Therapeutic Exercise

Exercise Techniques for Patients with Common Orthopedic Conditions

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To: Kris, Karleigh, Katie, Cam, Lilo, Koa, Akamu, and Stitch

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Preface

Therapeutic exercise has been and I suspect always will be the foundation of physical therapy intervention. It is our profession's primary form of intervention and is what distinguishes physical therapy from other health-related disciplines. I have been a certified orthopedic manual physical therapist for over 34 years. I feel that providing skilled joint and soft tissue manipulation is one of the most important interventions that can be provided to a patient seeking our help. Nevertheless, I also feel the prescription of therapeutic exercise is the most important intervention we provide.

There are many different modalities and intervention techniques associated with physical therapy. The popularity of numerous modalities and interventions has risen and fallen over the years. Therapeutic exercise has stood the test of time. In fact, I like to tell my students, when all else fails to help your patient, therapeutic exercise will not. At some level most patients, many of whom come to us in pain, lacking mobility, lacking strength, lacking balance, have minor instabilities, or are just deconditioned, benefit in some way from exercise.

The primary purpose of this textbook is to assist entry-level students. Students seeking advanced clinical competencies in orthopedic manual physical therapy will also find that this text offers a nice review of basic exercise concepts and many creative exercises that even seasoned therapists may not have considered. While the title of this book relates to patients with impairments and functional limitations associated to common orthopedic conditions, many of the exercises shown in this text can assist patients in other practice settings as well.

The exercise techniques found within this text seek to reduce pain, and facilitate, not retard tissue healing by modifying speed of therapeutic motion, arc of therapeutic motion and providing assistance or partial assistance to joint movements when necessary. Further, the exercises shown within this text seek to enhance muscular strength and stability, soft tissue mobility and human locomotion without significant provocation of symptoms or damage to joint cartilage and other sensitive joint tissues.

This is the preface, so I will not speak to this a great deal now but I would like to briefly expand on the idea of damaging to joint cartilage or other joint-related tissues during the performance of therapeutic exercise. I think if we are not careful it is possible to overstretch, irritate, and possibly damage muscular and more importantly capsuloligamentous stabilizing structures, including the intervertebral disc, with the prescription of certain self-stretching and self-mobilization exercises. This damage may have occurred when patients complain of increased soreness or achiness after repetitively performing these types of exercise motions. Further, I think it is possible to over load joint cartilage with closed kinetic chain single leg stance strength building exercises if prescribed to the wrong patient, or if performed for too long a period of time. I am not saying to not prescribe these things just consider who is doing them, how large and how loaded the motion is, and how long are you going to have the patient perform them. Many of the exercises in this text are prescribed with an eye on the patient's future years. The movement patterns and exercise positions shown in Chapters 10 -18 challenge musculoskeletal structures but they also support and control load the soft tissues, joint cartilage, and spinal segments. In other words, the musculoskeletal structures that commonly degenerate and become painful during life. I believe, that a good therapeutic motion or a good therapeutic exercise can be performed for the better part of one's life span. Meaning, the therapeutic motion, and the resultant load that motion causes, is not so great, that it would damage supportive musculosketeletal structures that might be is various stages of decline or degeneration.

We should encourage our patients to get and stay as strong and as flexible as possible, but not at all costs. For example, many of our patients can build a reasonable degree of spinal, upper extremity, and lower extremity strength by performing reduced load and reduced arc of motion exercises. For example, if a lower extremity lunge (spilt stance squat) strength building exercise causes pain secondary to injury or degenerative change, be clever and make a simple load modification. Have the patient stand between and press down on the backs of two chairs. This will often allow a patient with symptomatic hip, knee, or ankle-foot injury or arthritis to perform this strength building motion. In Chapter 14 we term this assisted lunge training.

This book is simply organized into nine foundational chapters, which review basic exercise definitions, types of therapeutic motion, various exercise positions,

posture, tissue healing, arthritis, and basic aspects of patient examination and intervention planning. For example, in Chapter 6, Musculoskeletal Injury and Repair, and the Application of Therapeutic Motions; students will note numerous guidelines regarding exercise application in relation to general tissue healing time frames. The guidelines presented in this foundational chapter are very conservative and will serve clinicians particularly clinicians new to the profession in terms of minimizing adverse reactions to prescribed therapeutic exercise therapeutic motion. A chapter dedicated to each upper extremity joint, each lower extremity joint, and all three spinal regions follows the foundational chapters.

