Aquatic Exercise

CHAPTER 9

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The use of water for healing purposes dates back several centuries. Near the end of the 19th century in Europe, and soon after in the United States, the use of an aquatic environment to facilitate exercise began to grow in popularity. In recent years, health care practitioners have increasingly utilized the aquatic medium to facilitate therapeutic exercises. The unique properties of the aquatic environment provide clinicians with treatment options that would otherwise be difficult or impossible to implement on land. Through the use of buoyant devices and varied depths of immersion the practitioner may position the patient supine, seated, kneeling, prone, side-lying, or vertically with any desired amount of weight bearing. Aquatic exercise has been successfully used for a wide variety of rehabilitation populations including pediatric, orthopedic, neurological, and cardiopulmonary patients.

BACKGROUND AND PRINCIPLES FOR AQUATIC EXERCISE

Definition of Aquatic Exercise

Aquatic exercise refers to the use of multidepth immersion pools or tanks that facilitate the application of various established therapeutic interventions, including stretching, strengthening, joint mobilization, balance and gait training, and endurance training.

Goals and Indications for Aquatic Exercise

The specific purpose of aquatic exercise is to facilitate functional recovery by providing an environment that augments a patient's and/or practitioner's ability to perform various therapeutic interventions. The specific goals include:

- Facilitate range of motion (ROM) exercise*
- Initiate resistance training[6,18,28,36,38,40,52]
- Facilitate weight-bearing activities[38,39]
- Enhance delivery of manual techniques[4,5,54]
- Provide three-dimensional access to the patient[5,51,54]
- Facilitate cardiovascular exercise†
- Initiate functional activity replication‡
- Minimize risk of injury or reinjury during rehabilitation[4,18,60,61]
- Enhance patient relaxation[4,41,42]

Precautions and Contraindications to Aquatic Exercise

Although most patients easily tolerate aquatic exercise, the practitioner must consider several physiological and psychological aspects of immersion that affect selection of an aquatic environment.

Precautions

Fear of Water

Fear of water can limit the effectiveness of any immersed activity. Fearful patients often experience increased symptoms during and after immersion because of muscle guarding, stress response, and improper form with exercise.[19,20] Often patients require an orientation period designed to provide instruction regarding the effects of immersion on balance, control of the immersed body, and proper use of flotation devices.[51]

Neurological Disorders

Ataxic patients may experience increased difficulty controlling purposeful movements.[51] Patients with heat-intolerant multiple sclerosis may fatigue with immersion in temperatures greater than 33°C.[51]

Seizures

Patients with controlled epilepsy require close monitoring during immersed treatment and must be compliant with medication prior to treatment.[51]

Cardiac Dysfunction

Patients with angina and abnormal blood pressure also require close monitoring. For patients with cardiac disease, low-intensity aquatic exercise may result in lower cardiac demand than similar land exercise.[35,44,47]

Small Open Wounds and Lines

Small, open wounds and tracheotomies may be covered by waterproof dressings. Patients with intravenous lines, Hickman lines, and other open lines require proper clamping and fixation.[51]

Contraindications

- Incipient cardiac failure and unstable angina.
- Respiratory dysfunction; vital capacity of less than 1 liter.
- Severe peripheral vascular disease.
- Danger of bleeding or hemorrhage.
- Severe kidney disease: Patients are unable to adjust to fluid loss during immersion.
- Open wounds, colostomy, and skin infections such as tinea pedis and ringworm.
- Uncontrolled bowel or bladder: Bowel accidents require pool evacuation, chemical treatment, and possibly drainage.
- Water and airborne infections or diseases: Examples include influenza, gastrointestinal infections, typhoid, cholera, and poliomyelitis.
- Uncontrolled seizures: They create a safety issue for both clinician and patient if immediate removal from the pool is necessary.

Properties of Water

The unique properties of water and immersion have profound physiological implications in the delivery of therapeutic exercise. To utilize aquatics efficiently, practitioners must have a basic understanding of the clinical significance of the static and dynamic properties of water as they affect human immersion and exercise.

Physical Properties of Water

The properties provided by buoyancy,[4,8,19,37,51] hydrostatic pressure,[2,4,8,9,51] viscosity,[4,8,51] and surface tension[4,8,51] have a direct effect on the body in the aquatic environment.

Buoyancy (Fig. 9.1)

Definition. Buoyancy is the upward force that works opposite to gravity.

Properties. Archimedes' principle states that an immersed body experiences upward thrust equal to the volume of liquid displaced.

* See references 6, 18, 19, 28, 30, 32, 36, 38, 39, 40, 59.
† See references 3, 10, 12, 13, 15, 21, 23, 33, 45, 47, 48, 50–52, 58, 60.
‡ See references 6, 8, 19, 28, 30, 40, 51, 56, 59, 62, 63.

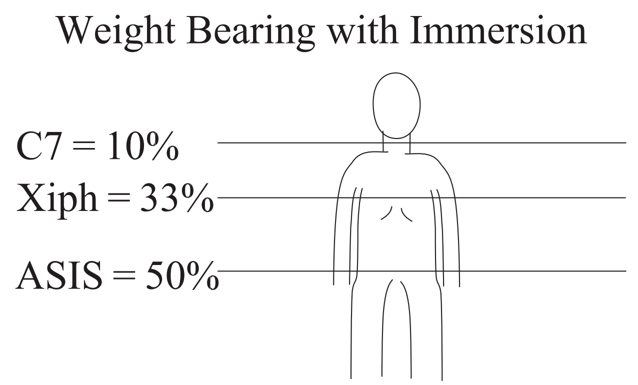

FIGURE 9.1 Percentage of weight bearing at various immersion depths.

Clinical Significance

- Buoyancy provides the patient with relative weightlessness and joint unloading, allowing performance of active motion with increased ease.
- Buoyancy allows the practitioner three-dimensional access to the patient.

Hydrostatic Pressure

Definition. Hydrostatic pressure is the pressure exerted on immersed objects.

Properties

- Pascal's law states that the pressure exerted by fluid on an immersed object is equal on all surfaces of the object.
- As the density of water and depth of immersion increase, so does hydrostatic pressure.

Clinical Significance

- Increased pressure reduces or limits effusion, assists venous return, induces bradycardia, and centralizes peripheral blood flow.
- The proportionality of depth and pressure allows patients to perform exercise more easily when closer to the surface.

Viscosity

Definition. Viscosity is friction occurring between molecules of liquid resulting in resistance to flow.

Properties. Resistance from viscosity is proportional to the velocity of movement through liquid.

Clinical Significance

- Water's viscosity creates resistance with all active movements.
- A shorter lever arm results in increased resistance. During manual resistance exercises stabilizing an extremity proximally require the patient to perform more work. Stabilizing an extremity distally requires the patient to perform less work.
- Increasing the surface area moving through water increases resistance.

Surface Tension

Definition. The surface of a fluid acts as a membrane under tension. Surface tension is measured as force per unit length.

Properties

- The attraction of surface molecules is parallel to the surface.
- The resistive force of surface tension changes proportionally to the size of the object moving through the fluid surface.

Clinical Significance

- An extremity that moves through the surface performs more work than if kept under water.
- Using equipment at the surface of the water increases the resistance.

Hydromechanics

Definition. Hydromechanics comprise the physical properties and characteristics of fluid in motion.[4,8,51]

Components of Flow Motion

- *Laminar flow.* Movement where all molecules move parallel to each other, typically slow movement.
- *Turbulent flow.* Movement where molecules do not move parallel to each other, typically faster movements.
- *Drag.* The cumulative effects of turbulence and fluid viscosity acting on an object in motion.

Clinical Significance of Drag

- As the speed of movement through water increases, resistance to motion increases.
- Moving water past the patient requires the patient to work harder to maintain his/her position in pool.
- Application of equipment (glove/paddle/boot) increases drag and resistance as the patient moves the extremity through water.

Thermodynamics

Water temperature has an effect on the body and, therefore, performance in an aquatic environment.[4,7,8,51]

Specific Heat

Definition. Specific heat is the amount of heat (calories) required to raise the temperature of 1 gram of substance by 1°C.

Properties. The rate of temperature change is dependent on the mass and the specific heat of the object.

Clinical Significance

- Water retains heat 1000 times more than air.
- Differences in temperature between an immersed object and water equilibrate with minimal change in the temperature of the water.

Temperature Transfer

- Water conducts temperature 25 times faster than air.
- Heat transfer increases with velocity. A patient moving through the water loses body temperature faster than an immersed patient at rest.

