



Mid-Term Evaluation

Continuous Passive Motion (CPM) Machine for Ankle Rehabilitation

DFP-88

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Introduction

What is a Continuous Passive Motion (CPM) Machine?

- Therapeutic Device
- Designed to move a joint
- Controlled Range of Motion
- Not Require any efforts from patient
- Used in Rehabilitation after injuries or surgeries
- Improves joint function

Key Features of CPM Machines

Gentle Movement

Provides slow and gentle movements to prevent stiffness and promote circulation in the affected joint.

Programmable Settings

Allows healthcare providers to program the machine to gradually increase the range of motion over time for tailored rehabilitation.

Non-Invasive Therapy

Offers a non-invasive method of therapy that can be used alongside other treatments, such as physical therapy.

Common Applications

- Post-Surgery Recovery
- Injury Rehabilitation
- Chronic Conditions



Key Insights on Active and Passive Recovery in Ankle Rehabilitation [11]

Combination of Active and Passive Training:

- Many rehabilitation devices allow switching between active and passive training modes to adapt to the patient's recovery stage.
- Combining both modes ensures comprehensive rehabilitation from muscle relaxation to strength building.

Objective Feedback and Evaluation:

- Modern devices, especially robotic systems, record precise data (e.g., motion angles, torque) during both active and passive training to assess recovery progress.

Challenges in Traditional Methods:

- Active and passive recovery exercises require significant effort and supervision by therapists, leading to inefficiencies and therapist fatigue.
- Rehabilitation robots aim to address this by automating passive exercises and supporting active recovery.

Design Implications:

- Devices need to offer seamless transitions between active and passive modes with clear customization to suit individual patient needs.
- Safety and comfort are crucial, particularly in passive systems, to prevent secondary injuries.



User Study Findings

*questionnaires & semi-structured interviews

Participant Demographics

- 20 patients (aged 22–55)
- 4 physiotherapists (experience: 2–10 years)

Rehabilitation Challenges

60% of patients found it hard to perform consistent rehabilitation exercises at home due to pain or lack of guidance.

80% of physiotherapists reported non-compliance as the biggest hurdle in rehabilitation success.

Device Preferences

85% of patients prioritized comfort during use.

75% of patients preferred a portable and home-friendly design.

70% of physiotherapists considered adjustability in motion range critical.

Features Ranking

Patients

1. Comfort padding
2. Adjustable motion settings
3. Ease of use
4. Progress tracking

Concerns

Patients:

50% cited concerns about cost.

30% were worried about setup complexity.

Physiotherapists:

40% emphasized the need for fail-safes to prevent overextension during unsupervised use.



Stakeholder Verbatims

I'm worried about the price—most devices are too expensive.

Adjustable motion settings are essential; every patient's recovery path is different.

If I could track my progress visually, I'd feel more motivated to continue.

A comfortable, easy-to-use device that I can use at home would be a game-changer.

I often skip my exercises because they're painful and hard to keep track of without supervision.

Portability would make it easier to integrate into both home and clinic settings.

Safety is a top concern. Unsupervised use should not lead to overstrain or injury.

Patients often struggle with consistency, so a progress tracker could help keep them on track



Insight Synthesis

Pain Points in Rehabilitation:

- Lack of supervision and guidance leads to inconsistent exercise routines among patients.
- Physiotherapists struggle with ensuring compliance in home-based rehabilitation programs.

User Priorities:

- Comfort is the most critical factor for patients, followed by ease of use.
- Physiotherapists emphasize the need for adjustable motion ranges and safety features.

Feature Opportunities:

- Progress tracking (e.g., through a mobile app or display) is a desired feature to enhance engagement.
- Portability is valued equally by patients and physiotherapists for flexibility in usage.

Concerns to Address:

- Cost remains a significant barrier for patients, requiring consideration during the design phase.
- Setup complexity should be minimized to ensure adoption by a wide range of users.

