IAPMR KERALA CHAPTER

Kerala Journal of Physical Medicine & Rehabilitation

KJPMR

Volume 25 | Issue 2 | June 2026

Featuring
Movement Analysis

Original research article
Narrative Reviews
Recent Advances

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Kerala Journal of
Physical Medicine & Rehabilitation
The Official Journal of IAPMR Kerala Chapter
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KJPMR is the official academic voice of the IAPMR Kerala Chapter, envisioned as a platform that brings together clinical experience, scientific thought, and reflective perspectives in Physical Medicine & Rehabilitation. As the specialty continues to evolve, the journal aims to foster a culture of learning, sharing, and collaboration, while strengthening the academic identity and visibility of rehabilitation practice.

VISION

To establish KJPMR as a dynamic, inclusive, and credible platform that reflects the evolving scope of Physical Medicine & Rehabilitation, promotes academic engagement, and contributes to improving the visibility and impact of rehabilitation practice.

MISSION

To provide a supportive and accessible platform for physiatrists, residents, and allied professionals to share clinical experiences, research, and ideas

To encourage the development of academic writing and critical thinking within the PMR community

To facilitate dissemination of practical, clinically relevant, and context-specific knowledge

To promote interdisciplinary collaboration and holistic perspectives in rehabilitation

To progressively enhance the quality and reach of the journal, with the long-term goal of indexing

CORE PRINCIPLES

1. Inclusivity

We encourage contributions from all levels—residents, early-career clinicians, and experienced professionals—fostering a culture of participation and learning.

2. Academic Integrity

We uphold ethical standards, scientific honesty, and responsible authorship in all publications.

3. Relevance to Practice

We prioritise content that is clinically meaningful, practical, and applicable to real-world rehabilitation settings.

4. Supportive Editorial Approach

We aim to provide constructive guidance and mentorship to help authors refine and improve their work.

5. Timeliness and Transparency

We strive for efficient review processes and clear communication with contributors.

6. Visibility and Outreach

We are committed to ensuring wide dissemination of published work across the PMR community and beyond.

7. Growth and Evolution

We continuously work towards improving the quality, structure, and reach of the journal, adapting to the changing needs of the speciality.

"By the community, for the community — advancing rehabilitation together."

From the Editor's Desk

Dear Esteemed Readers,

It is with a deep sense of responsibility and humility that we present this issue of the Kerala Journal of Physical Medicine & Rehabilitation (KJPMR), the first under the stewardship of the new editorial team.

At the outset, we record our sincere gratitude to the previous editorial team led by Dr Ravi Sankaran and Dr Nitha J, whose dedicated efforts strengthened the journal and enhanced its visibility within the PMR community. We also acknowledge the contributions of Dr Bineesh and team in shaping the journal. We are privileged to build upon this strong foundation. We further thank the office bearers of IAPMR Kerala, especially Dr Selvan (President) and Dr Sonu (Secretary), for their guidance and support.

The Theme : Movement Analysis

The theme of the present issue, Movement Analysis, reflects a core domain of Physical Medicine & Rehabilitation. Understanding movement in health and disease forms the basis of functional assessment, clinical reasoning, and rehabilitation planning. With the growing integration of techno-logy, biomechanics, and clinical expertise, movement analysis is evolving from observational assessment to objective, data-driven approaches. Through this theme, we aim to highlight its relevance across clinical practice, research, and future innovations in rehabilitation.

Highlights of this Issue

This issue brings together a balanced mix of scientific, clinical, and reflective content.

We are highly honoured to feature a Guest Editorial by Dr P C Muralidharan, National President of IAPMR, exploring the evolving role of the physiatrist in modern healthcare. The scientific section includes contributions ranging from original work to clinical insights, reflecting the realities and academic pursuits of physiatrists. We are also pleased to include a thoughtful humanities piece by Dr Ravi Sankaran, bringing together a patient's journey and the physiatrist's perspective, highlighting the often-under-recognized role of rehabilitation in patient narratives.

Our recurring sections provide concise, practical insights, while the Resident and Community sections highlight the experiences and initiatives of colleagues and trainees, reinforcing the collective nature of our specialty.

Looking Ahead

As a team, we aim to build KJPMR as a supportive, inclusive, and academically vibrant platform for physiatrists. We hope to encourage contributions from residents, early-career clinicians, and experienced practitioners alike, while maintaining quality and relevance. We believe every clinical experience, observation, and reflection has value. By sharing them, we strengthen not only the journal but also the academic culture of our specialty.

We thank all contributors, reviewers, and readers for their continued support, and we look forward to your active participation in the journey ahead.

Dr Arun A John
Chief Editor, KJPMR
(On behalf of the Editorial Team)

The President's Message

Dear Esteemed Members and Colleagues,

It is a matter of immense pride and pleasure to address you through this latest edition of the Kerala Journal of Physical Medicine and Rehabilitation (KJPMR). Our chapter has consistently spearheaded academic excellence and clinical advancements in physiatry across the region.

This particular edition marks a significant milestone in our journal's journey. A dynamic, newly elected editorial team takes charge of KJPMR with this issue. I extend my warmest congratulations and enthusiastic welcome to the new Editor-in-Chief, Dr. Arun A John and the entire editorial board, Dr. Jijo Varghese and Dr. Anand Raja.

A New Era for KJPMR

The outgoing team, Chief Editor, Dr. Ravi Sankaran and the Associate Editor, Dr. Nitha J has set an exceptionally high benchmark, establishing KJPMR as a trusted repository of scientific research. Heartfelt congratulations to them. The incoming team inherits a strong foundation but also carries the vital responsibility of elevating our publication to global indexing standards.

The core mission for this new editorial tenure focuses on:

- **Enhanced Peer Review:** Strengthening the scientific rigor of all accepted manuscripts.
- **Diverse Research**: Encouraging high-quality submissions from postgraduates, residents, and senior clinicians alike.
- **Digital Outreach:** Improving the online visibility and accessibility of our published literature.

Moving Physiatry Forward

The landscape of Physical Medicine and Rehabilitation is evolving rapidly with technological integrations, robotic rehabilitation, and advanced pain management modalities. KJPMR must serve as the primary vehicle to document these innovations within our chapter. I urge every member to actively support the new editorial board by contributing original research, rare case reports, and insightful review articles.

I offer my unwavering support to the new editorial team. I am confident that their vision, energy, and dedication will guide KJPMR to unparalleled academic heights.

National PMR Day is on 6th July. Organize various programs of your capacity in your place. Our prestigious FIDR (Fellowship in Diabetic Rehabilitation) is going well.

Long Live IAPMR!

Warm regards,

Dr. Selvan. P
President,
Kerala Chapter of IAPMR

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Association Updates

Dr. Sonu Mohan M S
Secretary IAPMR Kerala Chapter

Regular monthly academic sessions were conducted with eminent National and International faculties, with excellent participation from Physiatrists across the country. These sessions will continue in the coming months with faculties from both within and outside the Physiatry community.

Multiple Legal Cell Committee meetings were convened to discuss various legal issues, and several legal representations were submitted accordingly. Procedures for rectifying the irregularities in the current insurance packages are progressing successfully.

For the first time in the history of the IAPMR Kerala Chapter, the Fellowship Programme in Diabetic Rehabilitation (FIDR) was started in coordination with the Kerala State Resource Centre. Owing to the overwhelming response from Physiatrists across the country, registrations had to be closed before the official deadline. The programme was inaugurated by Hon'ble Justice of the Kerala High Court, Justice Devan Ramachandran, on 12th February 2026 during IAPMRCON 2026 at Le Meridien, Kochi. The course is progressing successfully with weekly online classes by eminent faculties from major specialities related to diabetes management.

On 5th April 2026, an official representation was submitted to the Hon'ble Union Minister for Health and Family Welfare, Sri J. P. Nadda, regarding inclusion of PMR in health insurance packages and curriculum modifications in MBBS to make PMR a mandatory subject.

The auditing process of the IAPMR Kerala Chapter accounts was successfully completed, and Income Tax filing was carried out successfully for the first time, with a significant refund expected this year.

In view of recent studies regarding polytrauma among road traffic accident victims in Kerala, a proposal for rehabilitation of polytrauma patients is being planned for submission to the Government of Kerala.

A new enthusiastic and energetic editorial team under the leadership of Dr. Arun A. John assumed charge of KJPMR in March 2026. Regular PST meetings, bank visits, timely communications with authorities, and coordination with other specialities for the betterment of the speciality are continuing successfully.

The last academic year of the IAPMR Kerala Chapter has been highly fruitful under the visionary leadership of Hon'ble President Dr. Selvan P., and the same momentum is expected to continue throughout the remaining tenure.

Editorial

The Evolving Role of Physiatrist in Modern Health Care

P C Muralidharan[1]

The field of Physical Medicine and Rehabilitation has witnessed a remarkable transformation from the traditional role of disability management and functional restoration after illness or injury into a dynamic specialty forming central component of comprehensive health care. The core of this transformation is the responsibility of the Physiatrist who has to respond to the challenges imposed by the changing disease patterns and disease burden, technological advancements and health priorities. Modern healthcare is witnessing an unprecedented rise in chronic diseases such as stroke and spinal cord injury, musculoskeletal disorders, trauma, pain, neurodegenerative conditions and life style diseases. The advancements in acute care and technology has brought about an increase in survival after critical illness and trauma, but has contributed to a proportionate increase in long term impairments and functional limitations. The rising prevalence of non-communicable and life style diseases, chronic painful states and age-related conditions has brought about a paradigm shift in the clinical profile of illnesses in the community.

Rehabilitation 2030 initiative

The call for Rehabilitation for all by 2030, rooted in the momentum of WHO'S Rehabilitation 2030 initiative and reinforced by World Health Assembly Resolution WHA 76.6 is a testimony to this effect. Rehabilitation is no longer seen as an optional or specialized service, but one essential to achieve Universal Health Coverage. This can be effectively achieved by integration of rehabilitation into all levels of health care, including primary care.

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By incorporating rehabilitation services, health systems can ensure comprehensive, continuous & individual centred services. Community based models supported by digital health services also contribute to achieve this end. This resolution becomes more significant in the Indian scenario as we face a significant increase in the burden of communicable and non communicable diseases alongside increasing instances of trauma and an aging population.

Core Concept in Rehabilitation

Earlier, rehabilitation was conceived as a service delivered after completion of acute medical or surgical treatment. This is now replaced by an integrated approach initiated early in the acute phase and continues across different phases of care extending into long-term community reintegration. This ensures physical recovery, optimization of function and independence, return to work and community participation. This transition from fragmented care to continuum of care is one of the most significant advances in modern physiatry.

Integration of rehabilitation is significant in each of the following phases:

Acute Phase: Early rehabilitation initiation within 24–48 hours

Subacute Phase: Intensive interdisciplinary rehabilitation

Chronic Phase: Community-based rehabilitation and long-term follow-up

This continuum of care is essential for ensuring continuity, coordination, consistency of goals and patient centred progression. Physiatry today is no longer confined to post-acute care; it is deeply embedded in:

- Intensive care units (early mobilization)
- Acute stroke units
- Oncology and cardio pulmonary rehabilitation

- Geriatric and palliative care
- Life style disease management
- Interventional physiatry for pain, spasticity
- Disability management

The specialty has thus transitioned from a supportive service to a central, coordinating discipline. The interventions include multidisciplinary programs with Physiatrist as the team leader. This transforms rehabilitation from a time limited intervention into a coordinated life long process focused on function, independence and enhanced quality of life.

Broadening Scope

The scope of physiatry has broadened to include interventional and procedural skills . This includes performing ultrasound and C-arm guided injections, nerve blocks, spasticity management, hyperbaric oxygen therapy, prolotherapy, radio frequency ablations, transcranial magnetic and direct current stimulations etc. This blending of rehabilitation with interventions represents significant expansion of the clinical domain of the specialty. Our involvement in cardiac rehabilitation and life style disease management is noteworthy. The expanding horizons in Prosthetics and Orthotics will add on to our armamentarium.

Physiatrist as an anchor

The Physiatrist forms an anchor across all phases of rehabilitation. Rehabilitation is a multidisciplinary intervention and the patient care is continuous, goal directed and function focused. The role of Physiatrist is to establish realistic, patient centred goals, monitor progress using functional scales and modify plans according to the responses. The Physiatrist integrates medical management and functional training. He/she conducts frequent case conferences involving other members of the rehabilitation team. Without the central anchor, care becomes fragmented, goals inconsistent and outcomes suboptimal.

Structured Rehabilitation Pathways

These are standardized and evidence-based care plans which are important for the successful implementation of the Continuum of care plans in each settings. This identifies the journey of the patient from acute care through inpatient, outpatient, home based care into the community. This defines timelines, interventions, referrals and discharge and ensures continuity and coordination across all levels. Structured rehabilitation pathways provide a systematic coordinated framework and ensures that patients receive right rehabilitation at the right time and place. This also ensures smooth transitions without loss to follow up. Late rehabilitation can lead to complications and poor outcome. The existence of a structured pathway mandates early referral and initiation of rehabilitation. In addition, it promotes standardization based on evidence-based practices, efficient and cost-effective practices and timely referral and transition protocols. It is also essential to facilitate alignment with schemes like Ayushman Bharath.

