Brunnstrom's Approach

Signe Brunnstrom worked with patients who had suffered damage to the nervous system due to a CVA. She made detailed observations regarding the movement patterns these patients exhibited as they recovered. She was thus able to precisely describe the natural history of recovery of movement and function after a stroke. Based on her observations, as well as her extensive search and interpretation of the literature available, she made specific recommendations regarding the sequence of movements and activities that would facilitate recovery and function. Her observations have been replicated, and her recommendations regarding treatment continue to be used.

Neurodevelopmental Treatment (NDT)

This approach was developed by Berta Bobath and Karel Bobath, her husband. Mrs. Bobath worked extensively with children with cerebral palsy and adult patients with stroke. Based on her observations in these patient populations and her interpretation of the works of Jackson, Sherrington, etc., she developed her theories and treatment approach. Her hypothesis, especially in regard to adult patients with stroke, asserts that because of the damage caused by the stroke, the patient is unable to direct the nervous impulses appropriately. This results in abnormal patterns of coordination in posture and movement and in abnormal qualities of tone. The aim of treatment is to inhibit the abnormal patterns of movement and facilitate integrated, automatic reactions and voluntary functional activity.

Techniques based on all these approaches continue to be used to improve motor control. Their efficacy is still being established and researched. No specific technique has been proven to be more effective than others, and therapists continue to mix and match them based on patient needs.

Current Approaches

Over the past 20 years our understanding of motor development, motor control, and motor learning has increased tremendously. This has led to a review and re-evaluation of the earlier techniques—those that emphasized inhibitory and facilitatory inputs and modifying motor behavior through handling. Based on the principles of motor learning and skill acquisition, current approaches put less emphasis on passive handling of the patient. They recommend a more active involvement on the part of the patient, especially in terms of problem solving and finding appropriate solutions. They emphasize the need for the therapist to create the appropriate environment for learning and the appropriate use of feedback to facilitate learning.
identified, the therapist and patient develop goals to address each problem. Common goals are to decrease pain, decrease edema, increase strength, or increase motion. The ultimate goal for patients with orthopaedic dysfunctions is to achieve an optimal level of function, whether that means returning to work, returning to the athletic field, or resuming the ability to perform daily activities independently. Therapeutic goals should include the anticipated return of strength or function, and the expected time frame for rehabilitation. Once goals have been established, the therapist then develops a treatment plan designed to achieve these goals.

TREATMENT PRINCIPLES AND TECHNIQUES

Treatment planning is based on determining what intervention will most effectively improve a patient's function by decreasing pain, decreasing edema, increasing strength, or increasing motion. The treatment options and rehabilitation approaches available to the orthopaedic physical therapist are numerous. Some therapists may focus their treatment approaches on exercises, while others may incorporate physical agents or manual techniques. In most instances, a combination of techniques is most appropriate when designing a comprehensive plan to address the needs of the orthopaedic patient. Whatever approach is selected, the most important factor to consider when planning the treatment is to consider the goals of treatment and the goals of the patient.

The following discussion of treatment options is meant to introduce the reader to the typical indications and uses of various treatment techniques. The techniques described include: physical agents, manual techniques (including soft tissue and joint mobilization) and therapeutic exercise. The reader is referred to the reading list at the end of the chapter for sources which provide in-depth information regarding the application of these techniques.

Physical Agents

Many therapeutic agents are available for physical therapists to incorporate into orthopaedic rehabilitation programs. Based on the intended purpose and method of application, physical agents can be divided into two categories: thermal agents (thermotherapy) and electrical stimulation (electrotherapy). Thermal agents can be subdivided into agents that apply superficial heat, deep heat, and cold. The decision as to which agent to use is based on a thorough evaluation of the patient's symptoms, the goals of therapy, and the therapist's knowledge of the physiological and clinical effects of each physical agent. Table 9-2 lists the common physical agents used in physical therapy according to their physical effects and includes their physiological effects and clinical indications.

