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Effective Therapeutic Exercise Prescription: The Right Exercise at the Right Dose

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ABSTRACT: The prescription of an effective therapeutic exercise program requires the right dosage of the right exercise, at the right time for that patient. The therapist must understand and apply training principles effectively in the presence of pathology, injury, or otherwise unhealthy tissue. The intervention goal is to close the gap between current performance and the desired goal or capacity. Although there may be a preferred linear path from current performance to optimal outcome, complexities of the human body, internal factors, and external variables may create barriers to this direct path. Successful programs include key program design considerations such as ensuring a stable baseline before progression, treating the right impairments and activity limitations, understanding contextual factors, considering the principles of specificity and optimal loading, and applying dosing principles. Program progression can be achieved through increases in total exercise volume and/or through manipulation of exercise challenges at the same exercise volume. Effective application of these principles will guide patients toward their goals as quickly and efficiently as possible.
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The effective application of therapeutic exercise is equal parts science and art. Although much is known about the effects of many types of exercise in uninjured tissues and healthy individuals, less is known about these effects in pathological tissues and in those who lack good health. Therapeutic exercise is the systematic performance or execution of planned physical movements, postures, or activities intended to enable the patient/client to 1) remediate or prevent impairments, 2) enhance function, 3) reduce risk, 4) optimize overall health, and 5) enhance fitness and well-being.[1]

Therapeutic exercise programs differ from traditional exercise programs and are designed by rehabilitation professionals to achieve specific measurable outcomes. The purpose of this article is to describe if and how the general principles of training apply to therapeutic exercise prescription in the presence of pathology. An overview of exercise prescription principles such as achieving baseline stability, treating the right impairments, understanding contextual factors, and determining exercise dosage are discussed. Case studies demonstrate application of these principles in treating impaired mobility and impaired muscle performance, as well as describing progression and return to functional activities. Although the focus of this article is with primary musculoskeletal problems,[1] many of the concepts and principles described here can be applied to both the positive aspects of the functioning and disability continuum and to other body systems.[2]

OVERVIEW OF EXERCISE PRESCRIPTION

The application of therapeutic exercise in a patient population follows a similar decision-making process as prescribing other treatments or medications. Too often, those associated with this interaction (therapist, patient, family, other health providers on the team, etc.) consider the exercise program to be a simple matter of choosing a few exercises to be performed a certain number of times per day. In fact, the planning process involved in the initial design and subsequent progression of an effective therapeutic exercise program are relatively complex.

Therapeutic exercise prescription must consider activity in terms of dosage. As a physician considers factors such as the patient's pathology, comorbidities, age, body size, concurrent medications, and support systems when determining a medication's dosage, so the therapist must also consider such factors

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when prescribing therapeutic exercise. A partial list of additional key factors might include stage of healing, limb dominance, home and workplace demands and requirements, current impairments, activity limitations and/or participation restrictions, motor control abilities, presence of wounds, psychosocial issues, and the ability to effectively participate in a rehabilitative exercise program.[1,2] Once these issues are evaluated, therapeutic dosage parameters such as mode of delivery, type of muscle contraction, type of mobility activity, volume, frequency, intensity, duration, speed, sequencing, environment, and feedback are all considered and applied in the therapeutic exercise prescription.[3]

CLINICAL DECISION MAKING

Effective therapeutic exercise program prescription requires 1) assessing the patient's current status and 2) determining appropriate, relevant, and achievable goals. These two points mark the beginning and ending anchors for the structured rehabilitation program. Contained within these two points are a number of progression variables (i.e., exercise dosage parameters), supporting factors (i.e., good tissue quality, low pain levels, few comorbidities), barriers (i.e., high demand occupation, poor tissue quality, multiple comorbidities), and benchmarks (i.e., short-term goals).

The ultimate goal is to close the gap between current performance and the patient's goals or capacity. Although numerous pathways exist that may close this gap, the preferred pathways are those that are more expeditious and direct. Although the ideal scenario would be a predictable and linear progression from initial evaluation to discharge, progress is frequently marked by setbacks, development of secondary problems, or plateaus. Successful navigation of these changes in forward trajectory is the hallmark of a skilled therapist. To facilitate successful and expeditious closing of this gap, therapists make a variety of clinical decisions such as identifying the involved or injured tissue(s), identifying the stage of tissue healing and irritability, and determining the appropriate criteria and timing for exercise progression. Additional clinical decisions include ensuring a stable baseline before progression, treating the right impairments and activity limitations, understanding contextual factors, considering specificity and optimal loading principles, and applying dosing principles within the framework of the stages of healing. Guiding questions can elucidate some of these issues for the therapist (Table 1).[4]

Ensuring Baseline Stability

The initial program should provide a stable baseline of activity from which the therapeutic exercise program can be advanced. It is difficult to initiate or progress a therapeutic exercise program when a patient's symptoms are fluctuating. An exercise program that is appropriately dosed on one day may be too much or too little on another. Patient response to the program will then be variable, making progression choices unclear. Although the patient may still have symptoms, and those symptoms may vary throughout the day or the week, these symptoms should be somewhat predictable. Ideally the patient's symptoms would be stable or decreasing and have a predictable response to activity or the therapeutic exercise program. This stability helps clarify the additive effect of the rehabilitation program on the patient's overall condition.

