Physical inactivity – prolonged immobilization

dr. Aulia Syavitri Dhamayanti

FAKULTAS KEDOKTERAN
UNIVERSITAS MUHAMMADIYAH MALANG

2024

Background

Bed rest and immobilization were widely used before 1950 in the management of trauma and acute and chronic illness

It was generally assumed that rest → fostered healing of the affected part of the body

Is immobility and inactivity could be harmful to the unaffected parts of the body?

For example, the immobilization of long bones with a rigid cast has a beneficial effect on bone healing after fractures. However, it may also result in undesirable effects, such as joint contracture and atrophy of the healthy muscles and bones.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Background

TABLE 48.1 Adverse Effects of Immobility and Inactivity

System(s)	Effect(s)
Musculoskeletal	Muscle weakness, fatigue, and atrophy
	Muscle and joint contractures
	Muscle stiffness and pain
	Osteoporosis
	Hypercalcemia
Cardiovascular and pulmonary	Redistribution of body fluids
	Dehydration
	Orthostatic intolerance
	Reduction of cardiopulmonary capacity
	Reduction of VO_{2max}
	Elimination of bronchial secretions
	Hypostatic pneumonia
Genitourinary and gastrointestinal	Urinary stasis, stones, and urinary infections
	Loss of appetite
	Constipation
Metabolic and endocrine	Glucose intolerance
	Electrolyte alterations
	Increased parathyroid hormone production
	Other hormone alterations
Immune system	Impaired wound healing
	Reduction in cellular immunity
	Resistance to infection reduced
	Anti-inflammatory suppression reduced
Cognitive and behavioral	Sensory deprivation
	Confusion and disorientation
	Anxiety and depression, memory
	Decrease in intellectual capacity
	Impaired balance and coordination
Cellular/Genetic	Diminished gene expression
	Mitochondrial dysfunction

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Background

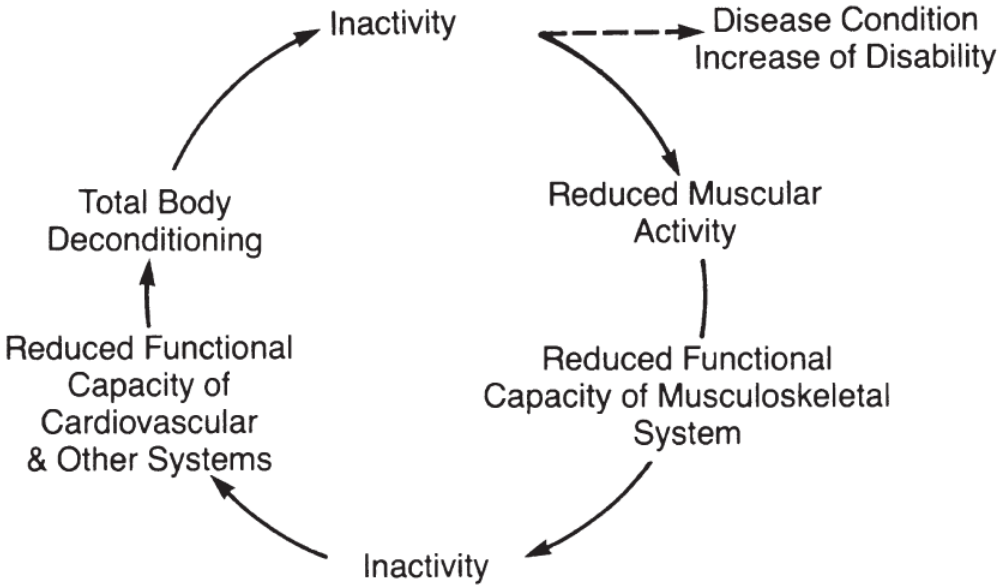


FIGURE 48-1. Inactivity, immobility, and prolonged bed rest influence total body functioning.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Definitions ?

The duration that constitutes "prolonged" can **vary** depending on the context, the individual, and the specific health concern being addressed, but it generally refers to periods that are long enough to cause noticeable physiological changes or functional deficits.

Table 1. Definitions of Immobility and Their Duration Across Studies in Acutely Ill Medical Patients With Restricted Mobility.

Study	Definition of Immobility	Duration of Immobility
Registry study		
RIETE Registry[16,17]	Total bed rest (with bathroom privileges)	≥4 days within 2 months prior to venous thromboembolism
IMPROVE Registry[18]	Confinement to bed or chair all day	≥7 days
MASTER Registry[19]	Not stated	>7 days
Trial study		
THE PRIME[20]	Expected immobilization for more than half the day	Whole study period; 7 days
THE PRINCE[21]	Confinement to bed for more than two thirds of each day	Duration of the study period, 10 ± 2 days
PREVENT[22]	Hospitalization	≤3 days prior to hospitalization; ≥4 days predicted duration of hospitalization
ARTEMIS[23]	Confinement to bed	≥4 days predicted duration
EXCLAIM[24]	Level 1: Total bed rest or sedentary without bathroom privileges; Level 2: Total bed rest or sedentary with bathroom privileges	≤3 days recent reduced mobility; ≥3 days anticipated duration of hospitalization
MEDENOX[a,25]	Inability to attain autonomous walking distance >10 m at 10 ± 4 days	≤3 days prior to hospitalization; ≥6 days predicted duration of hospitalization
MAGELLAN[26]	Anticipated complete immobilization for ≥1 day during the hospitalization and anticipated decreased level of mobility for ≥4 days after randomization in any type of care setting	
ADOPT[27]	Moderately restricted: walking within hospital room or to the bathroom; severely restricted: confined to bed or chair at the bedside	Expected hospital stay of ≥3 days

