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Simplified Textbook of Physiotherapy

1

As per the NCAHP Curriculum

Volume I


Fundamentals of Physiotherapy


Human Anatomy and Physiology


Biochemistry


Exercise Therapy


Electrotherapy


Pharmacology


Sociology


AYUSH and Yoga


English and Communication Skills



JAYPEE BROTHERS

Gitesh Amrohit

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36 CHAPTER

Muscle Strength and Techniques of Strengthening Muscles

MUSCLE STRENGTH

Muscle strength is one of the fundamental components of physical fitness and functional performance. In physiotherapy, it plays a crucial role in movement, posture, stability, and overall health. Strength enables the body to overcome resistance, perform daily activities efficiently, and prevent injuries. A deficit in muscle strength can lead to **functional limitations, joint instability,** and **impaired coordination**.

It is a vital determinant of human movement, posture, and health. It reflects the **ability of the neuromuscular system** to generate and sustain force efficiently. Through **regular, progressive, and well-designed strength training,** muscles adapt structurally and functionally—improving performance, stability, and quality of life.

Physiotherapists assess, maintain, and improve muscle strength through various **exercise interventions, therapeutic techniques,** and **progressive resistance training** programs tailored to individual needs.

In physiotherapy, the restoration of muscle strength is not merely about building power but ensuring **functional recovery, injury prevention,** and **sustainable movement efficiency** across all stages of rehabilitation.

Definition

Muscle strength is the maximum amount of force that a muscle or muscle group can generate during a single maximal voluntary contraction against resistance.
—American College of Sports Medicine (ACSM)

In simpler terms, it is the **capacity of a muscle to exert tension or force** to overcome resistance, whether that resistance comes from gravity, body weight, or external loads.

Physiological Basis of Muscle Strength

Muscle strength depends on several **neuromuscular and structural factors** that determine how effectively a muscle can generate force.

- **Muscle fiber composition:**
  - Muscles consist of two main types of fibers:
    i. *Type I (Slow-twitch) fibers:* High endurance, low power output, fatigue-resistant (used in postural and aerobic activities).
    ii. *Type II (Fast-twitch) fibers:* High power, low endurance, quickly fatigued (used in sprinting, jumping, lifting).
  - Individuals with a higher proportion of **fast-twitch fibers** tend to have greater potential for strength.
- **Cross-sectional area of muscle:**
  - The greater the **muscle cross-sectional area,** the higher the potential force.
  - **Hypertrophy** (increase in muscle size) results from resistance training, which enlarges individual muscle fibers.
- **Motor unit recruitment:**
  - A **motor unit** consists of a motor neuron and the muscle fibers it controls.
  - Strength increases when more motor units are recruited and fired in synchronization, improving muscle contraction efficiency.
- **Neural adaptation:**
  - Early strength gains in training are often due to improved **neuromuscular coordination** rather than muscle growth.

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  - *This includes:*
    - Enhanced motor unit recruitment.
    - Better synchronization.
    - Reduced inhibitory reflexes.
- **Muscle length-tension relationship:** Muscle generates maximum force at its **optimal resting length**—neither too stretched nor too shortened.
- **Energy systems:**
  - **ATP-CP system (phosphagen system)** provides immediate energy for short, powerful efforts (e.g., weight lifting).
  - Adequate ATP availability and metabolic efficiency are vital for maximal muscle strength.

Determinants of Muscle Strength

Determinant	*Effect on strength*
Muscle size and cross-sectional area	Larger muscles produce greater force
Fiber type distribution	More Type II fibers increase power
Neural activation	Improves coordination and recruitment
Muscle length	Optimal length produces maximum force
Joint angle	Strength varies through the range of motion
Age and sex	Strength decreases with age; males generally have higher absolute strength due to muscle mass
Training level	Progressive resistance increases strength
Motivation and psychological factors	Affect effort and consistency

Principles of Strengthening

The effectiveness of any strengthening program depends on following certain fundamental principles:

- **Principle of overload:** To strengthen a muscle, it must be challenged to perform at a level **greater than it is accustomed to**. This can be achieved by increasing:
  - *Resistance (load):* E.g., adding weights or using resistance bands.
  - *Repetitions or sets:* increasing the number of contractions.
  - *Speed of movement:* introducing power or plyometric training.
  - *Duration or frequency:* more sessions or longer exercise periods.