Treating the Right Impairments

Determining which impairments, if any, to treat is also an important part of the initial exercise prescription. It is tempting to treat all impairments under the assumption that remediating impairments leads to improvements in function. However, the relationship between impairments and activity limitations is not always predictable or linear.[5–9] For example, patients with rotator cuff tears often function well despite strength limitations.[5] A patient with osteoarthritis in the hand may be able to perform all daily activities with the use of modified tools and appropriate pacing. The impairments chosen for intervention should be linked to an activity limitation or participation restriction and should be prioritized based on a well-constructed plan of care.[10]

Understanding Contextual Factors

Contextual factors (environmental and personal) are also overarching considerations in exercise prescription and can negatively or positively impact outcomes.[2,11–14] For example, two patients with the same impairments might have different initial programs based on their fitness level and goals. Environmental factors reflect the external influences on functioning and disability and include the physical environment or societal attitudes. Personal factors reflect the internal influences and include factors such as gender, race, age, comorbidities, fitness, lifestyle, coping styles, education, individual psychological assets, and life experiences.

Dosing: Physical Stress Theory, Specificity, and Optimal Loading

Consideration of specificity, or the Specific Adaptations to Imposed Demands (SAID) principle, grounded in the Physical Stress Theory (PST) provides guidance for initial exercise prescription and

TABLE 1. **Template for Clinical Decision Making and Determining Initial Therapeutic Exercise Prescription**

Examination Question	*Therapeutic Exercise Intervention Model Dimension*	*Therapeutic Exercise Prescription Information Obtained*	*Application to Case A*
What muscle is impaired?	Muscle or muscle group	Muscle group to be trained	Supraspinatus, infraspinatus
How does this muscle function primarily in this patient's activities? Is this the appropriate contraction type to begin with?	Movement	Type of muscle contraction for initial rehabilitation program, as well as contraction type to be progressed toward (if different)	Isometrically, eccentrically, concentrically
In what range does the muscle function, and does it need to be trained through that full range?	Movement	Working range of motion	Typically below shoulder height and often with elbow at side
What is the best mode for applying the resistance?	Mode	Exercise mode such as manual, pulley, elastic band, variable resistance equipment, etc.	Isometric and resistive bands
What posture or position is this muscle used in functionally for this patient? Is this the best position to initiate training?	Posture	Beginning exercise posture as well as postural goal (if different)	Typically standing or crouching
At what speed does this muscle typically function? Is this the best speed to initiate training?	Speed	Beginning exercise speed as well as speed goal (if different)	Usually slow and controlled speeds but must be ready for sudden movements
What is the patient's baseline strength? What are the functional strength demands?	Intensity	Initial training resistance and resistance goals	Range of 3–4/5
What muscle function is the primary requirement? (i.e., power, strength, endurance) and at what frequency?	Frequency/duration	Initial training sets and repetitions and sets and repetitions goal	Strength and endurance
What other associated muscle or muscle groups need training? How do they work with the muscle group of interest? (i.e., synergist)	Sequence	Other supportive muscle groups to be trained and sequence for training	Scapular muscles and core
Are there any medical precautions or contraindications?	Overarching	Precautions and contraindications to exercise	No specific precautions or contraindications
What is the stage of healing?	Overarching	Volume and intensity limitations	Subacute

Modified from Brody L, Hall C. Therapeutic Exercise: Moving Toward Function. 3rd ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins, 2010.

progression.[15,16] The SAID principle is based on Wolff's Law, the PST, and the specificity of training concepts.[16–18] These concepts suggest that muscle and other connective tissues will remodel according to stresses placed on them. The PST states that biologic tissues have five responses to physical stress available: decreased stress tolerance (i.e., atrophy), maintenance, increased stress tolerance (i.e., hypertrophy), injury, or death.[16] Thus, dosing therapeutic exercise requires making choices about variables that apply stress to tissue such as frequency, intensity, duration, muscle contraction type, range of motion (ROM), speed of movement, and mode.[19–22] Of these variables, frequency (how often exercise is performed), intensity (amount of force necessary to achieve the activity), and duration (number of repetitions or time the exercise is performed) are most often manipulated.[4] The exercise volume is the total amount of exercise performed in a single session and is an additional consideration when determining exercise dosage.[4] The PST considers not only the exercise volume when determining the total physical stress on a tissue but also movement and alignment factors, extrinsic factors, psychosocial factors, and physiological factors.[16] The goal when applying the PST is to provide a safe and sufficient volume of physical stress to produce tissue adaptation without causing tissue injury or death.[16]

Beyond volume considerations, other aspects of specificity include such variables as ROM, speed, and muscle contraction type. The greatest training effects are evident when the same exercise type is used for testing and training, although this varies by muscle contraction type. For example, some research has shown that there is greater carryover when training eccentrically at fast speeds than similar concentric training.[23] Strength gains are also greatest at the joint angles at which the exercise is performed.[24]