Starting with Chapter 10, the text will have a large number of digital photographs of self-stretching, self-mobilization, assisted movements and stabilization exercise. Each photograph will note a key position for therapeutic exercise performance and detailed legends will describe the therapeutic motion and clinical applications particularly in relation to common orthopedic conditions and commonly associated pain and movement impairments. In certain sections of some chapters, readers will note a sequenced progression of strength building such as the Swiss Ball Supported lumbar stabilization exercises (Chapter 18) and sequenced progression of therapeutic movements and resisted motion (Chapters 3 and 10). Clinicians will find useful updates in terms of creative patient positioning and creative arcs of movement that will add to their current repertoire of therapeutic exercise intervention.

Acknowledgments

I would like to thank my friends, family and colleagues, particularly my colleagues at Oakland University in Rochester Michigan where I have had the pleasure of working with and learning from many talented individuals. I hesitate to name any names at all for fear of leaving out a good friend or colleague but that being said; an acknowledgement page would not be complete without listing as many talented people as I can think of. I have learned a great deal from all who are listed below and without these people, projects such as this text would not be possible.

Olaf Evjenth

Jeff Annis

Stanley Paris

Robert Rinke

John Krauss

Michael Moore

Bjorn Svensen

Lasse Thue

Contents

Chapter 1

A Brief Overview on the History of Therapeutic Exercise

Historically or at least as far back as I can remember which by the way is 32 years at the time of this writing and now revision; orthopedic physical therapy seemed to focus a bit more on measuring and attempting to improve, alleviate, or lessen dysfunctions. Dysfunction was an interesting term. Back in the 1980's it seemed to count for everything but really meant nothing or it meant something a little different to most everyone. I am glad not many of us use such a general and generally meaningless term any longer.

The term impairment is so much better and happily, our profession has smartly moved toward finding impairments during our examination, treating those impairments, and hopefully improving (reducing) functional limitations and associated disabilities along the way. Just to review, impairments can be thought of as a loss or abnormality in psychological, anatomical, or physiological structure or function. A functional limitation as the term would seem to indicate can be thought of as a limitation in one's ability or abilities. Said another way, it is a limitation in the ability of a person to perform an activity or activities. Lastly, the term disability brings society and social roles into play. In effect, disability principally refers to how impairments and functional limitations adversely affect a person's ability to perform socially defined roles.

So, that is a quick review of and one way to define the terms impairment, functional limitation, and associated disabilities. Speaking of definitions, a word or a topic could have more than one good or even correct definition. I like it when a word or a topic has a simple and easy to remember definition. For example, the words mobilization and manipulation has historically

been defined as a "skilled passive movement." I think of these two terms as skilled passive therapeutic motions Either way, this is a short, simple and easy to remember definition. Well how about therapeutic exercise, the best definition I have ever read is credited to Licht who defined therapeutic exercise as motions of the body or its parts to relieve symptoms or improve function.[1] I think that definition sums things up pretty nicely. It is short and simple and it notes how therapeutic exercise, which is really therapeutic motion, can relieve pain and improve function. There, I sort of re-worked Licht's definition. Licht came up with this definition way back in the 1960's. Seeing as how I was brought up the 60's, which is ancient history, let's look at some other historical aspects of therapeutic exercise.

MY HISTORY

My personal history with therapeutic exercise started at Oakland University (OU) in the 1980's. What a great decade! Bought my first Camaro in the 1980's. But that does not have anything to do with therapeutic exercise. In undergrad at OU I learned many of the important basics regarding the prescription of therapeutic motion. Simple basic movements like passive oscillations which can be used to reduce pain impairments and simple strength building motions that can be used to correct weakness impairments. These basic aspects of therapeutic exercise/movement still apply today. In fact, to this day, I often say to my students the following thing; "show me a PT clinician who is well grounded in the *basics* and I will show you a good clinician." I believe that statement applies to consistently prescribing the correct therapeutic exercises/therapeutic motions. In the 1990's I was fortunate enough to meet and learn from numerous talented clinicians who through the efforts of Kornelia Kulig and John Krauss came to OU to teach different pieces of course work in our Orthopedic Manual Physical Therapy Program. People like Olaf Evjenth, Freddy Kaltenborn, Michael Moore, Robert Rinke, and Bjorn Svensen and Lasse Thue. These people were excellent clinicians and they really had a great handle on how to therapeutically self-stretch, self-mobilize, strength train (stabilize), and unload musculoskeletal tissues. My work in this text is in part a reflection of these talented individuals.

ANCIENT HISTORY

Seeing as how I have been name dropping, how about a few more names just so we can legitimize the title of this chapter. If we step into the "Way Back Machine," (1960's cartoon

reference), and I do mean way back, all the way to around 400 or 500 BC a physician named Herodicus claimed to have used therapeutic exercise to cure himself of a terrible disease. That probably did not happen, not real critical thinking if you ask me, but this person was also credited for developing exercises for the athletes of that time. Who knows, maybe that is when pylometrics first started? How about Hippocrates? His name seems to come up fairly often and he was a student of Herodicus. Hippocrates wrote about the beneficial effects of therapeutic exercise in terms of strengthening muscles, improving mental outlook and reducing obesity. So, you see, most of your PT instructors and exercise gurus are not talking about anything new!