Abbreviations: ADOPT, Apixaban Dosing to Optimize Protection from Thrombosis; ARTEMIS, Arixtra for Thromboembolism Prevention in Medical Indications Study; EXCLAIM, Extended Clinical Prophylaxis in Acutely Ill Medical Patients; IMPROVE, International Medical Prevention Registry on Venous Thromboembolism; MAGELLAN, Multicenter, rAndomized, parallel Group Efficacy and safety study for the prevention of VTE in hospitalized acutely iLL medical patients comparing rivaroxabAN with enoxaparin; MEDENOX, Prophylaxis in Medical Patients with Enoxaparin; PREVENT, Prospective Evaluation of Dalteparin Efficacy for Prevention of VTE in Immobilized Patients Trial; PRIME, Prophylaxis in Internal Medicine with Enoxaparin; PRINCE, Thromboembolism Prevention in Cardiac or Respiratory Disease with Enoxaparin; RIETE, Registro Informatizado de Enfermedad TromboEmbólica.
[a]Post hoc analysis of the MEDENOX trial.[28]

Hull, R. D. (2013). Relevance of immobility and importance of risk assessment management for medically ill patients. 19(3), 268-276.

01.

MUSCULOSKELETAL EFFECTS OF IMMOBILITY AND INACTIVITY

Musculoskeletal Effects of Immobility And Inactivity

Significance of Movement

- Moving freely is a primary physical function.
- Muscles, nerves, bones, and joints need to be in an optimal physiological state for free movement.

Effects of Disuse

- Leads to muscle weakness and limited joint movement.
- Initial effects might be subtle.
- Over time, results in advanced contractures, significant ↓ of mobility, and ↓ ADL functions.

Impacts on Special Populations:

- For neurologically impaired or trauma victims, preserving range of motion (ROM) might seem secondary.
- However, neglecting ROM can lead to longer hospital stays, increased health care resource use, and extended dependency in mobility and ADL

Adverse Effects of Inactivity

- Muscle atrophy and weakness.
- Joint contracture.
- Immobilization osteoporosis.

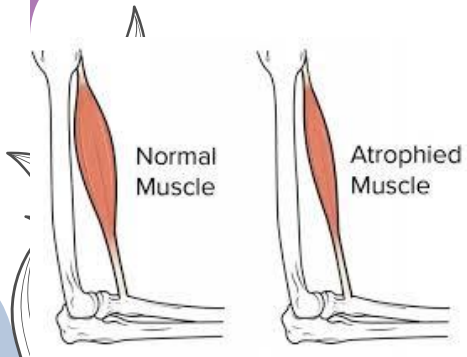
Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

02.

INACTIVITY OF SKELETAL MUSCLE

INACTIVITY OF SKELETAL MUSCLE

Physiological Impairment



Disuse Atrophy

- Disuse atrophy → an alteration of metabolism and muscle cell homeostasis in response to muscle inactivity.
- The rate of muscle wastage accelerates after the first two days of bed rest, leading to significant muscle weight loss by 10 days
- Pathophysiology: significant reduction in muscle protein synthesis, combined with increased protein degradation in later stages

Loss of strength

- The loss of strength is rapid after the first day of immobilization and reaches its maximum 10 to 14 days later
- Loss of strength & disuse atrophy → more prominent in lower limbs than upper limbs

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

INACTIVITY OF SKELETAL MUSCLE

Physiological Impairment

Loss endurance

- Unexercised muscle → reduction of adenosine triphosphate (ATP) and glycogen storage sites and rapid depletion of them after resumption of activity.
- The loss of muscle mass leads to reduction of muscle strength and endurance, reducing muscle blood flow, red blood cell delivery, oxidative enzyme activity, and oxygen utilization in the muscle

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

INACTIVITY OF SKELETAL MUSCLE

Functional Impairment

Mobility & ADL

In the lower limbs, type I muscle fibers, which are active during standing and slow ambulation, are especially affected with a rapid reduction in endurance

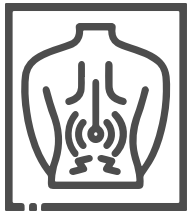
FIGURE 48-2. A sequence of contracture development occurred from hip down to knee in a patient with traumatic hip fracture treated operatively with the pins. As a result of hip-flexion contracture and immobility, the hamstring and eventually posterior capsule with neurovascular soft tissue of the knee became tight and contracted, causing knee-flexion contracture. With these contractures, a person must walk on the toes, which increases energy expenditure.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