That being said, training specificity is not absolute. Muscles trained isometrically demonstrate increased isokinetic strength.[24] Isometric training shows carryover to additional ranges, especially when the training occurs in more lengthened positions.[25,26] Training the rotator cuff with resistive bands or free weights results in increased isokinetic strength and functional performance.[27] Activities such as rope jumping also improve shoulder muscle torque production.[28] These concepts provide the prescribing clinician with both a preferred path as well as numerous alternative paths for achieving rehabilitative outcomes. For example, eccentric exercises for the common wrist extensor muscles are the preferred exercise path for a patient with lateral epicondylitis.[29–31] However, this mode of resistive exercise may overload the tendon or its bony insertion, increasing pain and decreasing function. Starting the program with isometric or concentric exercise for the common wrist extensors or by exercising a muscle group more proximal or by training a synergist are options to provide a tolerable initial training load.[19]

The principle of optimal loading provides additional guidance in exercise prescription. On any given day or portion thereof, the recovering tissue has a range of loading that is optimal. That is, the patient's daily activities neither overload nor underload the tissue. If the patient has work activities or activities of daily living (ADL) that place a high demand on the recovering tissue, then the rehabilitation exercises must be adjusted to keep overall loading within the optimal loading range. Patient education is necessary to maintain this balance. Patients often understand examples such as ''you have a certain number of activity dollars each day to spend on all your work, leisure, home care and therapy activities; therefore, if one of these areas increases, other areas will have to decrease.'' Some patients have low tissue irritability and can tolerate a wide variety of activity challenges without increasing symptoms. Exercise prescription is easier in this group than in those patients with high tissue irritability and negative or unpredictable responses to activity.[32] (Figure 1) In these cases, keeping the exercise and activity levels within the optimal loading range can be challenging.

If the patient regularly decreases the rehabilitation exercises due to high demands in daily activities, then the therapist should encourage and support work and ADL relief. Patient and key stakeholder (i.e., employer, family, etc.) education regarding these loads and how to manage activity choices to keep loading within the optimal range is essential to a successful outcome.

EXERCISE PRESCRIPTION

There are many facets to successful exercise prescription, including identifying key impairments and activity limitations, choosing activities or techniques that remediate these limitations, and dosing these activities appropriately. See Figure 2 for exercise dosage variables. Although a variety of impairments and activity limitations can be remediated with therapeutic exercise, impaired mobility and impaired muscle performance are discussed through two patient cases to provide examples of therapeutic exercise prescription. See Table 2 for key aspects of the examination and evaluation for both case studies.

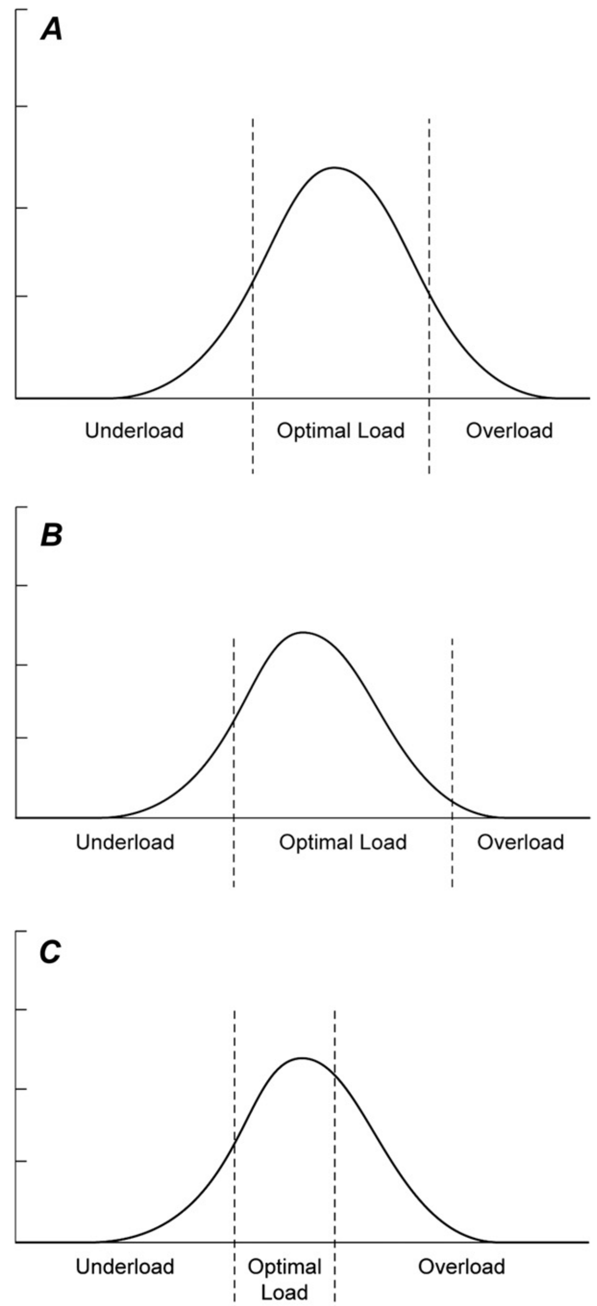

*FIGURE 1. Optimal loading and its variations. (**A**) A typical optimal loading range. (**B**) A patient with less irritable tissues and a wide range of activity tolerance. (**C**) A patient with tissue irritability and a small range of activity tolerance.*