Thermal Agents. When a tissue in the body sustains an injury, an automatic response is initiated in an attempt to heal the tissue and return it to its pre-injured state. These naturally occurring processes are referred to as inflammation and repair.14 The inflammation and repair stages of tissue healing can be altered through the use of thermal agents or electrotherapy. Thermal agents are used to modify the temperature of surrounding tissue and result in a change in the amount of blood flow to the injured area. In addition to vascular changes, temperature changes also have an effect on the metabolism of the surrounding tissue, as well as altering the neuromuscular and connective tissue. Through the use of therapeutic changes in temperature, the healing process can be accelerated and the injured tissue restored to optimal strength and integrity.
### Table 9-2. Summary of Common Physical Agents Used in Physical Therapy

<table>
<thead>
<tr>
<th>Physical Agents</th>
<th>Physiological Effects</th>
<th>Clinical Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Superficial Heat</strong></td>
<td>Hot packs</td>
<td>Increases blood flow</td>
</tr>
<tr>
<td></td>
<td>Infrared</td>
<td>Increases metabolism: promotes healing and removal of waste products</td>
</tr>
<tr>
<td></td>
<td>Paraffin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fluidotherapy</td>
<td>Decreases pain</td>
</tr>
<tr>
<td></td>
<td>Whirlpool</td>
<td>Decreases stiffness</td>
</tr>
<tr>
<td><strong>Deep Heat</strong></td>
<td>Ultrasound</td>
<td>Increases blood flow</td>
</tr>
<tr>
<td></td>
<td>Short-wave diathermy</td>
<td>Increases metabolism: promotes healing and removal of waste products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreases pain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreases stiffness</td>
</tr>
<tr>
<td><strong>Cold</strong></td>
<td>Ice packs</td>
<td>Decreases blood flow</td>
</tr>
<tr>
<td></td>
<td>Ice massage</td>
<td>Decreases metabolism</td>
</tr>
<tr>
<td></td>
<td>Cold whirlpool</td>
<td>Decreases edema</td>
</tr>
<tr>
<td></td>
<td>Cold compression</td>
<td>Decreases pain</td>
</tr>
<tr>
<td><strong>Electrical Simulation</strong></td>
<td>Transcutaneous Electrical Nerve Stimulation (TENS)</td>
<td>Decreases pain</td>
</tr>
<tr>
<td></td>
<td>Iontophoresis</td>
<td>Decreases edema</td>
</tr>
<tr>
<td></td>
<td>Electrical Stimulation for Tissue Repair (ESTR)</td>
<td>Promotes wound healing</td>
</tr>
<tr>
<td></td>
<td>Neuromuscular Electrical Stimulation (NMES)</td>
<td>Muscle reeducation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Decreases spasticity</td>
</tr>
</tbody>
</table>
The extent of therapeutic changes caused by a change in tissue temperature depends on the intensity of the thermal agent applied, the length of time the tissue is exposed to the agent, and characteristics of the tissue being treated. The therapist must continually monitor and re-evaluate the patient to ensure that the thermal agent selected is appropriate and that the treatment goals are being achieved.

Thermal agents can be classified as those that provide superficial heat, deep heat, or cold. Superficial heat modalities create an increase in the blood flow to cutaneous tissues close to the surface, thereby reducing pain, reducing muscle spasm, allowing for increased motion, and promoting healing. Examples of superficial heat agents include: hot packs, infrared, paraffin, fluidotherapy, and whirlpools.