MORE RECENT HISTORY

There are so many important names associated with therapeutic exercise, names like Codman who in the 1930's developed therapeutic motions to relieve pain in the shoulder.[2] There was Delorme who is credited with advancing and refining ideas regarding resistance training or progressive resistance exercise.[3] We shouldn't forget Kabat who took the "*straight"* out of therapeutic exercise and introduced the idea of moving in diagonal movement patterns. What a great common-sense idea seeing as how humans typically don't move like robots! [4] And one of manual therapies, greatest clinician's, Olaf Evjenth, his career has spanned more the five decades. I maintain there is still no better stretching text then his, Autostretching, a book which he published in the 1980s.[5] Well, I doubt that it is possible to credit everyone or maybe it is but I don't want to take the time, I would rather write this book. Just remember, we should not forget history and the people who worked hard trying to originate and refine something in order to help others out.

Chapter 2

A Review of Basic Forms of Resistance and Endurance Exercise Training

As PT clinicians, we frequently need to address strength or a lack thereof with some form of resistance training. In Chapter 1 I mentioned that there is usually more than one way to define something. That applies to the term strength too. Strength could be defined as the maximum force that a muscle can develop during a single contraction. I like that definition; it fits my short and simple rule for defining things. However, seeing as how strength is important, how about another definition? How about: the maximum voluntary force that can be produced by the neuromusculoskeletal system? Well, I think that definition does not really get to the point. Therefore, I prefer to define it as: the maximum weight a person can lift one time, otherwise known as the famous One Repetition Maximum. (1RM). In all seriousness now, impaired muscle performance is commonly seen and is a real problem for many of our injured, sedentary, aged, and metabolically impaired patients. The great news is that most all of the research now demonstrates many patients with various musculoskeletal impairments and other medical conditions will benefit from correctly prescribed muscular resistance training.[6]

ISOMETRIC

Seeing as how the first paragraph discussed strength and resistance training, let's look and review some of the other terms associated with resistance training. How about the term isometric exercise? No, how about just the term *isometric*? That word alone means same or constant. In particular, *iso* means the same or constant and *metric* is a word that describes length among other things. Now let's get back to isometric exercise. This form of exercise is commonly

used to address muscle strength impairments. As a muscle contracts isometrically, tension develops within that muscle but no change in joint angle occurs and the change in the length of the target muscle in minimal.

You might ask, does this really help our patients who typically need and want to move better and with less pain? Moving, from what I can recall, requires changes in joint angles. Well, I like to think that isometric muscle strength building provides a platform upon which we can further build our patients muscular strength with additional isotonic exercises. Further, isometric muscle contraction can be a valuable clinical intervention for our patients who cannot move their joints though certain portions of a range of movement due to injury, degeneration, pain, or the constraints of post-injury and post-surgical immobilization.

Still don't believe me that isometric muscle contraction is important? Well, we should also consider all those postural muscles that work isometrically the better part of their day. These postural muscles have feelings too and they happen to like training with this form of muscle contraction. The deep spinal extensor muscles are an example of this. Remember, if attempting to build a platform of strength with isometrics, before you prescribe other forms of dynamic muscle contraction, isometric strength building is pretty much range specific give or take 15-20 some odd degrees. Lastly, because I really want to move onto isotonic muscle training, isometric exercise should be used with care in our hypertensive patients, cardiovascular patients, and any spinal patient with radiculitis. Tell all your patients, "no fair holding your breathing" while performing isometric muscle contractions. "If you do your BP will go up!"

ISOTONIC

The definition of *iso* has not changed, but what about the word *tonic*? Tonic has a number of definitions, but the one that fits here is tension. So strictly speaking, an isotonic exercise or muscular contraction is one that produces the same (iso) amount of tension in order to move some form of resistance. The truth is muscle tension will vary over an arc of joint movement when lifting a constant resistance. This all has to do with the angle of muscular pull on a bony lever that is changing position in space, but let's not get to technical. Instead, how about we expand the definition of isotonic and stay in keeping with the title of this chapter, which I think, is "Basic Forms of Resistance and Endurance Exercise Training." Do you

remember the term concentric? This is a type of isotonic contraction where the internal forces generated within the target muscle or muscles exceed the resistance being lifted and the muscle(s) is able to shorten. Yes, the other term to review is eccentric and this refers to a type of contraction in a muscle that is not fully lengthened, somewhat slackened, and now the external force affecting that target muscle is greater than the internal force it is able to generate. This will produce a lengthening of the muscle as it continues to maintain tension. Manual resistive exercise (MRE), something we will practice a lot of in class is great for eccentric muscle training for our patients. It is easy too. Just start moving the patient limb and tell him or her to "slow you down." Before you know it, you are strength training the patient with eccentric muscle contractions.