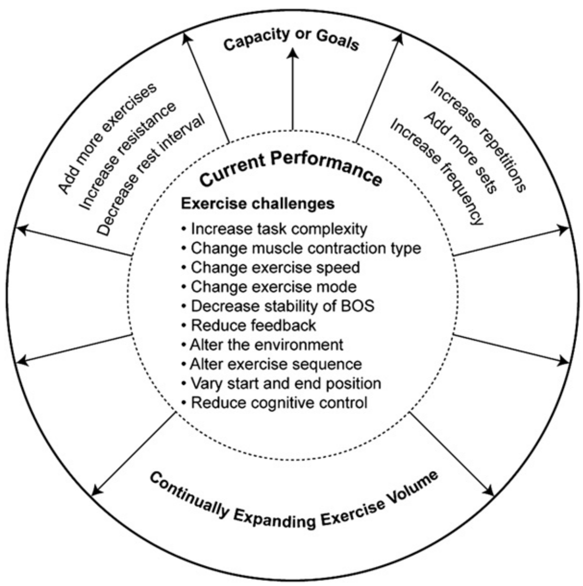

FIGURE 2. *Exercise progression model. BOS = base of support. (Reprinted from Brody L, Hall C. Therapeutic Exercise: Moving Toward Function. 3rd ed. Philadelphia, PA: Wolters Kluwer/Lippincott Williams & Wilkins; 2010.)*

Case A (EM) is a 53-year-old female who slipped and fell on her dominant outstretched hand. She had immediate pain in her shoulder but continued to milk her goats. She was seen by her primary care physician three days later and started physical therapy one week later. EM's initial therapeutic exercise program consisted of both mobility and muscle performance activities.

Case B (HJ) is a 41-year-old female who works as a waitress. She injured her shoulder three months ago when she strained to catch a tray of food. She did not notice any significant pain and continued to work, but over the course of the next month, she developed increased pain and loss of shoulder motion. Her primary care physician determined that she strained her shoulder and developed bursitis. HJ was placed on work restrictions (max, 10 lb. lifting) and was referred to physical therapy. HJ's primary issue was loss of motion and functional lifting abilities at the shoulder.

Initial Therapeutic Exercise Prescription

After determining the initial patient status and the achievable goals or end points, the starting point for the therapeutic exercise program is established. Frequently, therapists prescribe exercises to be performed independently between clinic visits. It is often presumed that the patient response to the exercise program will be the same on subsequent days as it is on the day the exercises are prescribed. Although the exercises may be dosed correctly on one day, they may either overload or underload the tissue on other days. Additionally, when exercises are initially prescribed, they are performed once in the clinic, and on subsequent visits when new exercises are added, only a portion of the exercise program may be performed in the clinic. This makes it difficult to ascertain whether the dosage of activity is right. The therapist must consider that what seems to be the correct dosage on any one day in clinic, which may not be the right dosage when implemented at home. The therapeutic exercise program should be designed with enough flexibility and the patient sufficiently educated to accommodate these dosage issues.

Impaired Mobility

Mobility can be impaired for a number of reasons and can result from pain and/or a combination of limited joint, muscle, tendon, or other connective tissue extensibility.[33] Impaired mobility is not always a loss of mobility, as hypermobility and instability are also forms of mobility impairment. Each of these causes of mobility loss requires a specific intervention to match the right exercise, at the right time, at the correct dose to meet the patient's needs and capabilities.

Range of motion exercises are beneficial, as they provide nutrition to joint surfaces, lengthen tissues around a joint, provide a stimulus to connective tissues stressed during activity, and stimulate joint receptors. When ROM is active, the additional benefit of muscle activation is noted, which also enhances circulation, assists in proprioception and kinesthesia, and provides a stimulus for bone activity at the site of muscle attachment.[34]

The ROM activity must be appropriately chosen and implemented in order to be successful. A number of variables, such as posture, ROM, and speed will impact the response to the exercise. For example, although Codman's exercises are traditionally meant to be a passive pendular exercise, many patients perform this exercise actively, lifting the arm through the ROM. If muscle activation is contraindicated, this exercise can be detrimental. Similarly, active ROM for shoulder abduction in standing is actually a resistive exercise, given the lever arm and position against gravity.[34] Therefore, careful consideration of the many prescription variables is key to ensuring that the right exercise is prescribed at the right time.