Technological advancements in Rehabilitation medicine

Technologic innovations are transforming rehabilitation medicine from the earlier concept of therapist driven service into a precision based, data driven and patient engaging specialty with improved accessibility. These innovations reshape rehabilitation into a high intensity, patient centred discipline with enhanced precision, increased reach and improved outcomes. They also compliment clinical expertise and enhance recovery by promoting intensity, repetition, feedback and personalization which are the key principles of modern rehabilitation.

The integration of technology has revolutionized rehabilitation practice. Some of the areas where technology has provided impetus to improved outcome are worth mentioning here.

- Robotics and Exoskeletons: Enhancing gait training and motor recovery
- Virtual Reality (VR) and Gamification: Improving patient engagement and neuroplasticity
- Neuro modulation techniques like Transcranial Direct Current Stimulation, Functional Electric Stimulation
- Tele-rehabilitation: Expanding access to care, especially in resource-limited settings
- Artificial Intelligence (AI): Enabling personalized rehabilitation protocols
- Assistive Technologies: Advanced prosthetics, orthotics, Smart wheel chairs and communication devices

These innovations are not replacing clinicians but augmenting the capabilities of physiatrists and other rehabilitation personnel, enabling precision rehabilitation.

Interdisciplinary and Patient-Centred Care

Modern physiatry thrives on team-based care, involving physiotherapists, occupational therapists, speech-language pathologists, psychologists, nurses, and social workers. The focus has shifted from impairment-based treatment to participation and quality of life, aligning with the International Classification of Functioning, Disability and Health (ICF) framework. Patient-centred care, shared decision-making, and individualized goal setting are now fundamental principles.

Community Based Rehabilitation and Inclusivity

CBR plays a vital role in addressing social, economic and environmental barriers to participation in rehabilitation as a continuous program. Without strong community participation the goal of Rehabilitation for all will remain a distant dream. In addition, rehabilitation must be inclusive of vulnerable populations, like persons with disabilities, older adults and those living in poverty. The policies and programs have to be directed at these targets also.

Rehabilitation in a Global Health Perspective

The recognition of rehabilitation as a fundamental component of universal health coverage marks a historic milestone. The World Health Organization's ***Rehabilitation 2030: A Call for Action*** emphasizes:

- Integration of rehabilitation into all levels of healthcare
- Strengthening workforce capacity
- Improving accessibility and affordability

India, with its vast and diverse population, faces unique challenges. The role of Indian Association of Physical Medicine and Rehabilitation is crucial in advocacy, training, and policy development to ensure "Rehabilitation for All."

The Expanding Role of the Physiatrist

The modern physiatrist is:

- A clinician managing complex disability
- A team leader coordinating interdisciplinary care
- A technologist leveraging advanced rehabilitation tools
- A policy advocate promoting disability-inclusive healthcare
- A researcher and educator advancing evidence-based practice and contribute to growing base of rehabilitation.

This expanded role positions physiatry at the intersection of medicine, technology, and social integration. This recognizes the modern physiatrist as a clinician, proceduralist, team leader, technologist and a public health advocate.

Challenges and the Way Forward

Despite significant progress, several challenges remain:

- Inadequate rehabilitation infrastructure
- Workforce shortages
- Limited awareness among healthcare professionals and the public
- Variability in access between urban and rural areas
- Limited accessibility to insurance for PMR patients

Addressing these requires:

- Policy-level commitment
- Standardized rehabilitation pathways
- Integration into primary healthcare
- Capacity building and training programs

For IAPMR, this opens avenues to

1. Develop national guidelines
2. Partner with Government bodies or NGOs or similar associations
3. Strengthen academic and training programmes
4. Promote technologic adaptations
5. Advocate for strengthening national rehabilitation policy
6. Promote CBR models
7. Foster interdisciplinary collaboration

Physiatry has evolved from a niche specialty into a cornerstone of modern healthcare. Its emphasis on function, independence, and quality of life makes it uniquely positioned to address the growing burden of disability worldwide. As we move forward, the vision is clear: rehabilitation must be accessible, affordable, and integrated across the continuum of care. The Physiatrist has to take up the challenges and ensure that appropriate rehabilitation is delivered to the patients at the right time and at the right place.

Under the aegis of Indian Association of Physical Medicine and Rehabilitation, and aligned with global initiatives, the specialty is poised to play a transformative role in achieving holistic healthcare. The future of physiatry lies not only in restoring function but in enabling lives with dignity and participation

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Original Article

Ultrasonographic Measurement of Median Nerve Cross-Sectional Area for the Diagnosis and Severity Assessment of Carpal Tunnel Syndrome: A Cross-Sectional Diagnostic Study

Arya Vijayan[1]

Abstract

Background: Carpal tunnel syndrome (CTS) is the most common form of peripheral nerve entrapment. Nerve conduction studies (NCS) are considered the gold standard for diagnosis; however, ultrasonography (US) has emerged as a non-invasive alternative.

Objectives: To evaluate the efficacy of ultrasonographic measurement of median nerve cross-sectional area (CSA) in diagnosing and grading the severity of CTS and to assess its association with comorbidities such as diabetes mellitus.

Methods: This cross-sectional diagnostic study was conducted in the Department of Physical Medicine and Rehabilitation at a tertiary care centre. A total of 67 wrists from 37 patients were included. All participants underwent clinical examination along with assessment using Boston Carpal Tunnel Questionnaire (BCTQ). NCS were followed by ultrasonographic measurement of median nerve CSA at the carpal tunnel inlet. Severity was graded using Modified Bland's scale and receiver operating characteristic (ROC) analysis was used to determine optimal cut-off values.

Results: Mean CSA increased significantly with CTS severity. The optimal CSA cut-off for diagnosing CTS was 9.5 mm^2 with sensitivity 95.1% and specificity 96.2% (AUC = 0.959). Cut-offs of 10.5 mm^2 and 14.5 mm^2 effectively differentiated mild-to-moderate and moderate-to-severe CTS respectively. Clinical tests showed no significant association with NCS severity. No statistically significant association was found between CTS and comorbidities.

Conclusion: Ultrasonographic measurement of median nerve CSA demonstrates excellent diagnostic accuracy and effectively grades CTS severity. It can serve as a reliable, non-invasive alternative or adjunct to NCS in appropriate clinical settings.

Keywords: Carpal tunnel syndrome, Ultrasound, Cross-sectional area, Diagnostic accuracy

Introduction

Carpal tunnel syndrome (CTS) is the most common entrapment neuropathy, resulting from compression of the median nerve within the carpal tunnel. It is characterized by increased intracarpal tunnel pressure and impaired nerve conduction, leading to symptoms such as numbness, tingling, pain, and weakness in the hand.[1] The prevalence ranges from 2.7% to 5.8% in the general population, with a higher incidence in females.[2]

Nerve conduction studies (NCS) are considered the gold standard for diagnosing CTS. However, they are time-consuming, uncomfortable, and not always readily available. Ultrasonography (US) has emerged as a promising alternative due to its non-invasive nature, accessibility, and ability to visualize structural changes in the median nerve.

Measurement of the median nerve cross-sectional area (CSA) at the carpal tunnel inlet has been widely investigated as a diagnostic parameter. However, reported cut-off values vary across studies, and data on its utility in severity grading, particularly in the Indian population, remain limited.

This study aims to evaluate the diagnostic accuracy of ultrasonographic CSA measurement and its ability to assess CTS severity in comparison with NCS.

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Email : vijayanarya555@gmail.com
Conflicts of Interest : Nil
Funding : Nil

Objectives

The primary objective of this study is to evaluate the diagnostic accuracy of ultrasonographic measurement of median nerve CSA in CTS and its ability to grade disease severity. The secondary objective is to assess the association between CTS and comorbidities including diabetes mellitus, hypertension, dyslipidaemia, and hypothyroidism.

Materials and Methods

This cross-sectional diagnostic study was conducted in the Department of Physical Medicine and Rehabilitation, General Hospital, Thiruvananthapuram over a period of 1 month among patients undergoing electrodiagnostic evaluation in the PMR outpatient department. As this was a pilot study conducted over a limited study period, formal sample size calculation was not performed. All eligible patients meeting the inclusion criteria were included using consecutive sampling technique. A total of 67 wrists from 37 patients were analysed. Participants presenting with symptoms suggestive of CTS and who were posted for electrodiagnostic studies during the study period were included in the study. Only those aged above 18 years and willing to provide an informed written consent were recruited. Patients with a history of upper limb surgery, prior steroid infiltration for CTS, upper limb trauma or fracture, known peripheral neuropathy or with evidence of polyneuropathy on NCS were excluded.

Study Procedure

All study participants were initially asked to fill Boston Carpal Tunnel Questionnaire (BCTQ). This was followed by a full clinical examination including Phalen's test, Tinel's sign and carpal compression test. Electrodiagnostic studies were then carried out for all subjects, which served as the reference standard in this study. Wrists were classified into four categories: normal, mild, moderate, and severe using Modified Bland's Neurophysiological grading scale [Table 1].

CSA of the median nerve was assessed using a 5 - 17 MHz linear probe of the ultrasound machine [Figure 1]. CSA was measured at carpal tunnel inlet (at the proximal margin of the flexor retinaculum between the scaphoid bone and the pisiform bone). Distal wrist crease was used as an external landmark. Both the diagnostic procedures (NCS and US) were performed independently by two investigators, each blinded to the results of the other (independent blinded assessment).

Table 1: Modified Bland's Neurophysiological Grading Scale

Grade	Nerve Conduction Findings
Normal	NCS are normal, no electrophysiological evidence of CTS
Mild	Sensory nerve conduction velocity decreased. Normal terminal motor latency
Moderate	Distal motor latency to APB prolonged, but less than 6.5 ms
Severe	Distal motor latency to APB prolonged more than 6.5 ms or CMAP absent

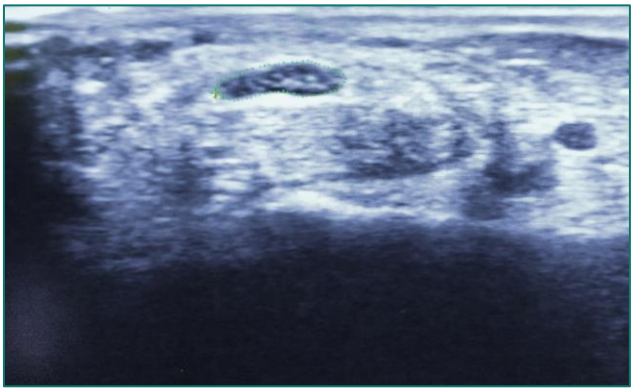


Figure 1 : Transverse sonogram of the median nerve at the carpal tunnel inlet

Statistical Analysis

The unit of analysis in this study was the wrist. Each wrist was treated as an independent observation, and statistical analyses were performed on a per-wrist basis. Data were analysed using SPSS version 25. Continuous variables were expressed as mean ± standard deviation. Comparison of mean CSA across severity groups was performed using one-way analysis of variance (ANOVA), and effect size was assessed using eta squared (η^2). Association between categorical variables was evaluated using Chi-square test. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the ability of ultrasonographic median nerve cross-sectional area (CSA) to discriminate between different categories of carpal tunnel syndrome severity by plotting sensitivity against 1 − specificity for all possible CSA cut-off values. The diagnostic performance of CSA was quantified by calculating the area under the curve (AUC), where values closer to 1.0 indicate better discriminative ability and higher overall diagnostic accuracy. A p value less than 0.05 was considered statistically significant.

Ethical considerations

Informed consent was obtained from all participants. Participant confidentiality was maintained throughout and after the study. No intervention was carried out. No additional costs were incurred by the participants. The study results are used for scientific purposes only. The authors declare that there are no conflicts of interest.

Results

A total of 67 wrists from 37 patients were included in the study. Out of this, 15 were males (41%) and 22 were females (59%). Within the study population, 13 (35.14%) were housewives, 6 (16.22%) were skilled labourers, 5 (13.51%) were unskilled labourers, 3 (8.11%) were drivers, 1 (2.7%) was a typist and 9 (24.32%) were engaged in other occupations.

On categorizing according to severity based on NCS, out of 67 wrists, 26 (39%) were normal, 10 (15%) had mild, 21 (31%) had moderate and 10 (15%) had severe CTS. [Figure 2]

Mean CSA increased progressively with severity: Normal: 7.8 ± 1.1 mm^2 , Mild: 10.0 ± 1.7 mm^2, Moderate: 12.4 ± 1.7 mm^2 , Severe: 19.9 ± 5.5 mm^2.

Strong association was observed between severity based on NCS and CSA obtained by ultrasound (η^2 = 0.741) (p value < 0.05) [Graph 1].

ROC curve was plotted for assessing the diagnostic accuracy of ultrasound in differentiating between normal and abnormal. The area under curve (AUC) obtained was 0.959 (excellent) [Graph 2]. Optimal cut-off between normal and abnormal was found as 9.5 mm^2 with sensitivity 95.1% and specificity 96.2%. [Table 2]

Receiver operating characteristic (ROC) curve analysis was further performed to determine ultrasonographic median nerve cross-sectional area (CSA) thresholds for differentiating between successive grades of carpal tunnel syndrome severity based on nerve conduction studies. When mild CTS was compared with moderate CTS, the ROC curve demonstrated excellent discriminative ability, with an area under the curve (AUC) of 0.974. The optimal CSA cut-off value was 10.5 mm^2, which yielded a sensitivity of 93.5% and a specificity of 86.1% for identifying moderate or more severe disease (Graph 3; Table 3).