Center of Buoyancy (Fig. 9.2)

Center of buoyancy, rather than center of gravity, affects the body in an aquatic environment.[4,8,51]

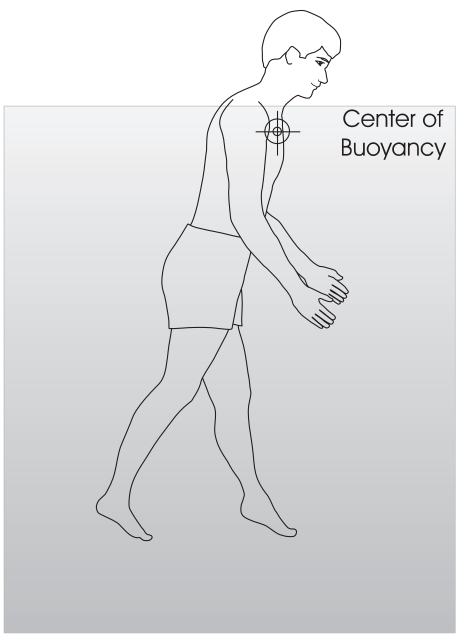

FIGURE 9.2 Center of buoyancy.

Definition. The center of buoyancy is the reference point of an immersed object on which buoyant (vertical) forces of fluid predictably act.

Properties. Vertical forces that do not intersect the center of buoyancy create rotational motion.

Clinical Significance

- In the vertical position, the human center is located at the sternum.
- In the vertical position, posteriorly placed buoyancy devices cause the patient to lean forward; anterior buoyancy causes the patient to lean back.
- During unilateral manual resistance exercises the patient revolves around the practitioner in a circular motion.
- A patient with a unilateral lower extremity amputation leans toward the residual limb side when in a vertical position.
- Patients bearing weight on the floor of the pool (i.e., sitting, kneeling, standing) experience aspects of both the center of buoyancy and center of gravity.

Aquatic Temperature and Therapeutic Exercise

A patient's impairments and the intervention goals determine the water temperature selection. In general, utilize cooler temperatures for higher-intensity exercise and utilize warmer temperatures for mobility and flexibility exercise and for muscle relaxation.[4,7,14,51] The ambient air temperature should be 3°C higher than the water temperature for patient comfort. Incorrect water or ambient air temperature selection may adversely affect a patient's ability to tolerate or maintain immersed exercise.*

Temperature Regulation

- Temperature regulation during immersed exercise differs from that during land exercise because of alterations in temperature conduction and the body's ability to dissipate heat.[4,8,19,37,51] With immersion there is less skin exposed to air, resulting in less opportunity to dissipate heat through normal sweating mechanisms.
- Water conducts temperature 25 times faster than air[11]—more if the patient is moving through the water and molecules are forced past the patient.
- Patients perceive small changes in water temperature more profoundly than small changes in air temperature.
- Over time, water temperature may penetrate to deeper tissues. Internal temperature changes are known to be inversely proportional to subcutaneous fat thickness.[11]
- Patients are unable to maintain adequate core warmth during immersed exercise at temperatures less than 25°C.[11]
- Conversely, exercise at temperatures greater than 37°C may be harmful if prolonged or maintained at high intensities. Hot water immersion may increase the cardiovascular demands at rest and with exercise.[53]
- In waist-deep water exercise at 37°C, the thermal stimulus to increase the heart rate overcomes the centralization of peripheral blood flow due to hydrostatic pressure.
- At temperatures greater than or equal to 37°C, cardiac output increases significantly at rest alone.[7,16]

Mobility and Functional Control Exercise

- Aquatic exercises, including flexibility, strengthening, gait training, and relaxation, may be performed in temperatures between 26°C and 33°C.[4,8,51]

* See references 3, 11, 16, 19, 22, 27, 28, 37, 54, 56.

- Therapeutic exercise performed in warm water (33°C) may be beneficial for patients with acute painful musculoskeletal injuries because of the effects of relaxation, elevated pain threshold, and decreased muscle spasm.[4,8,51]

Aerobic Conditioning

- Cardiovascular training and aerobic exercise should be performed in water temperatures between 26°C and 28°C. This range maximizes exercise efficiency, increases stroke volume, and decreases heart rate.[3,16,51,60]
- Intense aerobic training performed above 80% of a patient's maximum heart rate should take place in temperatures between 22°C and 26°C to minimize the risk of heat illness.[3,16,51,60]

Special Equipment for Aquatic Exercise

A large variety of equipment exists for use with aquatic exercise. Aquatic equipment is used to provide buoyant support to the body or an extremity, challenge or assist balance, and generate resistance to movement. By adding or removing equipment, the practitioner can progress exercise intensity.

Collars, Rings, Belts, and Vests

Equipment designed to assist with patient positioning by providing buoyancy assistance can be applied to the neck, extremities, or trunk. Inflatable cervical collars are used for the supine patient to support the neck and maintain the head out of the water (Fig. 9.3). Flotation rings come in various sizes and are used to support the extremities in any immersed position (Fig. 9.4). Often the rings are used at the wrists and ankles during manual techniques to assist with patient positioning and relaxation. Several types of belt exist that may be used to assist with buoyancy of an extremity or the entire body (Fig. 9.5). Belts and vests are used to position patients supine, prone, or vertically for shallow and deep water activities.

FIGURE 9.3 Cervical collar. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

FIGURE 9.4 Flotation rings. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

FIGURE 9.5 Buoyancy belts. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

Swim Bars

Buoyant dumbbells (swim bars) are available in short and long lengths. They are useful for supporting the upper body or trunk in upright positions and the lower extremities in the supine or prone positions (Fig. 9.6). Patients can balance (seated or standing) on long swim bars in deep water to challenge balance, proprioception, and trunk strength.

FIGURE 9.6 Swim bars. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

Gloves, Hand Paddles, and Hydro-tone® Balls

Resistance to upper extremity movements is achieved by applying webbed gloves or progressively larger paddles to the hands (Fig. 9.7). These devices are not buoyant and, therefore, only resist motion in the direction of movement. Hydro-tone® bells are large, slotted plastic devices that increase drag during upper extremity motions. The bells generate substantially more resistance than gloves or hand paddles.

FIGURE 9.7 Hand paddles. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

Fins and Hydro-tone® Boots

The application of fins or boots to the feet during lower extremity motions generates resistance by increasing the surface area moving through the water. Fins are especially useful for challenging hip, knee, and ankle strength. Hydro-tone® boots are most effective during deep water walking and running (Fig. 9.8).

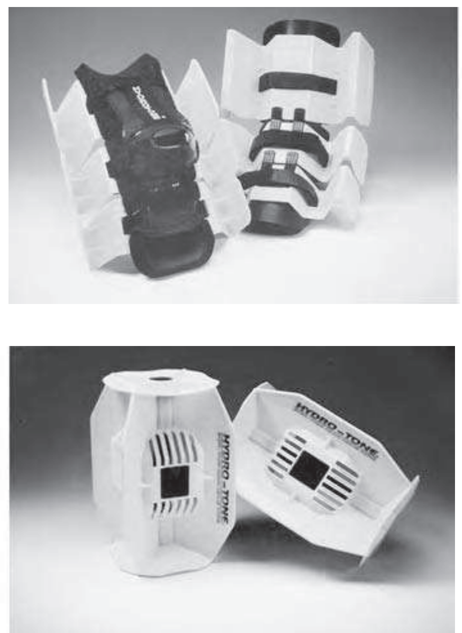

FIGURE 9.8 Hydro-tone boots and bells. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

Kickboards

The shapes and styles of kickboards (Fig. 9.9) vary extensively among manufacturers. Nevertheless, kickboards remain a versatile and effective aquatic tool for augmenting any exercise program. Kickboards may be used to provide buoyancy in the prone or supine positions, create resistance to walking patterns in shallow water when held vertically, or used to challenge seated, kneeling, or standing balance in the deep water.

FIGURE 9.9 Kickboards. *(Courtesy of Rothhammer International Inc., San Luis Obispo, CA.)*

EXERCISE INTERVENTIONS USING AN AQUATIC ENVIRONMENT

Stretching Exercises

Patients may tolerate immersed stretching exercises better than land stretching because of the effects of relaxation, soft tissue warming, and ease of positioning. However, buoyancy creates an inherently less stable environment than the land. Therefore, careful consideration is warranted when recommending aquatic stretching.

Manual Stretching Techniques

Manual stretching is typically performed with the patient supine in waist depth water with buoyancy devices at the neck, waist, and feet. Alternatively, the patient may be seated on steps. The buoyancy-supported supine position improves (versus land techniques) both access to the patient and control by the practitioner, as well as the position of the patient.

However, turbulence from wave activity can adversely affect both the patient and practitioner's ability to perform manual stretching. Difficulties may be experienced maintaining and perceiving the subtleties of end-range stretching and scapular stabilization in the supine buoyancy supported position. Anecdotal evidence indicates that careful consideration of all factors is warranted prior to initiating manual stretching in an aquatic environment.[5,54]

The manual stretching techniques described in this section are considered passive techniques but may be adapted to utilize muscle inhibition techniques. The principles of stretching are the same as those discussed in Chapter 4.

The following terms are used to describe the stretching techniques.

- ***Practitioner position.*** Describes the orientation of the practitioner to the patient.
- ***Patient position.*** Includes buoyancy-assisted (BA) seated or upright positioning and buoyancy-supported (BS) supine positioning.
- ***Hand placement.*** The fixed hand, which stabilizes the patient, is typically the same (ipsilateral) hand as the patient's affected extremity, and it is positioned proximally on the affected extremity. The movement hand, which guides the patient's extremity through the desired motion and applies the stretch force, is typically the opposite (contralateral) hand as the patient's affected extremity and is positioned distally.
- ***Direction of movement***. Describes the motion of the movement hand.