Hot packs are pouches of various shapes that are filled with silica gel and soaked in thermostatically controlled water (Fig. 9-9). Hot packs are applied to the affected body part with layers of towels to prevent overheating (See Fig. 2-10 in Chapter 2). Similar to a heat lamp, infrared uses infrared radiation to warm the superficial tissue and create a general feeling of relaxation and pain relief. Paraffin treatment involves dipping a patient's involved body part (usually hands or feet) into a mixture of melted paraffin wax and mineral oil that is maintained at a temperature of approximately 135° F. The heat from the paraffin produces the relaxing and pain-reducing effects of other superficial heat treatments, and also leaves the skin feeling warm and soft, allowing for greater comfort when performing range-of-motion exercises. Fluidotherapy is the use of a self-contained unit filled with finely-chopped corn cobs into a sawdust-type substance. The particles are heated to the desired temperature and circulated by air pressure around
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the involved body part. In addition to receiving the effects of heating, the patient is also able to exercise while the treatment is in progress. Whirlpools make use of the therapeutic effects of water by immersing the body part or entire body into a tank of water. Use of this physical agent is known as hydrotherapy. A variety of sizes of tanks are available, ranging from a small tank for distal extremities (Fig. 9-10) to a full-body tank known as a Hubbard Tank. In addition to its heating effects, hydrotherapy has the added advantage of assisting with wound healing.

![Fig. 9-10. Small whirlpool to administer hydrotherapy to a lower limb segment (Photo credit: Dewey Neild).](image)

Deep heat modalities produce physiological effects similar to superficial heat agents, but the depth of tissues affected is deeper. Therefore, patients with deep muscle or joint dysfunctions may receive more therapeutic benefits from the application of deep heat than a superficial heating agent. Deep heat modalities include ultrasound and short wave diathermy. Ultrasound is the therapeutic application of high frequency sound waves that penetrate through tissue and cause an increase in the tissue temperature to promote healing and reduce pain (Fig. 9-11). Similar results are achieved with short-wave diathermy, although diathermy uses electromagnetic energy to produce deep therapeutic heating effects.
Fig. 9-11. Application of ultrasound to produce deep heat in the shoulder region (Photo credit: Dewey Neild).

In contrast to heating agents, therapeutic cold (cryotherapy) may be applied. Temperature differences with the application of cold agents cause a decrease in blood flow and decreased metabolism, which result in a decrease in swelling and diminished pain. Cold is the physical agent of choice in patients with acute injuries who present with clinical symptoms of swelling and/or pain (See Fig. 2-11 in Chapter 2). Cold may also be incorporated into a treatment protocol after exercises to help reduce post-exercise soreness. Cryotherapy may take the form of commercial cold packs, ice massage, cold whirlpool, or cold used in conjunction with compression.

Electrical stimulation. Physical therapists and physical therapist assistants who use physical agents as part of their treatment plans may also use electrical stimulation to achieve therapeutic results. With the use of electrical stimulation units, electrodes are placed on the skin at specified locations to stimulate nerves, muscles, and other soft tissues in attempts to reduce pain and swelling, increase strength and range of motion, and facilitate wound healing (Fig. 9-12). The use of electricity to generate therapeutic benefits is not new, but the numerous electrotherapy devices on the market can make the selection of the appropriate device confusing. The therapist must have a clear understanding of the desired effects from the electrical stimulation intervention, and have knowledge of the appropriate parameters to use with regard to treatment intensity, voltage, and current type. Common physical agents used in electrotherapy are listed in Table 9-2.
Fig. 9-12. Use of transcutaneous electrical nerve stimulation (TENS) for treatment of pain in the low back region. (Photo credit: Dewey Neild).

Other physical agents. Additional physical agents that may be used in the treatment of orthopaedic patients include: mechanical traction, hyperbaric oxygen, biofeedback, laser, and ultraviolet. These modalities achieve therapeutic benefits through mechanisms different than thermal or electrical, but may also be used to decrease a patient’s pain or improve strength or motion in an attempt to maximize function.

Manual techniques

Physical therapists working with orthopaedic patients always have two tools at their ready disposal—their hands. Perhaps in no other patient population is touch so important as it is in the orthopaedic population. Whether palpating a structure during an evaluation, providing manual force for a patient to resist against when exercising, or performing a mobilization to increase range of motion, a therapist’s hands are an important therapeutic instrument. A variety of manual techniques are currently being used by orthopaedic physical therapists, and many of these techniques are the subject of clinical research in order to validate and clarify their purpose and clinical efficacy.