Safety and Usability:

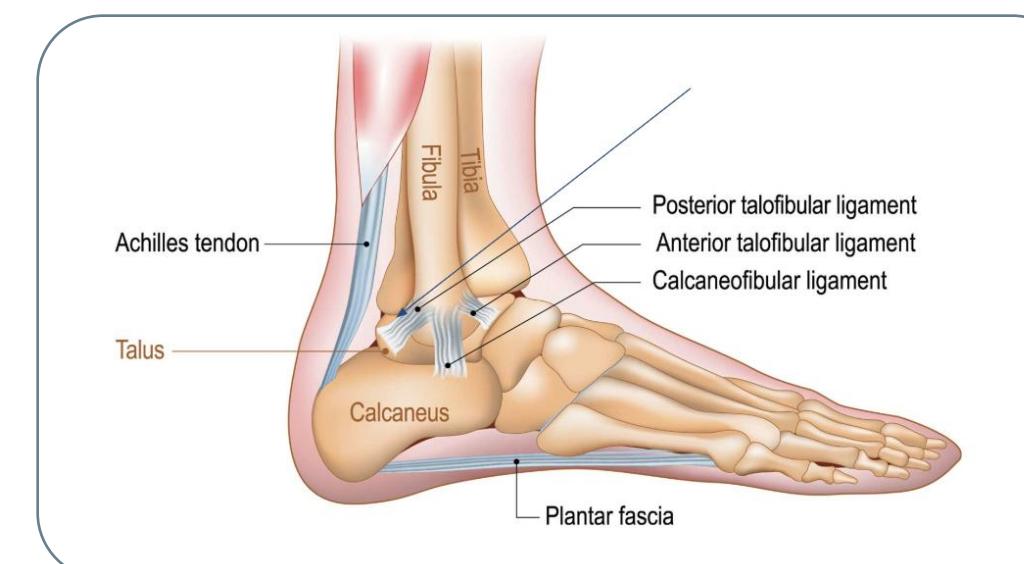
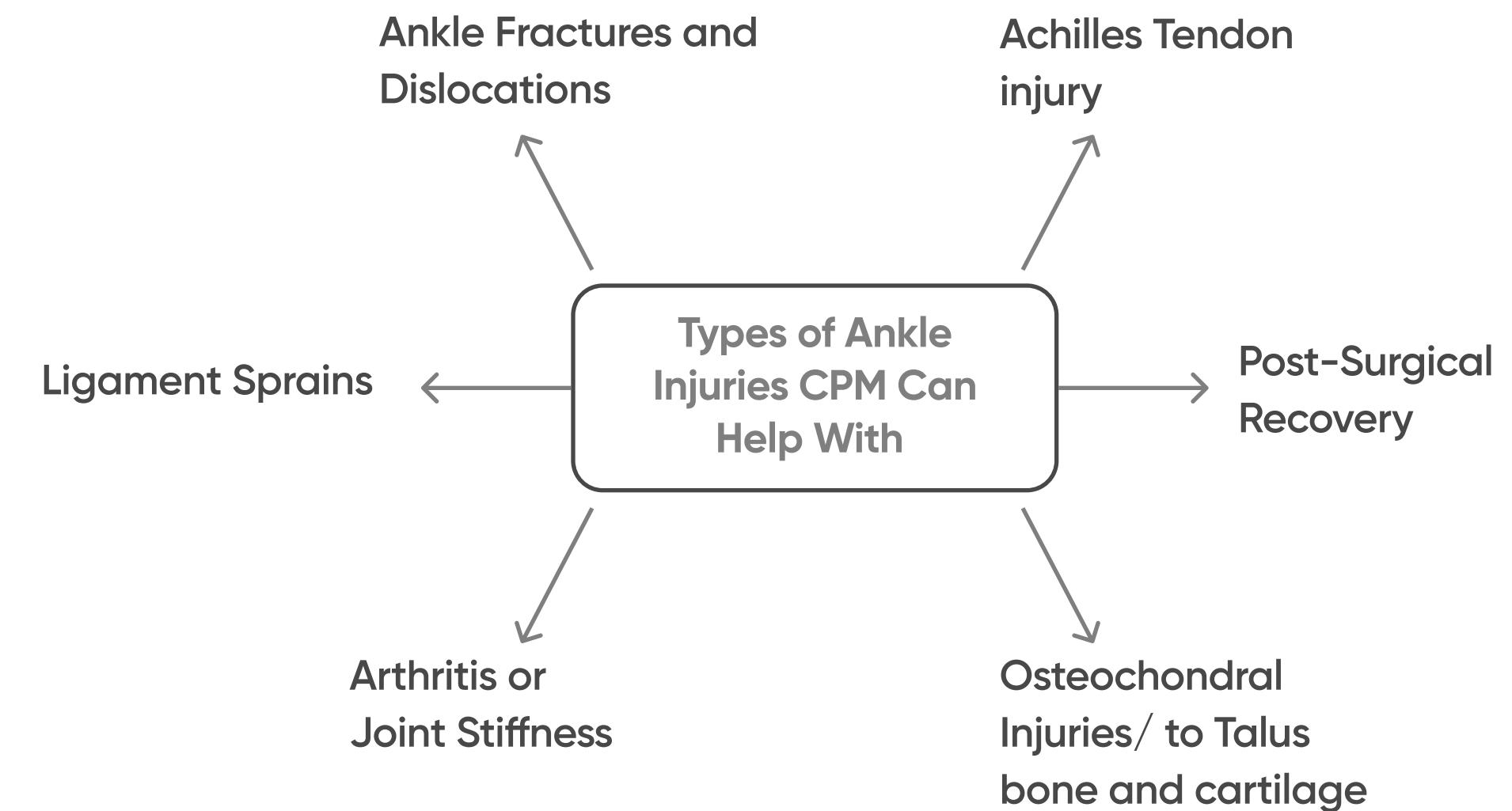
- Safety features, such as auto-stop to prevent overextension, are necessary for unsupervised usage at home.