Cervical Spine: Flexion

Practitioner Position
Stand at the patient's head facing caudalward.

Patient Position
BS supine without cervical collar.

Hand Placement
Cup the patient's head with your hands, the forearms supinated and thumbs placed laterally. Alternatively, place your hands in a pronated position with the thumbs at the occiput. This results in a more neutral wrist position at end-range stretch.

Direction of Movement
As you flex the cervical spine, the patient has a tendency to drift away from you if care is not taken to perform the motion slowly.

Cervical Spine: Lateral Flexion (Fig. 9.10)

Practitioner Position
Stand at the side facing the patient.

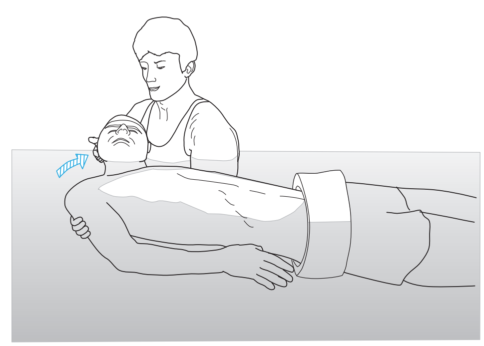

FIGURE 9.10 Hand placement and stabilization for stretching to increase cervical lateral flexion.

Patient Position
BS supine without a cervical collar.

Hand Placement
Reach the fixed hand dorsally under the patient and grasp the contralateral arm; support the head with the movement hand.

Direction of Movement
Move the patient into lateral flexion and apply stretch force at desired intensity. This position prevents patient drift as the fixed hand stabilizes the patient against the practitioner.

Thoracic and Lumbar Spine: Lateral Flexion/Side Bending (Fig. 9.11)

Practitioner Position
Stand on the side opposite that to be stretched, facing cephalad with ipsilateral hips in contact (e.g., if stretching the left side of the trunk, the therapist's right hip is against patient's right hip).

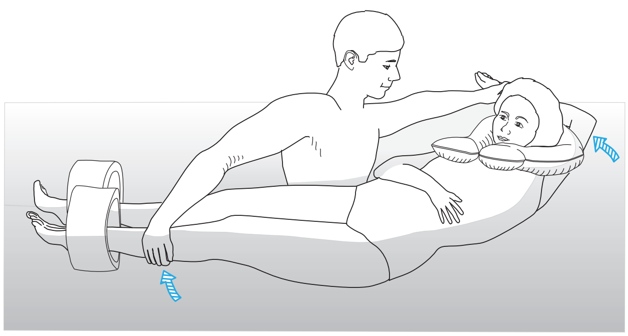

FIGURE 9.11 Hand placement and stabilization for stretching to increase lateral trunk flexion.

Patient Position
BS supine, if tolerated. The patient's stretch side arm is abducted to end range to facilitate stretch.

Hand Placement
Grasp the patient's abducted arm with the fixed hand; alternately, grasp at the deltoid if patient's arm is not abducted. The movement hand is at the lateral aspect of the lower extremity of the side to be stretched (more distal placement improves leverage with stretch).

Direction of Movement
With the patient stabilized by your hip, pull the patient into lateral flexion. This technique allows variability in positioning and hand placement to isolate distinct segments of the spine.

Shoulder Flexion (Fig. 9.12)

Practitioner Position
Stand on the side to be stretched facing cephalad.

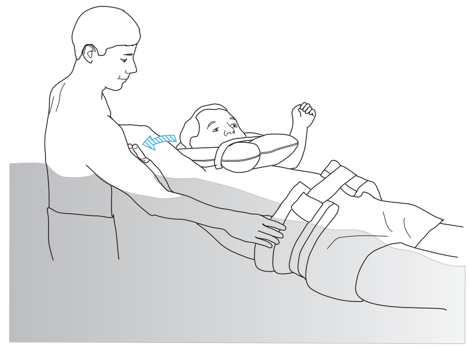

FIGURE 9.12 Hand placement and stabilization for stretching to increase shoulder flexion.

Patient Position
BS supine with the affected shoulder positioned in slight abduction.

Hand Placement
Grasp the buoyancy belt with the fixed hand; the movement hand is at the elbow of the affected extremity.

Direction of Movement
After positioning the arm in the desired degree of abduction, direct the arm into flexion and apply the stretch force with the movement hand.

Shoulder Abduction

Practitioner Position
Stand on the affected side facing cephalad with your hip in contact with the patient's hip.

Patient Position
BS supine.

Hand Placement
Stabilize the scapula with the fixed hand; the movement hand grasps medially on the affected elbow joint.

Direction of Movement
Guide the arm into abduction and apply the stretch force. The hip contact provides additional stabilization as the stretch force is applied.

Shoulder External Rotation

Practitioner Position
Stand lateral to the affected extremity facing cephalad.

Patient Position
BS supine; position arm in desired degree of abduction with elbow flexed to 90°.

Hand Placement
Grasp the medial side of the patient's elbow with the palmar aspect of the fixed hand while fingers hold laterally; grasp the midforearm with the movement hand.

Direction of Movement
Movement hand guides forearm dorsally to externally rotate the shoulder and apply stretch force.

Shoulder Internal Rotation

Practitioner Position
Stand lateral to the patient's affected extremity facing caudalward.

Patient Position
BS supine; position arm in desired degree of abduction with elbow flexed to 90°.

Hand Placement
Stabilize the scapula with the dorsal aspect of the fixed hand entering from the axilla; the movement hand is at the distal forearm.

Direction of Movement
Direct the forearm palmarward and apply the stretch force. Use care to observe the glenohumeral joint to avoid a forward thrust and substitution.

Hip Extension

Practitioner Position
Kneel on one knee at the patient's affected side.

Patient Position
BS supine with the hip extended and the knee slightly flexed.

Hand Placement
Stabilize the patient's affected extremity by hooking the top of the foot with your ipsilateral thigh. Grasp the buoyancy belt with the movement hand and guide the motion with the fixed hand on the knee.

Direction of Movement
Direct the patient caudally with the movement hand. To increase the stretch on the rectus femoris, lower the patient's knee in the water. Motion is performed slowly to limit spinal and pelvic substitution.

Hip External Rotation

Practitioner Position
Face the lateral aspect of the patient's thigh with your ipsilateral arm under the patient's flexed knee.

Patient Position
BS supine; hip flexed 70° and knee flexed 90°.

Hand Placement
Grasp the buoyancy belt with the contralateral (fixed) hand while the ipsilateral (movement) hand grasps the thigh.

Direction of Movement
Externally rotate hip with the movement hand as the patient's body lags through water to create stretch force.

Hip Internal Rotation

Practitioner Position
Face the lateral aspect of the involved thigh with the ipsilateral arm under the flexed knee.

Patient Position
BS supine, hip flexed 70° and knee flexed 90°.

Hand Placement
Stabilize the buoyancy belt with the contralateral (fixed) hand while grasping the thigh with the ipsilateral (movement) hand.

Direction of Movement
Internally rotate the hip as the patient's body lags through water to create the stretch force.

Knee Extension with Patient on Steps

Practitioner Position
Half-kneel lateral to the affected knee with the ankle of the affected extremity resting on your thigh.

Patient Position
Semi-reclined on pool steps.

Hand Placement
Place one hand just proximal and one just distal to the knee joint.

Direction of Movement
Extend the patient's knee.

Knee Flexion with Patient on Steps

Practitioner Position
Half-kneel lateral to the affected knee.

Patient Position
Semi-reclined on pool steps.

Hand Placement
Grasp the distal tibia with the ipsilateral hand; the contralateral hand stabilizes the lateral aspect of affected knee.

Direction of Movement
Apply the stretch force into flexion.

Knee Flexion with Patient Supine (Fig. 9.13)

Practitioner Position
Half-kneel lateral to the affected knee with the dorsal aspect of the patient's foot hooked under the ipsilateral thigh.

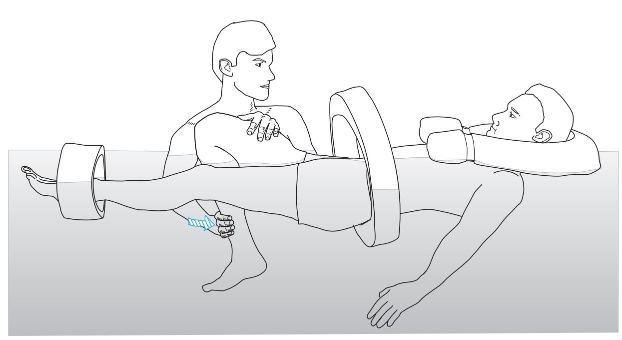

FIGURE 9.13 Hand placement and stabilization for stretching to increase knee flexion.