Applications: Impaired Mobility Case A

The initial program to increase mobility considers whether mobility limitations are the result of arthrokinematic limitations, osteokinematic limitations, or both. Loss of arthrokinematic motion suggests the need for joint mobilization interventions, whereas osteokinematic motion losses are often treated with ROM activities.[35,36] Joint mobilization techniques

TABLE 2. **Key Examination Findings at Initial Evaluation for EM and HJ**

Measure	*Findings in Case A: EM*	*Findings in Case B: HJ*
Chief complaint	Pain, loss of motion, inability to do her usual work, weakness	Pain, loss of motion, inability to do her usual work, weakness
Pain with movement	4/10	8/10
Glenohumeral active range of motion	Flexion: 0°–100° Abduction: 0°–110° External rotation at 0° of abduction: 0°–60° Internal rotation at 0° of abduction: 0°–40° Extension with internal rotation: to sacrum	Flexion: 0°–58° Abduction: 0°–47° External rotation at 0° of abduction: 0°–15° Internal rotation at 0° of abduction: 0°–40° Extension with internal rotation: to greater trochanter
Glenohumeral passive range of motion	Flexion: 0°–170° Abduction: 0°–170° External rotation: 0°–90° Internal rotation: 0°–50°	Flexion: 0°–93° Abduction: 0°–70° External rotation: 0°–20° Internal rotation: 0°–35°
Muscle performance testing	External rotation: 4−/5 Empty can (supraspinatus): 3+/5 Abduction: 4−/5 Internal rotation: 4/5	External rotation: 3/5 Empty can (supraspinatus): 3/5 Abduction: 3/5 Internal rotation: 4/5
Palpation	Tender over long head of biceps, subacromial space	Tender over long head of biceps, subacromial space, rotator cuff tendon, posterior capsule, upper trapezius trigger points
Special tests	Negative for instability Neer impingement sign: + Joint play: normal in all directions	Decreased glenohumeral glide in all directions
Activity limitations	Unable to carry hay without pain Unable to pull goats onto ramp for milking without pain Unable to manipulate milking machine without pain	Unable to sleep on her right side Unable to perform self-care activities with her right arm Unable to lift more than 10# Unable to drive the stick shift in her car Unable to perform ADLs or IADLs requiring dominant arm mobility or strength
Participation restrictions	Unable to perform all work-related duties without pain or requiring assistance	Unable to perform any reach or lifting-related work-related duties without pain or requiring assistance

ADL = activities of daily living; IADL = instrumental activities of daily living.

were not indicated for EM because her mobility loss was small, her ROM was limited by pain from tissue stretching, and her arthrokinematic motion analysis was normal. The addition of shoulder joint mobilization provides no significant additional benefit beyond the therapeutic exercise program in cases where mobility limitations are minimal.[37,38]

EM had a limitation of full overhead elevation due to pain, although this lack of full overhead ROM did not contribute to functional limitations. However, leaving this impairment untreated might lead to activity limitations in the future; treating it might be advisable. In this case, it was determined that "watchful waiting" was appropriate at the initial intervention stage. Intervention for this impairment could be initiated at a subsequent visit if reevaluation determined that this motion loss was progressing or was contributing to activity limitations.

In contrast, her limitations in internal and external rotation were key impairments to treat, as they limited her home and work activities. Due to pain concurrent with muscle guarding, the patient was instructed in active ROM for shoulder internal and external rotation in a gravity-minimized position. Although EM was capable of performing those motions against gravity, lifting against gravity placed a higher load on the musculotendinous unit.[39] This is consistent with the PST where the total amount of stress on the tissue is considered as a composite value related to the time, magnitude, and direction of applied stresses.[16] By limiting the load during ROM activities, the patient had more latitude for functional activities and rehabilitative strengthening exercises, keeping her total loading within the optimal loading range.

Applications: Impaired Mobility Case B

HJ demonstrated loss of arthrokinematic motion, suggesting a current or developing adhesive capsulitis (stage 1).[40] She had pain with active shoulder movement, and her condition was highly irritable by the classification system proposed by Kelley et al.[41] Interventions were chosen based on the stage and tissue irritability. Although controversy exists regarding the frequency and intensity of supervised interventions, some evidence suggests improvements in pain and function with early intervention.[40,42,43] HJ was initiated on a program using gentle isometric exercise combined with superficial heat, followed by active assisted ROM (AAROM) with a low total end range time (TERT) alternated with low-grade joint mobilization.[41] TERT is the total amount of time that a tissue is held at or near end range.[41,44–46] Because of HJ's high irritability, ROM activities were kept to low repetition and short duration. AAROM was altered with low-grade joint mobilizations in anterior, inferior, and posterior directions, combined with joint distraction.[47] The circle concept of the glenohumeral joint capsule suggests that mobilization in one direction can lead to improvements in a variety of directions.[48] Although high-grade mobilizations have been shown to be slightly more effective than low-grade mobilizations in long-term follow-up, it was felt that the high irritability was a contraindication for high-grade mobilizations.[49] There is also evidence that joint mobilization decreases pain.[40,50]

In the clinic, gradual increases in TERT and total activity volume occurred, although both of these remained low. HJ's home exercise program (HEP) consisted of pulleys within a comfortable range and well-arm assist activities to keep exercises at an assisted level. HJ also performed therapy in a warm pool and performed a series of buoyancy-assisted and buoyancy-supported exercises. Buoyancy-assisted movements included shoulder flexion, extension, and abduction, whereas buoyancy-supported exercises included shoulder internal rotation, external rotation, and horizontal abduction. HJ also performed walking exercises with the small buoyant cuffs, which provided assistance to shoulder flexion while requiring scapular stabilization.