Common Complications After Surgeries or Injuries & Role of Continuous Passive Motion (CPM)

Common Complications	How CPM helps ?
Joint Stiffness	Provides controlled and gradual movement
Muscle Atrophy	Encourages early activity without active effort
Scar Tissue Formation	Promotes tissue remodeling
Pain & Swelling	Improves circulation and reduces inflammation
Delayed Recovery	Enhancing flexibility and healing Faster recovery

[1]





Comparison of CPM with Other Rehabilitation Methods

Aspects	Continuous Passive Motion [2]	Physical Therapy	Active Exercises
Effort Required	No active effort from the patient.	Requires patient participation and efforts of therapist.	High patient involvement.
Suitability	Post-surgery or injury with limited mobility. (3 days after the injury)	All stages of recovery, personalized.	Intermediate/advanced stages of recovery.
Scar Tissue Prevention	Effective due to continuous, gentle motion.	Moderate; depends on exercise intensity.	Effective if performed consistently.
Pain Management	Gentle movement reduces pain and swelling.	Effective with proper techniques.	Painful if joints are stiff. And patient don't know the proper techniques.
Cost [3] [India Mart]	₹500 - ₹1,000/day (rental) or ₹30,000 - ₹1,50,000 (purchase of device).	₹500 - ₹3,500 per session. A typical recovery might require 20–40 sessions	Minimal cost if done at home; gym memberships may cost ₹1,000 - ₹3,000/month.
Recovery Speed	Speeds recovery in early stages.	Effective across all stages.	Moderate, depends on patient's ability.