For the purpose of this text, manual techniques will be divided into two categories: soft tissue mobilization and joint mobilization. It is beyond the scope of this text to cover specific procedures and the schools of thought behind the various techniques. The reader
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is again referred to the reading list at the end of this chapter for further information regarding this topic.

**Soft Tissue Mobilization.** Soft tissue mobilizations include a variety of “hands-on” techniques designed to improve movement and function. The techniques are designed to decrease pain or swelling and relax muscle or fascia tension in order to create proper postural alignment and optimal muscle function.

Two common forms of soft tissue mobilization are massage and myofascial release. Massage involves the systematic use of various manual strokes designed to produce certain physiological, mechanical, and psychological effects. To achieve relaxation, Swedish massage strokes are used to help decrease pain or swelling, relieve tension, and improve the metabolism of surrounding tissue. More vigorous massage strokes may also be used prior to physical activity to stimulate and prepare the muscles for exertion. Another specific stroke known as transverse friction massage is useful in improving the flexibility and function of soft tissues such as muscles, ligaments, and tendons.

Myofascial release involves manual stretching of the layers of the body’s fascia, which is connective tissue that surrounds muscle and other soft tissues in the body (See Fig. 2-8 in Chapter 2). Myofascial release techniques are thought to soften and loosen restrictions in the muscles and fascia that are limiting normal movement. These techniques are unique in that the stretching force applied by the therapist depends on the response of the patient’s tissues to the stretch. The therapist must be able to “feel” facial tension diminish as a stretch is applied and adjust the amount of stretch to the patient’s comfort.

**Joint Mobilization.** In contrast to soft tissue mobilizations which focus on stretching or relaxing soft tissue, joint mobilization techniques are used when a patient’s dysfunction is the result of joint stiffness or hypomobility (loss of motion). Based on knowledge of the anatomy of joint surfaces and the findings from joint evaluation, the therapist applies specific passive movements to a joint, either oscillatory (rapid, repeated movements) or sustained. Joint mobilization techniques are intended to reduce the pain and stiffness affecting movement and restore normal joint motion.

**Therapeutic Exercise**

Therapeutic exercise has been and continues to be the foundation of a rehabilitation program. This foundation is based on scientific principles and the knowledge that the human body has the ability to react and respond to physical stresses placed upon it. In particular, the muscular and cardiovascular systems are adaptable depending on the stresses and forces placed on them. When these systems are stressed with a program of progressive exercise, positive changes will occur such as improvements in strength and endurance. Likewise, the effects of abnormal stresses, such as prolonged bed rest, can lead to detrimental changes including osteoporosis and muscle atrophy.
The goals of therapeutic exercise are not only to facilitate and restore normal function in an individual, but also to prevent an initial injury, educate the patient on how to prevent reoccurrence of an injury, and help maintain normal function. These goals are based on the results of the patient's evaluation and assessment of needs.

The level of sophistication of an exercise program should not be determined by the type of equipment the clinic may have. Some of the most sophisticated exercises can be performed with very inexpensive equipment. With creativity, many pieces of equipment can be adapted to incorporate many of the goals of therapeutic exercise. This section will describe a variety of therapeutic exercise techniques that may be used with a patient who has an orthopaedic dysfunction. These include exercises to improve range of motion, strength, flexibility, balance and coordination, cardiovascular endurance, and function.

Range-of-Motion Exercise. As mentioned earlier in the chapter, range-of-motion exercises can be categorized into two types: PROM and AROM. Passive range of motion may be provided manually by the therapist, or mechanically by a machine. This type of exercise might be used with (but not limited to) patients who are restricted to bed rest, who have paralysis of one or more limbs, or are in a coma. It may also be used when AROM is contraindicated. Active range of motion can be subdivided into active-assisted movement, active-free movement, and active-resisted movement. When performing active-assisted ROM, the patient may be assisted either manually or mechanically if the prime muscle mover is weak (Fig. 9-13A). Pendulum exercises are an example of active-free ROM, in which the patient does not receive any support or resistance (Fig. 9-13B). In active-resisted exercises, an external force resists the movement. The last category includes a variety of techniques, several of which are described in the next section.