Impaired Muscle Performance

The many interventions chosen to treat impairments in muscle performance should be matched to the specific type of impairment. Muscle performance impairments can be categorized as impairments in strength, power, and/or endurance. Strength is the maximum force that a muscle can develop during a single contraction, whereas endurance is the ability of a muscle to generate forces repeatedly over a certain period of time. Power is the rate of performing work.

Resistive exercise is classified as isometric (static) or dynamic. Dynamic muscle contractions can be performed concentrically (shortening contractions) or eccentrically (lengthening contractions). Concentric contractions occur when the internal force generated by the muscle exceeds the external load, whereas the external load exceeds the internal muscle force during an eccentric contraction. Eccentric contractions generate more tension per contractile unit at a lower metabolic cost than concentric contractions.[51–54] Eccentric muscle contractions are essential in most functional activities, working to decelerate limbs during movement. They are an important component of the stretch–shorten cycle, where the combination of concentric and eccentric contractions results in a final action that is more powerful than the concentric contraction alone.[55]

Different types of muscle contractions are preferred for different rehabilitation goals. For example, eccentric muscle contractions are generally preferred over concentric contractions in the treatment of tendinopathy.[56–58] Chronic tendinopathy is associated with neovascularity in the area of greatest pain and tenderness. The success of eccentric exercise in treating tendinopathy may be due to the tension placed on the series elastic component during eccentric loading. It has been suggested that the neovascularization associated with chronic tendinopathy is disrupted by eccentric exercises.[59–61] Several differences among muscle contraction types highlight the importance of matching the correct exercise to the patient. In isometric exercise, no joint motion occurs, making these exercises useful in situations where joint movement is painful or contraindicated. Isometric exercises are used for neuromuscular reeducation and are often incorporated into proprioceptive neuromuscular facilitation exercises.[62] Isometric exercises for muscle reeducation are also evident in setting exercises such as gluteal setting, quadriceps setting, and hand squeeze exercises used in the perioperative period. Importantly, isometric exercises are also an integral part of eccentric exercise, as patients must be able to successfully maintain an isometric muscle contraction before the lowering phase of an eccentric contraction.

The force–velocity relationship also varies between concentric and eccentric muscle contractions. Muscles adjust their active force to match the applied load. When performing concentric contractions, slowing the speed allows the patient time to develop more tension. However, during eccentric contractions, increasing the speed of lengthening produces more tension, which appears to be a safety mechanism to prevent limbs from becoming excessively loaded. Clinically, increasing the speed of an eccentric contraction increases the amount of torque developed, whereas decreasing the speed of a concentric contraction increases torque development. This allows the therapist to increase or decrease torque production within the same exercise by simply adjusting the exercise speed. In either case, the therapist must ensure that the tissue is able to withstand the increase in physical stress to avoid injury.

Applications: Impaired Muscle Performance Case A

Given these fundamental differences among muscle contraction types, it is important to match the exercise to the patient's needs. For EM, although full remediation of the muscle performance impairment was not expected, return to all daily and work activities was expected. This demonstrates how impairments and activity limitations and/or participation restrictions are not always directly correlated.[63] The resistive exercise program was designed with the patient's functional demands providing the overarching framework.

Overarching considerations in the initial exercise program included contextual factors and optimal loading. In the case of EM, positive environmental factors included the support of her husband and coworkers, flexibility in her work duties, and the ability to self-pace her activities. Negative environmental factors that created barriers to progress included her physical work environments and the inability to stop working. Positive personal factors included her work ethic, general good health, coping style, and a positive attitude, whereas negative personal factors included gender, age, and fitness.

Dosing exercises to keep her activity in the optimal loading range was challenging due to work demands and the inability to defer many of these tasks to others. When EM had greater demands and less assistance, the additional load of resistive training could overload the healing tissue.[16] On these days, she was encouraged to perform simple ROM exercises and to use ice to keep loading in the optimal range. Performing resistive exercises on busy days had the potential to produce chronic inflammation, pain, and loss of normal shoulder biomechanics.

After estimating the volume of activity EM's shoulder could tolerate given her daily work demands, a specific exercise prescription was considered. The initial exercise prescription consisted of isometric shoulder abduction and internal and external rotation to avoid repetitive shoulder motion. On a daily basis, her ROM exercises combined with her work activities required shoulder muscle activation through an ROM. Therefore, adding resistance through this range could overload her tissues. She was taught isometric exercises in a variety of shoulder positions, consistent with her work and lifestyle. She was encouraged to perform them to fatigue, not pain, as frequently as she could throughout her day, without exceeding 70+ repetitions. This strategy helped keep her within her optimal loading capacity.