  Example: If a patient can lift 2 kg easily, the therapist may increase it to 3 kg or add more repetitions to create an overload.
- **Principle of specificity (SAID principle):** The **Specific Adaptation to Imposed Demands (SAID)** principle states that muscles adapt specifically to the type of stress or exercise imposed on them.
  - Strength training improves **muscle strength**.
  - Endurance training improves **muscle stamina**.
  - Power training improves **speed and force of contraction**.

  Example: Training for stair climbing should mimic the same movement pattern to achieve functional carryover.
- **Principle of progression:** To continue gaining strength, the intensity of exercise must be **gradually and systematically increased** over time.
  - Begin with low resistance and progress to higher loads as the muscle adapts.
  - Sudden large increases may cause fatigue or injury.

  Example: Increasing weight by 5–10% every 1–2 weeks is considered a safe progression.
- **Principle of reversibility (use it or lose it):** The strength gains achieved through training are **not permanent**. When training stops, the muscles begin to lose strength—a process known as **detraining**.
  - Decrease in muscle size, strength, and endurance may occur within 2–3 weeks of inactivity.

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  - Regular maintenance exercises are necessary to sustain improvements.
- **Principle of individualization:** Each individual responds differently to a strengthening program depending on factors such as:
  - Age and gender
  - Muscle fiber composition
  - Fitness level and health status
  - Motivation and compliance

  Physiotherapists must design **personalized programs** based on these differences to achieve optimal results.
- **Principle of Warm-up and Cool-down:** Proper **warm-up** prepares muscles, joints, and the cardiovascular system for exercise, while **cool-down** prevents muscle soreness and promotes recovery.
  - *Warm-up:* 5–10 minutes of light aerobic activity and dynamic stretching.
  - *Cool-down:* Gentle stretching and breathing exercises to restore resting levels.
- **Principle of specificity of velocity:** Muscle strength gains are **velocity-specific,** meaning that training at a certain speed of movement improves strength at that particular speed.

  Example: Slow, controlled lifting improves static strength, while fast, explosive movements enhance power.
- **Principle of range of motion (ROM):** Strengthening exercises should be performed through the **complete, pain-free range of motion** to ensure full functional improvement. Partial range exercises may be used initially in post-injury or post-surgical conditions.
- **Principle of functional integration:** Strengthening should focus on **functional movement patterns** rather than isolated muscle actions. The goal is to translate strength gains into improved daily activity and performance.

  Example: Training squats improves standing and sitting functions better than isolated knee extensions.
- **Principle of recovery and rest:** Muscles need adequate time to **recover and rebuild** after strengthening sessions. Overtraining without sufficient rest leads to fatigue, injury, and reduced performance.
  - Minimum of **48 hours** rest between intense sessions for the same muscle group.
  - Incorporate rest days and sleep for optimal adaptation.

Measurement of Muscle Strength

Muscle strength can be **quantitatively** or **qualitatively** assessed using standardized tools and tests.

- **Manual muscle testing (MMT):** It is a Common clinical method for assessing individual muscle strength. This test is used to assess strength of Muscles in cases of LMN injuries.

  Grades muscle power on a **0–5 scale:**

Grade	*Description*
0	No contraction
1	Trace contraction
2	Movement possible in gravity-eliminated position
3	Movement possible against gravity
4	Movement possible against moderate resistance
5	Normal strength (full resistance)

- **Dynamometry:**
  - **Hand-held dynamometers** measure force output in kilograms or Newtons.
  - Provides **objective and reproducible** data.
- **Isokinetic testing:**
  - Uses machines that maintain a constant speed of movement (e.g., **Cybex, Biodex**).
  - Measures **peak torque** and **power** throughout the range of motion.
- **1 Repetition maximum (1RM) test:**
  - Measures the **maximum load** an individual can lift once with proper technique.

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  - Commonly used in sports and resistance training.
- **Functional strength tests:**
  - Evaluate how strength translates into **daily or athletic activities**.
    Examples:
    - Sit-to-stand test.
    - Step-up test.
    - Grip strength test.
    - Timed up and go (TUG) test.