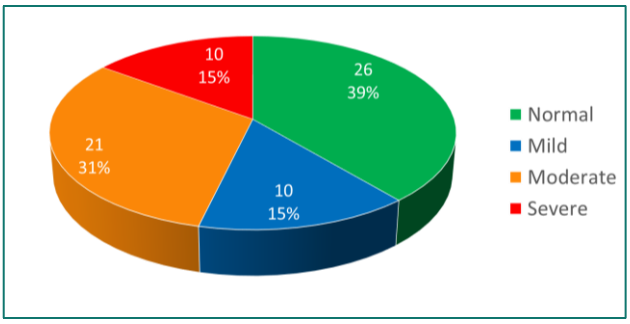
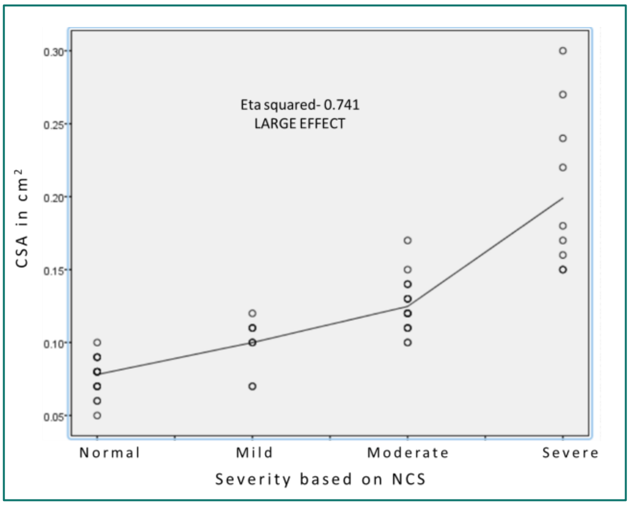
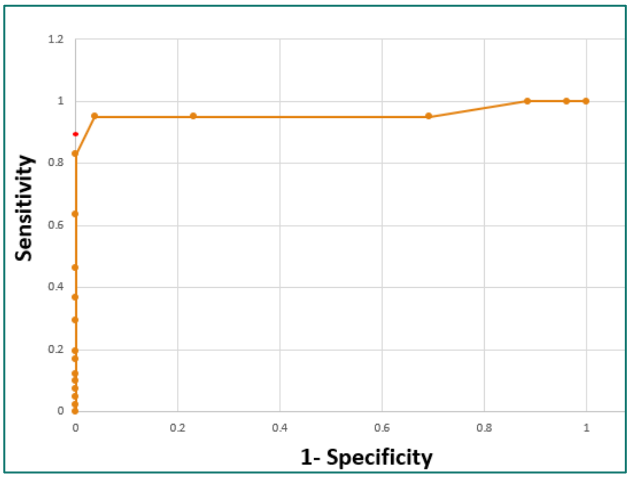


Figure 2. Severity Categorisation Based on NCS



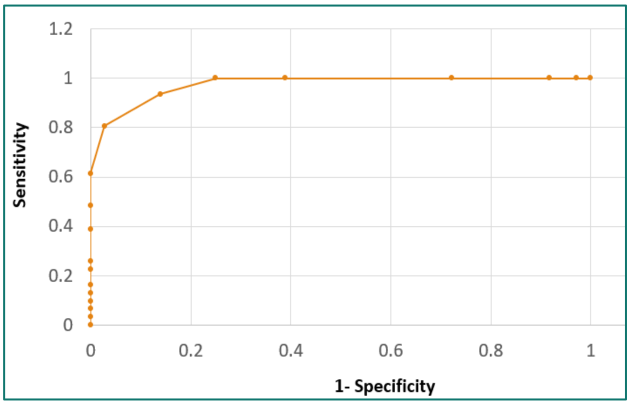
Graph 1: Association between severity based on NCS and CSA obtained by ultrasound



Graph 2: ROC curve – Normal to Abnormal

Table 2: ROC Analysis- Normal to Abnormal

Parameter	Value
AUC	0.959
CSA Cut off	9.5 mm^2
Sensitivity	95.1%
Specificity	96.2%

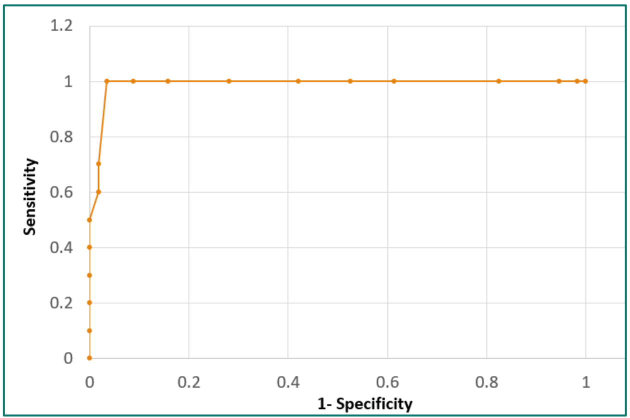


Graph 3: ROC curve – Mild to Moderate

Table 3: ROC Analysis - Mild to Moderate

Parameter	Value
AUC	0.974
CSA Cut off	10.5 mm^2
Sensitivity	93.5%
Specificity	86.1%

Similarly, in differentiating moderate CTS from severe CTS, ROC analysis showed outstanding diagnostic performance, with an AUC of 0.989. A CSA threshold of 14.5 mm^2 provided 100% sensitivity and 96.5% specificity for detecting severe CTS (Graph 4; Table 4).



Graph 4: ROC curve -Moderate to Severe

Table 4: ROC Analysis- Moderate to Severe

Parameter	Value
AUC	0.989
CSA Cut off	14.5 mm^2
Sensitivity	100%
Specificity	96.5%

The AUC values of 0.959, 0.974, and 0.989 indicate excellent to near-perfect diagnostic performance of median nerve CSA in distinguishing between normal and abnormal wrists, mild and moderate CTS, and moderate and severe CTS, respectively. These findings indicate that ultrasonographic measurement of median nerve CSA not only distinguishes normal from abnormal wrists with high accuracy, but also reliably differentiates between clinically relevant severity categories.

Clinical provocative tests, including Phalen's test, Tinel's sign, and Durkan's carpal compression test, did not demonstrate a statistically significant association with electrophysiological severity as determined by nerve conduction studies. In addition, no statistically significant relationship was observed between the presence or severity of carpal tunnel syndrome and comorbid conditions such as diabetes mellitus, hypertension, dyslipidaemia, and hypothyroidism.

Discussion

The present study demonstrates that ultrasonographic measurement of median nerve CSA is a highly accurate diagnostic tool for CTS, with excellent correlation to disease severity assessed by NCS. The findings support the growing body of evidence that US is not only a diagnostic adjunct but also a potential alternative in selected clinical settings.

The optimal CSA cut-off value of 9.5 mm^2 identified in this study showed high sensitivity (95.1%) and specificity (96.2%), with an AUC of 0.959, indicating excellent diagnostic performance. These findings are consistent with previous studies, although reported cut-offs vary slightly across populations and methodologies.[3-5]

For instance, Ghasemi M et al. (2017) reported a cut-off value of 10 mm^2, which is very close to our findings, suggesting good external validity across different populations.[5] Similarly, Fowler JR et al. (2011) in a meta-analysis demonstrated pooled sensitivity and specificity of ultrasound to be approximately 77.6% and 86.8%, respectively—lower than those observed in the present study.[4]

Higher diagnostic accuracy in our study may be attributed to standardized measurement at the carpal tunnel inlet and use of a high-frequency probe, both of which have been emphasized in prior research as critical for improving reliability.[6]

A key strength of this study is the strong correlation observed between CSA and CTS severity (η^2 = 0.741). Mean CSA increased progressively from normal to severe CTS, reflecting the pathophysiological progression of nerve oedema, fibrosis, and structural enlargement due to chronic compression.

This finding aligns closely with the work of Karadağ YS et al. (2010), who demonstrated that median nerve CSA increases proportionally with electrophysiological severity.[7] Similarly, El-Habashy H et al. (2016) found a strong positive correlation between CSA and NCS parameters, supporting the utility of ultrasound in severity grading.[2]

The ability of CSA to differentiate between severity categories (mild–moderate at 10.5 mm^2 and moderate–severe at 14.5 mm^2) further strengthens its clinical applicability. Comparable stratification thresholds have been reported in earlier studies, although with some variation. For example, Aurangzeb et al. (2018) also demonstrated good agreement between ultrasonographic grading and electrophysiological severity, reinforcing the role of USG in disease stratification.[3]

In the present study, clinical provocative tests such as Phalen's, Tinel's, and Durkan's tests showed no significant association with NCS severity. This finding is consistent with existing literature, which suggests that while these tests are useful for screening, they lack sensitivity and specificity when used alone.

Previous studies have reported variable diagnostic accuracy of these clinical tests, often influenced by examiner technique and patient factors. The lack of correlation in this study underscores the limitation of relying solely on clinical examination and highlights the importance of objective diagnostic tools such as NCS and USG.

No statistically significant association was found between CTS and comorbidities such as diabetes mellitus, hypertension, dyslipidaemia, and hypothyroidism in this study. This contrasts with several previous studies that have reported strong associations, particularly with diabetes mellitus.[1]

For example, multiple epidemiological studies have identified diabetes as a major risk factor due to mechanisms such as glycation-induced nerve damage and microvascular ischemia. The absence of such an association in the present study is likely attributable to the small sample size and limited statistical power, rather than a true lack of correlation.

Limitations

Because the analysis was performed on a per-wrist basis, potential intra-subject correlation resulting from inclusion of both wrists from some participants was not accounted for, which may have affected the estimates. Additional limitations include operator dependency of US, small sample size, short study duration, and the single-centre design.

Conclusion

Ultrasonographic measurement of median nerve CSA demonstrates excellent diagnostic accuracy for CTS, with sensitivity and specificity comparable to NCS. The progressive increase in CSA with worsening electrophysiological severity highlights its utility not only as a diagnostic modality but also as a reliable tool for severity stratification.

Given its non-invasive nature, ease of availability, cost-effectiveness, and ability to provide real-time structural assessment, US can serve as a valuable alternative or adjunct to NCS, particularly in resource-limited settings or in patients who are intolerant to electrodiagnostic testing.

However, considering variability in cut-off values across populations and operator dependency, standardization of measurement techniques and larger multicentric studies are warranted.

Integration of US into routine clinical practice may enhance early diagnosis, guide management decisions, and improve patient outcomes in CTS.

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Narrative Review

Beyond Bleeds: Restoring Function in Haemophilia

Archana N[1]

Abstract

Haemophilia is an inherited bleeding disorder with significant musculoskeletal and functional consequences. Although factor replacement therapy remains the cornerstone of management, the role of rehabilitation in preventing disability and improving long-term functional outcomes is increasingly recognised. Recurrent hemarthroses can lead to chronic synovitis, haemophilic arthropathy, pain, muscle weakness, gait abnormalities, and reduced participation in daily activities. This narrative review summarises the pathophysiology of musculoskeletal involvement in haemophilia, common functional impairments, rehabilitation assessment, exercise therapy, physical modalities, orthotic management, and multidisciplinary rehabilitation strategies. The review aims to provide a concise and clinically relevant overview for Physiatrists and rehabilitation professionals involved in haemophilia care.

Introduction

Haemophilia is a rare inherited X-linked recessive bleeding disorder caused by deficiency of clotting factors. Haemophilia A results from factor VIII deficiency, whereas the less common haemophilia B is caused by factor IX deficiency. Individuals with haemophilia experience prolonged bleeding because of inadequate clotting factor activity.

Traditionally, haemophilia was considered a disorder affecting only males, while female carriers were believed to remain asymptomatic. However, it is now recognised that many women and girls carrying the haemophilia gene may also experience bleeding manifestations[1].

It is estimated that approximately 21 per 100,000 males have haemophilia A and around 4 per 100,000 males have haemophilia B. In Kerala, this corresponds to nearly 3600 persons with haemophilia (PWH)[2]. Based on factor activity levels, haemophilia is classified as:

- Mild: 5% - 40% of normal factor activity
- Moderate: 1- 5% normal factor activity
- Severe: < 1% normal factor activity

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Clinical manifestations include:

- Easy bruising
- Prolonged bleeding after injury
- Bleeding into muscles and joints
- Spontaneous bleeding episodes

Bleeding into joints or muscles may produce:

- Pain or discomfort
- Swelling and warmth
- Joint stiffness
- Difficulty using the affected limb

Musculoskeletal bleeding is the hallmark manifestation of haemophilia and contributes substantially to morbidity and long-term disability. Recurrent hemarthroses involving the knees, ankles, and elbows may lead to synovial hypertrophy, cartilage destruction, deformities, chronic pain, muscle wasting, impaired mobility, and reduced quality of life.

Although haemophilia management primarily focuses on factor replacement therapy, increasing recognition of chronic musculoskeletal impairment has highlighted the importance of rehabilitation in comprehensive haemophilia care. Rehabilitation aims not only to restore function after bleeding episodes but also to prevent disability, optimise mobility, improve participation, and enhance psychosocial well-being.

This narrative review discusses the role of rehabilitation in haemophilia, with emphasis on functional restoration, prevention of disability, and rehabilitation strategies across different stages of the disease.