EM's initial exercise prescription is an example of how one exercise prescription principle may take precedence over another. EM's daily work required primarily concentric and eccentric muscle contractions. Applying the SAID principle, resistive concentric and eccentric exercises would appear to be more appropriate. However, the principle of optimal loading was prioritized, given the high likelihood of overloading the healing tissue given her daily work demands. It was expected that this initial exercise program would provide a stable baseline of rehabilitative activity that could be progressed using the SAID principle on subsequent visits.

Applications: Impaired Muscle Performance Case B

HJ's muscle performance impairments were generally related to pain during muscle contraction. She was initiated on a simple isometric HEP to allow a graded application of resistance in a variety of positions. In this way, the shoulder and upper quarter muscle groups were trained in positions and at intensities that were the least painful for her.[4] The exercises were performed in many locations increasing the ease of performance, and the exercises were dosed in such a way that the composite tissue stress levels were within the tissue tolerance or optimal loading range.[16,32] On days when she spent more time at work, her HEP was decreased to optimize tissue stress and decrease chance of injury.

HJ was also instructed in gentle isometric exercise in the pool. She began performing ''walking isometric exercises'' where she wore resistive gloves and walked in a variety of directions while holding her arms in a fixed position to provide some resistance to the shoulder muscles.[64] She held on to submerged railings with her shoulders in neutral and her body in vertical while bicycling and cross-country skiing with her legs, which provided limited weight bearing on the hands to challenge upper quarter musculature through the kinetic chain in a comfortable position.

EXERCISE PROGRESSION

Therapeutic exercise programs can be progressed in a multitude of ways. Progression must balance the positive factors with the potential barriers and must balance the therapeutic exercise load (the amount of stress and strain placed on the tissue) with the daily activity load. In general, two overarching strategies guide therapeutic exercise program progression. The first approach is to change the exercise challenge variables *without* significantly increasing the total exercise volume. The second approach increases the total exercise volume (Figure 2). A key consideration when deciding on approaches is the difference between current performance and current capacity. For patients who are functioning close to their current physical/physiological capacity given the stage of healing, increases in volume can overload the tissues. In this case, the exercise program can be advanced by altering the exercise performance variables.

Changing Exercise Performance Variables

Exercise performance variables include strategies such as changing the muscle contraction type, sequence, exercise speed, exercise mode, base of support, or cognitive control.[3] For example, a patient with tendinopathy might begin a therapeutic exercise program using isometric or concentric contractions and advance to performing the same number of sets and repetitions with eccentric contractions.[65–67] This represents an increase in challenge consistent with the SAID principle, without an increase in total exercise volume. Exercise speed can be altered to increase fatigue and cocontraction or to approach more functional speeds. These changes are within the current training volume and generally do not increase the total activity volume. However, it is important to note that the physiological changes that occur with these parameter changes exist despite holding training volume constant.[68]

Changing Total Exercise Volume

When the patient is able to consistently tolerate the exercise volume without increasing symptoms (i.e., stable baseline), the total exercise volume can be increased. The volume can be expanded in a number of ways, but increasing the *frequency, intensity,* or *duration* is the most common strategy.[69,70] When choosing a strategy for increasing exercise volume, consider the patient's current status and goals. In some situations, increasing resistance increases symptoms, either due to healing tissue intolerance or from comorbidities. For example, increasing the resistance of handheld weights when strengthening the biceps brachii muscle may overload existing wrist osteoarthritis. Alternatively, for patients who need a day of recovery between exercise sessions, increasing the frequency would overload the tissues. Effective exercise prescription requires finding the right balance of activity, therapeutic exercise, and dosage.

It is not always necessary to choose among increases in frequency, intensity, and duration for program progression. Instead, a combination of changes might prove more successful. Introducing variety into the program can be helpful in preventing overload. Rather than performing the same exercise program every day, some days can be "harder" days, with greater intensity and/or duration, whereas other days can be "easier" days with lower intensity and/or duration. Additionally, within those days, exercises can be varied by altering the exercise parameters within that dose. For example, on a "hard day," exercises can be stacked, with two or more challenging exercises performed in sequence, and on another "hard day," those exercises can be unstacked but performed with greater resistance or using a different mode of delivery. Likewise, speed and contraction type can be varied within or between sessions. If a patient is performing two sets of a specific exercise, one set might be performed with a light resistive band at a high speed, whereas the second set is performed in a different ROM or with a heavier band at a slower speed. This type of variety provides a more comprehensive therapeutic exercise program.

Therapeutic Exercise Progression: Case A

EM's therapeutic exercise program was modified without increasing the exercise volume. Changes were made to the exercise mode, by either changing from isometric exercise to dynamic exercise or adding light resistive band for dynamic concentric and eccentric contraction of the rotator cuff muscles. Exercise sequence was also modified. Exercises that isolated the supraspinatus were initially separated by alternative muscle group training. As she progressed, the supraspinatus exercises were "stacked" one after the other to increase the fatigue and training for this muscle group.[71–73] She was also encouraged to vary the speed of her exercises.