ISOKINETIC

Are you ready to review the last *iso* term? As you most likely know, the term is isokinetic or in our case, isokinetic exercise. Let's look at isokinetic exercise from the perspective of what isokinetic devices or machines are able to offer our patients. An isokinetic device is able to provide passive range of motion, concentric resistance at a fixed speed, eccentric resistance at a fixed speed and multi-angle isometric resistance. There are several nice clinical (patient oriented) features of isokinetic training. First, the fixed or set speed resistance can accommodate to a patient's changing muscular abilities throughout a given range of movement. This accommodating resistance may convey a greater degree of safety to a patient's tissues if pain is encountered during a particular arc of motion. In other words, if the patient reduces their muscular contraction, the isokinetic device will reduce the resistance it is providing. While some might argue that this is not what happens in the real world of lifting objects and overcoming gravity, it can still be important during certain phases of tissue healing after an injury or after a flare up of a chronic condition. Further, in terms of protecting a patient's tissues, some feel, and I agree, that higher speed isokinetic resistance training promotes reduced muscular torque or force production and therefore reduced joint compression loads.

Above are some of the positive attributes of isokinetic training; there may be some disadvantages as well. Many if not most isokinetic devices offer single plane muscular training only, are most typically open kinetic chain, and clinically it is difficult for a clinician training a patient in this type of device to really know exactly where in a range of movement their muscular

strength impairment is. So, regarding these disadvantages let me make the following two points very clear. Patients with strength impairments should receive more than just one form of resistance intervention as they progress through a program of rehabilitation. Moreover, in my opinion, there is no better way to deliver multi-angle, variable, and accommodating or progressive resistance than with your own hands. MRE intervention allows a clinician to determine where in the range of movement the muscular impairment lies so that the intervention becomes much more specific. MRE intervention is an important aspect of orthopedic and orthopedic manual physical therapy training and one that should continue to be emphasized in all PT curriculums.

OTHER FORMS OF RESISTANCE

So that is a brief review of isometric, isotonic, isokinetic and a quick comment or two on MRE. Regarding patients with muscle strength impairments, there are two other important forms of resistance intervention to review. The first is Free-weight exercise. Free-weight exercise training is typically performed with various sized bars and plate weights. This is the exercise of choice for healthy weight lifters and athletes, but is this form of resistance training OK for patients with orthopedic conditions? The answer is both yes and no. If there is not a significant degree of cartilaginous degeneration or soft tissue injury free weight can be easily adapted for the injured and the non-injured side of the body. For example, hamstring curls could be performed with 40 pounds on the non-injured side and 15 pounds on the side of a healing muscle tear. In addition, free-weights offer the advantage of exact incremental progression of resistance as a tissue heals or as a patient becomes stronger. A possible negative aspect to using free weights includes the potential for greater loading of joint cartilage and the potential for movement errors once a particular therapeutic range is demonstrated to the patient. Lastly, let's not forget elastic bands and elastic tubing. These therapeutic tools are also a form of free-weight and similar to a plate-weight pulley system, elastic resistance has many positive attributes such as multi-plane movement patterns, and both balance and spinal stabilization requirements when performed by our patients in certain positions.

I mentioned that there were two last forms of resistance to review, and the second one is plyometrics. Clearly, most daily movement patterns do not call for a pure isometric or isolated concentric isotonic muscular contraction. It is understandable to all therapists that many daily

movement patterns require that muscles work both concentrically and eccentrically. Plyometric exercise training allows for quick shifting between concentric and eccentric muscle work. In addition, plyometrics have been described as quick, powerful movements. I like to think of them as quick transitioning muscle contractions. This form of training is typically thought of as closed chain movements such as mini-hops, jumps and other explosive bounding types of lower extremity movement. It is also important to consider that quick shifting of concentric and eccentric muscle contractions, an attribute of plyometrics, can also be applied in an open kinetic chain environment. This can be accomplished with creative patient positioning and the application of MRE training. That being said, plyometric exercises are more "advanced" exercises and often are a necessary part of athletic rehabilitation and return to sport. Lastly, with regard to plyometrics, when transitioning a patient who has been successful in the performance of other basic therapeutic motions, please keep the following general guidelines in mind. Make sure that your patient's tissues have had the right amount of time to heal (see Chapter 6) and confirm that the patient can walk, squat, jump, and stand on one lower limb without discomfort before starting too many full load plyometric exercise motions.