Market Analysis

Reference : [4]

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Historical Range : 2018 - 2022

Forecast Period : 2024 - 2030

Growth Rate

Global - 6.2%

India - 5.3%

Market Size in 2024 (USD MILLION)

Global - 766

India - 53

Market Size in 2033 (USD MILLION)

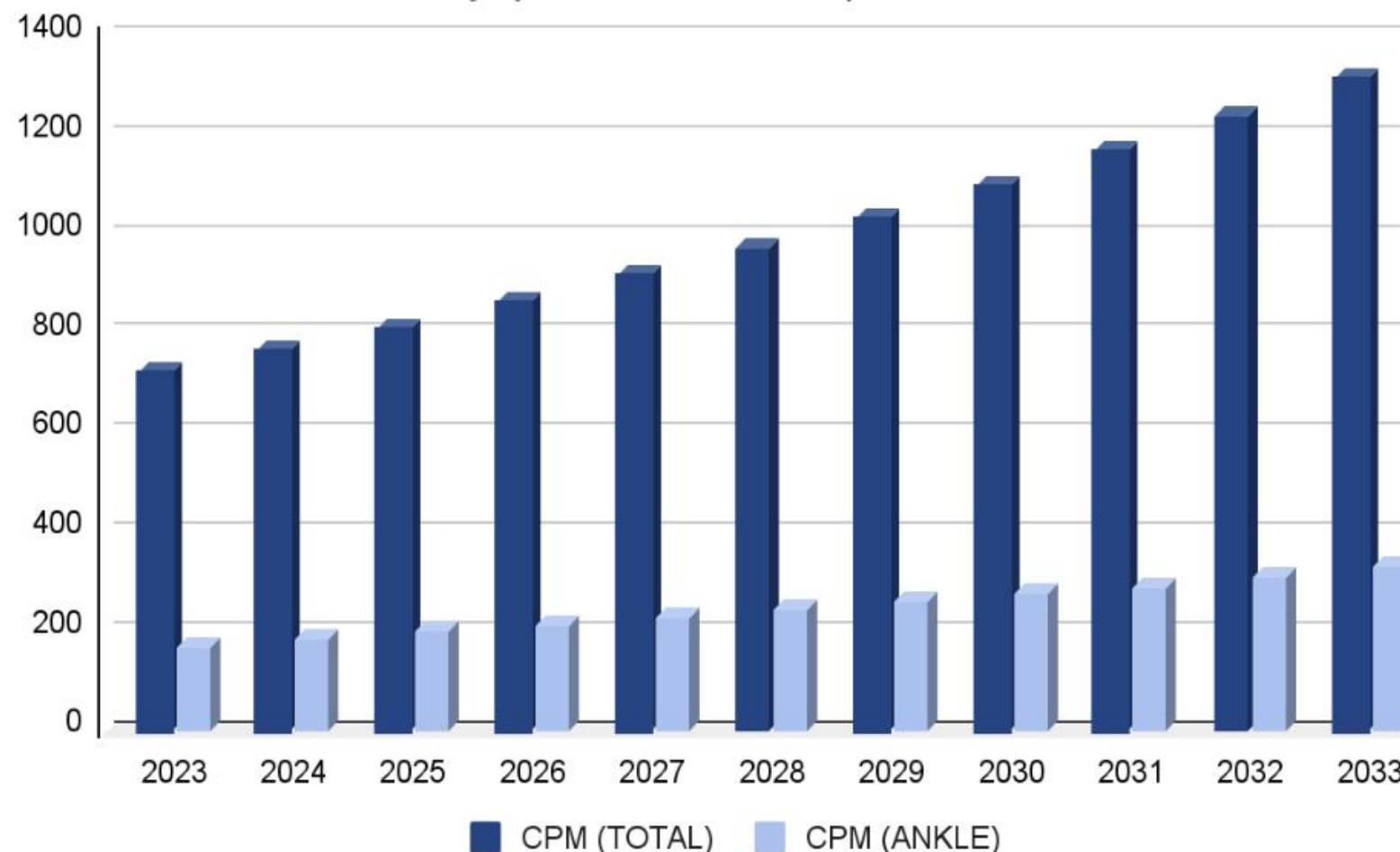
Global - 1316

India - 92

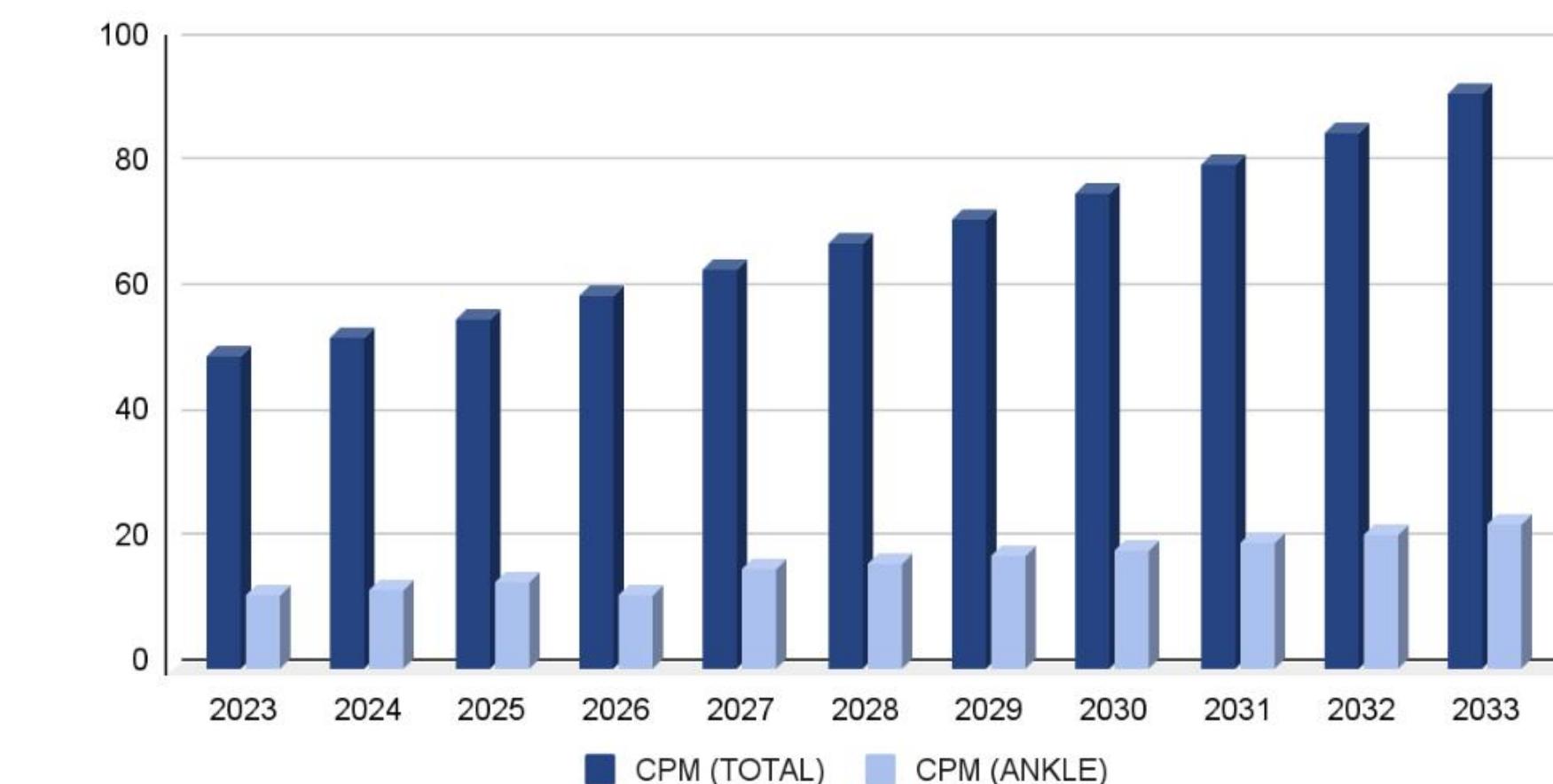
Growth Rate (Global > India)

- Limited Awareness
- High Cost
- Low Adoption of Technology
- Healthcare system strain

Key Features of CPM Machines



Key Features of CPM Machines





Market Analysis

73.5% of athletes reported chronic ankle instability. [10]

Incidence of Ankle Sprains in General Population
(rate per 1000 person-years) - **3.29** [12]