Patient Position
BS supine, affected knee flexed.

Hand Placement
Place the ipsilateral (fixed) hand on distal tibia and the contralateral (movement) hand on buoyancy belt to pull the body over the fixed foot.

Direction of Movement
Pull the patient's body over the fixed foot, creating the stretch to increase knee flexion. Lower the patient's knee into the water to extend the hip and increase the stretch on the rectus femoris. Perform the motion slowly to limit spinal and pelvic substitution.

Hamstrings Stretch

Practitioner Position
Face the patient and rest the patient's affected extremity on your ipsilateral shoulder.

Patient Position
BS supine, knee extended.

Hand Placement
Place both hands at distal thigh.

Direction of Movement
Start in the squatting position and gradually stand to flex the hip and apply the stretch force. Maintain knee extension by pulling the patient closer and increasing the stretch.

Self-Stretching with Aquatic Equipment

Often the intervention plan is to instruct the patient to perform independent stretching.* Self-stretching can be performed in either waist-depth or deep water. The patient frequently utilizes the edge of the pool for stabilization in both waist-depth and deep water.

Applying buoyancy devices may assist with stretching and increase the intensity of the aquatic stretch.[60] However, buoyancy devices are not required to achieve buoyancy-assisted stretching. That is, as buoyancy acts on any submersed extremity, correct patient positioning adequately produces a gentle stretch. The following guidelines describe the use of equipment for mechanical stretching; the descriptions apply similarly for use without buoyancy equipment. Providing verbal cueing and visual demonstration for patient positioning and form aids in achieving the desired stretching effects.

Positioning for self-stretching of every body part is not described in this section. Typically, positioning for immersed self-stretches reflects traditional land positioning.

The following terms are used to describe the self-stretching techniques.

- ***Patient position***. Includes buoyancy-assisted (seated/upright), buoyancy-supported (supine), or vertical.
- ***Buoyancy-assisted***. Using the natural buoyancy of water to "float" the extremity toward the surface.
- ***Equipment-assisted.*** Includes use of buoyancy devices attached or held distally on an extremity.

The following are some examples of self-stretching.

Shoulder Flexion and Abduction

Patient Position
Upright, neck level immersion.

Equipment
Small or large buoyant dumbbell or wrist strap.

Direction of Movement
Grasping the buoyant device with the affected extremity allows the extremity to float to the surface as the buoyancy device provides a gentle stretch.

Hip Flexion (Fig. 9.14)

Patient Position
Upright, immersed to waist, or seated at edge of pool/on steps with hips immersed.

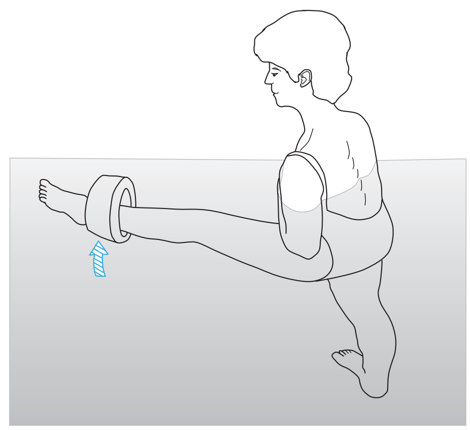

FIGURE 9.14 Self-stretching technique to increase hip flexion (stretch the hamstrings) using aquatic equipment.

Equipment
Small buoyant dumbbell or ankle strap. For hip flexion with knee flexion, place strap/dumbbell proximal to the knee. For hip flexion with knee extension (to stretch the hamstrings), place strap/dumbbell at the ankle.

Direction of Movement
Allow buoyancy device to float hip into flexion, applying stretch to hip extensors or hamstrings.

Knee Extension

Patient Position
Seated on steps/edge of pool with knee in a position of comfort.

Equipment
Small dumbbell or ankle strap.

Direction of Movement
Allow buoyancy device to extend knee toward the surface applying stretch to increase knee extension.

* See references 6, 29, 43, 46, 48, 49, 51, 57, 63.

Knee Flexion

Patient Position
Stand immersed to waist with hip and knee in neutral position; increasing the amount of hip extension increases the stretch on the two joint knee extensors.

Equipment
Small dumbbell or ankle strap.

Direction of Movement
Allow buoyancy device to flex the knee toward the surface, applying stretch to knee extensors.

Strengthening Exercises

By reducing joint compression, providing three-dimensional resistance, and dampening perceived pain, immersed strengthening exercises may be safely initiated earlier in the rehabilitation program than traditional land strengthening exercises.[4] Both manual and mechanical immersed strengthening exercises typically are done in waist-depth water. However, some mechanical strengthening exercises may also be performed in deep water. Frequently, immersion alters the mechanics of active motion. For example, the vertical forces of buoyancy support the immersed upper extremity and alter the muscular demands on the shoulder girdle.[60] Furthermore, studies have demonstrated that lower extremity demand is inversely related to the level of immersion during closed-chain strengthening.[25]

Manual Resistance Exercises

Application of aquatic manual resistance exercises for the extremities typically occurs in a concentric, closed-chain fashion.[5,54] Manual aquatic resistance exercises are designed to fixate the distal segment of the extremity as the patient contracts the designated muscle group(s). The practitioner's hands provide primary fixation and guidance during contraction. As the patient contracts his or her muscles, the body moves over or away from the fixed distal segment (generally over the fixed segment for the lower extremity and away from the fixed segment for the upper extremity). The patient's movement through the viscous water generates resistance; and the patient's body produces the drag forces. Verbal cueing by the practitioner is essential to direct the patient when to contract and when to relax, thereby synchronizing practitioner and patient.

Stabilization of the distal extremity segment is essential for maintaining proper form and isolating desired muscles. However, appropriate stabilization is not possible in the buoyancy-supported supine position for eccentric exercises or rhythmic stabilization of the extremities. The patient's body will have a tendency to tip and rotate in the water. In addition, the practitioner will have difficulty generating adequate resistance force, and the patient's body will move easily across the surface of the water with minimal drag producing inadequate counterforce to the practitioner's resistance. When supine, some motions, including horizontal shoulder adduction and abduction, should be avoided because of the difficulty the patient may have isolating proper muscle groups. Nevertheless, for many motions, the aquatic environment allows closed-chain resistive training through virtually limitless planes of motion.

The following terms refer to manual resistance exercise in water.

- ***Practitioner position.*** Describes the orientation of the practitioner to the patient.
- ***Patient position***. Buoyancy-supported (BS) in the supine position.
- ***Hand placement.*** The guide hand is generally the ipsilateral hand as the patient's affected extremity and typically is positioned more proximally. It directs the patient's body as muscles contract to move the body through the water. The resistance hand is generally the contralateral hand and typically is placed at the distal end of the contracting segment. More distal placement increases overall resistance.
- ***Direction of movement.*** Describes the motion of the patient.

Shoulder Flexion/Extension (Fig. 9.15 A&B)

Practitioner Position
Face caudal, lateral to the patient's affected shoulder.

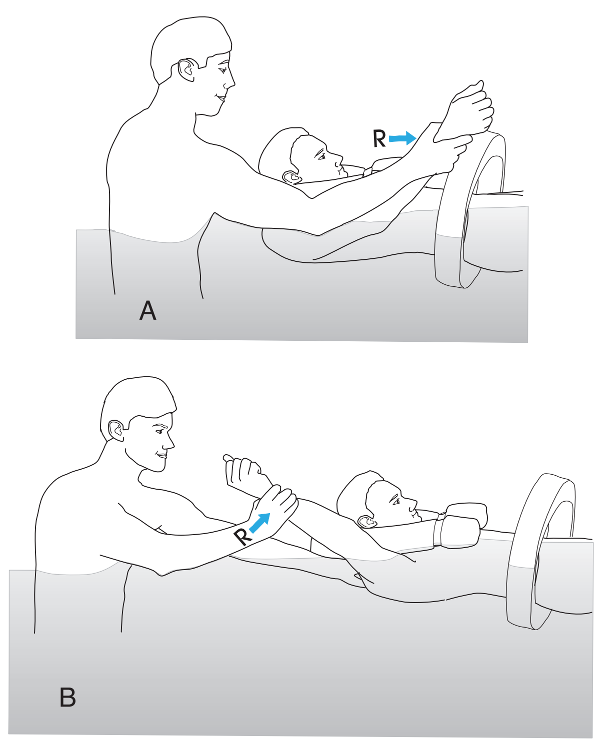

FIGURE 9.15 Manual resistance exercise for strengthening shoulder flexion, (*A*) start position, and (*B*) end position.

Patient Position
BS supine; affected extremity flexed to 30°.

Hand Placement
Place the palmar aspect of the guide hand at the patient's acromioclavicular joint. The resistance hand grasps the distal forearm. An alternative placement for the resistance hand may be the distal humerus; this placement alters muscle recruitment.

Direction of Movement
Active shoulder flexion against the resistance hand causes the body to move away from the practitioner. Active shoulder extension from a flexed position causes the body to glide toward the practitioner.