Pathophysiology of Musculoskeletal Involvement

The development of haemophilic arthropathy typically progresses through three stages:[3]

1. Acute hemarthrosis
2. Chronic synovitis
3. Degenerative arthritis

The synovium has limited ability to clear blood following repeated joint bleeds. Accumulation of blood breakdown products, particularly iron-containing hemosiderin, promotes synovial inflammation and proliferation. Pro-inflammatory cytokines including interleukin-1, interleukin-6, and tumour necrosis factor-alpha contribute to chronic synovitis and joint destruction[4–6].

The synovium gradually becomes hypertrophic and highly vascular, increasing susceptibility to recurrent bleeding and creating a vicious cycle of hemarthrosis and inflammation. Inflammatory mediators also interfere with cartilage maintenance, resulting in progressive cartilage degeneration[4,5].

The pathological changes in haemophilic arthropathy share similarities with both rheumatoid arthritis and osteoarthritis. Persistent inflammation, cartilage degeneration, deformity, and joint destruction eventually lead to chronic disability and impaired function.

Musculoskeletal Complications of Haemophilia

Musculoskeletal complications include:

- Recurrent hemarthrosis
- Chronic synovitis
- Flexion deformities
- Growth abnormalities
- Cartilage damage
- Haemophilic arthropathy
- Muscle wasting
- Gait abnormalities
- Functional impairment

The joints most commonly affected are the ankle, knee, elbow, and hip [7–9].

Pain and recurrent bleeding may lead initially to correctable deformities, which can later become fixed. Muscle weakness, altered biomechanics, and reduced physical activity further contribute to functional decline. Fear of bleeding often results in reduced participation in physical activity, leading to deconditioning, obesity, osteoporosis, and social isolation.

Functional Impairments In Haemophilia

Functional impairment in haemophilia is multifactorial and depends on bleeding severity, frequency of hemarthroses, treatment access, and rehabilitation availability. Reduced mobility may result from chronic pain, synovitis, arthropathy, restricted range of motion, muscle weakness and secondary musculoskeletal strain

Patients may develop antalgic gait, reduced stride length, toe walking due to ankle contractures, and compensatory movement patterns. Children may avoid sports participation, while adults may experience occupational limitations and psychosocial distress.

Rehabilitation Assessment

A comprehensive rehabilitation assessment should include evaluation of the target joints, muscle strength, range of motion, posture, balance, gait patterns, and functional abilities. The Hemophilia Joint Health Score (HJHS) is commonly used to assess joint involvement, particularly in the elbows, knees, and ankles[10]. The Functional Independence Score in Hemophilia (FISH) is a performance-based tool that evaluates the impact of musculoskeletal impairment on daily functioning and assists in planning rehabilitation interventions[11]. Imaging modalities such as ultrasound and MRI may help detect synovitis and early joint damage.

Role of Physical Medicine And Rehabilitation

Physical Medicine and Rehabilitation plays an important role in the prevention and management of disability in haemophilia. Rehabilitation aims to maintain functional independence, reduce participation restrictions, and improve quality of life.

Optimal haemophilia care requires a multidisciplinary team consisting of Haematologists, Physiatrists, Physiotherapists, Occupational Therapists, Orthopaedic Surgeons, Psychologists, Social Workers and Nurses. Collaborative care improves treatment adherence, reduces complications, and enhances functional outcomes.

Under appropriate haemostatic control, individuals with haemophilia can achieve good physical conditioning and participate safely in physical activity and daily life[12].

Rehabilitation goals include:

- Preventing recurrent bleeds and deformities
- Preserving joint integrity
- Restoring mobility and strength
- Improving balance and proprioception
- Managing pain
- Enhancing participation in daily activities
- Improving quality of life

Rehabilitation should be individualised according to age, disease severity, bleeding status, and functional goals.

Exercise Therapy

Exercise therapy is a core component of rehabilitation in haemophilia. Earlier concerns regarding exercise-induced bleeding have gradually shifted toward supervised and individualised exercise prescription.

Exercise offers several important benefits, including improved muscle strength, better cardiovascular fitness, enhanced joint stability, improved proprioception and balance, effective weight management, and improved psychological well-being.

Types of exercises commonly recommended include:

- **Range of Motion Exercises :** Gentle exercises help maintain flexibility and prevent contractures.
- **Strengthening Exercises :** Progressive resistance training improves periarticular muscle support and joint stability.
- **Aerobic Training :** Low-impact activities such as walking, cycling, and swimming improve endurance and cardiovascular health.
- **Proprioceptive Training :** Balance training and neuromuscular exercises improve joint awareness and may reduce injury risk.
- **Flexibility Exercises :** Stretching exercises help reduce stiffness and improve functional mobility.

Important considerations before prescribing exercise include bleeding risk, joint status, timing of factor replacement, presence of inhibitors, and the patient's pain levels. Exercise programmes should begin gradually and progress according to patient tolerance and clinical status[1].

Care should be taken to avoid overexertion, especially in individuals with active joint disease or recent bleeding episodes. High-impact and contact sports should be approached cautiously[13]. Proprioceptive rehabilitation is particularly important, as impaired joint proprioception may increase the risk of recurrent injury and instability.

A professionally supervised and individualised exercise programme has been shown to be feasible, safe, and beneficial in people with haemophilia, including those with haemophilic arthropathy[14].

Physical Modalities and Interventional Procedures

Physical modalities such as Transcutaneous Electrical Nerve Stimulation (TENS) may be used for pain management in selected patients. Orthoses and shoe insoles may help reduce pain and improve biomechanical alignment in individuals with arthropathy[15]. However, rigid orthotic devices should be used cautiously in unstable joints[16]. Arthrocentesis may occasionally be performed in acute, tense knee under adequate haemostatic cover to reduce pain and intra-articular pressure[15]. Patients with chronic synovitis and recurrent bleeding refractory to medical management may benefit from synoviorthesis or synovectomy. Radiosynovectomy has shown promising outcomes in selected cases[17].

Conclusion

Haemophilia is no longer viewed solely as a bleeding disorder but as a chronic condition with important musculoskeletal and functional consequences. Advances in medical management have improved survival and shifted attention toward long-term functional independence and quality of life.

Rehabilitation plays a central role in preventing disability, optimising mobility, reducing pain, and improving participation across the lifespan. Early intervention, patient education, structured exercise programmes, and coordinated multidisciplinary care can substantially improve outcomes in individuals with haemophilia. A comprehensive and individualised rehabilitation approach is essential to help patients move beyond bleeds towards meaningful functional recovery.

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Narrative Review

Above Cuff Vocalisation in Tracheostomised Patients

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Abstract

Above-Cuff Vocalisation (ACV) is an emerging communication rehabilitation technique that enables selected tracheostomised patients to speak while maintaining cuff inflation. Communication impairment in critically ill and ventilator-dependent patients contributes to psychological distress, reduced autonomy, and impaired participation in rehabilitation. By restoring airflow through the larynx, ACV may improve communication, patient engagement, and rehabilitation outcomes.

This narrative review discusses the physiological basis, clinical applications, safety considerations, and multidisciplinary implementation of ACV, with emphasis on its relevance to Physical Medicine and Rehabilitation (PM&R). Current evidence suggests that ACV is feasible and generally safe in appropriately selected patients when performed by trained multidisciplinary teams. ACV represents a promising adjunct in tracheostomy rehabilitation and early neurorehabilitation, although further research is needed to establish standardised protocols and long-term functional outcomes.

Introduction

Communication is one of the most fundamental human needs. For patients with tracheostomy tubes requiring prolonged cuff inflation, the inability to speak often becomes one of the most distressing aspects of critical illness and rehabilitation. Patients may remain conscious, cooperative, and cognitively intact, yet remain unable to communicate effectively with caregivers and family members. This communication barrier contributes significantly to anxiety, frustration, emotional distress, and impaired participation in rehabilitation.

Above Cuff Vocalisation (ACV) has emerged as an innovative technique that enables selected tracheostomised patients to produce speech even while the tracheostomy cuff remains inflated[1,2]. By restoring airflow through the upper airway and vocal cords, ACV allows selected patients to communicate while maintaining important airway and ventilatory requirements. For many patients and families, the return of spoken communication after severe injury or prolonged ventilation represents a meaningful milestone in recovery.

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As survival after critical illness and prolonged mechanical ventilation increases, communication rehabilitation is becoming increasingly relevant in rehabilitation medicine practice, including in Indian critical care and neurorehabilitation settings. Restoration of communication may significantly improve participation in therapy, psychological adjustment, and patient-centred care. However, awareness regarding ACV remains limited across many rehabilitation centres.

What is Above Cuff Vocalisation?

Above Cuff Vocalisation refers to the delivery of airflow above the inflated tracheostomy cuff through the subglottic suction port of specialised tracheostomy tubes. The retrograde airflow passes upward through the larynx and vocal cords, thereby facilitating phonation[1].

Unlike traditional speaking valves, which generally require cuff deflation, ACV allows speech while maintaining cuff inflation in carefully selected patients[1,2]. This becomes especially useful in patients who continue to require positive pressure ventilation or cannot yet tolerate cuff deflation because of respiratory instability, secretion burden, or aspiration concerns.

The technique is usually performed using humidified air or oxygen delivered at controlled flow rates through the subglottic port under multidisciplinary supervision involving Physiatrists, Respiratory Therapists, and Speech-Language Pathologists[2].

Physiological Basis

During normal speech, expired air passes through the vocal folds, causing vibration and sound production. In patients with inflated tracheostomy cuffs, airflow bypasses the upper airway entirely, making phonation impossible. ACV restores airflow to the larynx despite the cuff remaining inflated[1]

In addition to voice restoration, ACV may help improve laryngeal sensation, swallowing frequency, cough effectiveness, and secretion management[2].

Clinical Benefits

1. Restoration of Communication

The primary advantage of ACV is the restoration of verbal communication. Patients are able to express needs, discomfort, emotions, and concerns directly. This reduces dependence on non-verbal communication methods such as writing boards or gestures. The ability to communicate with family members after severe neurological injury, trauma, or prolonged ICU stay may have substantial psychological importance[1].

2. Psychological and Emotional Benefits

Loss of voice during critical illness is associated with anxiety, helplessness, social isolation, and reduced autonomy. Restoration of speech may improve emotional well-being and enhance patient participation in rehabilitation programmes[4]. Patients who can communicate effectively are often better able to engage with multidisciplinary rehabilitation care.

3. Rehabilitation Advantages

Emerging evidence suggests that ACV may support laryngeal rehabilitation and swallowing recovery. Clinical studies have demonstrated improvements in cough and swallowing frequency in ventilator-dependent patients undergoing ACV[2]. Improved upper airway airflow may also contribute to better secretion clearance and sensory stimulation of the aerodigestive tract.

Safety and Patient Selection

Although ACV is promising, careful patient selection remains essential. Appropriate candidates generally include:

- Patients with intact or functional vocal cords
- Patients with stable respiratory status
- Individuals unable to tolerate cuff deflation
- Patients requiring ongoing mechanical ventilation
- Patients with tracheostomy tubes containing subglottic suction ports

AI generated image

Contraindications may include severe upper airway obstruction, significant surgical emphysema, severe agitation, or unstable cardiopulmonary status.

Clinical studies have shown ACV to be feasible and generally safe when performed by trained teams using standardised protocols[2]. Nevertheless, clinicians should monitor for:

- Air trapping
- Discomfort
- Excessive airway pressures
- Subcutaneous emphysema
- Desaturation
- Poor voice quality or fatigue

Multidisciplinary Approach

Successful implementation of Above-Cuff Vocalisation (ACV) requires coordinated multidisciplinary collaboration involving speech-language pathologists, respiratory therapists, nursing staff, intensivists, and rehabilitation physicians. Speech-language pathologists play a central role in communication assessment and vocalisation training, while respiratory therapists contribute to airway management, ventilator optimisation, and cuff-related adjustments. Rehabilitation physicians assist in patient selection, monitoring physiological tolerance, and ensuring overall procedural safety[4]

International studies suggest increasing clinical interest in ACV across critical care and rehabilitation settings; however, variability persists in implementation practices due to differences in institutional protocols, clinician expertise, and resource availability[4]. A structured multidisciplinary approach may facilitate safer implementation, improve communication outcomes, and promote integration of communication-focused rehabilitation within tracheostomy care pathways.

Limitations and Future Directions

Despite growing interest in ACV, the current evidence base remains relatively limited. Many available studies are feasibility studies or observational reports involving small patient populations. Standardised protocols regarding airflow settings, patient selection, monitoring, and outcome assessment are still evolving.

Awareness regarding communication rehabilitation in critically ill patients is increasing worldwide. Newer tracheostomy technologies and standardised ACV protocols may improve accessibility and safety in the future. Further research is still needed regarding optimal flow settings, long-term outcomes, swallowing benefits, and standardised safety guidelines[2]

Conclusion

Above Cuff Vocalisation represents an important advancement in tracheostomy rehabilitation. By enabling speech while maintaining cuff inflation, ACV allows carefully selected patients to reconnect with caregivers and loved ones during vulnerable phases of illness[1,2].

Restoration of speech may contribute substantially to emotional well-being, autonomy, and participation in rehabilitation. As rehabilitation medicine increasingly embraces patient-centred care, techniques such as ACV highlight the importance of communication as both a clinical and human priority.