INACTIVITY OF SKELETAL MUSCLE

Functional Impairment

Muscle pain & stiffness



- The cause of this pain is still not fully understood.
- the position in which a joint is immobilized has a significant influence on the number of sarcomeres present in a single muscle fiber → weakness and muscle stiffness

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Disuse Weakness, Deconditioning, and Cardiovascular Disease

- A lack of adequate muscle activity adversely affects the cardiovascular and related systems.
- Chronic inactivity impairs and reduces maximal oxygen consumption (VO2max), cardiovascular reserve, and fitness
- Individuals with an inactive lifestyle and low level of fitness are more prone to develop coronary artery disease (CAD) and have greater odds of suffering myocardial infarction and death.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

03

Prevention and Treatment of Muscle Weakness

Prevention and Treatment of Muscle Weakness

PRINCIPLES

- Identify clinical and subclinical changes in strength, endurance, and physical function.
- Determine whether additional conditions exist that may exacerbate atrophy & weakness caused by inactivity, such as acute trauma or chronic disease.
- Ascertain the necessity for continued bed rest or immobility.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Prevention and Treatment of Muscle Weakness

STRATEGIES

- Prevent muscle weakness by prescribing progressive resistive exercise, stretching, and aerobic exercise.
- In most cases, use a combination of specific exercises to address all aspects of muscle weakness, including exercise for flexibility, strength, endurance, and fitness.
- Remobilize the patient as quickly as possible; provide progressive mobility training.
- Encourage 30 minutes of walking and leisure activities for at least 3 days a week for the general population.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

04

JOINT CONTRACTURE

Definition of joint contracture

Joint contracture refers to the permanent shortening of a joint or muscle, which results in a reduction in the range of motion of that joint

FIGURE 48-2. A sequence of contracture development occurred from hip down to knee in a patient with traumatic hip fracture treated operatively with the pins. As a result of hip-flexion contracture and immobility, the hamstring and eventually posterior capsule with neurovascular soft tissue of the knee became tight and contracted, causing knee-flexion contracture. With these contractures, a person must walk on the toes, which increases energy expenditure.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Etiology of joint contracture

Muscle Atrophy	Lack of use or immobilization of a muscle can lead to muscle shortening
Scar Tissue	Injury or surgery can lead to the formation of scar tissue, which might restrict joint movement.
Joint Pathologies	Conditions such as arthritis can result in contractures due to pain and inflammation leading to decreased use and movement of the joint.
Nerve Damage	Conditions like a stroke or spinal cord injury can result in nerve damage, leading to muscle spasticity and contracture.
Prolonged Immobilization	Extended periods of immobility (like long-term bed rest or wearing a cast) can lead to joint stiffness and eventual contracture.
Connective Tissue Disorders	Some conditions, such as Dupuytren's contracture, involve abnormal formation of tissue in the hand that can lead to contractures of the fingers.
Skin Conditions	Diseases such as scleroderma harden the skin and can limit the movement of the underlying joints.

Cifu, D.X., 2021. Braddom’s Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Classification of contracture

TABLE 48.3 Anatomical Classification of Contractures

Type	Primary Cause	Secondary Cause
Arthrogenic	Cartilage damage, congenital deformities, infection, trauma, degenerative joint disease	Immobility
	Synovial and fibrofatty tissue proliferation (e.g., inflammation, effusion)	Immobility
	Capsular fibrosis (e.g., trauma, inflammation)	Lack of ROM
	Immobilization as primary cause	Mechanical position
Soft and dense tissue	Periarticular soft tissue (e.g., trauma, inflammation)	Immobility
	Skin, subcutaneous tissue (e.g., trauma, burns, infection, systemic sclerosis)	
	Tendons and ligaments (e.g., tendinitis, bursitis, ligamentous tear, and fibrosis)	Immobility
Myogenic		
Intrinsic (structural)	Traumatic (e.g., bleeding, edema)	Immobility
	Inflammatory (e.g., myositis, polymyositis)	Fibrosis
	Degenerative (e.g., muscular dystrophy)	
	Ischemic (e.g., diabetes, peripheral vascular disease, compartment syndrome)	Immobility
Extrinsic	Spasticity (e.g., strokes, multiple sclerosis, spinal cord injuries), hypertonicity	Lack of stretch
	Flaccid paralysis (e.g., muscle imbalance)	Faulty joint position
	Mechanical (e.g., faulty position in bed or chair)	Immobility
	Immobilization as primary cause	Lack of stretch
Mixed	Combined arthrogenic, soft-tissue and muscle contractures noted in a single joint	

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Prevention & Treatment of contracture