Classification of Muscle Strength Exercises

1. Isometric exercises
2. Isotonic exercises
3. Isokinetic exercises
4. Open chain exercises
5. Closed chain exercises

Factors Affecting Muscle Strength

- **Age:** Peak strength in 20s–30s; declines with aging due to muscle mass reduction (sarcopenia).
- **Sex:** Males have greater absolute strength; females have comparable strength relative to body weight.
- **Physical activity level:** Regular resistance training enhances strength and endurance.
- **Nutrition:** Adequate protein and energy intake are necessary for muscle synthesis.
- **Hormonal influence:** Testosterone, growth hormone, and insulin-like growth factors promote muscle hypertrophy.
- **Fatigue:** Reduces muscle's ability to generate force temporarily.
- **Injury or immobilization:** Leads to muscle atrophy and decreased strength.
- **Motivation:** Psychological state influences exertion and performance.

Physiotherapy Interventions to Improve Muscle Strength

- **Progressive resistance exercise (PRE):**
  - Involves gradually increasing resistance as the muscle adapts.
  - *Common methods:*
    - DeLorme method: Starts at 50% of 10RM and progresses to 100%.
    - Oxford method: Begins at 100% of 10RM and decreases resistance gradually.
    - MacQueen method: Progressive loading over multiple sets.
    - DAPRE
- **Circuit training:** Combines strength and endurance exercises targeting multiple muscle groups in sequence.
- **Functional strength training:** Integrates resistance exercises with real-life activities (lifting, climbing, reaching).
- **Neuromuscular electrical stimulation (NMES):** Electrical impulses stimulate muscle contraction, used in cases of weakness or paralysis.
- **Isokinetic training:** Maintains a constant speed and variable resistance to enhance strength uniformly across the range of motion.

Adaptations to Strength Training

Adaptation	*Effect*
Neural adaptation	Improved recruitment and firing of motor units
Hypertrophy	Increase in muscle fiber size
Increased enzyme activity	Enhanced energy production for contraction
Improved connective tissue strength	Better tendon and ligament support
Enhanced bone density	Reduced risk of osteoporosis
Improved posture and coordination	Better functional performance

Clinical Importance

- Restores function after injury or surgery.
- Prevents muscle atrophy during immobilization.
- Enhances joint stability and postural control.
- Improves performance in athletes and active individuals.

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- Reduces risk of falls in elderly populations.
- Aids in chronic disease management (e.g., diabetes, arthritis, stroke).

TECHNIQUES OF STRENGTHENING MUSCLES

Introduction

- **Muscle strengthening** is an essential component of physiotherapy aimed at improving **muscle power, endurance, tone, and functional capacity**.
- Various **equipment's and tools** are used to provide **resistance or load,** which stimulates muscle fibers to adapt and become stronger.

The choice of equipment depends on:

- The **muscle group** being trained,
- The **stage of rehabilitation,**
- The **type of exercise** (isometric, isotonic, or isokinetic), and
- The **patient's condition and goals** (rehabilitation vs fitness).

Classification of Equipments Used in Muscle Strengthening

Equipment's can be broadly **categorized as:**

1. Manual Resistance Devices

a. Therapist's manual resistance:

- *Description:* The therapist provides external resistance using hands during movement.
- *Use:* Ideal for early rehabilitation when strength is low.
- *Advantages:* Resistance can be adjusted instantly; allows control and feedback.
- *Example:* Manual muscle testing positions used as exercises.

b. Weighted cuffs:

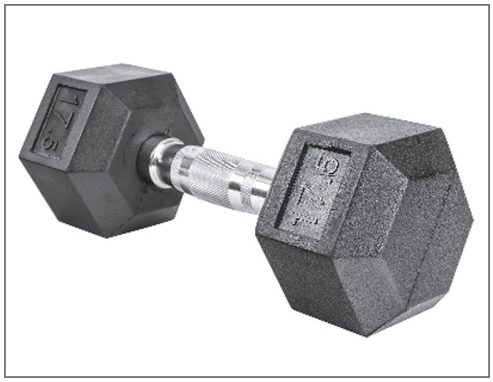
- *Description:* Small adjustable cuffs filled with sand or metal granules strapped to limbs.
- *Use:* Strengthens arms or legs during isotonic exercises.
- *Advantages:* Portable, inexpensive, progressive resistance possible.
- *Example:* Ankle cuff for knee extension exercise.