Resisted Exercise. Resisted exercise is a form of active movement in which some form of resistance is provided. The goals of a resisted exercise program are to increase muscular strength and endurance. Muscular strength refers to the maximal amount of tension an individual can produce in one repetition. Muscle endurance refers to the ability to produce and sustain tension over a prolonged period of time. If the goal is to increase strength, then the program would concentrate on low repetitions using heavy resistance. If the goal is to increase endurance, then the exercise program would concentrate on using low resistance for high repetitions. The type of exercise performed depends on the types of activities to which the patient is planning to return. When designing a program, the therapist must also consider the type(s) of resisted exercise on which the patient should concentrate. Resisted exercise can be categorized into three types: isometric, isotonic, and isokinetic. Definitions and examples of these types are outlined in Table 9-3. Typically, a combination of all three types of exercise is necessary to perform any type of functional activity.
Fig. 9-13. Range-of-motion exercises are used to maintain/improve joint motion. A. A cane can be used to conduct simple active-assistive range-of-motion exercises for the shoulder. B. Pendulum exercises are effective active-free exercises and require no special equipment. (Photo credits: Devey Neild).
In resisted exercise, resistance can be applied either manually by the therapist, or mechanically by the use of equipment. Manual resistance can be applied to isolated muscle groups (as is the case with manual muscle testing positions), or can be applied in patterns of movement using several muscle groups. An example of the latter is a technique called proprioceptive neuromuscular facilitation (PNF) described in Chapter 8. The use of manual resistance offers many advantages. The primary advantage is that it gives the therapist the ability to control the amount of resistance provided. This is particularly useful when working with patients who are in the early stages of rehabilitation where ROM may need to be limited and/or the patient is only able to tolerate mild to moderate resistance. The disadvantage is that it is very difficult to quantify the amount of resistance provided, and also difficult for another therapist to replicate the same amount of resistance on that patient.

There are many pieces of equipment that can be used when applying mechanical resistance. These can vary from an inexpensive strip of elastic tubing (Fig. 9-14A) to very costly and highly technological isokinetic equipment (Fig. 9-14B). Other common and frequently used equipment in the clinic includes free weights. (Fig. 9-14C) nautilus machines, and pulley systems.
Fig. 9.14. Different methods of using mechanical resistance for exercise. A. Elastic tubing is inexpensive and easy to use. B. Isokinetic equipment is generally very expensive and sophisticated. (Photo credits: Dewey Neild).
Fig. 9-14. Different methods of using mechanical resistance for exercise. C. Free weights are readily available to produce mechanical resistance. (Photo credits: Dewey Neild).

Flexibility Exercise. Patients recovering from a musculoskeletal injury frequently have decreased flexibility in the muscles crossing the involved joint. Conditions that may produce decreased flexibility include prolonged immobilization and tissue trauma. Many times, previous decreased flexibility may have contributed to or have been the primary cause of the injury. Therefore, flexibility is a very important component to address with the patient.

Soft tissue, such as muscle, has the ability to change length or adapt over time with stress. While there are a variety of techniques that can be used to increase flexibility, the research in this area indicates that there is no consensus on the most effective way to stretch. Further, a stretching technique that works well for one patient may be ineffective in another.

Stretching techniques can be performed passively with an external force applied either manually or mechanically. Stretching can also be performed by actively inhibiting the shortened muscle. This technique, called contract-relax, requires the shortened muscle to actively contract prior to applying a stretching force.4

Balance and Coordination Exercise. Proprioception is a term used to describe one’s awareness of position and movement. The body is made aware of proprioception through the various receptors found in the skin and joints. These proprioceptors respond to stimuli such as pressure, stretch, and position. Following injury, particularly
to the knee and ankle, there may be loss of proprioception, and therefore a loss in balance and/or coordination. Unfortunately, there are not many well documented tests to evaluate balance in patients with orthopaedic dysfunctions. This makes it difficult to monitor changes in balance in a rehabilitation program. However, there are numerous exercises and equipment that can be used to facilitate proper balance. One popular piece of equipment seen in the clinic is a balance board (Fig. 9-15). The patient progresses from a sitting to a standing position while shifting weight from side to side and front to back. This can also be progressed from two-legged weight shift to one-legged weight shift (balancing on one leg). The exercise can be made more challenging by having the patients close their eyes and incorporating upper extremity movement with and without weights.