NOTE: The patient must be able to actively flex through 120° for proper resistance to be provided.

Shoulder Abduction

Practitioner Position
Face medially, lateral to the patient's affected extremity.

Patient Position
BS supine; affected extremity in neutral.

Hand Placement
Place the palmar aspect of guide hand at the proximal humerus as the thumb wraps anteriorly and the fingers wrap posteriorly. Place the resistance hand at the lateral aspect of distal humerus.

Direction of Movement
The practitioner determines the amount of external rotation and elbow flexion. Active abduction against the resistance hand causes the body to glide away from the affected extremity and the practitioner.

Shoulder Internal/External Rotation (Fig. 9.16 A&B)

Practitioner Position
Face medially on the lateral side of the patient's affected extremity.

Patient Position
BS supine; affected extremity's elbow flexed to 90° with the shoulder in the desired amount of abduction and initial rotation.

Hand Placement
Place the palmar aspect of the guide hand at the lateral aspect of the elbow. The resistance hand grasps the palmar aspect of the distal forearm. An alternative method requires the practitioner to "switch" hands. The practitioner's ipsilateral hand becomes the guide hand and grasps the buoyancy belt laterally. The practitioner's contralateral hand becomes the resistance hand, as described above. This approach allows improved stabilization; however, the practitioner loses contact with the patient's elbow and must cue the patient to maintain the desired degree of shoulder abduction during the exercise.

Direction of Movement
Active internal rotation by the patient against the resistance hand causes the body to glide toward the affected extremity; active external rotation causes the body to glide away from the affected extremity.

Unilateral Diagonal Pattern D_1 Flexion/Extension of the Upper Extremity

Practitioner Position
Stand lateral to the patient's unaffected extremity and face medially and caudally.

Patient Position
BS supine; affected extremity internally rotated and pronated with slight forward flexion.

Hand Placement
Secure the medial and lateral epicondyles of the distal humerus with the guide hand. Place the resistance hand on the dorsal surface of the distal forearm.

Direction of Movement
Prior to contraction, cue the patient to execute the specific joint motions expected in the diagonal patterns. Active contraction through the D_1 flexion pattern causes the body to glide away from the practitioner. At the end position of D_1, secure the medial and lateral epicondyles of the distal humerus with the guide hand. The resistance hand will be on the palmar aspect of the distal forearm. From the flexed position, the practitioner cues the patient to contract through the D_1 extension pattern.

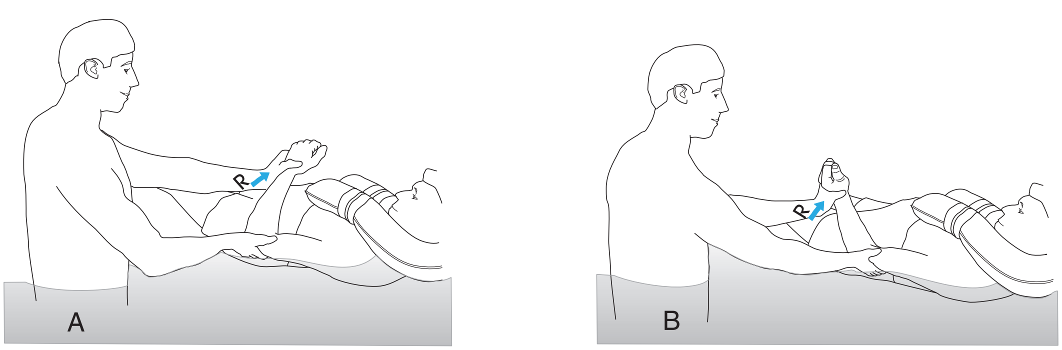

FIGURE 9.16 Manual resistance exercise for strengthening shoulder external rotation, (*A*) start position, and (*B*) end position.

Unilateral Diagonal D_2 Flexion/Extension of the Upper Extremity (Fig. 9.17 A&B)

Practitioner Position
Stand lateral to the patient's affected shoulder, face medially and caudally.

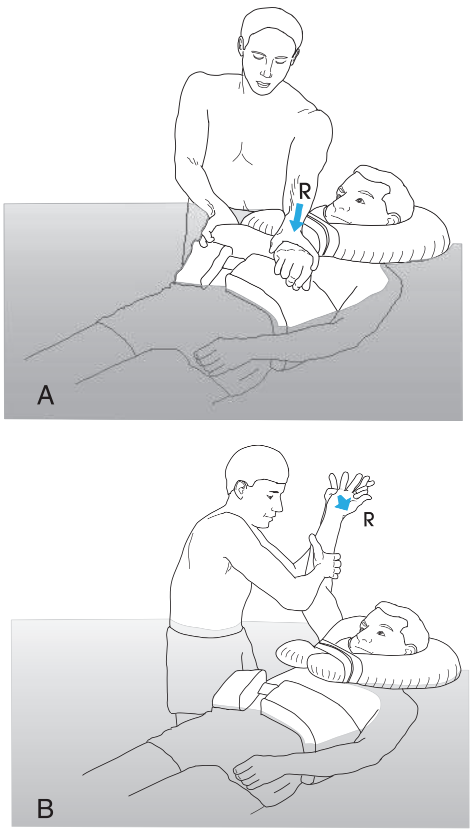

FIGURE 9.17 Manual resistance exercise for upper extremity unilateral diagonal D_2 flexion pattern, (*A*) start position, and (*B*) end position.

Patient Position
BS supine; affected extremity adducted and internally rotated.

Hand Placement
Secure the medial and lateral epicondyles of the distal humerus with the guide hand. Wrap the palmar aspect of the resistance hand on the dorsal wrist medial to the palmar surface.

Direction of Movement
Active movement through the D_2 flexion pattern causes the body to glide away from the practitioner. From the fully flexed position, cue the patient to then move into the D_2 extension pattern. This causes the body to glide toward the practitioner.

Bilateral Diagonal D_2 Flexion/Extension of the Upper Extremities (Fig. 9.18 A&B)

Practitioner Position
Stand cephalad to patient, facing caudally.

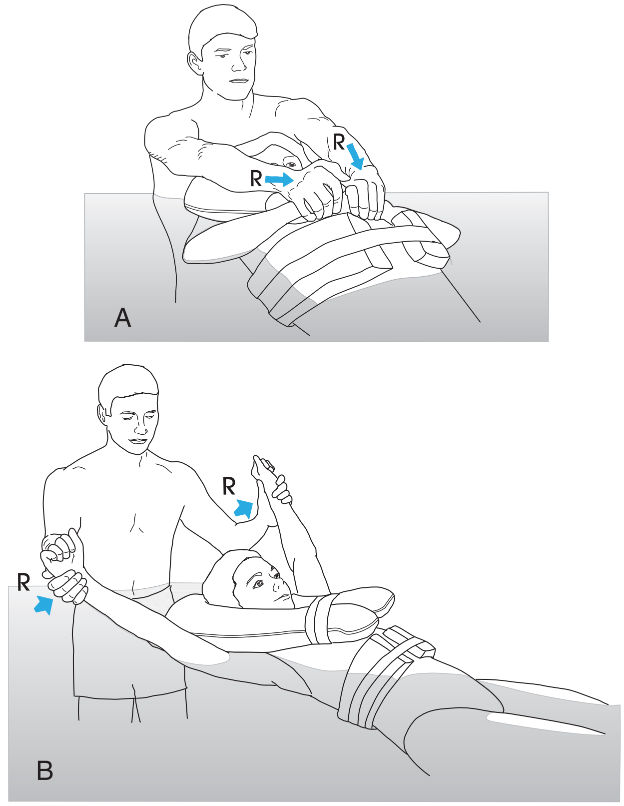

FIGURE 9.18 Manual resistance exercise for upper extremity bilateral diagonal D_2 pattern, (*A*) start position, and (*B*) end position.

Patient Position
BS supine; upper extremities adducted and internally rotated.

Hand Placement
Use both hands to provide resistance. Grasp the dorsal aspect of each of the patient's wrists, wrapping medially to the palmar surface.

Direction of Motion
Active contraction through the D_2 flexion pattern causes the body to glide away from the practitioner. From the fully flexed position, cue the patient to contract through D_2 extension, causing the patient to move toward the practitioner.

Hip Adduction

Practitioner Position
Stand lateral to the patient's affected extremity and face medially.

Patient Position
BS supine; hip abducted.

Hand Placement
Place the guide hand on the buoyancy belt and the resistance hand on the patient's medial thigh.

Direction of Movement
Active contraction of the hip adductors causes the affected leg to adduct as the contralateral leg and body glides toward the affected leg and the practitioner.

Hip Abduction (Fig. 9.19)

Practitioner Position
Stand lateral to patient's affected extremity, facing medially.