Chronic ankle Instability has high prevalence in spots like -

- Soccer (61%)
- Basketball (65%)
- Volleyball (46%)
- Netball (46%)
- Baseball (34%) and
- Badminton, tennis, sprinting, golf, wrestling (10-20%). [10]

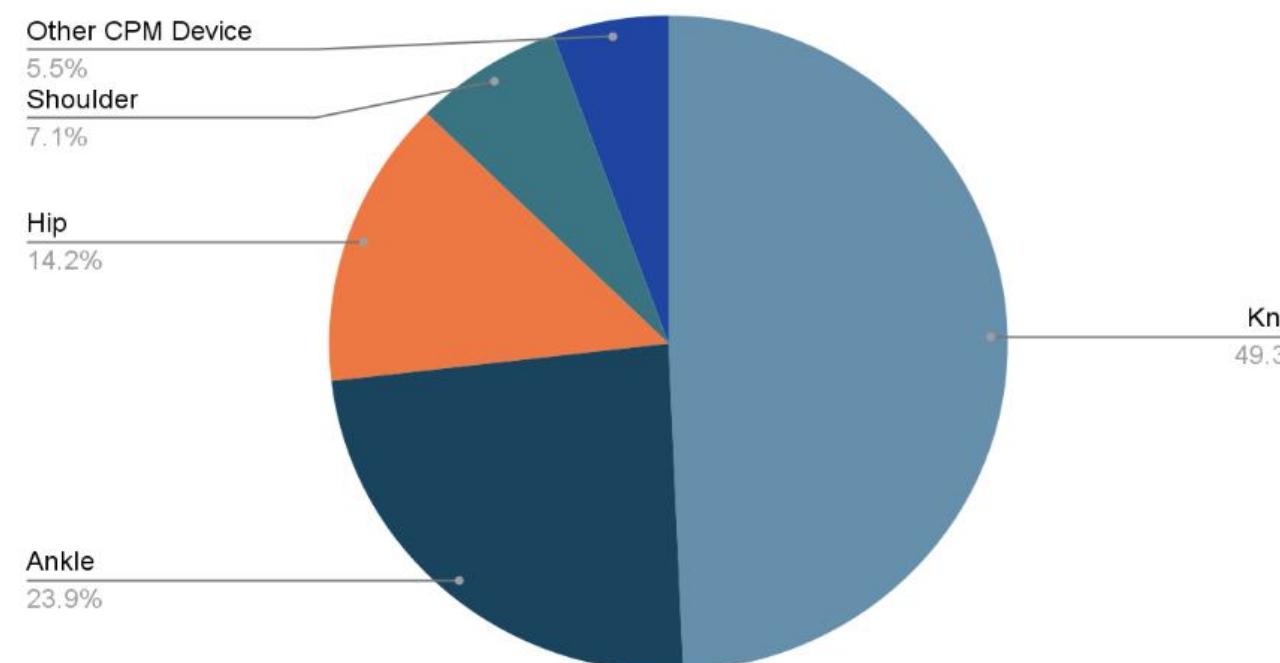
Market Segments of Different CPMs

Knee - 50% Hip - 14.2%
Ankle - 24% Shoulder - 7.1%

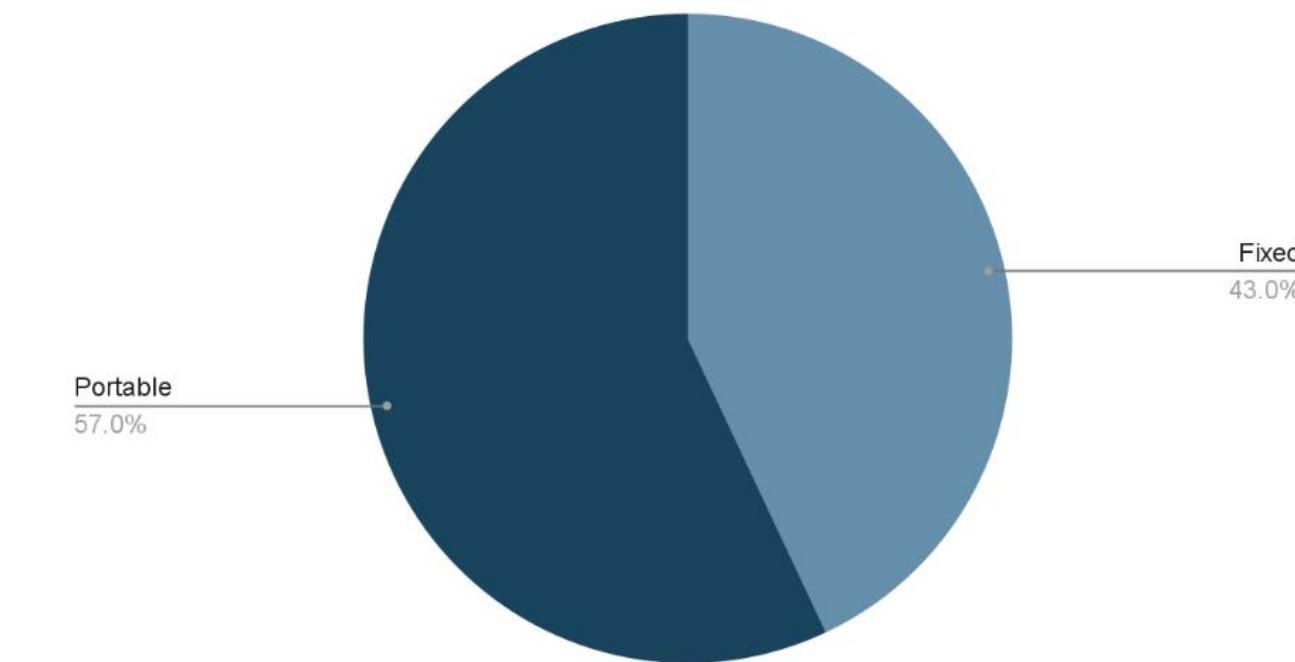
Market Segmentation by User [4]

More than **60%** of total purchase are made by hospitals and physiotherapy centers.

Market Segments of Different CPMs



CPM Market Share By Design





Expected Outcomes

Patient feedback

Patient feedback aids in fine-tuning the ankle CPM device's alignment, motion range, and user interface for improved therapeutic efficiency and comfort. Currently, it is only available in the high-cost range.

Multi DOF

Nearly all current products in the market have a single or dual degree of freedom, incorporating multiple DOF can help mimic natural joint movements, aiding better recovery. [11]

Customizability

Custom ankle placement according to the patient ensures proper joint alignment within the CPM, reducing strain and improving the effectiveness of targeted therapy, which can be done using 3D printing.

Cost-effectiveness

Reducing the cost of CPM devices can improve their accessibility in developing countries like India