2. Mechanical or Weight-based Equipments

a. Dumbbells:

- *Description:* Short bars with fixed or adjustable weights at each end.
- *Use:* Strengthens upper limb muscles (biceps, triceps, deltoids).
- *Type:* Fixed-weight or adjustable dumbbells.
- *Advantage:* Simple, easy progression by changing weight load.



b. Barbells:

- *Description:* Long metal bars with weight plates on both ends.

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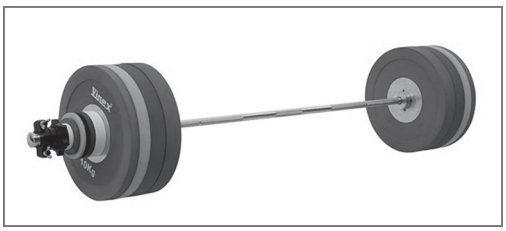
- *Use:* Strengthening large muscle groups (quadriceps, pectorals, back extensors).
- *Example:* Squats, bench press, deadlifts.



c. Weight machines (Pulley systems):

- *Description:* Machine with stack weights connected via pulleys to adjustable handles or levers.
- *Use:* Isotonic and controlled strengthening.
- *Examples:*
  - Lat pulldown
  - Leg press
  - Seated row
  - Cable crossover
- *Advantage:* Resistance can be changed easily; safer for beginners.



d. Resistance benches and multi-gyms:

- *Description:* Adjustable benches or integrated gym systems with cables and levers.
- *Use:* Full-body strengthening in clinical or gym settings.
- *Example:* Chest press, leg curl, abdominal crunches.



e. Medicine balls:

- *Description:* Weighted rubber or leather balls of varying weights (1–10 kg).
- *Use:* Functional strengthening, power, and coordination exercises.
- *Example:* Overhead throws, trunk rotations.



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3. Elastic Resistance Devices

a. Therabands/resistance bands:

- *Description:* Flat or tubular elastic bands of different color-coded resistance levels.
- *Use:* Progressive resistance training for all muscle groups.
- *Advantages:* Lightweight, portable, safe for patients recovering from injury.
- *Example:* Shoulder external rotation, hip abduction.



Resistance of different elastic resistance devices:

Color	*Resistance level*	*Approx. Resistance 100% elongation (lbs/kg)*	*Approx. Resistance 200% elongation (lbs/kg)*	*Typical use/patient group*
Yellow	Extra light	2.0 lbs/0.9 kg	3.0 lbs/1.4 kg	For beginners, elderly, or post-surgery patients—early rehabilitation stage
Red	Light	2.5 lbs/1.1 kg	3.7 lbs/1.7 kg	Early to mid-stage rehab, for small muscle groups (shoulders, wrists)
Green	Medium	3.0 lbs/1.4 kg	4.6 lbs/2.1 kg	Intermediate strength level, used for upper and lower limb exercises
Blue	Heavy	4.0 lbs/1.8 kg	5.8 lbs/2.6 kg	For general strengthening of large muscles (legs, chest, back)
Black	Extra heavy	6.5 lbs/2.9 kg	9.5 lbs/4.3 kg	Advanced strengthening, athletic training
Silver	Super heavy	10.0 lbs/4.5 kg	15.0 lbs/6.8 kg	High-level conditioning and sports rehab
Gold	Max heavy	14.2 lbs/6.4 kg	21.3 lbs/9.7 kg	Elite and power training—not for clinical beginners

b. Resistance tubes:

- *Description:* Elastic tubes with handles on both ends.
- *Use:* Suitable for dynamic strengthening and endurance training.
- *Example:* Chest press, bicep curls, squats with bands.

4. Body Weight and Functional Tools

a. Suspension trainers (e.g., TRX system):

- *Description:* Straps anchored overhead allowing body-weight resistance in multiple planes.
- *Use:* Functional strengthening and proprioceptive control.