TABLE 48.4 Basic Principles in the Prevention and Treatment of Contractures

Prevention
- *In healthy individuals with sedentary lifestyle, elderly:*
- Flexibility exercises, stretch of two-jointed muscles, yoga, pilates
- *In individual with preexisting condition or predisposition:*
- Range-of-motion exercises (active or passive) with terminal stretch
- Proper positioning in bed, wheelchair, splinting, casting
- Early mobilization and ambulation (weight bearing)
- CPM (continuous passive motion)
- Resistance exercise to opposing muscles

Treatment
- Passive range-of-motion exercises with terminal stretch
- Prolonged stretch using low passive tension and heat (e.g., ultrasound)
- Progressive (e.g., dynamic) splinting, casting
- Treatment of spasticity; phamacologic, motor point or nerve blocks using phenol, muscle injection of botulinum toxin A or B
- Pain management
- Surgical interventions (e.g., tendon lengthening, osteotomies, joint replacement)

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

05

DISUSE OSTEOPOROSIS

Definition of disuse osteoporosis

Disuse osteopenia is characterized by a loss of calcium and hydroxyproline from the cancellous portion of long bone, epiphyses, metaphyses, and cortical bone near the bone marrow cavity.

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Disuse osteoporosis treatment

PRINCIPLES & framework

- Recognize immobility and the lack of exercise or loading as a risk factor acting either alone or in combination with other factors.
- Understand the structural, content and strength, bone changes in response to non–weight bearing and lack of muscle contraction.
- Understand the value of remobilization, weight bearing, and physical activity, including resistance exercises, in prevention and treatment.
- Calcium, vitamin D, and physical activity are essential in maintaining the healthy bones

Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Disuse osteoporosis treatment

Typical Prescription

- Progressive strengthening resistance exercise training for back extensors, hip extensors and abductors, and shoulder girdle muscles
- Posture, balance training, and long walks
- Avoidance of flexion exercise of lumbar spine or high-impact exercises in flexion position for those with vertebral fractures or advanced osteoporosis
- Controlled axial loading (use of a weighted vest) for reversing vertebral osteopenia

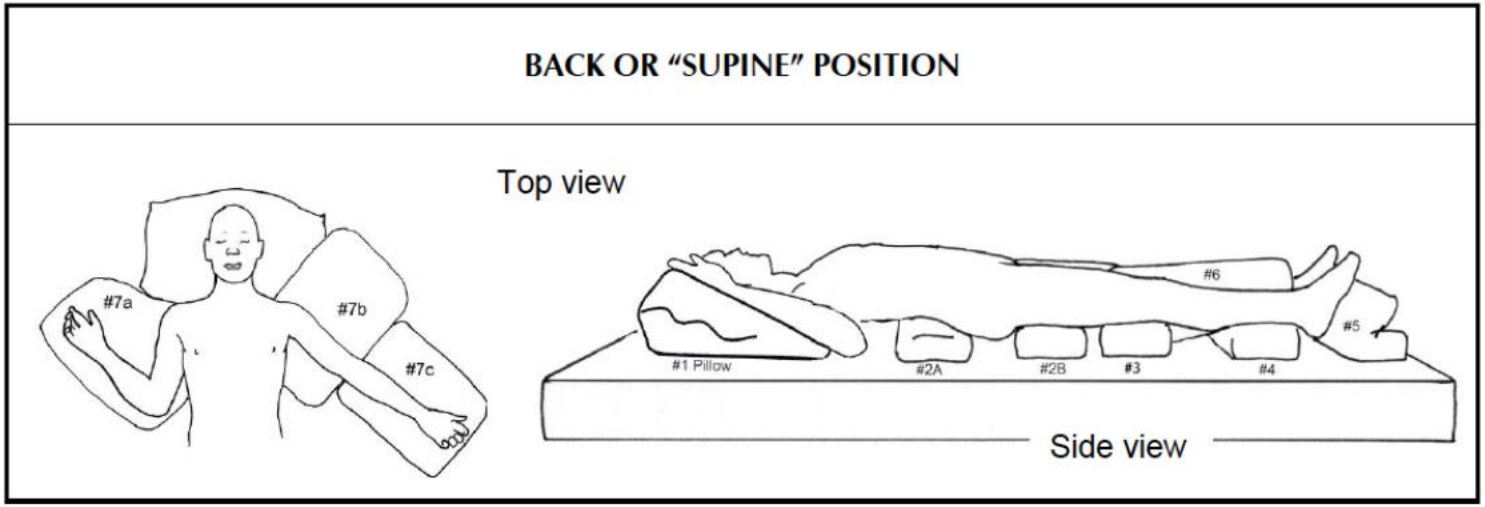
Cifu, D.X., 2021. Braddom's Physical Medicine and Rehabilitation (Sixth Edition). Elsevier., Philadelphia, PA

Rehabilitation program for prolonged immobilization

06.