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Feature

Gait Analysis: From the Clinic to the Lab

Vipin Kumar K[1]

Abstract

Gait analysis is a fundamental component of physiatric evaluation, providing objective insight into locomotor function and movement disorders. Walking is a complex biomechanical activity requiring coordinated integration of musculoskeletal, neurological, sensory, and cardiopulmonary systems to achieve efficient forward progression while maintaining stability. Understanding normal gait biomechanics is essential for recognizing pathological gait patterns and interpreting quantitative gait data. Traditionally, gait assessment relied primarily on clinical observation; however, advances in motion capture systems, force platforms, electromyography, wearable sensors, and artificial intelligence have transformed gait analysis into a sophisticated multidisciplinary science. Clinical gait analysis assists rehabilitation physicians in diagnosis, treatment planning, orthotic prescription, surgical decision-making, and outcome evaluation, while laboratory-based gait analysis objectively quantifies spatiotemporal, kinematic, kinetic, and electromyographic parameters. This review discusses normal gait biomechanics, spatiotemporal gait characteristics, clinical and instrumented gait assessment, major rehabilitation applications, and emerging advances that continue to reshape locomotor evaluation. Integration of clinical expertise with modern biomechanical technologies has significantly enhanced the precision of rehabilitation interventions across neurological, orthopaedic, paediatric, geriatric, and sports rehabilitation populations.

Keywords: Gait analysis, gait cycle, rehabilitation medicine, biomechanics, kinematics, kinetics, electromyography, motion analysis laboratory.

Introduction

Walking is one of the most important functional activities performed by humans and serves as a key indicator of independence, participation, and quality of life. Efficient gait requires coordinated interaction of the musculoskeletal, neurological, sensory, and cardiopulmonary systems. Disruption of any of these components may result in gait dysfunction, leading to impaired mobility, increased risk of falls, reduced community participation, and diminished quality of life[3,4]

Assessment of gait is therefore a corner-stone of rehabilitation. Observation of walking frequently provides valuable information regarding neurological, orthopaedic, and functional impairments

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Traditionally, gait evaluation was largely descriptive and dependent upon clinician experience. Although observational gait analysis remains indispensable in everyday practice, its subjective nature limits reliability and sensitivity, particularly in subtle gait abnormalities [2]

Modern gait analysis combines clinical assessment with motion capture systems, force platforms, electromyography, pressure mapping technologies, and wearable sensors to provide objective evaluation of locomotor performance[1,5]. These technological advances have transformed gait assessment from a predominantly observational skill into a quantitative scientific discipline and have improved diagnostic accuracy, treatment planning, outcome evaluation, and understanding of pathological movement patterns.

A sound understanding of normal gait biomechanics forms the foundation for interpreting both clinical observations and laboratory-derived gait data. This review discusses the principles of normal gait, methods of clinical and instrumented gait

Biomechanical Basis of Normal Gait

Human gait is a cyclic and coordinated pattern of movement that enables forward progression of the body while maintaining postural stability and minimizing energy expenditure[3,4]. Walking requires precise integration of the musculoskeletal, neurological, sensory, and cardiopulmonary systems, and disruption of any of these components may result in gait dysfunction. The basic unit of locomotion is the gait cycle or stride, defined as the interval between two successive initial contacts of the same foot[3].

The Rancho Los Amigos terminology divides the gait cycle into eight functional intervals consisting of five stance-phase periods and three swing-phase periods. This classification emphasizes functional events during locomotion and is widely used in contemporary clinical gait analysis [3]. The gait cycle consists of two principal phases:

- Stance phase (approximately 60% of the gait cycle)
- Swing phase (approximately 40% of the gait cycle)

During stance phase, the lower extremity accepts body weight, maintains balance, and generates forward propulsion [3,6]. Initial contact and loading response are responsible for weight acceptance and shock absorption, while midstance and terminal stance maintain single-limb stability and forward progression. Pre-swing initiates limb unloading and contributes to push-off through plantar flexor activity[4]. During swing phase, the limb advances forward while maintaining adequate foot clearance and preparing for the next cycle of weight acceptance[3].

Spatiotemporal parameters provide quantitative description of walking performance and form the basis of both clinical and laboratory gait analysis[1]. Important spatial parameters include stride length, step length, step width, and foot progression angle. Reduced step length commonly occurs in Parkinson disease, painful conditions, frailty, and neurological disorders. Increased step width may reflect impaired balance, cerebellar dysfunction, or fear of falling[3,6].

Temporal parameters include stance time, swing time, cadence, stride time, single-limb support time, and double-limb support time[3]. Prolonged double-support time often indicates instability or impaired balance, while reduced single-limb support may occur in weakness, pain, or neurological impairment. Walking velocity or gait speed has been described as the "sixth vital sign" because of its strong association with functional independence, frailty, hospitalization, and survival[15]. Gait symmetry and gait variability are also clinically important because asymmetry frequently reflects neurological or musculoskeletal pathology and increased gait variability is associated with fall risk and cognitive decline in older adults[15].

Normal walking accomplishes three major functional tasks: weight acceptance, single-limb support, and limb advancement[3]. Weight acceptance occurs during initial contact and loading response and requires coordinated eccentric muscle activity to absorb impact forces while preserving stability[4]. Single-limb support during midstance and terminal stance demands adequate balance, proprioception, hip abductor strength, and postural control. Limb advancement during swing requires coordinated joint motion, limb shortening, and adequate foot clearance. Weakness, spasticity, contracture, or impaired motor control may disrupt these mechanisms and produce compensatory gait deviations such as circumduction, hip hiking, or vaulting[4,6].

To improve walking efficiency and reduce vertical and lateral displacement of the centre of mass, the body utilizes several biomechanical mechanisms collectively known as the determinants of gait[7]. These include pelvic rotation, pelvic obliquity, lateral pelvic displacement, knee flexion during stance, coordinated ankle rocker mechanisms, and knee flexion during swing. Pelvic rotation effectively lengthens the lower extremity and increases step length, while pelvic obliquity and controlled lateral displacement reduce unnecessary movement of the centre of mass[4,7]. Early knee flexion functions as a shock absorber during loading response, whereas coordinated foot and ankle rocker mechanisms preserve forward momentum and facilitate smooth progression over the supporting limb [6].

Gait analysis requires understanding not only visible movement patterns but also the forces and muscular activity responsible for locomotion[1,3]. Kinematics describes movement without consideration of the forces producing that movement. During normal walking, coordinated motion occurs at the hip, knee, ankle, and pelvis throughout the gait cycle[3]. The hip progresses from flexion at initial contact to extension during terminal stance before returning to flexion during swing. The knee flexes during loading response to absorb impact forces, extends during stance, and flexes again during swing to facilitate limb advancement[4]. The ankle undergoes controlled plantarflexion following initial contact, progressive dorsiflexion during stance, and rapid plantarflexion during push-off before returning to neutral during swing[3].

Kinetics examines the forces responsible for movement[6]. Ground reaction forces generate external moments around the hip, knee, and ankle joints that must be counteracted by coordinated muscular activity. Hip extensors stabilize the trunk during weight acceptance, quadriceps eccentrically control knee flexion during loading response, and plantar flexors generate substantial propulsive power during terminal stance and pre-swing[4,6]. Reduced ankle plantar flexor power generation is a major contributor to impaired propulsion and increased energy expenditure in stroke gait [1].

Electromyographic studies demonstrate highly coordinated muscle activation patterns during walking[8]. Hip extensors are active during early stance, dorsiflexors maintain toe clearance during swing, quadriceps stabilize the knee during loading response, and plantar flexors regulate tibial progression and generate push-off power[3,4]. Hamstrings decelerate forward limb progression during terminal swing and assist preparation for weight acceptance. Abnormal muscle activation patterns, including spasticity, co-contraction, and impaired timing, are common in neurological disorders and contribute significantly to pathological gait deviations[8].

A comprehensive understanding of gait biomechanics is essential for recognizing pathological gait patterns, interpreting instrumented gait analysis data, and developing targeted rehabilitation interventions in PMR practice[1,3].

Clinical Gait Analysis

Clinical gait analysis remains the foundation of locomotor assessment in Physical Medicine and Rehabilitation because it combines biomechanical observation with functional interpretation and rehabilitation planning[2,3]. Although advanced gait laboratories provide objective quantitative data, bedside observational gait assessment continues to play a major role in routine clinical practice due to its accessibility, low cost, and immediate applicability.

Evaluation begins with detailed history taking, including onset and progression of symptoms, falls, pain, fatigue, assistive device use, and functional limitations[3]. A focused neuromuscular examination should assess posture, joint range of motion, muscle strength, tone, coordination, balance, sensory function, and limb alignment.

Observational gait analysis is performed from anterior, posterior, and lateral views while assessing spatiotemporal symmetry, stance and swing phase transitions, trunk and pelvic movements, arm swing, foot clearance, heel strike, and compensatory strategies[2]. Physiatric gait assessment emphasizes interpretation of the relationship between impairments, compensations, and functional limitations rather than merely describing visible abnormalities.

Recognition of compensatory mechanisms is particularly important because many gait deviations are secondary adaptations. Circumduction, hip hiking, and vaulting commonly compensate for impaired foot clearance, while trunk lean in Trendelenburg gait may partially compensate for hip abductor weakness [4,6].

Characteristic pathological gait patterns provide valuable diagnostic clue as illustrated in Table 1.

Table 1: Pathological Gait Patterns

Gait pattern	Key features	Common causes
Hemiplegic	circumduction, hip hiking, equinus	stroke
Parkinsonian	shuffling, festination, reduced arm swing	Parkinson disease
Steppage	high stepping, excessive hip & knee flexion	foot drop
Trendelen-burg	pelvic drop, trunk lean	hip abductor weakness
Cerebellar	broad base, instability	cerebellar lesion

Simple clinical tools such as the Timed Up and Go Test, 10-Meter Walk Test, 6-Minute Walk Test, and smartphone-based video analysis improve assessment reliability and facilitate outcome monitoring[5,10]. Despite its limitations, clinical gait analysis remains indispensable because it provides functional context that cannot be fully captured by laboratory-derived numerical data[2].

Instrumented Gait Analysis and Modern Gait Lab

Instrumented gait analysis objectively quantifies locomotor function using motion capture systems, force platforms, electromyography, and plantar pressure analysis[1,3]. Modern gait laboratories integrate biomechanics and rehabilitation medicine to generate detailed analysis of pathological movement patterns.

Three-dimensional motion capture systems utilize reflective markers and infrared cameras to produce kinematic data describing joint motion throughout the gait cycle[11]. Kinematic analysis allows precise evaluation of abnormalities such as stiff-knee gait, crouch gait, pelvic obliquity, and abnormal ankle kinematics.

Kinetic analysis evaluates the forces responsible for movement using force plates embedded within the walkway[6]. Ground reaction forces permit calculation of joint moments and powers, enabling identification of abnormal loading patterns and impaired propulsion[1,6].

Dynamic electromyography provides information regarding muscle activation timing, co-contraction, and spasticity during walking[8]. EMG is particularly useful in neurorehabilitation because it helps distinguish primary spasticity from compensatory muscle activation and may guide botulinum toxin injection planning.

Instrumented gait analysis is especially valuable in cerebral palsy, stroke rehabilitation, movement disorders, amputee rehabilitation, and complex orthopaedic conditions where mere observational assessment may be insufficient[1,13]. However, gait labs remain expensive, require specialized expertise, and may not be available in resource-limited settings[5,16].

Clinical Applications in Rehabilitation

Gait analysis plays a central role in rehabilitation medicine because locomotor dysfunction directly affects independence, participation, safety, and quality of life[1,3]. Beyond diagnosis, gait analysis assists physiatrists in identifying biomechanical impairments, understanding compensatory strategies, selecting interventions, and monitoring rehabilitation outcomes.

In stroke rehabilitation, gait analysis helps identify asymmetry, weakness, spasticity-related deviations, and compensatory pelvic movements[5]. Instrumented assessment may differentiate abnormalities caused by weakness, spasticity, contracture, or impaired motor control, thereby guiding orthotic prescription, gait retraining, functional electrical stimulation, and botulinum toxin therapy[3,8]. In cerebral palsy, gait analysis assists in differentiating primary abnormalities from compensatory mechanisms and plays an important role in surgical planning and postoperative evaluation[13]. In Parkinson disease, gait analysis identifies reduced stride length, gait variability, freezing episodes, and impaired turning[5]. Wearable technologies allow home-based monitoring of mobility fluctuations and fall risk[16].

Biomechanical gait assessment is also important in amputee rehabilitation, osteoarthritis, sports injuries, and geriatric rehabilitation[6,14]. Among older adults, reduced gait speed and increased gait variability are strongly associated with frailty, falls, hospitalization, and mortality[15]. Importantly, gait analysis should not be viewed merely as a technological exercise but as a tool for rehabilitation decision-making. Effective interpretation requires integration of biomechanical findings with patient goals, functional limitations, cognition, endurance, and participation restrictions. The ultimate objective of gait analysis in PMR is to improve safe, efficient, and meaningful mobility through individualized rehabilitation interventions[1,3].

Emerging Technologies and Limitations

Recent technological advances have expanded gait analysis beyond specialized laboratories and improved accessibility in routine rehabilitation practice. Wearable inertial sensors containing accelerometers and gyroscopes enable continuous gait monitoring in real-world and facilitate home-based assessment [5].

Markerless motion capture systems utilize computer vision and artificial intelligence to analyse movement directly from video recordings, reducing equipment costs and improving accessibility[11]. Machine-learning algorithms are increasingly being used to identify disease-specific gait signatures, predict falls, monitor rehabilitation progress, and support intelligent prosthetic control systems[16]. Virtual reality platforms and robotic gait-training systems combine task-specific practice with objective movement analysis and have become useful adjuncts to neurorehabilitation programs.