EXERCISE DOSAGE

Before we conclude this section on various forms of resistance, we should review an important related concept termed exercise dosage. The concept of exercise dosage is pretty simple to understand, but there are some unanswered questions as to which method of strength building is most effective. A dose of exercise can be easily increased by increasing the amount of weight lifted (intensity), increasing the number of sets, increasing the number of repetitions, increasing the lever arm length, or changing a patient's position relative to gravity. Clearly, reducing any of the above, assisting a movement, or changing a patient's position so that gravity is eliminated would reduce the exercise dose.

Now regarding the exercise dose, there are three important terms to remember. First, as just mentioned, is the term intensity or amount of weight lifted. Research regarding this parameter of dosage has been extensive and dates back to some classic work in the 1940's by DeLorme[7] and in the 1950's by Zinovieff.[8] Both researchers established strength-building parameters with multi-set repetition maximum (RM) programs in non-injured individuals.

The second parameter of exercise dosage is duration. Duration can be considered the number of sets or repetitions in an exercise program. This parameter also concerns itself with the all-important rest phase that is necessary during resistance training. It probably is obvious but, we should remember that as the intensity (weight) of a training program increases the duration (sets and reps) will often decrease.

The third and final parameter regarding exercise dosage is frequency. As you probably guessed, the frequency is the number of times an exercise is performed during the day or week. The frequency of resistance training can depend on a number of things including your patient's medical (health) status, their strength, the rehabilitation goals, and the type of exercise or muscle contraction being performed. Isometric and light, unloaded, and non-weight-bearing isotonic exercise training can be performed daily, while heavier isotonic training should often be performed every other day. In addition, the intensity of endurance training is typically low, and in some cases, endurance exercises can be performed every day. Walking programs and postural exercise are example of low intensity activities, which can be performed each day.

Our patients performing resisted training should exercise three or four times a week. If we are responsible for building strength in athletes, "split lifting routines" can be effective and help minimize overtraining. A split routine involving training three to four major muscle groups one day and then training a different set of three to four major muscle groups on the next day. Obviously, this allows for consecutive day training with a one-day rest break for the groups of muscle trained on the previous day. I would like to make one last comment with regard to exercise dosage. This textbook contains exercises for people who have pain due to an injury or who are predisposed to developing pain during movement due to degenerative changes. There are some exercises demonstrated in this text where the figure legend below makes reference to performing the exercise with equal work-rest ratios.

I have found this an effective way to minimize the development of painful symptoms both during and after the therapeutic motion/exercise if the patient is in the acute phase after an injury or if exercise motion(s) are being performed through a significantly degenerated joint surface or spinal motion segment. During the rest break, the patient is to report whether or not they have developed any discomfort. If so, the therapist can then change the intensity (weight) of the exercise, which typically means reduce, the arc of the exercise motion, change the speed of

the exercise motion, or change (increase) the amount of assistance given to complete the exercise motion. In addition, if pain is encountered the clinician can reduce compressive loading on the joint cartilage or intervertebral disc during exercise performance. If we control these parameters mentioned above, (arc, speed, load, assistance, resistance, ect.) requires patient cooperation, professional ingenuity and diligence during the monitoring of the exercise we stand a good chance of prescribing an exercise that will increase tissue strength or flexibility without provoking our patient's symptoms.

ENDURANCE

Thus far in this chapter we have focused a bit more on strength and the different types of resisted motion exercise. Another important therapeutic exercise concept is endurance and we should probably review it. How about a general definition first? Endurance could probably be defined as sufficient aerobic capacity to perform and control various movements for a sustained period of time.[9] Endurance is a important aspect of our patient's lives. I believe endurance becomes even more important as people age. If you think about it, there are some daily and some recreational activities that require brute strength, but there are many more daily activities, which require endurance.

We started out with a general definition of endurance, how about we define the term further and relate it to some of the body systems. When looking at endurance, it makes sense to start with the cardiovascular system. This system really runs the show when it comes to delivering oxygen to the muscle groups, which are required to perform activities for an extended period of time. In simple terms our lungs need to extract oxygen from the blood and the heart must be sufficiently strong to deliver an adequate supply of that oxygenated blood to the working muscles. On the musculoskeletal system side of things, the working muscles need to have a sufficient capillary network in order to make use of the blood delivered by the cardiovascular system.