Positioning

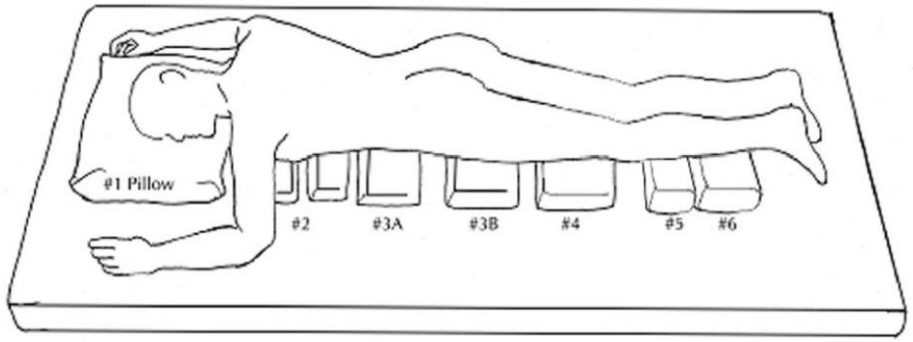
- Aim : to relieve pressure between bones and the surfaces patient's sleep or sit on
- Tools : foam pads or "quad pads," a new pillow, or a new mattress
- Change position every 2 hour



Positioning

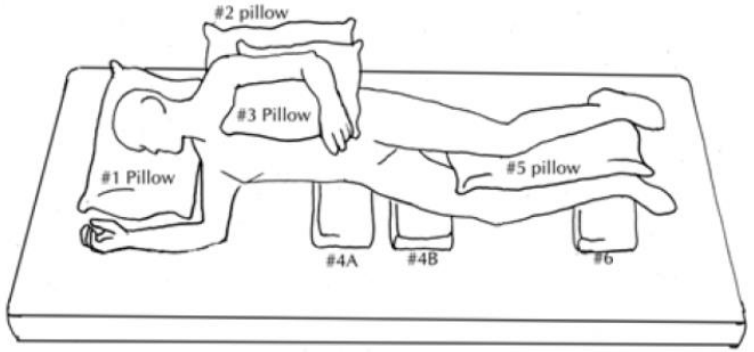
HALF-BACK OR "SEMI SUPINE" POSITION

STOMACH OR "PRONE" POSITION
Do not lay on your stomach if you have trouble breathing

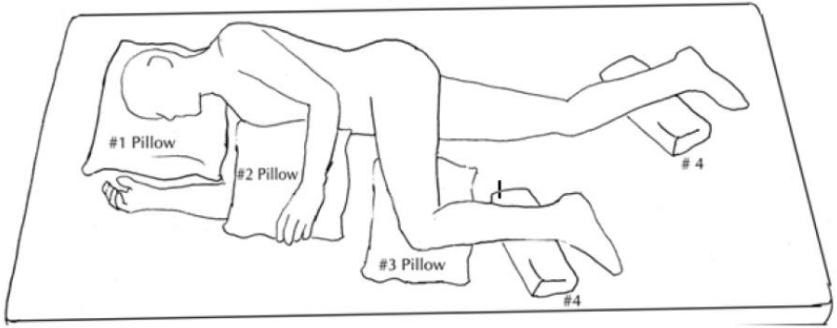


Positioning

SIDE POSITION



¾ STOMACH OR "¾ PRONE" PADDING



Range of Motion exercise

TYPE OF RANGE OF MOTION EXERCISE

Passive ROM	• Passive ROM (PROM) is movement of a segment within the unrestricted ROM that is produced entirely by an external force; there is little to no voluntary muscle contraction. • The external force may be from gravity, a machine, another individual, or another part of the individual's own body. PROM and passive stretching are not synonymous
Active ROM	• Active ROM (AROM) is movement of a segment within the unrestricted ROM that is produced by active contraction of the muscles crossing that joint
Active-assistive ROM	• Active-assistive ROM (A-AROM) is a type of AROM in which assistance is provided manually or mechanically by an outside force because the prime mover muscles need assistance to complete the motion.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

Goals for PROM

- Maintain joint and connective tissue mobility.
- Minimize the effects of the formation of contractures.
- Maintain mechanical elasticity of muscle.
- Assist circulation and vascular dynamics.
- Enhance synovial movement for cartilage nutrition and diffusion of materials in the joint.
- Decrease or inhibit pain.

Goals for AROM

- Maintain physiological elasticity and contractility of the participating muscles.
- Provide sensory feedback from the contracting muscles.
- Provide a stimulus for bone and joint tissue integrity.
- Increase circulation and prevent thrombus formation.
- Develop coordination and motor skills for functional activities.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

BOX 3.1 Summary of Precautions and Contraindications to ROM Exercises

ROM should not be done when motion is disruptive to the healing process.

- Carefully controlled motion within the limits of pain-free motion during early phases of healing has been shown to benefit healing and early recovery.
- Signs of too much or the wrong motion include increased pain and inflammation.
- ROM should not be done when patient response or the condition is life-threatening.
- PROM may be carefully initiated to major joints and AROM to ankles and feet to minimize venous stasis and thrombus formation.
- After myocardial infarction, coronary artery bypass surgery, or percutaneous transluminal coronary angioplasty, AROM of upper extremities and limited walking are usually tolerated under careful monitoring of symptoms.
- Sedative interruption followed by AROM with progression to sitting, standing, and walking may be initiated early on mechanically ventilated patients

Note: ROM is not synonymous with stretching. For precautions and contraindications to passive and active stretching techniques, see Chapters 4 and 5.