Despite these advances, important limitations remain. Comprehensive gait laboratories are expensive, require specialized expertise, and may not be readily available in many rehabilitation settings, particularly in low- and middle-income countries[1]. Marker-based systems are susceptible to soft-tissue artifacts, and laboratory walking conditions may not fully reflect real-world mobility patterns.

Future developments are expected to focus on wearable technologies, artificial intelligence, tele-rehabilitation, cloud-based analytics, and low-cost markerless systems capable of delivering laboratory-quality gait assessment in routine clinical practice.

Conclusion

Gait analysis has evolved from subjective clinical observation to a multidisciplinary science integrating biomechanics, engineering, and rehabilitation medicine. Understanding normal gait biomechanics is essential for recognizing pathological movement patterns and interpreting quantitative gait data. Clinical gait analysis remains indispensable for rehabilitation physicians, while instrumented assessment objectively evaluates spatiotemporal, kinematic, kinetic, and electromyographic abnormalities and assists rehabilitation planning and outcome assessment.

Advances in motion capture systems, force platforms, electromyography, wearable sensors, and artificial intelligence have enhanced the precision and clinical applicability of gait evaluation. As these technologies become increasingly accessible, gait analysis will continue to play an important role in personalized rehabilitation, evidence-based clinical decision-making, and optimization of functional outcomes.

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Functional gait disorders

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INTRODUCTION

Functional gait disorders (FGD), previously termed psychogenic gait disorders are a subset of functional neurological disorders (FND) characterized by abnormal gait patterns that are incongruent with recognized neurological disease. Functional neurological disorder (FND) can include both motor and non-motor presentations. Abnormal gait is common in patients with motor-FND, being the sole presentation in 5.7% and part of a mixed movement disorder in 36.6% according to one study.[1]

The terminology used to describe Functional Neurologic disorders (FND) has undergone significant changes over time and is currently designated under 'Functional neurological symptom disorder (Conversion disorder)' in DSM-5TR, and 'Dissociative neurological symptom disorder' in ICD-11.[2]

EPIDEMIOLOGY

Functional motor disorders (FMD) account for approximately 3%–8% of visits to movement disorder clinics.[3,4] Functional gait disorders are more common in middle-aged and older adults and show a female preponderance. Recent studies suggest that gait symptoms are relatively more common in older individuals when compared with other functional movement phenotypes.[5,6]

PATHOPHYSIOLOGY

The pathophysiology of functional gait disorders is best understood using a biopsychosocial framework involving biological, psychological, and social factors. Neurobiological studies have demonstrated abnormalities in brain networks involved in motor planning, emotional processing, attention, and sense of agency.[7] Altered connectivity between motor and limbic regions may interfere with normal voluntary movement control.[8]

Current models explain FND using predictive processing theory, in which abnormal expectations and heightened self-focused attention override normal sensory feedback, leading to impaired perception of voluntary control over movement.[9] Psychological stressors, maladaptive illness beliefs, anxiety, and behavioural reinforcement may contribute to symptom development and persistence.[10] However, a precipitating psychological event is not necessary for diagnosis.

CLINICAL FEATURES AND DIAGNOSIS

The diagnosis of FND is primarily based on the identification of characteristic positive features, particularly inconsistency and incongruency with recognized organic gait disorders, rather than solely on the exclusion of an underlying organic neurological condition.[11] *Inconsistency* refers to unexplained variability across time and situations like discrepancy between examination findings and actual movement patterns, drastic fluctuation in symptoms, absence of falls despite severe abnormalities in gait and mismatch between observed disability and daily functioning. *Incongruency* refers to gait patterns or examination findings that are incompatible with recognized neurological disease, such as buckling gait despite normal strength, scissoring gait without corticospinal signs, or improvement of gait during distraction or dual-tasking.[12] Nonnekes et.al have classified functional gait symptoms into seven broad categories - ataxic gait, spastic gait, weak gait, antalgic gait, parkinsonian gait, hemiparetic gait, and dystonic gait.[12] The supportive tests to distinguish between functional and organic gait symptoms are shown in Table.1.

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Table 1 Classified Functional Gait Symptoms (Adapted from Nonnekes et al)[12]

Predominant sign	Supportive test	Suggest functional	Suggest organic
1. Ataxic gait : Variability in base. Claims of poor balance	Straight walking	Veering from side to side. Better balance than claimed	Vestibular / cerebellar – veering consistently to the side of lesion
	Walking backwards/ Walk with eyes closed	Improved performance	No change. Sensory/Vestibular ataxia worsen with eyes closed.
2. Spastic gait : Spasticity	Evaluation of tone	No adductor spasticity. Normal reflexes.	Adductor spasticity +. Brisk reflexes.
	Walking backwards	Scissoring disappears	Scissoring persists.
3. Weak gait : Weakness (Knees buckling/ Trendelenburg gait)	Muscle strength	No weakness	Weakness of quadriceps/gluteus
	Walk backwards/eyes closed	Buckling is inconsistent	Buckling consistently present
4. Antalgic gait : Limping	Physical examination	No pain	Pain +
5. Slowness (parkinsonian gait / bradykinetic)	Straight walking	Prolonged single leg stance time	Increase in double support time
	Pull test	Excessive trunk sway without falling. Balance appears good.	Small balance correcting steps .
6. Hemiparetic gait : Dragging	Physical Examination	No spasticity	Spasticity +
	Hoover test /Abductor sign	positive	negative
7. Dystonic gait : Abnormal posturing	Physical examination	No contractures or spasticity	Contractures or spasticity +

History taking: General principles

History taking should explore precipitating physical or emotional stressors, abrupt onset of symptoms, rapid progression, and marked variability across situations. Patients may report disability disproportionate to objective neurological findings, with fluctuations in gait and occasional spontaneous improvement.

Psychiatric comorbidities such as anxiety, depression, and post-traumatic stress disorder are common. Associated non-motor symptoms including pain, fatigue, sleep disturbance, cognitive complaints, fear of falling, and excessive self-monitoring may also be present.[19] Many patients have undergone multiple prior consultations and investigations before diagnosis.

Gait phenotypes

The term "astasia-abasia" was introduced in the 19th century, to describe psychogenic gait disorder. *Astasia* refers to the inability to stand upright, while *abasia* denotes an inability to walk with coordination.[13]

- *Psychogenic Romberg*: Large amplitude body sway, building up after a silent latency of a few seconds, with improvement by distraction.[14]
- *Uneconomic postures*: Body maintained in poorly balanced postures, like a shifted centre of gravity or flexed hips and knees, which requires excessive muscular effort and energy expenditure.[14]
- *Walking on ice gait*: Wide based, cautious steps with decreased stride length, stiff knees and ankles, and shuffling of the feet resembling walking on a slippery surface.[14]
- *Sudden buckling of knees*: Patient falls forward with sudden flexion of hips and knees and remains in an uneconomic half-flexed posture. Falling is often prevented by activating antigravity muscles.[14]
- *Monoparesis with leg dragging*: Monoparesis with normal swing on the unaffected side. Affected leg drags with forefoot in contact with the floor. The limb may be externally or medially rotated, with exaggerated effort to advance it during swing, often with extended hip or knee.[14,15]
- *Tightrope walking*: Exaggerated truncal sway while maintaining a narrow base, with legs appearing to follow a tightrope, truncal instability and targeting of nearby walls or furniture to avoid falls.[2]
- *Functional dystonic gait:* Abnormal posturing of the leg or trunk during gait cycle. Abnormal posturing may change with varying positions.[2]
- Neurological disease mimics like camptocormic gait, spastic, ataxic, sensory- ataxic, choreoballistic, parkinsonian and trendelenberg gait.[2]

Functional gait disorders are often equated with bizarre gait patterns. This is a common diagnostic pitfall because organic conditions can also result in seemingly atypical gait like dystonic gait, chorea, dyskinesias. Conversely FGDs need not always manifest bizarre gait patterns. For instance, the sudden knee buckling which is a common phenotype of functional gait, can also occur in negative myoclonus of lower extremities. [12]

Positive clinical signs

The diagnosis of functional gait disorders is supported by the presence of positive clinical signs demonstrating inconsistency, incongruity, distractibility, and preserved automatic movement.

Hoover's sign: In organic hemiparesis, when the patient is asked to flex the *unaffected* hip against resistance, there is no downward pressure from the affected heel on the examiner's hand. In functional weakness, increased pressure is felt under the affected heel.[16]

Abductor sign: In patients with unilateral functional leg weakness, voluntary abduction of the affected leg is weak when tested directly. However, strength normalizes when the contralateral leg abducts against resistance.[18]

"Huffing and puffing" sign: Excessive demonstration of effort through behaviours like grimacing, huffing, grunting, crying, and breath holding, which is inconsistent with objective neurological impairment.[17]

Swivel chair sign: Patients who show even bizarre gait patterns are able to propel themselves normally on a swivel chair. [17]

"Whack-a-mole" sign: Whack-a-mole is a simple arcade-style game where players use a soft mallet to hit ("whack") toy moles that randomly pop up from holes on a board. It describes the immediate reemergence of an involuntary movement in another body part after suppression of the movement of an affected part by the examiner holding that part of the body.[18]

Tandem walking test: Patients with a functional gait pattern resembling ataxia may perform the tandem gait without sidesteps . Might display scissoring or an exaggerated performance with prolonged single-leg stance or "windmill like" movements of the arms, but without falling.[12]

Non-motor symptoms are also common in patients with motor-FND. Anxiety, fatigue and pain were found to be the most common non-motor symptoms. Somatosensory symptoms, insomnia, cognitive symptoms and fatigue also might be present and can significantly impact the gait and functional mobility.[19] Fear of falling and kinesiophobia are common associated features in elderly population with functional gait disorders. Often a "cautious gait" is present in these patients when postural instability and fear of falling is present.[2]

It is vital to recognize that, presence of any of these signs and a diagnosis of functional movement disorder doesn't rule out an underlying medical or "organic" disorder. Functional symptoms could coexist with neurological disorders like brain injury, parkinsonism and multiple sclerosis.[2] In a study by stone et al, 12% patients with confirmed neurological disorders also demonstrated functional symptoms.[20]

MANAGEMENT

Delivering the diagnosis

Delivering the diagnosis of functional neurological disorder (FND) to patients requires clarity, empathy, and reassurance. The diagnosis should be presented as a positive clinical diagnosis based on characteristic examination findings rather than as a diagnosis of exclusion. It should be emphasised that their symptoms are genuine and arise from a dysfunction in nervous system functioning and not due to structural damage. Avoiding stigmatizing language and emphasizing the potential reversibility of symptoms and availability of treatment can enhance patient engagement and therapeutic outcomes.[2]

General Principles of Management

1. Multidisciplinary care.
2. Motor retraining and goal setting with graded approach.
3. Individualized treatment tailored to the patient.
4. Address psychiatric comorbidities like anxiety disorders, depressive disorders, PTSD and related psychiatric conditions.
5. Manage associated non-motor symptoms like insomnia, fatigue, cognitive impairment and pain.
6. Psychoeducation of patient and family.
7. Facilitation rather than support.
8. Minimising reinforcement.

Many studies have assessed multidisciplinary rehabilitation programs with duration ranging from 3 to 14 weeks which combine multiple specialties. It has been demonstrated that majority of patients had a significant improvement in physical functioning and quality of life.[21-23]

Psychotherapy

Psychotherapy plays an important role in the management of FNDs, particularly in addressing maladaptive thoughts, emotional stressors, and illness-related behaviours. Cognitive Behavioural Therapy (CBT) and Psychodynamic therapy have shown benefits in improving symptom severity, functional outcomes, and quality of life. Psychotherapy also helps patients develop coping strategies and improve insight into symptom triggers.[24]

Pharmacotherapy has only a limited role . Presence of psychiatric comorbidities might require treatment with medications like SSRIs or antipsychotics .

Rehabilitation

Rehabilitation has a key role in the multidisciplinary management of patients with FGD. Treatment should address illness beliefs, self-directed attention and abnormal habitual movement patterns through a process of education, movement retraining and self-management strategies within a non-judgemental context.[25]

General principles of rehabilitation for functional movement disorders include building trust, creating an expectation of improvement while helping the patient recognise and challenge maladaptive beliefs and behaviours. Emphasis should be more on facilitation rather than support. Rehabilitation efforts should be goal directed, focusing on function and automatic movement (e.g. walking) rather than the impairment (e.g. weakness) and controlled movement (e.g. strengthening exercises). Minimising reinforcement of maladaptive movement patterns and postures, and the use of adaptive equipment and mobility aids is crucial. Use of splints and devices that immobilise joints should be avoided.

Additional strategies include retraining movement with diverted attention, non-specific graded exercise, visualization techniques, mirrors and videos to give feedback about posture or gait pattern and keeping a rehabilitation diary.[26]

PROGNOSIS

Overall, the prognosis of functional motor symptoms appears unfavourable. A systematic review with more than 10,000 patients reported that more than one third of patients did not show improvement or were worse at follow up. Short duration of symptoms, early diagnosis and high satisfaction with care were good prognostic factors. Gender had minimal effect. Delayed diagnosis and personality disorders were poor prognostic factors. Age, comorbid anxiety and depression, IQ, educational status, marital status and pending litigation showed marked heterogeneity across studies.[27]

CONCLUSION

Functional gait disorders are a disabling subtype of functional neurological disorder. Diagnosis relies on identifying positive clinical signs demonstrating inconsistency and incongruency of the functional symptoms. Management requires a multidisciplinary approach involving physiotherapy, psychotherapy, psychoeducation, and treatment of associated psychiatric and non-motor symptoms. Although prognosis is variable, early diagnosis and individualized multidisciplinary rehabilitation are associated with better functional recovery and quality of life.