Various traumas causing injury to muscles, surgery, and a whole host of various cardiovascular and neuromuscular diseases can cause muscular strength and endurance impairments. Luckily, muscles typically respond well to therapeutic endurance training exercises. Endurance training can improve a muscle's metabolic capacity, including its

mitochondrial size, number and enzymatic activity. This will better allow a muscle to use the delivered O_2. [10]

It is not my intent to write an exercise physiology text but we do need to complete a couple of important points. Regarding endurance training, things have not changed very much. To build muscular endurance, high-repetition, low-intensity (resistance) training at about 25% of a muscle's voluntary contraction ability will produce improvements in muscular endurance.[10] Aerobic exercise endurance training needs to occur for 20-30 minutes at least four times a week. In order to protect injured joints, arthritic lower extremity joints, or degenerated spinal segments with narrowed disc, patient positioning for aerobic training and other exercises often needs to be modified. This idea will be demonstrated throughout the text. Note, for our much-deconditioned patients, breaking up endurance training into two 10-minute segments or four 5-minute segments throughout the day can still be helpful. Do we need to take care when prescribing endurance exercise training to our patients? Yes, that goes without saying. This is particularly true in patients with cardiovascular conditions. Know what type of cardiac medication your patient is taking, where his or her nitroglycerin is and what the pill looks like. Above all, monitor vital signs as your patients' exercise. One last thing, don't think of endurance exercise training as just improving a patient's aerobic capacity. It is our job to build or improve endurance or tolerance if you prefer, for things like standing, sitting and walking.

Chapter 3

Therapeutic Motions and Movements

Strength and endurance were the focus of the last chapter. Strength and endurance impairments are two of the most common activity limiting impairments encountered by our patients. In this chapter we will detail other forms of therapeutic motion, but before we do, let's go back to a definition from Chapter 1. Licht defined therapeutic exercise as *motions of the body or its parts to relieve symptoms or improve function*. In keeping with that definition, we reviewed common types of resisted motion in Chapter 2. Resisted forms of therapeutic motion has been shown to improve function and relieve symptoms for some patients with certain orthopedic conditions. In addition to resisted motion, there are other forms of therapeutic motion that can do the very same thing, and with regard to symptom relief, part of Licht's definition, often need to be prescribed before or in place of resisted motion.

In this chapter we will review these commonly applied therapeutic motions and their effects on pain, circulation, contractile and non-contractile tissues. Usually a discussion along this line begins with passive motion and ends with resisted motion with active assisted motion and active motion thrown in between. That is a good way to sequence this discussion because it mirrors the typical progression of movement intervention that is applied to a patient whose musculoskeletal tissues have been injured, are degenerated, surgically repaired, or are otherwise irritated and painful due to a flare up in a chronic condition. Chapter 6 will cover the application of motion intervention in relation to phases of tissue healing in greater detail. This chapter will highlight the various attributes of therapeutic motion. So, let's get rolling with passive range of motion (PROM).

PROM

PROM is a form of joint movement that is performed and controlled by an external force without the incorporation of any muscular contraction. The external force can take the form of a clinician, a family member, a machine, a pulley system, elastic bands or the patient himself. PROM has many important attributes. This form of motion can assist circulation, assist synovial fluid movement, decrease pain, and minimize and prevent the numerous negative effects of immobilization including minimizing scar tissue formation, adaptive tissue shortening and joint contracture. PROM cannot prevent muscle atrophy, increase muscle strength, or increase cardiovascular (CV) endurance. Does it take skill, training, and experience to perform PROM effectively? The answer is a resounding yes! A clinician's manual contacts must be relaxed and tailored to the patient and the patient's anatomy. Patient positioning, the speed of the passive movement, and the arc of the passive movement must be performed in a way that allows the patient to relax so that pain and reflex muscular contraction does not prevent effective movement intervention. Repeated arcs of passive motion including passive oscillatory motion is an important form of manual intervention when we are dealing with both extremity and spinal pain impairment. After an injury or after a flare up of a chronic condition, I like to deliver PROM with small arcs of oscillatory angular and translatory (joint traction) motion, fashioned after both the Maitland and Kaltenborn-Evjenth systems of manual therapy. These small oscillatory therapeutic motions are performed with the injured joint close to its resting position. This is a simple form of therapeutic motion that can really reduce your patient's discomfort. You see, that is a good reason to memorize the resting position for each upper and lower extremity joint.

AAROM

Active assisted range of motion (AAROM) is the next movement intervention to discuss. AAROM is joint motion performed and controlled in part by voluntary muscle contraction and in part by an external force. A clinician, a family member, a machine, a pulley system, elastic bands or the patient himself, may give the assistance. This form of intervention is indicated when a patient is able and allowed to lightly contract his or her their muscles. The amount of assistance can vary greatly dependent upon the patient's strength, pain intensity level, or stage of tissue healing post injury or surgery.