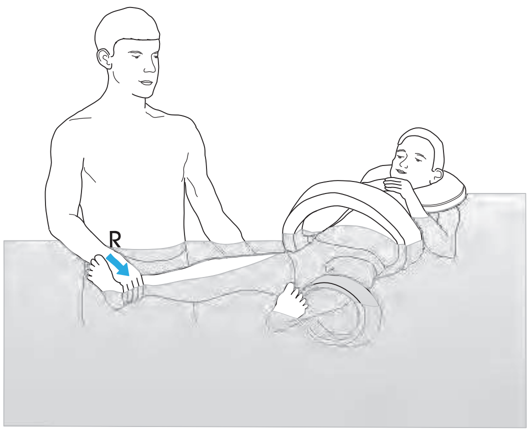

FIGURE 9.19 Manual resistance exercise for strengthening hip abduction with resistance applied to lateral aspect of the leg.

Patient Position
BS supine; hip adducted.

Hand Placement
Place the guide hand on the buoyancy belt or lateral thigh and the thumb and base of the resistance hand on the patient's lateral leg.

Direction of Movement
Active contraction of the hip abductors causes the affected leg to abduct as the contralateral leg and body glides away from the affected leg and the practitioner.

Hip Flexion with Knee Flexion (Fig. 9.20)

Practitioner Position
Stand at the side of the patient's affected extremity, facing cephalad.

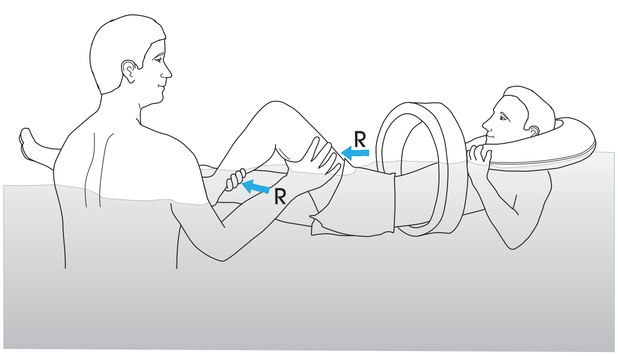

FIGURE 9.20 Manual resistance exercise for strengthening hip and knee flexion.

Patient Position
BS supine.

Hand Placement
Place the guide hand on the buoyancy belt or lateral hip. The resistance hand grasps proximal to the distal tibiofibular joint.

Direction of Movement
Active contraction of the hip and knee flexors causes the patient's body to glide toward the practitioner and fixed distal extremity.

Hip Internal/External Rotation

Practitioner Position
Stand lateral to the patient's affected extremity, facing medially.

Patient Position
BS supine; hip in neutral at 0° extension with knee flexed to 90°.

Hand Placement
Contact the distal thigh medially with the guide hand for resisted internal rotation and laterally for resisted external rotation. Place the resistance hand at the distal leg.

Direction of Movement
Active contraction of hip rotators (alternating between internal and external rotation) causes the patient's body to glide away from the distal fixed segment.

PRECAUTION: Avoid this exercise for patients with possible medial or lateral knee joint instability.

Knee Extension

Practitioner Position
Stand at the patient's feet, facing cephalad.

Patient Position
BS supine.

Hand Placement
Place the guide hand at the patient's lateral thigh and the resistance hand on the dorsal aspect of the distal tibiofibular joint.

Direction of Movement
Active contraction of the quadriceps against the practitioner's resistance hand directs the body away from the practitioner as the knee extends.

Ankle Motions

Practitioner Position
Stand lateral to the affected leg, facing caudally.

Patient Position
BS supine.

Hand Placement
The hand placement creates a short lever arm at the patient's ankle. As the patient moves through the resisted ankle motions, the patient's entire body moves through the

water, producing a significant amount of drag and demand on the ankle complex.

PRECAUTION: For patients with ligamentous laxity and unstable ankles or compromised ankle musculature, the practitioner should cue the patient to avoid maximum effort during contraction to avoid potential injury.

Ankle Dorsiflexion and Plantarflexion

Hand Placement
Place the guide hand on the lateral aspect of the leg and the resistance hand over the dorsal aspect of the foot to resist dorsiflexion and on the plantar aspect to resist plantarflexion.

Direction of Movement
The body moves toward the practitioner during dorsiflexion and away from the practitioner during plantarflexion.

Ankle Inversion and Eversion

Hand Placement
Place the guide hand on the lateral aspect of the lower leg during inversion and on the medial aspect of tibia during eversion. To resist inversion grasp the dorsal medial aspect of the foot and to resist eversion grasp the lateral foot.

Direction of Movement
During inversion the body glides toward the practitioner, and during eversion the body glide aways from the practitioner.

Dynamic Trunk Stabilization

By applying concepts utilized for spinal stabilization exercises on land (see Chapters 15 and 16), the practitioner can challenge the dynamic control and strength of the trunk muscles in the aquatic environment. The BS supine position creates a unique perceptual environment for the patient.

- *Dynamic trunk stabilization—frontal plane* (Fig. 9.21).

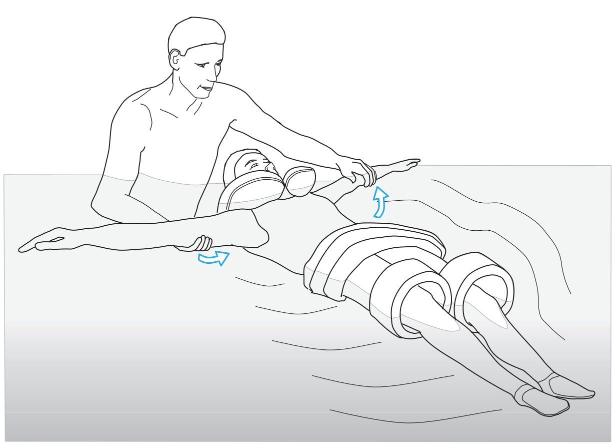

FIGURE 9.21 Isometric trunk stabilization exercise using side to side motions of the trunk.

Practitioner Position
Hold the patient at the shoulders or feet.

Patient Position
Typically, the patient is placed in a supine position with buoyancy devices at the neck, waist, and legs.

Execution
Have the patient identify his or her neutral spine position, perform a "drawing-in maneuver" (see Chapter 16), and maintain the spinal position (isometric abdominal contraction). Move the patient from side to side through the water; monitor and cue the patient to avoid lateral trunk flexion, an indication that the patient is no longer stabilizing the spine.

Intensity
Moving the patient through the water faster increases drag and exercise intensity. Holding the patient more distally increases exercise intensity.

- *Dynamic trunk stabilization—multidirectional*.

Practitioner Position
Stand at the shoulders or feet of the patient and grasp the patient's extremity to provide fixation as the patient contracts.

Patient Position
Typically, the patient is placed in a supine position with buoyancy devices at the neck, waist, and legs.

Execution
Instruct the patient to assume a neutral spine, perform the drawing-in maneuver, and "hold" the spine stable. Instruct the patient to perform either unilateral or bilateral resisted extremity patterns while maintaining a neutral spine and abdominal control. Monitor and cue the patient to avoid motion at the trunk, an indication that the patient is no longer stabilizing with the deep abdominal and spinal muscles. Upper extremity motions include shoulder flexion, abduction, and diagonal patterns. Lower extremity motions include hip and knee flexion and hip abduction and adduction.

Intensity
Unilateral patterns are more demanding than bilateral patterns. Increasing speed or duration increases exercise intensity.

Independent Strengthening Exercises

Often patients perform immersed strengthening exercises independently. Because the resistance created during movement through water is speed-dependent, patients are able to control the amount of work performed and thedemands imposed on contractile elements.[4,24,51] Typically, positioning and performance of equipment-assisted strengthening activities in water reflect that of traditional land exercise. However, the aquatic environment allows patients to assume many positions (supine, prone, side-lying, seated, vertical). Attention to specific patient positioning allows the practitioner to utilize the buoyant properties of water and/or the buoyant and resistive properties of equipment that can either assist or resist patient movement.[31,34] Before initiating immersed strengthening activities, patients should be oriented to the effects of speed and surface area on resistance. Specific exercises for mechanical strengthening of every body part are not described. Only selected exercises are discussed and illustrated to reinforce major concepts and principles of application.

The following terms are used for equipment-assisted exercise.

- **Buoyancy assisted (BA):** Vertical movement directed parallel to vertical forces of buoyancy that assist motion (patient may use buoyant equipment to assist with motion).
- **Buoyancy supported (BS):** Horizontal movement with vertical forces of buoyancy eliminating or minimizing the need to support an extremity against gravity (patient may use buoyant equipment to assist with motion).
- **Buoyancy resisted (BR):** Movement directed against or perpendicular to vertical forces of buoyancy, creating drag (performed without equipment).
- **Buoyancy superresisted (BSR):** Use of equipment generates resistance by increasing the total surface area moving through water by creating greater drag. Increasing the speed of motion through water generates further drag.