The next phase of her progression increased the total activity volume. The consideration was whether to increase frequency, intensity, duration, or some combination. Her initial exercise program had her exercising daily between work activities. Given her lifestyle and work schedule, she was already functioning close to her capacity for frequency, so we chose to increase intensity. If she was only able to complete a few repetitions (ten or less) with the increased intensity before the onset of pain or significant fatigue, then increasing duration would be a more appropriate progression choice. In EM's case, the resistive band thickness was increased and she was encouraged to work her way up in repetitions. Eventually, the exercise was changed to a more functional lifting activity that replicated the patterns necessary for goat milking. Resistance was given in the functional pattern rather than in isolated rotational patterns. This pattern of changing variables followed by increasing volume was continued until EM reached her goals.

Therapeutic Exercise Progression: Case B

HJ followed a different course of progression with a primary focus on increased mobility. Although strengthening exercises were an important part of her rehabilitation program, her strength was limited primarily by pain and motion restrictions. Thus, strengthening exercises were modified as her mobility increased and pain decreased. HJ's improvements in pain and motion were gradual, and it was felt that her tissue irritability was decreasing from highly irritable to moderately irritable. Therefore, her TERT time was slowly increased. Rather than holding at end range for <5 seconds, her hold time was increased to 8–10 seconds. Joint mobilizations gradually increased from low-grade mobilizations to higher grade mobilizations and from mobilizations performed in a neutral position to closer to end range.

HJ's aquatic rehabilitation program was similarly progressed from isometric shoulder strengthening to isotonic activities. The isometric exercises with gloves were progressed to isotonic exercises through an ROM. Exercises using viscosity as resistance are surface area and speed dependent. Therefore, the patient can self-determine the appropriate amount of torque developed by regulating the speed with which the exercise is performed.[74] Increasing speed from 30 degrees/second to 90 degrees/second significantly increases the electromyographic activity of shoulder musculature.[74] HJ was able to choose a nonpainful ROM and progress as she felt able. The weight-bearing exercises on railings were progressed to dynamic weight bearing using buoyant equipment, which required increased stabilization due to the unstable surface. Additionally, HJ was progressed to static stretching exercises supported by the water's buoyancy.

HJ's return to work was gradual. As tolerated, her resistive exercises were modified to replicate the postures and movements required in her waitressing work. As her pain and irritability decreased, she was able to manage loads that were heavy as long as her arm stayed close to her side. She modified her work by performing two-handed activities, and by four months postinjury, she was back to work as a waitress with modifications. As her ROM, strength, and pain improved, her HEP, including her aquatic program, was modified to reflect the postures, movements, and loads consistent with her work activities.

SUMMARY

Effective therapeutic exercise prescription requires clinical decision-making skills that extend beyond the application of overload principles. Although overload is essential for increasing tissue stress tolerance, that overload must be applied in a way that does not cause or perpetuate injury. The therapist must decide which impairments and activity limitations are treatment priorities and at what dosage therapeutic exercise intervention should be initiated. The therapist must determine the stage of healing and tissue irritability to ensure application at the right dosage applied to a stable baseline of symptoms. Contextual factors may impact the decisions and choices therapists make about the exercise intervention. The PST, the SAID principle, and the principles of specificity and optimal load inform the therapeutic exercise initiation and progression. The goal of the program is to close the gap between current performance and the desired goal or capacity. The program progression can be achieved through changes in total exercise volume (i.e., increased activity levels) and/or through manipulation of exercise parameters (i.e., changing exercise sequence or muscle contraction type) to achieve the desired outcomes in as linear a path as possible. Due to the complexities of the human body and the multiple internal and external factors impacting response to intervention, the successful therapist will need to continue to manage the challenges associated with successful integration of both the science and art of therapeutic exercise prescription.

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Quiz: Article #226

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#1. The physical stress theory states that all of the following are responses to physical stress EXCEPT
- a. atrophy
- b. hypertrophy
- c. death
- d. repair

#2. A patient with impaired posture of the thoracic spine and posterior shoulder girdle due to prolonged work at a computer terminal presents for a therapeutic exercise program to improve daily work posture. Considering the principles of exercise specificity, which exercise would be preferred to address this issue?
- a. seated rows on a weight machine
- b. bent over horizontal abduction with resistive bands
- c. seated isometric scapular retraction and depression contractions
- d. stretching of the anterior shoulder facing a corner

#3. All of the following represent an increase in exercise volume when training the common wrist extensor muscles EXCEPT
- a. increasing the speed of concentric wrist extensor exercises
- b. adding a second set of resisted elbow curls with free weights with the forearms in pronation
- c. increasing the holding time on isometric wrist extension exercises
- d. adding resisted band wrist extension exercises two days/week

#4. Which of the following statements about contextual factors is FALSE?
- a. contextual factors can support or create barriers to successful intervention implementation
- b. a person's physical environment (home or work) has only a small impact on therapeutic exercise intervention
- c. a person's coping style can modify the therapeutic exercise choices presented to a patient
- d. patients with similar impairments may have different intervention programs based upon their contextual factors

#5. The authors place little significance to external variables potential to create barriers to a direct path to recovery
- a. true
- b. false

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