- Frequency : 1 – 2 times/day, 3 – 5 days/week
- Repetition : 3 – 5/motion, can be increased

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

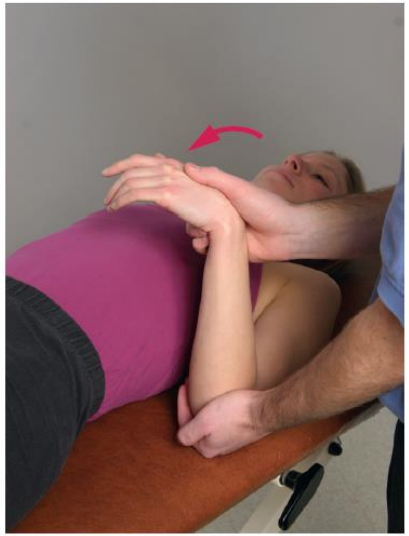


FIGURE 3.10 ROM at the wrist. Shown is wrist flexion; note that the fingers are free to move in response to passive tension in the extrinsic tendons.

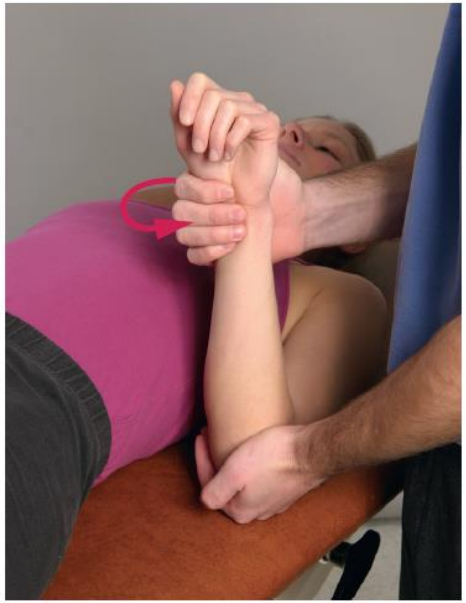


FIGURE 3.9 Pronation of the forearm.

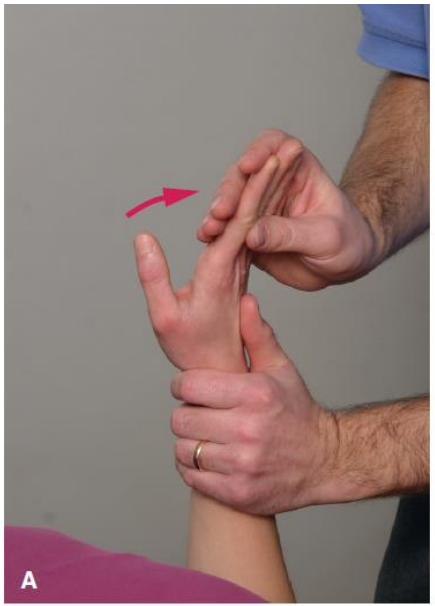


FIGURE 3.13 End of range for the extrinsic finger **(A)** flexors

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

FIGURE 3.7 Elbow **(A)** flexion and **(B)** extension with the forearm supinated.

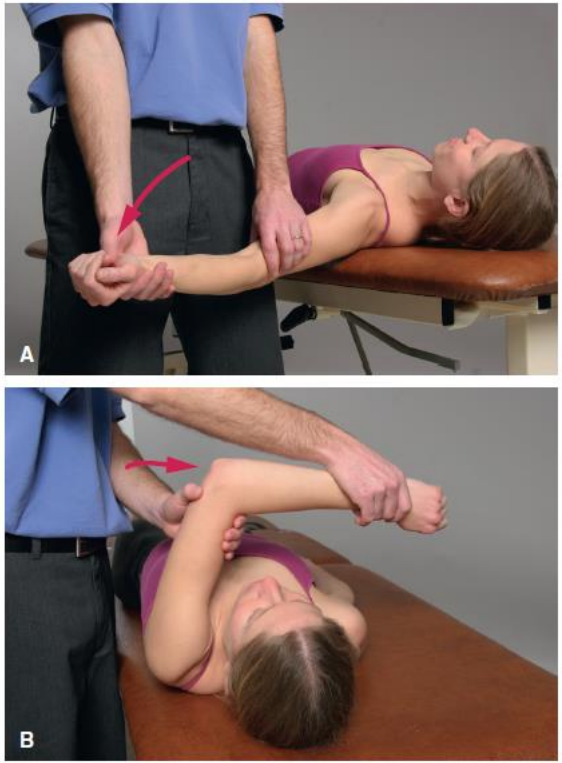


FIGURE 3.5 Horizontal **(A)** abduction and **(B)** adduction of the shoulder.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

FIGURE 3.14—cont'd (B) completing combined hip and knee flexion.