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Approach to Benign Paroxysmal Positional Vertigo

Sherin Sha S

BPPV is the commonest presenting cause of vertigo with an estimated lifetime prevalence of 2.4%. It has a characteristic history and can easily be diagnosed on examination. Treatment can be performed in the clinic with a good outcome, making it the most rewarding vestibular condition to manage.

The first clinical description of positional vertigo is attributed to Barany in 1921 and in 1952 Dix and Hallpike were the first to clearly describe the provoking manoeuvres. Dix and Hallpike coined the term 'benign paroxysmal positional vertigo' in view of the associated benign (non-cancerous) origin and momentary (paroxysmal) bursts of intense vertigo upon head movements (positional).

Pathophysiology

Otoconia are calcium carbonate crystals embedded in the macula of the utricle and saccule. They have a greater density than the surrounding endolymph thus making the macula sensitive to changes in linear acceleration and, importantly, gravity. The semicircular canals, on the other hand, are sensitive to changes in angular acceleration. [Fig. 1]

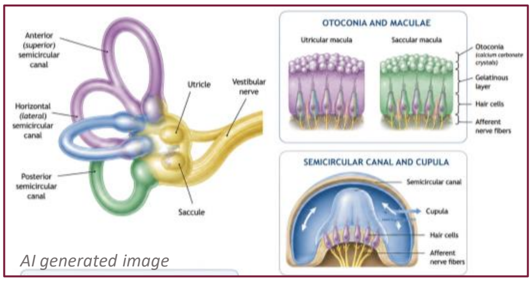

Fig. 1 Vestibular System

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In BPPV otoconia from the utricle are thought to collect in the semicircular canals, making them abnormally gravity-sensitive. The net result is that changes in head position with respect to gravity result in an abnormal displacement of the cupula and stimulation of the corresponding vestibular afferents. This results in the characteristic abnormal eye movements and vertigo. There are two theories of how this might occur.

Cupulolithiasis proposes that degenerative otoconia stick to the cupula making it gravity-sensitive. Canalolithiasis theory suggests that degenerative otoconial debris float freely in the endolymph of the semicircular canal. When exposed to gravity, the otoconia fall to the lowest part of the canal, causing a change in endolymph pressure with subsequent displacement of the cupula. [Fig. 2]

BPPV most commonly arises from the posterior semicircular canal (p-SCC). Much less frequently the horizontal semicircular canal (h-SCC) is involved while the anterior canal (a-SCC) is very rarely affected. The propensity for the accumulation of particles in the posterior canal is postulated to be related to anatomical factors such as the size of the common crus of the posterior

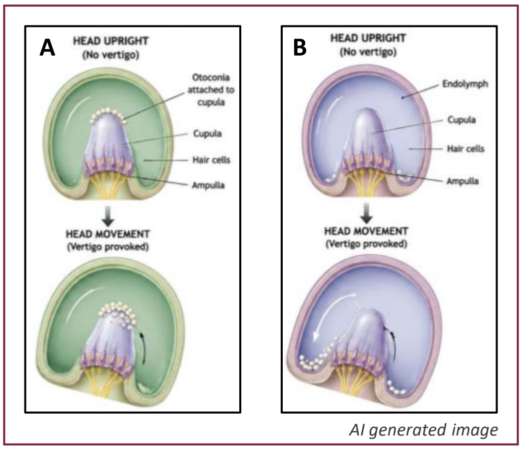


Fig 2 A Cupulolithiasis, B Canalolithiasis

and superior semicircular canals, its position below the utricle when supine and its dependent position when both erect and supine.

The hallmark of p-BPPV is vertigo lasting seconds with or without nausea and imbalance on lying down, sitting up from the lying position, or rolling in bed and when extending or flexing the neck. These symptoms can present in clusters with several attacks per day. In between attacks or shortly after successful treatment, patients are either symptom-free or experience a sensation of imbalance.

Risk factors that may initiate an acute episode of BPPV include prolonged bed rest, bending forward with the head down, and general anaesthesia, because the supine, head-down and head reclined position (e.g. during intubation) lower the opening of the posterior canal, thus promoting the penetration of particles.

Diagnosis of BPPV

Diagnosis of BPPV is made on the basis of typical signs (nystagmus) and symptoms (vertigo and nausea) provoked by specific positional tests. Understanding the characteristic eye movements during these tests will help in making the diagnosis.

Dix–Hallpike test to diagnose p-BPPV

The Dix–Hallpike test is the most important diagnostic manoeuvre for BPPV because posterior canal BPPV is the most common subtype and this test can identify the majority of affected patients. [Fig. 3]

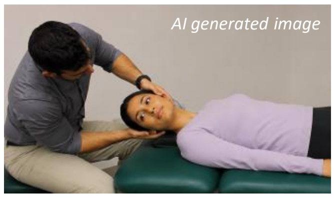
The patient is seated on the examination couch, feet up, and the head is turned 45 degrees towards the side being tested, aligning the vertical canals with the sagittal plane. The patient is rapidly brought into the head-hanging position over the end of the couch to lie 30 degrees below the horizontal while maintaining a position 45 degrees to the side being tested. Patients should be counselled before the test about dizziness and advised to keep their eyes open for examination.

Fig. 3 Dix–Hallpike test $

The test is positive if the patient experiences vertigo and exhibits specific eye movements (nystagmus). This nystagmus typically has a latency of 5–20 seconds and is transient (lasts less than 60 seconds).

Supine roll test to diagnose h-BPPV

The patient is placed in the supine position with the head flexed 30 degrees, bringing the horizontal canal into the axial plane, and the head is then briskly rolled to one side. The same is repeated to the opposite side. In the majority of cases, the nystagmus will be horizontal and geotropic (towards the ground) and towards the ear being tested. When turned to the opposite side, the nystagmus will reverse and beat towards the under most ear again.



Straight head-hanging manoeuvre to diagnose a-BPPV

The patient is moved from the sitting position to a supine head-hanging position with the head extending 30–40 degrees below the horizontal beyond the edge of the examination couch. The position is maintained while the examiner observes for vertigo and characteristic down-beating torsional nystagmus, which is suggestive of anterior canal BPPV. [Fig. 5]

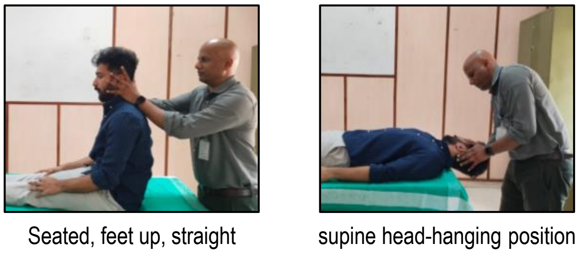


Fig. 5 Straight Head-hanging Manoeuvre $

Treatment

Treatment of p-BPPV

Epley's repositioning manoeuvre

It is considered the most effective treatment manoeuvre for posterior canal BPPV. The patient is initially seated upright with the head turned 45 degrees towards the affected side. The patient is then rapidly brought into the Dix–Hallpike position with the head hanging 30^{0} below the horizontal and maintained for 30–60 seconds. The head is subsequently rotated 90^{0} towards the unaffected side and held for another 30–60 seconds, following which the patient's body is

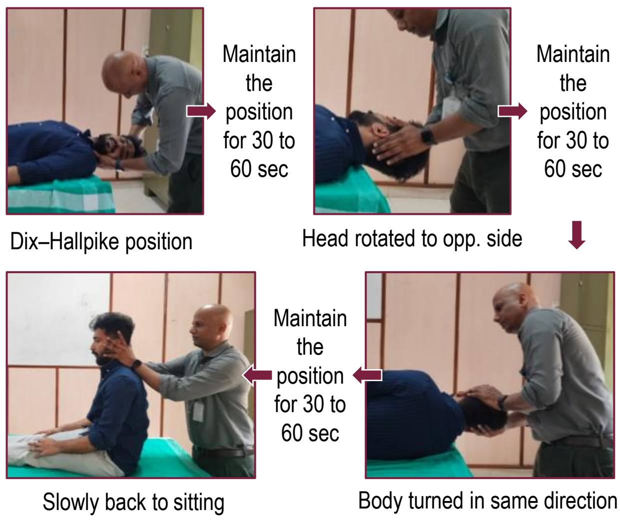


Fig. 6 Epley's repositioning manoeuvre $

turned further in the same direction into the lateral decubitus position with the nose facing downwards. After maintaining this position for 30–60 seconds, the patient is slowly brought back to the sitting position. The manoeuvre facilitates the movement of otoconial debris from the posterior semicircular canal into the vestibule by gravity.

Treatment of h-BPPV

Forced prolonged position on the healthy side

The patient is instructed to lie on the healthy side for 12 hours, facilitating gravitational movement of the debris into the vestibule by maintaining the affected horizontal semicircular canal uppermost.

270-degree 'barbecue' manoeuvre

This consists of turning the patient's head initially and then the body from the supine position in three 90-degree-step rotations (total 270 degrees) towards the unaffected ear. The body will eventually assume the prone position with the affected ear facing down, following which the patient will sit up. The rotation is performed within half a second and the head positions are maintained for 30–60 seconds.

Treatment of a-BPPV

Yacovino manoeuvre

The patient is moved from a seated to a head-hanging position with the head 30 degrees below the horizontal. After 30 seconds, the head is brought to a chin-to-chest position for 30 seconds and then to a seated position for another 30 seconds. [Fig. 7]

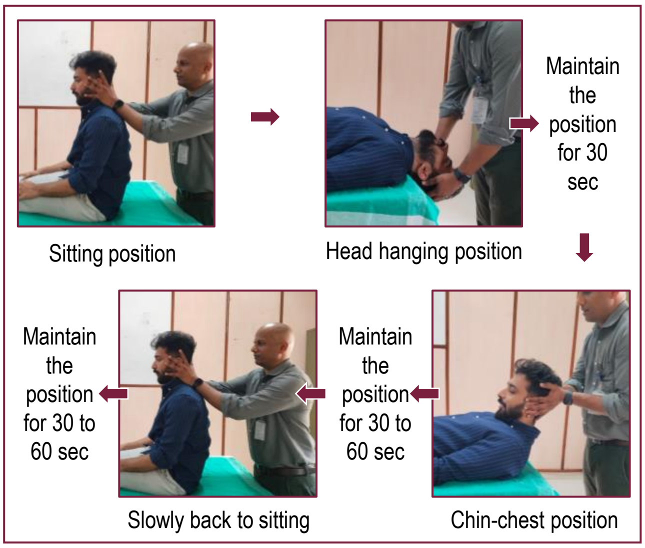


Fig. 7 Yacovino manoeuvre $

Role of imaging

Imaging of the posterior fossa is required in one of the following situations.

- Nystagmus is atypical for any of the BPPV syndromes
- Brainstem or cerebellar signs are present
- Positional vertigo does not resolve with repeated therapeutic manoeuvres

Conclusion

Benign Paroxysmal Positional Vertigo is the commonest cause of peripheral vertigo. If unrecognized or poorly treated, BPPV can lead to significant morbidity. It results from particles floating in the semicircular canals (canalolithiasis) or attached to the cupula (cupulolithiasis), with the posterior semicircular canal being most commonly affected. The vertigo is typically positional and lasts for a few seconds, and the majority of cases are idiopathic. Diagnosis is made using positional tests that produce characteristic nystagmus and vertigo, among which the Dix–Hallpike test remains the most effective diagnostic manoeuvre. Repositioning manoeuvres displace the particles back into the vestibule and are successful in the majority of cases, with Epley's manoeuvre being the most effective treatment manoeuvre for posterior canal BPPV. From a rehabilitation perspective, untreated BPPV can significantly impair balance, mobility, gait confidence, and increase fall risk, especially in older adults. Early recognition and appropriate repositioning manoeuvres can rapidly restore function and improve quality of life, while patients with persistent imbalance may benefit from vestibular rehabilitation and balance retraining.

