muscles, the desired effect will be easier to achieve. In effect, the client must be convinced of the ultimate benefit of the treatment.

During active movement, cooperation insures harder work on the client's behalf. The client must be aware of how to perform the exercises properly, and why specific exercises are integrated. Quality equipment will result in more efficient and comfortable rehabilitation. For those who are pain-free, there may not be much noticeable difference between low- and high-end equipment. For the injured, any slight nuance (e.g., friction, poor strength curve, etc.) can be felt and noticed. Consider walking with and without blisters on your heels. Without the damaged tissue, you may not determine fully whether the heel of a shoe fits properly, but with the damage each step becomes more painful than the last.

Passive and active exercise can be maximized further if a positive attitude and pleasantries are maintained. If the therapist appears calm and cheerful, chances are that the client will feel at ease, and able to concentrate much harder on the task at hand. If the therapist feels uptight, angry, or frustrated because of his personal life or business dealings, the client will not feel at ease. Consequently, problems must remain outside the rehab setting.

Treatment Area

Client confidence is also encouraged by organization and cleanliness, good room ventilation, plenty of light and a comfortable room temperature and low humidity. The floor should be a non-slip surface, such as rubber, and always clean in appearance. A floor with a speckle pattern or various shades of gray in black or white helps to camouflage any dirt between cleanings. The space between machines and other equipment must be sufficient for free movement without tripping, weaving in and out, or stepping over pieces.

Moreover, from the moment the client enters the facility to the moment he or she leaves, the atmosphere must be professional. That means not scrambling to find certain equipment, a notepad, or the client's charts and file. That means not forgetting any case specifics. If an assistant is required to pull files, to greet clients, and to help organize the day's events, then one should be employed.

Exercise Application

Whenever possible, the client should have full view of the therapist and the procedures taking place. Viewing, comprehending, and learning help to instill client confidence and the ability to train hard and cooperate with the therapist's instruction. Likewise, the trainer should have a clear view of the client during all rehab procedures for obvious reasons.

If necessary, use benches, stools, or platforms so that the therapist and client can work at a comfortable working height. Doing so, of course, depends on what is being done and what equipment is being used. This is more important for the therapist in one respect – fundamentally, the greater the therapist's comfort, the less likely for fatigue to set in as the day progresses. Fatigue is one factor that leads to injuries as a result of poor biomechanics, changes in leverages, and lifting style. Hence, injury prevention is just as important for the therapist as it is for the client.

Proper positioning also helps the therapist move properly, and with good posture and mechanics. This serves as an example to the client. The therapist's mannerisms and attention to detail, as well as to the client, further serve to mold a good impression of the services provided.

When providing verbal instruction, refrain from moving around or making unnecessary gestures; this may distract the client and make it more difficult to absorb information. Verbal instructions should be expressed clearly and concisely in short sentences, while eliminating any unnecessary detail. A lower pitched voice is more soothing, and so speak in a lower tone and always use an expressive voice to establish the importance of key concepts or instructional terms. A monotone voice is dull, making it difficult for the client to pay attention or to know what points are most important.

Explain the entire concept (e.g., exercise technique) and have the patient practice if necessary or applicable. Only after that point, work in stages, offering small pieces of information at a time, then gradually add on to the instruction with greater detail. The objective is to have the client focus on the general concept of the procedure and not instructional sequences. Starting too quickly with excess information and detail can be intimidating and result in loss of focus for the client.

Once all information has been relayed, go over the entire instruction from beginning to end as a recap. Make certain the client understands and remembers most aspects of his or her rehab procedure before continuing. The therapist can always provide reminders (in a non-scolding manner) while he proceeds with treatment. Sometimes information provided first can be forgotten by the time instruction is finished. Conversely, other clients remember, or focus on remembering only the first set of instructions while not paying close attention to what was stated thereafter.

As the client performs an action properly, have him or her continue and provide appropriate praise. Doing so suggests that the therapist is noticing the client's effort to follow instructions properly. When the client performs something incorrectly, say the person's name before giving a verbal correction. This communication technique is more friendly and better attracts the client's attention. If the mistake is big, terminate the movement, point out the mistake, repeat the instruction and have the client try again. Watch closely for the client's reaction to correction, making certain proper changes have been made. Whenever possible, try to foresee mistakes to prevent them from happening. Further instruction or correction can be provided during rest periods.

Instruction also can be through demonstrating what needs to be done as the client watches. Together with verbal instruction, demonstration helps to reinforce the learning process. However, do keep demonstrations very brief to reduce downtime of client participation and the need for lengthy memorization.

Most important, any instruction must be relayed in a low intensity environment so that the focus is not on effort, but form and application. The use of the hands is necessary to help guide movement in the beginning, while pointing out what the client should focus on, and the technique employed to obtain an optimal muscular contraction. As the client learns the movement, the hands should be released so that the client can move independently.

After the client learns the proper movement and technique, only then implement a fixed cadence with a metronome, if preferred. No longer having to remember how to move properly, the client can focus on specific timing requirements for measurement purposes.