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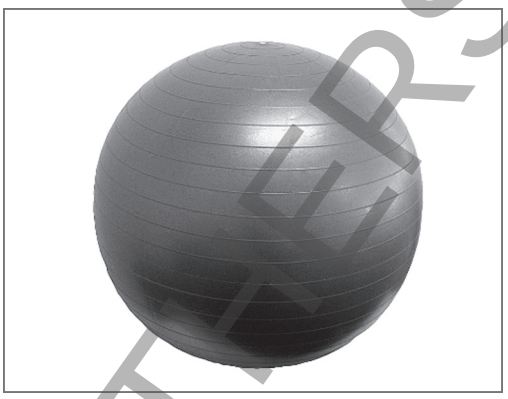
- *Example:* Push-ups, rows, squats, core stability exercises.

b. Swiss ball/stability ball:

- *Description:* Large inflatable ball used to challenge balance and core muscles.
- *Use:* Improves stability, coordination, and dynamic strength.
- *Example:* Wall squats, bridges, push-ups on ball.



Application of different diameter balls:

Ball diameter (cm)	*User height range (cm)*	*User height range (ft/in)*	*Recommended use/application*
45 cm	Up to 140 cm	Up to 4′7″	Children, small adults, or seated balance training
55 cm	140–160 cm	4′7″–5′3″	Teenagers or short adults; core and flexibility exercises
65 cm	160–180 cm	5′3″–5′11″	Average adults; general strengthening, posture training
75 cm	180–200 cm	5′11″–6′7″	Tall adults; advanced stability and strengthening exercises
85 cm	Over 200 cm	Over 6′7″	Very tall individuals; or for exercises requiring greater height/stability base

c. Parallel bars:

- *Description:* Fixed bars allowing partial weight-bearing exercises.
- *Use:* Gait training and lower limb strengthening in early rehabilitation.

d. Step platforms:

- *Description:* Raised platform for performing step-ups or lunges.
- *Use:* Functional lower limb strengthening (quadriceps, gluteals, calves).

e. Wall bars/stall bars:

- *Description:* Wooden or metal bars fixed to wall for stretching or strengthening support.
- *Use:* Assists trunk and limb strengthening with controlled movement.



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5. Electronic and Isokinetic Devices

a. Isokinetic dynamometer (e.g., Cybex, Biodex)
b. Functional electrical stimulation (FES)
c. Electromechanical resistance machines

6. Hydrotherapy and Suspension Systems

a. Water resistance (hydrotherapy pool):
- *Description:* Water provides uniform resistance and buoyancy reduces joint stress.
- *Use:* Ideal for early-stage strengthening and joint mobilization.
- *Example:* Walking, kicking, or arm movements in pool.

b. Suspension therapy equipment:
- *Description:* Slings, ropes, and pulleys support limbs for partial or full suspension.
- *Use:* Allows graded resistance and controlled movement in weak patients.
- *Example:* Sling exercises for shoulder and hip rehabilitation.

7. Small Accessories Used for Muscle Strengthening

Equipment	*Use/target area*
Hand grip strengthener	Strengthens forearm and finger flexors
Ankle weights	Lower limb resistance exercises
Weighted vest	Adds load during functional tasks
Sand bags	Simple adjustable resistance
Foam rollers	Improves core stability and flexibility
Balance boards	Functional strengthening and proprioception

Selection criteria for strengthening equipment: When selecting equipment for a patient, physiotherapists consider:
- **Stage of recovery:** Acute → Subacute → Chronic.
- **Type of contraction required:** Isometric, isotonic, isokinetic.
- **Muscle group involved:** Small vs large muscle groups.
- **Patient factors:** Age, endurance, motivation, comorbidities.
- **Safety and supervision level:** Independent or therapist-assisted exercise.
- **Availability and cost:** Clinical or home-based setup.

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Simplified Textbook of Physiotherapy

Salient Features

- Offers comprehensive coverage of the fundamental concepts and core principles underpinning physiotherapy practice.
- Presents human anatomy, physiology, and biochemistry in a simplified and clinically relevant manner.
- Explains the principles, techniques, indications, and applications of exercise therapy and electrotherapy.
- Introduces essential pharmacological concepts relevant to safe and effective physiotherapy practice.
- Integrates sociology, AYUSH, and yoga to promote holistic and patient-centered rehabilitation.
- Strengthens English, communication, interpersonal, and professional skills required for effective clinical practice.
- Promotes early clinical reasoning by linking theoretical concepts with therapeutic decision-making.

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ISBN 978-81-6799-996-2