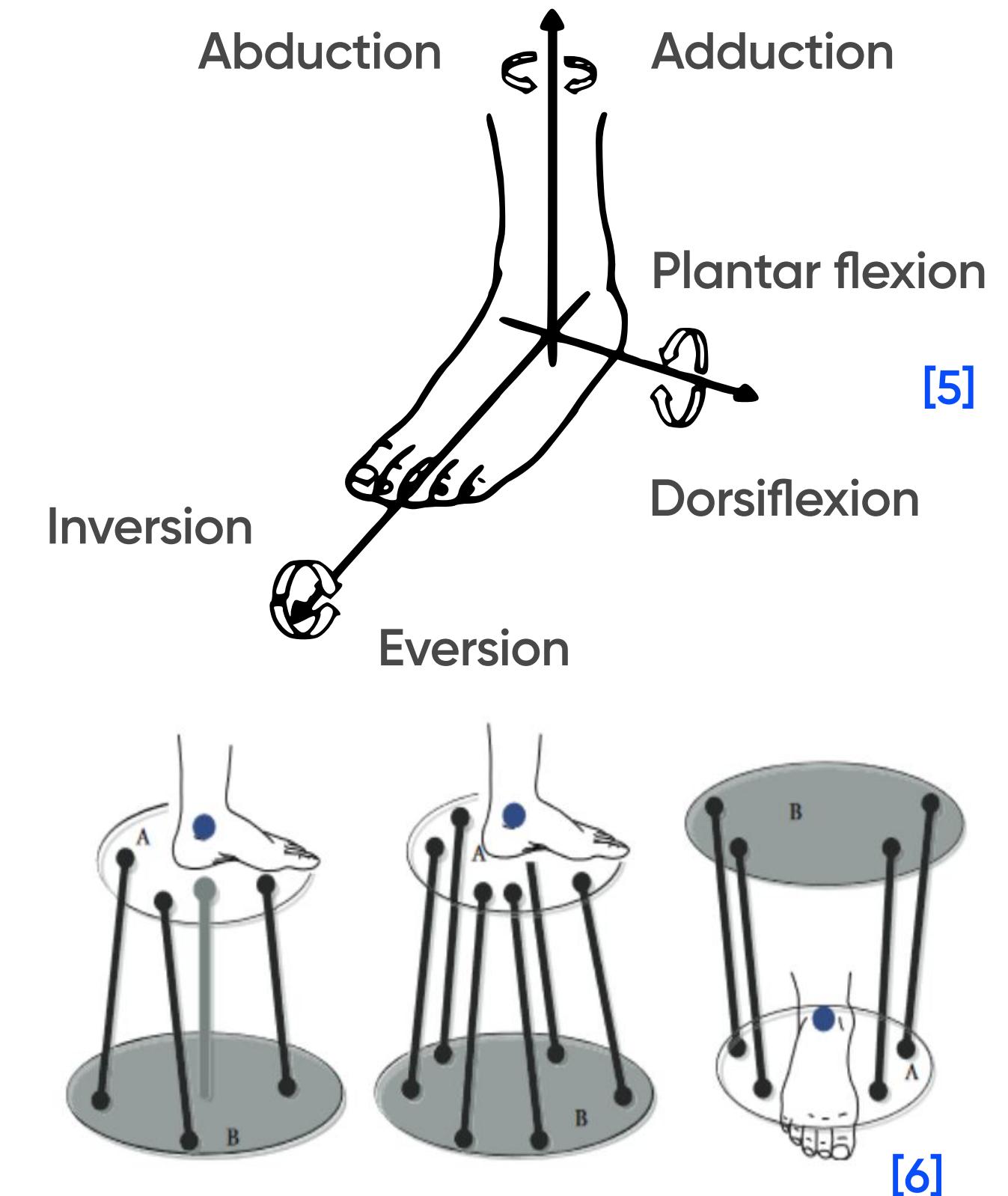
Portability

To ensure access to therapy for patients at home or patients living in rural areas.



Technical Specifications + Concepts

Motion	Angle Range	Angular Velocity (max)	Torque (N-m)
Dorsiflexion	0°-30°	80°/s	45
Plantar flexion	0°-40°	80°/s	45
Adduction	0°-20°	80°/s	10
Abduction	0°-30°	80°/s	10
Eversion	0°-20°	100°/s	20
Inversion	0°-30°	100°/s	20





Technical Specifications

- | | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none">• Accurately measure joint motion across key ranges, with an angular accuracy of $\pm 1^\circ$. [7] | <ul style="list-style-type: none">• Feedback in real time using intuitive display for real-time feedback on joint angles and treatment progress. | <ul style="list-style-type: none">• Remote assistance with physiotherapist |
| <ul style="list-style-type: none">• Create adjustable footplates and straps using 3D printing, that can accommodate foot sizes from EU 35 (225mm) to EU 45 (290mm). [8] | <ul style="list-style-type: none">• A platform-based approach in CPM design enhances adaptability and scalability improving both accessibility and treatment outcomes [11] | <ul style="list-style-type: none">• A platform-based design allows for multifunctionality, increasing utility and reducing costs associated with specialized devices. [9] |



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Thank you.

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