This intervention is often used when a patient lacks the strength to perform a movement without substitution, a full arc of movement, or when active movement is painful potentially damaging to a healing muscle or tendon. AAROM can maintain the physiologic properties of a muscle, but it is unlikely to significantly strengthen a muscle. Muscular contraction, even sub maximal contraction will enhance circulation more than PROM and similar to PROM will facilitate synovial fluid distribution. AAROM will enhance coordination by providing sensory feedback to the nervous system and will maintain bone and joint tissue integrity. Further, this type of movement, again similar to PROM can be used to demonstrate a desired motion. In fact, given the level of muscle contraction with active assisted motion, this form of movement is typically favored over passive motion when attempting to improve an individual's proprioception and kinesthesia. Regarding cardiovascular capacity, small gains may occur if many repetitions are performed. Clinic based exercises that incorporate weighted pulley systems and elastic bands to assist active muscle contraction a is great way to protect, that is reduce load, on degenerated cartilage while still achieving a mild muscle strength building effect. Lastly, clinicians must carefully consider their manual contacts when performing AAROM. When possible and when needed, given a patient's strength level or pain intensity, contacts should be on one side of a body part. Grips on both the flexor and extensor surface are desirable for PROM but will not give a tactile cue that is understandable to the patient when muscle contraction is called for by the clinician. Consider this comment regarding manual contacts when performing manually resisted range of motion as well.

AROM

Active range of motion (AROM) is an intervention performed by voluntary muscle contraction. I am sure you already knew that. AROM is often prescribed for many of the same reasons as AAROM is prescribed. Clinically, the patient who may have been receiving AAROM is now stronger or contraction of the target muscle-tendon unit is no longer painful so progression to AROM can now occur. In addition, this intervention can be applied if a previously injured or surgically repaired muscle or tendon has now healed sufficiently.

In Chapter 2 we discussed strength and endurance. A lack of either will affect a patient's ability to perform a full arc of movement against gravity. Prescribing AROM as an intervention requires that the movement pattern in question can be performed fully against the resistance of

gravity, and is both symptom and substitution free. AROM can maintain a particular range of movement, improve neuromuscular coordination if performed well, improve endurance, and possibly make small gains in strength if many repetitions are performed. Remember, and this is important, active motion causes muscular contraction. Muscular contraction causes joint compression and that muscular induced compression can further damage cartilage and cause subchondral pain. So, if a particular arc of AROM seems to be causing joint pain, that arc of movement should be avoided! Remember this too, muscle contraction produces a tensile load on tendons. In some cases, this can be beneficial in terms of improving tendon strength. In other cases, if there is a significant tear in said tendon, higher load muscle contraction (resisted range of motion or RROM) could make the tendon tear worse. Keep this mind, when implementing a plan of care for your patient, and when transitioning him/her from one form of therapeutic motion to another such as PROM to AAROM, AAROM to AROM, or AROM to RROM it may be necessary to reduce the arc or speed of the newly prescribed therapeutic motion in order to protect the joint cartilage, painful tendons, and other periarticular tissues.

STRETCHING

The last therapeutic motion to discuss in Chapter 3 is stretching. Muscle stretching seems like an easy concept. It is such an important intervention whether we as clinicians are applying this type of therapeutic motion passively to one of our patients or whether we are prescribing a self-stretching exercise. Funny, it seems like there should be very little disagreement or variation with an intervention we have been applying for so many years. Guess what, there seems to be! Not a day goes by where I don't observe an exercise guru on TV, a trainer in the gym, and even physical therapists and other health care practitioners in various types of clinics placing extremity joints or spinal regions in poor or even dangerous positions all for the sake of stretching. It does not have to be that way! Similarly, I have observed for years' clinicians unnecessarily tensioning peripheral nerves, overly compressing articular cartilage, and overloading the intervertebral disc joints with excessive amounts of spinal flexion, unnecessary hyperextension or worse yet large amplitude spinal rotation while performing manual muscle stretching and when prescribing various self-stretching procedures. We need to think about loading! Is the load on joint cartilage and supportive ligamentous structures, including the disc, which is a ligament by the way, worth that additional little bit of extra flexibility? I know how I

feel about it, and clearly, or at least it is clear in my mind, there are many in our profession and other similar lines of work who have not made the simple connection that joints and spinal motion segments need to be protected when manual stretching is performed or when self-stretching is prescribed. As we progress through the text, I will discuss certain key self-stretches at various joints and spinal regions and I will offer up some thoughts regarding the right and safest way to perform these selected stretches. I will also show you the "bad" stretching motions, the ones that should be avoided.

VERY BASIC ANATOMY AND NEUROPHYSIOLOGY

Well, that was slightly controversial. Why don't we get back to the facts, and if not the facts maybe some important definitions and a review of some basic anatomy and neurophysiology relevant to muscle stretching. First, how about muscle flexibility? What is that really? *How about the ability of a muscle and its tendon to lengthen over all the joints they cross allowing full reversal of that muscle's actions.* That works for me and I hope it also works for you. Next, let's review some of the basics regarding the neurophysiology of muscle stretching. Neurophysiology, that's a big word and a little scary too, but here goes nothing. Do you remember an anatomical structure called the muscle spindle? This structure is in essence a unique set of muscle fibers (intrafusal fibers) along with sensory and motor nerve endings. This structure connects directly to the regular (extrafusal) muscles fibers. Here comes the simplification. When a muscle is lengthened or stretched the muscle spindle sends an impulse to the central nervous system, which signals that same muscle to contract. Sounds counterproductive with regards to stretching, but it is an important protective mechanism and there is a balancing mechanism that we will review in the next paragraph.