FIGURE 3.16 ROM to the hamstring muscle group.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Range of Motion exercise

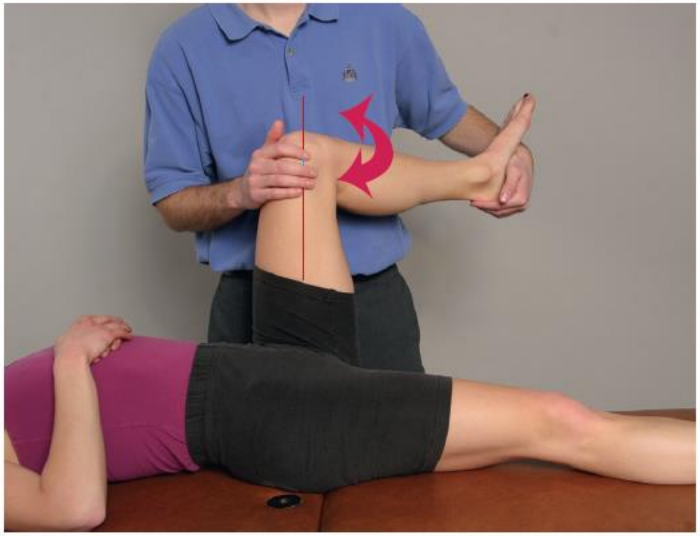


FIGURE 3.18 Rotation of the hip with the hip positioned in 90° of flexion.

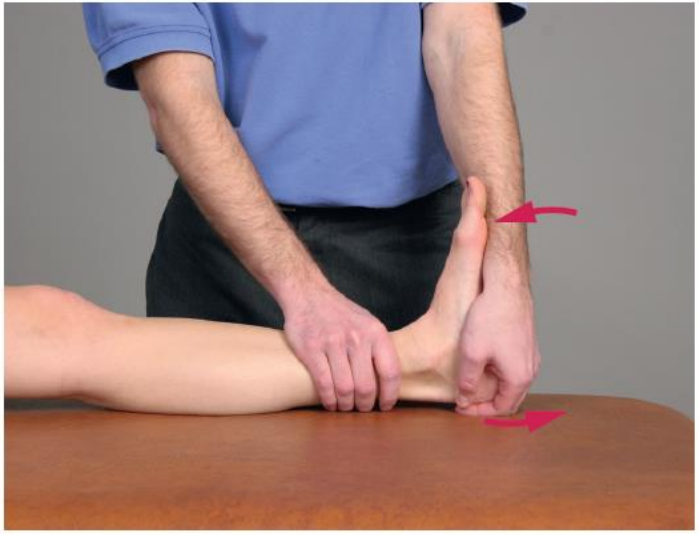


FIGURE 3.19 Dorsiflexion of the ankle.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Stretching exercise

BOX 4.1 Indications for Stretching

- ROM is limited because soft tissues have lost their extensibility as the result of adhesions, contractures, and scar tissue formation, causing activity limitations or participation restrictions.
- Restricted motion may lead to structural deformities that are otherwise preventable.
- Muscle weakness and shortening of opposing tissue have led to limited ROM.
- May be a component of a total fitness or sport-specific conditioning program designed to prevent or reduce the risk of musculoskeletal injuries.
- May be used prior to and after vigorous exercise.