Extremity Strengthening Exercises (Fig. 9.22 A–E)

The most common aquatic upper and lower extremity strengthening exercises are outlined in Box 9.1.[1,31,34] Typically, patients are positioned standing immersed to shoulder level for upper extremity strengthening and to mid-trunk level for lower extremity strengthening. How-

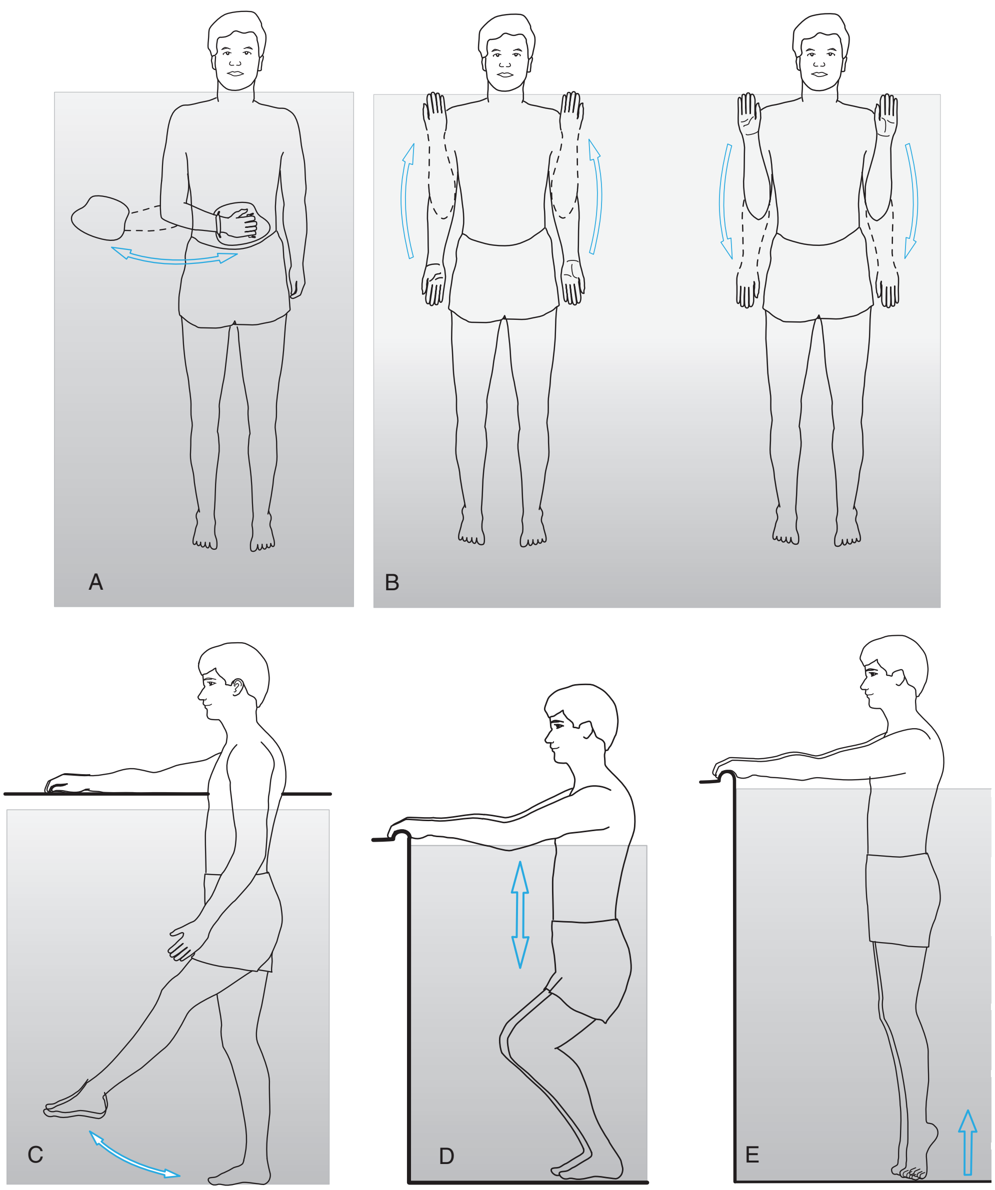

FIGURE 9.22 Mechanical resistance for strengthening (*A*) shoulder internal and external rotation, (*B*) elbow flexion and extension, (*C*) hip flexion and extension, (*D*) functional squatting, and (*E*) ankle plantarflexion. *(Adapted from Bates and Hanson.[6])*

BOX 9.1 Summary of Motions Used for Upper and Lower Strengthening Exercises

Shoulder	Flexion/extension Abduction/adduction Horizontal abduction/adduction Internal/external rotation Unilateral diagonals Bilateral diagonals
Elbow	Flexion/extension Diagonals Push/pull
Hip	Flexion/extension Abduction/adduction Internal/external rotation Unilateral diagonals Bilateral diagonals
Knee	Flexion/extension Diagonals

ever, many exercises may be performed with the patient positioned vertically in deep water. The prone or supine position is useful when practitioners wish to progress patients or when patients require position-specific or sports-specific strengthening. Some exercises, most notably bilateral lower extremity diagonals, require the patient to be positioned supine, prone, or vertical in deep water.

Lumbar Spine Strengthening

Spinal stabilization may be performed in shallow, mid-depth, or deep water levels. Typically, patients are instructed to maintain a neutral spine with the drawing-in maneuver (see Chapter 16) while performing functional activities or moving the extremities. The patient's ability to stabilize the spine can be challenged by increasing the duration of the activity, the speed or surface area moving through water, and by the addition of buoyant devices in the deep water. The exercises are summarized in Box 9.2.

Trunk-Strengthening Exercises: Standing

- ***Walking patterns.*** Holding a kickboard vertically in the water increases resistance.
- ***Unilateral and bilateral stance during upper extremity motions***. The buoyant and turbulent forces of the water require co-contraction of the trunk muscles to stabilize the immersed body; using equipment (Hydro-tone bells, paddles, resistive tubing) to increase resistance increases the need for co-contraction of the trunk muscles.

Trunk-Strengthening Exercises: Semi-Reclined

Patients may use noodles, dumbbells, or kickboards for support. The practitioner can further challenge the patient by having him or her hold buoyant equipment, such as paddles, and then stabilize the trunk against the movement. A variety of lower extremity movements are suggested in Box 9.2.

BOX 9.2 Summary of Lumbar Spine-Strengthening Exercises

Standing	Walking patterns: forward, backward, lateral, lunge walk, high stepping Unilateral/bilateral stance with upper extremity motions
Semi-reclined	Bicycling Hip abduction/adduction Flutter kick Bilateral lower extremity PNF patterns Unilateral/bilateral hip and knee flexion/extension
Supine	Bridging with long dumbbell placed at knees Swimming kicks
Prone	Swimming kicks
Deep water	Vertical stabilization exercises; abdominal bracing with arm and leg motions in the pike and iron-cross positions Seated on dumbbell; abdominal bracing and balance while performing unilateral or bilateral arm motions Standing on a kickboard or dumbbell; abdominal bracing and balance while performing bicycling motions and/or arm motions

Trunk-Strengthening Exercises: Supine

Various swimming kicks are used in the supine position. Instruct the patient to concentrate on the drawing-in maneuver and on maintaining the neutral spine position while moving the legs. Bridging while maintaining a neutral spine can be done with a long dumbbell placed at the knees.

Trunk-Strengthening Exercises: Prone

In the prone position, various swimming kicks, such as the flutter kick, are used while the patient performs the drawing-in maneuver and maintains a neutral spine.

Trunk-Strengthening Exercises in Deep Water

Stabilization exercises performed in deep water with the patient positioned vertically typically require the patient to brace with the abdominal muscles. Emphasize identifying the neutral spine, activating the drawing-in maneuver, and holding the spine in the stable position while performing the various activities. Utilize any combination of unilateral or bilateral upper and/or lower extremity motions to further challenge the stabilization effort. Add equipment devices to the hands or legs for additional resistance and increased challenge when the patient can maintain good stabilization control. Variations include:

- Altering trunk positions such as the pike position or the iron-cross position.
- Sitting on a dumbbell and bicycling forward or backward or moving the upper extremities through any combination of motions.

- Standing on a kickboard or dumbbell and moving the upper extremities through various combinations of motions, first without then with equipment. Such standing activities typically induce obligatory abdominal bracing and challenges to balance.

Aerobic Conditioning

Aquatic exercise that emphasizes aerobic/cardiovascular conditioning can be an integral component of many rehabilitation programs. Aerobic/cardiovascular exercise typically takes place with the patient suspended vertically in deep water pools without the feet touching the pool bottom. Alternative activities that may be performed in mid-level water, 4 to 6 feet in depth, include jogging, swimming strokes, immersed cycling, and immersed treadmill. Understanding the various treatment options, physiological responses, monitoring methods, proper form, and equipment selection allows the clinician to use this form of exercise effectively and safely in a rehabilitation program.

Treatment Interventions

Deep-water walking/running (Fig. 9.23). Deep water walking and running are the most common vertical deep-water cardiovascular endurance exercises. Alternatives include cross-country motions and high-knee marching. Deep-water cardiovascular training, which may be used as a precursor to mid-water or land-based cardiovascular training, eliminates the effects of impact on the lower extremities and spine.