How about that, the next paragraph is here already and the anatomical structure that sort of balances the effect of the muscle spindle are the Golgi tendon organs (GTOs). That by the way was also a great car made way back in the 1960s. The Pontiac GTO, which was one fast car! But I am showing my age and we need to get back to the role of Golgi tendon organs and therapeutic stretching. These little guys attach into the myotendinous junction and are sensitive to length changes in the muscle tendon unit. The GTOs are most sensitive to tendon elongation whether it is passive elongation or tendon elongation secondary to muscle contraction. Either way, if a muscle is passively stretched or an isometric contraction produces tendon lengthening, the GTO

will send an impulse to the CNS which allows the muscle to relax. Studies in muscle neurophysiology seem to show that the impulse sent to the CNS by way of the GTO can "override" the impulses coming from the muscle spindle. For example, if the quadriceps muscle is placed in a lengthened position for a sustained period of time, maybe somewhere in the neighborhood of 30 seconds or more, the GTO's signal to the CNS will allow the muscle to relax and elongate.

That is probably enough on our quick review of muscle neurophysiology. How about just a bit more review, this time on the anatomical structure of skeletal muscle. If you recall, there is well over 400 voluntary muscles in the body, all of which consist of different layers of connective tissue. Muscle fibers lay next to each other and are wrapped in a tissue called endomysium. On average, 150 muscle fibers are bundled together by perimysium. The entire muscle is then encased by, you know it, epimysium. So, that is the macroscopic arrangement of a muscle. Regarding the microstructure of a skeletal muscle, we should briefly look at the sarcomere. The microstructure of a skeletal muscle really consists of two progressively smaller anatomical structures. Each muscle fiber consists of smaller fibers called myofibrils, and the myofibrils are made of small little threads called myofilaments. These myofilaments are in essence made of two proteins called actin and myosin.

Now without going into a lot more detail, let's talk just a bit more about the microstructure of the muscle fiber in a way that as clinicians we will always be able to recall. The myofilaments that we just mentioned are arranged in a repeating and consistent structural pattern. That pattern runs from Z line to Z line and that is your sarcomere. So, what should we try to remember about the myofilaments? Just this, they play a key role in the mechanical process of muscle contraction and as a result muscular force development.

So now that we have briefly reviewed the structure of muscle, let's get back to muscle stretching and look at some of the effects of this therapeutic movement. There are numerous studies that have documented the importance of muscle stretching and injury prevention[11, 12]. I am in agreement with these studies and feel that good muscle flexibility can not only reduce injury risk but also enhance athletic performance. Reduced muscular flexibility may be the result of adhesions in the epimysium, perimysium, endomysium or in the contractile elements of the muscle fibers and tendon.[13] Clinical application of muscle stretching can promote both

immediate and short term lengthen effects on the connective tissue components of the target muscle. Long term application of stretching such as immobilization in a lengthened position will result in sarcomere addition.

OLAF Evjenth

Lastly, let's discuss correct clinical application and duration of muscle stretching. Olaf Evjenth, the master of manual muscle stretching and self-stretching has spoken for years on how the effectiveness of muscle stretching relates to force and time. A long time before research papers were written Olaf stated that effective muscle stretching needed to be applied slowly and held for 30 seconds at least and in many cases up to two minutes. [14,15] Further, he stated that a mild to moderate stretching sensation should be felt in the target muscle only. In other words, extremity joint and spinal segmental pain should not be felt during muscle stretching. Similar to me, Olaf also felt that we should not overload support structures such as the IVD or principal extremity joint ligaments in an attempt to elongate what we believe may be a shortened muscle.

A couple more points related points, Olaf noted that when possible stretching should occur over the largest and most stable extremity joint when stretching multi-joint muscles. In other words, pre-position the smaller joints first, make sure they are comfortable and then elongate the muscle over the larger joint that it crosses. Readers of this text will see how this applies to many of the self-stretching procedures in the various extremity chapters. In addition, and I made a similar point in the previous paragraph, the spinal segments should be kept close to mid-position when prescribing self-stretching. See the Swiss Ball supported self-stretches in Chapter 18. We seem to understand that the spine should be held in an in a neutral and stable position while lifting but many seem to forget that the spine should be held in that same position while stretching. If we don't do this, we run the risk of damaging stabilizing structures during a self-stretch procedure.