BOX 4.2 Contraindications to Stretching

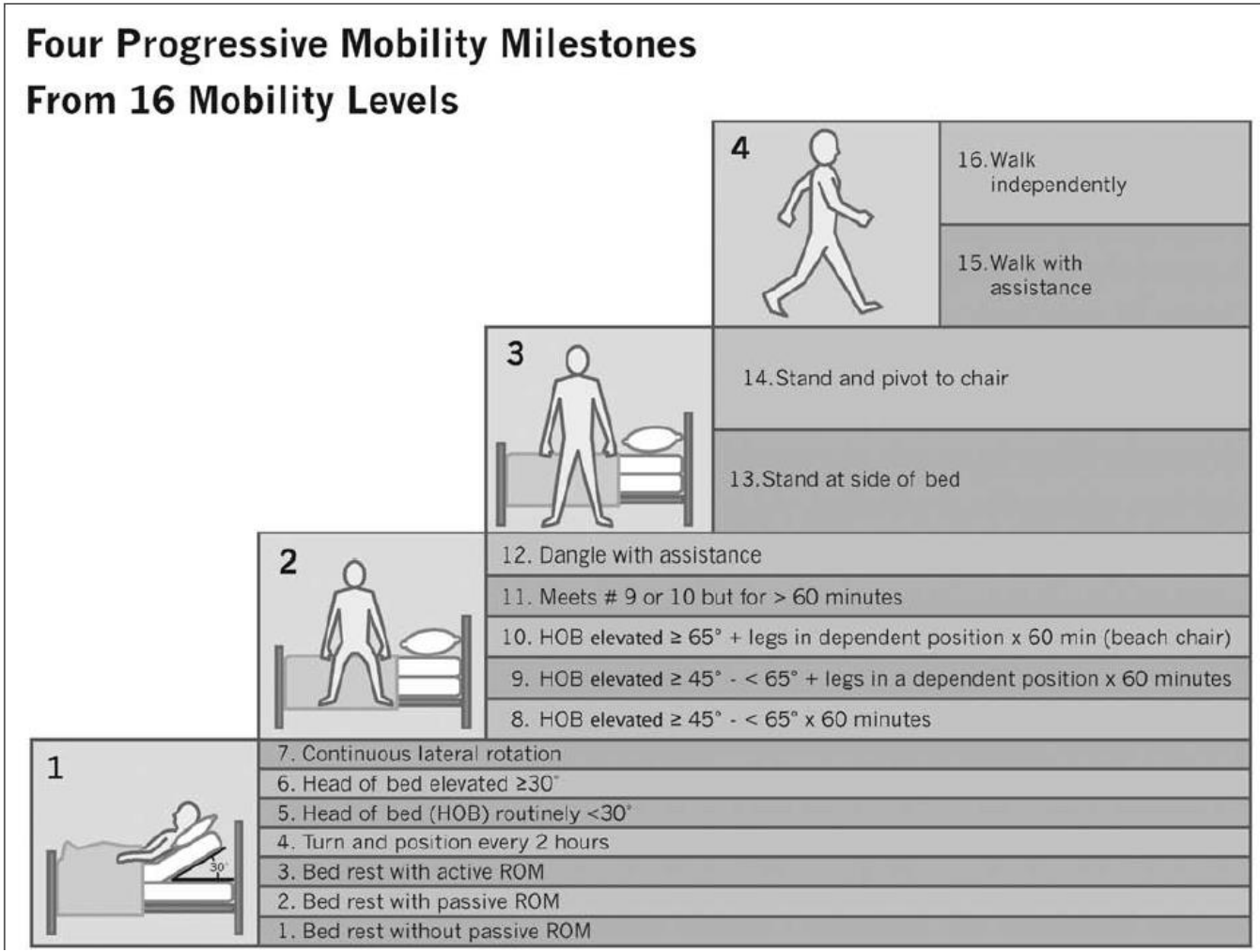
- A bony block limits joint motion.
- There was a recent fracture, and bony union is incomplete.
- There is evidence of an acute inflammatory or infectious process (heat and swelling), or soft tissue healing could be disrupted in the restricted tissues and surrounding region.
- There is sharp, acute pain with joint movement or muscle elongation.
- A hematoma or other indication of tissue trauma is observed.
- Joint hypermobility already exists.
- Shortened soft tissues provide necessary joint stability in lieu of normal structural stability or neuromuscular control.
- Shortened soft tissues enable a patient with paralysis or severe muscle weakness to perform specific functional skills otherwise not possible.

Kisner, C., Colby, L. A., Borstad, J. (2017). Therapeutic Exercise: Foundations and Techniques. United States: F.A. Davis Company.

Clinical and Psychological Effects of Early Mobilization in Patients Treated in a Neurologic ICU: A Comparative Study*

Kate Klein, ACNP-BC, CCRN[1]; Malissa Mulkey, MSN, RN, CCNS, CCRN, CNRN[2]; James F. Bena, MS[3]; Nancy M. Albert, PhD, CCNS, CCRN, FCCM[4]

Four Progressive Mobility Milestones From 16 Mobility Levels



neurocritical care society Neurocrit Care (2017) 27:141–150
DOI 10.1007/s12028-016-0338-7

CrossMark

CURRENT CONCEPTS

Early Mobilization in the Neuro-ICU: How Far Can We Go?

Brian F. Olkowski[1] · Syed Omar Shah[2]

	Level 1	Level 2	Level 3	Level 4
Location	Bed	Bed	Bedside chair	Room
		EOB	Standing	Hallway
Activity	HOB elevation	Bed mobility	Transfer to chair	Walking
	Bed mobility	Sitting EOB	Sitting OOB	
			Standing	
Therapeutic exercise	Passive ROM	Passive ROM	Active ROM	Endurance
	Active ROM	Active ROM	Weight shifting	Dual task
		Reaching		
Functional training	Bed mobility	Bed mobility	Transfers	Gait balance
	Positioning	Posture	Posture	Posture
		Balance	Standing balance	ADL
		ADL	ADL	
Education	Positioning	Positioning	Safety	Safety
	Family training	Safety	Assistive device	Assistive device
		Family training	Family training	Family training
Goal	Upright tolerance	Sitting balance	OOB activity	Strength
			Standing balance	Gait balance
				Endurance

HOB head of bed, *EOB* edge of bed, *OOB* out of bed, *ROM* range of motion, *ADL* activities of daily living

Terima kasih