![Fig. 9-15. A balance board can be used for balance exercises (Photo credit: Dewey Neild).](image)

**Cardiovascular Endurance Training.** Cardiovascular or aerobics training refers to exercise performed over a long period of time at low intensity. Aerobic exercise typically involves large muscle groups which are used in a rhythmic type of activity. There are many modes of exercise available to improve cardiovascular endurance. These include walking, running, stair climbing, cycling, cross-country skiing, and swimming. The physical therapist will choose the exercise modality that is most appropriate for the patient. For example, a patient who is recovering from a low back injury and has difficulty sitting may participate in a walking program rather than a cycling program. See Chapter 10 for a more detailed description of cardiovascular exercise.
Functional Exercises. As mentioned earlier in this chapter, the ultimate goal in physical therapy is to allow the patient to return to the prior level of function or highest level of function achievable. It is therefore imperative that exercises that mimic functional movements and activities be incorporated into the rehabilitation program. Functional movements incorporate strength, flexibility, balance and coordination. Incorporating all these factors allows patients to return to function with confidence, knowing that they performed the same or very similar exercises in the clinic.

The use of closed chain or kinetic chain exercises allows the patient to incorporate these functional movements. Closed chain exercise or kinetic chain exercise are those exercises in which movement at one joint affects the movement at other joints (e.g., a two-legged squat). Open chain exercises or joint isolation exercises are those exercises in which the end limb segment is free (e.g., biceps curl). Many of the exercises traditionally used to strengthen the lower extremity are those where the foot is off the ground. An example would be the use of isokinetic equipment for thigh strengthening. However, the lower extremity typically functions with the foot on the ground. Closed chain exercises are particularly important in the rehabilitation of the lower extremity. Therefore, exercises involving the movement of joints while the foot is on the ground facilitates proper proprioceptive feedback which mimics function (Fig. 9-16).

Fig. 9-16. Functional exercises, such as descending a step, are designed to mimic daily activities (Photo credit: Dewey Neild).
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Home Exercise Programs

The use of therapeutic exercise in a rehabilitation program is an important and essential activity. Aside from the physical benefits derived from exercise, it also allows the patient to assume responsibility for the care of the injury and encourages active participation in the rehabilitative process. For the same reasons, home exercise programs also become a very important aspect of patient care. Treatment in the clinic two to three times per week is usually not enough time to see the desired long-lasting effects of rehabilitation, unless the patient is performing appropriate exercises, given by the physical therapist, at home. The inability of a patient to pay for physical therapy services (often due to the lack of health care insurance coverage) may also limit the number of clinic visits, making home programs even more appropriate.

Patient Education

As mentioned earlier in the chapter, communication is a critical component of the orthopaedic physical therapy experience. The therapist’s depth of knowledge, effectiveness with performing and interpreting the evaluation, and the variety of treatment options available are of little value if the therapist does not share this information with patients and inform them of their role in the rehabilitation process. The patient and therapist must work together as a team, focusing on the same goals and sharing information in order to achieve optimal results.

It is the responsibility of the physical therapist and physical therapist assistant to educate the patient about exercises to perform at home, postures or positions to avoid during daily activities at work or home, and strategies to prevent dysfunctions from recurring (Fig. 9-17). In order to effectively communicate, the therapist must create a treatment atmosphere that ensures the patient’s comfort and must also provide the necessary information in a clear manner that is easily understood.

It is important for the physical therapist and physical therapist assistant, when working with a patient, to treat the whole person rather than just an injured joint. Each patient comes to the therapist with a different set of values, expectations, and background. All of these factors must be considered in order to successfully and effectively treat a patient.