FIGURE 9.23 Deep water walking/jogging. *(Courtesy of Rothhammer International Inc. San Luis Obispo, CA.)*

The patient can be tethered to the edge of the pool to perform deep-water running in those pools with limited space. Some small tanks provide resistance jets for the patient to move against.

Mid-water jogging/running (immersed treadmill running). Mid-water aerobic exercise, which may be used as a precursor to land training, lessens the effects of impact on the spine and lower extremities. As a patient's tolerance to impact improves, mid-water jogging may be performed in progressively shallower depths to provide increased weight bearing and functional replication. In pools with limited space, tethering with resistive tubing can provide resistance.

Immersed equipment. Immersed equipment includes an immersed cycle, treadmill, or upper body ergometer.

Swimming strokes. For patients able to tolerate the positions necessary to perform various swim strokes (neck and shoulder ROM and prone, supine, or side-lying positions), swimming can be an excellent tool to train and improve cardiovascular fitness. Swimming may elicit significantly higher elevations of heart rate, blood pressure, and $\dot{V}O_{2max}$ than other aquatic activities. Swimming contributes the added benefit of hip and trunk strengthening for some patients with spinal conditions.

PRECAUTION: Recommending swimming for poorly skilled swimmers with cardiac compromise may adversely challenge the patient's cardiovascular system.

Physiological Response to Deep-Water Walking/Running

Various physiological responses to deep-water walking and running have been reported.*

Cardiovascular Response

Patients without cardiovascular compromise may experience dampened elevation of heart rate, ventilation, and $\dot{V}O_{2max}$ compared to similar land-based exercise. During low-intensity exercise, cardiac patients may experience lower cardiovascular stresses.[22,23] As exercise intensity increases, cardiovascular stresses approach those of related exercise on land.[23,35]

Training Effect

Patients experience carryover gains in $\dot{V}O_{2max}$ from aquatic to land conditions.[45] Additionally, aquatic cardiovascular training maintains leg strength and maximum oxygen consumption in healthy runners.[33,45,58,60]

Proper Form for Deep-Water Running

Instruction for Beginners

Proper instruction is important to ensure correct form because many beginners experience a significant learning curve.[8] Once immersed, the patient should maintain a neu-

* See references 3, 10, 12, 13, 15, 21, 27, 33, 55, 58.

tral cervical spine and slightly forward flexed trunk with the arms at the sides. During running the hips should alternately flex to approximately 80° with the knee extended and then extend to neutral as the knee flexes.

Accommodating Specific Patient Populations

For patients with positional pain associated with spinal conditions, a posterior buoyancy belt helps maintain a slightly forward flexed position, and a flotation vest helps maintain more erect posture and a relatively extended spine. Patients with unilateral lower extremity amputations may have difficulty maintaining a vertical position. Placing the buoyancy belt laterally (on the contralateral side of the amputation) allows the patient to remain vertical more easily.

Exercise Monitoring

Monitoring Intensity of Exercise

- ***Rate of perceived exertion.*** Because skill may affect technique, subjective numerical scales depicting perceived effort may inadequately identify the level of intensity for novice deep-water runners. However, at both submaximal and maximal levels of exertion, subjective numerical rating of effort appears to correlate adequately with the heart rate during immersed exercise.[10,13,26,33]
- ***Heart rate.*** Because of the physiological changes that occur with neck level immersion, various adjustments have been suggested in the literature to lower the immersed maximum heart rate during near-maximum cardiovascular exercise.[12,13,17,50,60] The suggested decreases range from 7 to 20 beats per minute.[17,50,60] The immersed heart rate can be reliably monitored manually or with water-resistant electronic monitoring devices.

Monitoring Beginners

Care should be taken to monitor regularly the cardiovascular response of novice deep-water runners or patients with known cardiac, pulmonary, or peripheral vascular disease. Novice deep-water runners may experience higher levels of perceived exertion and $\dot{V}O_{2max}$ than they would during similar land exercise.[26]

Equipment Selection

Deep Water Equipment

Selection of buoyancy devices should reflect the desired patient posture, comfort, and projected intensity level. The most common buoyant device for deep-water running is the flotation belt positioned posteriorly (see Fig. 9.5). Patients presenting with injuries or sensitivity of the trunk may require an alternative buoyant device, such as vests, flotation dumbbells, or noodles. Providing the patient with smaller buoyant equipment (i.e., smaller belts, fewer noodles) requires the patient to work harder to maintain adequate buoyancy, thereby increasing the intensity of the activity. Fins and specially designed boots can be applied to the legs and feet to add resistance. Also, bells or buoyant dumbbells can be held in the hands to increase resistance (see Fig. 9.8).

Midwater Equipment

Specially designed socks can help eliminate the potential problem of skin breakdown on the feet during impact activities, such as running. Patients can run against a forced current or tethered with elastic tubing for resistance. Using noodles around the waist or running while holding a kickboard increases the amount of drag and resistance against which the patient must move.

INDEPENDENT LEARNING ACTIVITIES

Case Studies

POSTOPERATIVE ARTHROSCOPIC KNEE MENISCECTOMY

Mike is a 54-year-old man who tore his right medial meniscus playing basketball. He is 2 weeks status post-arthroscopic débridement of the torn piece of cartilage. Mike has returned to his desk job as a computer programmer but has a strong desire to return to his active workout schedule and weekend sports leagues. The surgeon has told Mike that he has no limitations except pain.

Past Medical History: Mike is healthy with no prior medical problems. He has never had an injury that made him miss more than a few days of sports participation.

Functional Status: Mike is ambulating without assistive devices, but he limps slightly because of a stiff knee. He is able to go up and down stairs but only one step at a time and has to lead with his left leg.

Musculoskeletal Status: Mike has only minimal swelling of the right knee. He rates his pain as a 1 out of 10 at rest and a 3 out of 10 with activity. His active knee ROM is 5° to 100°. He has normal ROM in the remaining joints of the right leg. Mike is able to perform a straight leg raise and has good quadriceps contraction. Manual muscle testing reveals 4/5 quadriceps strength, 4/5 hamstring and gastrocsoleus strength. He has good patellofemoral joint mobility.

Physician Referral: The prescription Mike's physician gave him states "Evaluate and treat right knee, S/P arthroscopic meniscal débridement; may utilize land and aquatic exercise for ROM and strength."

- Formalize a program to utilize the shallow water (4-ft depth) to start Mike with independent exercises for strength and flexibility.
- Describe what manual techniques you might be able to perform with Mike for strength or flexibility.
- As Mike progresses to full ROM and near-normal strength, how could you use aquatics to replicate the demands of basketball?
- What can Mike do in the pool to maintain his cardiovascular fitness while his knee heals?

CALF TEAR

Cecily is a 30-year-old weather anchor who happens to be an elite marathon runner. Four days ago she was running up a hill and felt a "pulling" in her left calf just distal to the knee. She decided to run in a 10K marathon the next day but had to quit after about 5K because of a sharp pain in her calf. The doctor has told her to use crutches and remain 25% weight bearing for the next 3 days. After that she can gradually begin to increase the weight she puts through the leg over the next week. The doctor has told Cecily that she should be full weight bearing in 1 week and able to run in 3 weeks. Cecily is anxious to return to her intensive training schedule.

Past Medical History: Cecily is healthy with no prior medical problems. She has worn orthotic inserts in her shoes for "flat feet" for as long as she can remember. She says she has pulled her left calf several times during a running career that goes back to high school.

Functional Status: Cecily enters the facility ambulating with crutches. She is putting about 25% of her weight through her left foot. She is able to perform stairs without difficulty using the crutches and/or a railing.

Musculoskeletal Status: Cecily has a visible bruise at the medial head of the left gastrocnemius muscle belly. She is very tender to palpation there and has some swelling. She rates her pain at rest as 1 on a 10-point scale and her pain with activity as 2. Her ankle ROM is normal for all motions actively and passively with the exception of dorsiflexion. She dorsiflexes actively 5° and passively 8°. You grade her ankle strength as 5/5 except for plantarflexion, which you grade as a 4–/5; this may be limited due to pain. You also notice that her left hip flexors, quadriceps, and hamstrings are all tight.

Physician Referral: The prescription that Cecily's doctor gives her states "Aquatic therapy; evaluate and treat for left calf strain: gait training, ROM, strength. Progress to land as tolerated."

- Write up a program to address Cecily's dysfunctions and impairments utilizing the aquatic environment.
- At what depth of mid-water does Cecily need to be to gait train in the water and still maintain 25% weight bearing?
- Write up a program for the deep water to help Cecily maintain her high level of cardiovascular fitness.
- What equipment might be useful to assist her with independent stretching in the deep water and for cardiovascular training in the deep water?

CHRONIC LOW BACK PAIN

Develop an aquatic program for a patient who has chronic low back pain and needs a comprehensive flexibility and strengthening program for the legs and trunk. The patient has only one visit approved by the insurance company. However, the patient has a pool in his or her back yard that gradually goes from 3 feet to 7 feet in depth. The 7-foot deep area is only 10 feet long and 5 feet wide. The patient has no other medical problems that would limit his or her performance of the aquatic program.

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