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$ *image courtesy : Dr Sonu Mohan, Asst Professor, Dr Amal Chandran, Junior Resident Govt Medical College, Trivandrum*

Sacral Neuromodulation: Emerging Technologies and Rehabilitation Implications

[1]Asha Mohan

Introduction

Lower urinary tract and bowel dysfunctions are common causes of disability and reduced quality of life. Although behavioural interventions, pelvic floor rehabilitation, and pharmacotherapy remain first-line treatments, a significant proportion of patients continue to experience persistent symptoms despite adequate conservative management.[1,2] Sacral neuromodulation (SNM) has become an established treatment for refractory overactive bladder (OAB), urgency urinary incontinence, non-obstructive urinary retention, and faecal incontinence.[3]

Since its introduction in the late 1980s, SNM has evolved from a niche therapy into a sophisticated neuromodulation platform supported by improved device technology and expanding clinical evidence. Modern understanding suggests that SNM exerts its effects primarily through modulation of abnormal afferent signalling within sacral and supraspinal neural pathways involved in continence control rather than through direct stimulation of bladder contraction alone.[4] Functional neuroimaging studies demonstrating altered cortical and subcortical activity following stimulation further support a role for central neuroplasticity in mediating therapeutic benefit.[5]

Expanding Clinical Applications

While OAB and urinary retention remain the most common indications, the scope of SNM continues to broaden. Growing evidence supports its use in selected patients with neurogenic lower urinary tract dysfunction, particularly those with multiple sclerosis incomplete spinal cord injury.[6] The therapy has also demonstrated durable efficacy in faecal incontinence, improving continence scores and quality of life in appropriately selected patients.[7]

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Emerging applications include chronic pelvic pain, constipation, incontinence, and selected neurological disorders. Although current evidence remains limited for these indications, ongoing studies suggest that neuro-modulation may have a wider role in functional pelvic disorders than previously recognized.[8] [Table 1]

Table 1. Established and Emerging Indications

Established Indications	Emerging Applications
Overactive bladder	Chronic pelvic pain
Urgency urinary incontinence	Constipation
Non-obstructive urinary retention	Neurogenic bladder dysfunction
Faecal incontinence	
Urgency-frequency syndrome	

Technological Advances and Outcomes

Technological innovation represents the most significant development in SNM during the last decade. Rechargeable implantable pulse generators have substantially increased battery longevity,

Reducing the need for replacement surgeries and improving long-term cost efficiency.[9] MRI-compatible systems have addressed a major limitation of earlier devices, allowing patients to safely undergo magnetic resonance imaging when clinically indicated.[9] Advances in lead design, including tined leads and improved anchoring systems, have reduced lead migration and revision rates. Device miniaturization has improved patient comfort and cosmetic acceptability, while remote programming and telemedicine-based follow-up have facilitated optimization of stimulation parameters with fewer hospital visits.[10]

Research is increasingly focused on adaptive or closed-loop neuromodulation systems capable of automatically adjusting stimulation according to physiological feedback signals. Such technologies may improve therapeutic precision and energy efficiency. Artificial intelligence-based approaches are also being investigated for predicting treatment response and individualizing programming parameters.[11]

Clinical outcomes remain highly favourable. Long-term studies report sustained success rates of approximately 70–80% in patients with refractory OAB, with benefits extending beyond five years in many cohorts.[12] Patients with non-obstructive urinary retention frequently achieve restoration of spontaneous voiding and reduced dependence on intermittent catheterization.[13] Similar improvements in continence and quality of life have been reported among patients treated for faecal incontinence.[7]

Comparative studies indicate that SNM provides greater durability than percutaneous tibial nerve stimulation (PTNS), although PTNS remains less invasive. In comparison with intra-detrusor botulinum toxin injections, SNM offers sustained continuous therapy while avoiding the need for repeated injections and reducing the risk of treatment-related urinary retention.[2] Consequently, treatment selection should be individualized according to patient characteristics, comorbidities, treatment goals, and resource availability.

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Table 2. Comparison of Third-Line Therapies for OAB

Parameter	SNM	PTNS	Botulinum
Efficacy	High	Moderate	High
Durability	Long-term	Maintenance required	Temporary
Repeat procedures	Infrequent	Frequent	Repeated injections
Urinary retention risk	Low	Minimal	Higher

Rehabilitation Implications and Future Directions

SNM has increasing relevance within neuro-urological rehabilitation. Restoration of continence and improved bladder emptying can significantly enhance independence, social participation, caregiver burden, and overall quality of life in patients with neurological disorders.[6] Integration of neuromodulation with pelvic floor rehabilitation, behavioural therapies, and multidisciplinary rehabilitation programs may further optimize functional outcomes.

Future developments are expected to focus on precision neuromodulation, wearable monitoring technologies, adaptive closed-loop stimulation, and artificial intelligence-assisted treatment selection.[11] These advances may facilitate individualized therapy, improve long-term outcomes, and expand the role of SNM in functional restoration and neurorehabilitation.

Conclusion

Sacral neuromodulation has evolved into a mature neuromodulation platform with expanding indications and increasingly sophisticated technology. Rechargeable systems, MRI compatibility, miniaturization, remote programming, and emerging adaptive stimulation strategies have improved safety, durability, and patient experience. As evidence continues to grow, SNM is likely to play an increasingly important role in the personalized management of bladder, bowel, and pelvic floor dysfunction, particularly within neuro-urological rehabilitation.

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Two for one:
A patient testimonial and clinician's perspective

Ravi Sankaran[1]

Part 1 – From Stillness to Strength: My Journey Back to Life!

By Patient name– Anonymous

It all started on June 5, 2024, a beautiful sunny day and my daughter's first day of school. When I held her little hand and walked her to school with happiness and pride, I had no idea that the very next day, my life would change completely.

The following morning, I woke up with a severe headache, double vision, and an inability to swallow food. I could sense that something was terribly wrong.

I was rushed to Amrita Hospital, where I was admitted under the Neurology department- Dr. [redacted]. It was a Thursday. Within just two to three days, my condition worsened drastically. On that Sunday, even though doctors usually take a break, Dr. [redacted] came to see me - perhaps he knew something was not right. He had warned us that we needed to be careful about any infection but at the time, none of us realized how critical that warning was. On the night of June 9, at around 2 a.m., everything changed. I said I needed to get up—but I couldn't. My body refused to respond. I couldn't move at all. I was immediately shifted to the ICU. After that, everything is a big void for me.

I don't remember what really happened—only fragments of strange dreams, some connected, some completely random. It felt like I was trapped between reality and an endless nightmare. I have a faint memory that one day when I opened my eyes, I saw my mother. I couldn't understand what she said. At first, I thought it was a dream—but the dream never ended. Nurses came and went. Doctors appeared occasionally. Sometimes I saw my father, sometimes my mother, sometimes my husband. But I had no idea what was happening to me.

After few days, I remember my mother telling me that I had developed an infection in my brain. She kept reassuring me that my daughter was fine, going to school, and being cared for by my in-laws. It was at this moment that I realized that I had a child but even that didn't fully sink in. It was as if I had lost a part of myself. My father would come, touch me, and pray. Watching him in that state somehow made me think that this was it, I am going to die. It also made me realise how severe my condition was.

Slowly I regained my consciousness, but I was completely immobile. My life was sustained through a feeding tube inserted through my nose, a urinary catheter and a tracheostomy tube in my neck to help me breathe. I couldn't move my body, couldn't even turn my head. I could only move my eyes and hear. Nothing else. Every five to six hours, the nurses would turn me. The pain that I had to endure then was unbearable but I couldn't cry or speak. I couldn't even shift slightly on my own to try and ease that pain.

For two long months, I lay there, unable to move, yet fully aware. Finally, on August 7, 2024, I was shifted from the ICU to a room. Slowly, my left side began to respond—tiny movements in my hand and leg. Later, the right side began to move too, though it remained more affected. Physiotherapy became my path forward.

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Conflict of Interest : Nil

Every day, therapists worked with me, helping my muscles regain strength. One day, they made me sit up. But my head had no control—it swayed like that of a newborn baby. Slowly, with time and effort, I learned to hold it steady. From being carried on a stretcher, I progressed to sitting in a wheelchair. Every small step felt like a victory. On October 7, 2024, I was discharged. But to continue with my rehabilitation via the hospital guest house. Every morning, it was the same routine, heading to physiotherapy—pushing through one to one-and-a-half hours of exercises before going back to rest.

Eating was truly a struggle. Because of the tubes in my throat and nose, I couldn't swallow. So, the nasal tube was replaced with a feeding tube directly into my stomach. Then came a moment I will never forget—I began to swallow again. At first, just the tiniest amounts. But it was my ray of hope. After six long months, with the approval of all my doctors, we finally returned home on December 22, 2024.

That's where I began learning to live again. I slowly started eating normally. I moved from a wheelchair to a walker. Step by step, I regained my independence. A huge part of my recovery was thanks to my therapists. Even after long workdays, they would come to my home and continue my therapy. Their dedication helped me rebuild my life.

The hospital visits continued. In May 2025, I had to return to the hospital due to stomach pain and fever. There was an infection around the feeding tube, but since I was able to eat through my mouth, I was prescribed some antibiotics and the tube was removed. In July, I was admitted again to remove the tracheostomy tube. Though it was removed, the opening in my neck didn't close and required a surgery in October. By then, the urinary catheter had already been removed. And finally, by October 2025, I was free from all the tubes and medical attachments that had once defined my existence. Even today, I am not fully back to who I was. My right side is still weak. I cannot walk independently with complete confidence. My balance is not fully restored.

But I am still here, walking slowly towards full recovery. From a point where I could only move my eyes - to standing and taking steps again—this journey has been painful, slow, and incredibly challenging. Through it all, my strength came from my family—my father, my mother, my husband, and my brother. And above all, my little daughter, who waited for me without even fully understanding what was happening. I have not yet recovered completely, but I am sure I will. I will not be defeated. Every step I take today is a victory. I am Grit and will power crystallized. This was an episode of fight, all the way with prayers of all dear and impeccable care by Hospital and grace of God. And this… is my story of coming back to life.

Part 2 – Being the Unmentioned Part of Someone's Story: Physiatrist's Perspective

By Dr Ravi Sankaran

One day I opened my work email and found this forward from Admin in my mailbox. It detailed the above patient testimonial. My first interest was to share this with the Physiatry community, so I contacted the person who initially had sent this on the patient's behalf. Permission to share was granted. To protect patient privacy, I had to redact some details. Reading this raised a question for me: Was PMR involved in this case? Certainly, much of what is described falls within our purview and has been our position since 2009 in Amrita. The only named individuals per the narrative are the neurologist and a single therapist. On receiving the MRD number everything fell into place. What follows are the missing details.

31 y/o female with hypothyroid for 3 years

12-16/3/2024: Nephrology admission: Primary glomerular disease s/p biopsy

6/6/2024- 22/8/24: Neurology admission: Listerial Rhombencephalitis Klebsiella & Acinetobacter pneumonia, SLE with Lupus nephritis

22/8/24-17/10/24: Physiatry admission: Impaired ADLs secondary to Infective Encephalopathy resulting in quadriparesis, dysphagia on Ryle's tube, respiratory insufficiency on tracheostomy tube, urinary incontinence on IDC, SLE with Lupus nephritis Hypothyroidism, Brainstem and upper cervical cord demyelination, Critical Illness Neuropathy w/ phrenic nerve demyelination

With the snapshot you can see how major organ dysfunction and secondary infection eventually warranted Acute Inpatient Rehabilitation. The biopsy led to the SLE diagnosis and mycophenolate being prescribed. The nephritis on immunosuppression led to the secondary infection of her brain, which was promptly treated. Once antibiotics were nearly over rehabilitation became central to her care. What we received was a semiconscious quadriplegic patient on continuous BiPAP who desaturated with position shifting daily. Weaning her off, getting her stable enough for therapy, swallowing, decannulation, etc became the responsibility of PMR. Accustomed to such work, she was taken up as routine care. She went home walking, talking and doing her ADLs independently in about three months. From there we never saw her again. She has ongoing rehabilitation needs home therapy has not solved and still visits the hospital. Just not PMR.

Why did she not mention Physiatry?

People remember experiences that make their story, not the whole thing. Memory tends to align with emotionally salient and visible phases of care. From a systems perspective, recovery is often understood in fragments, with different phases attributed to different visible contributors. In that way sleepless nights handling her emergencies and weaning her off supports may go unrecognized.

While many therapists were involved in care from ICU when unconscious to ward to home, only one is mentioned. This therapist does deserve credit for the work of getting the patient from sit to stand to walk. As therapists are closely involved in visible functional milestones like walking, they are more readily associated with recovery. They are then valued more than those involved earlier in care, when the patient is capable. Stepping back from this individual case, it reflects a broader pattern. Rehabilitation medicine is structurally under-recognized because our most critical contributions occur when patients are least able to perceive them.

This testimonial highlights a recurring pattern in rehabilitation medicine: the most critical interventions often occur when patients are critically ill, sedated, or cognitively impaired. As a result, these phases are rarely encoded into patient memory or narrative.

By the time recovery becomes visible—sitting, standing, walking—the contributors most directly associated with those milestones are remembered. Earlier work—ventilator weaning, secretion management, dysphagia care, early mobilization—remains largely invisible despite being foundational.

This is not a failure of the patient's perspective, but a limitation of how recovery is experienced and remembered.

The question, then, is not why patients fail to acknowledge physiatry—but how we can better make our role visible, understandable, and narratable within the patient journey.

A set of steps to a solution

1. Narrative ownership: Patients tell stories using: Names/ Roles/ Moments. If "Physiatry" is not explicitly introduced, it won't exist in their story.

2. Milestone labelling: PMR work is often invisible because it's continuous. The solution is to convert it into named milestones e.g. "Today we got you off BiPAP"/ "Today you swallowed safely"/ "Today you no longer need the trach". Patients remember moments, not processes.

3. Discharge narrative shaping: Before discharge, patients should leave with a coherent story: "You came in unable to move or breathe independently. The rehab team helped you regain breathing, swallowing, and mobility step by step." If you don't give them this story, someone else will.

4. Written summary for patients: A simple one-page summary/ "Your recovery journey". Patients often use this when writing testimonials later.

5. Institutional branding problem: The term 'physiatry' itself is often not understood by patients, limiting recognition of the specialty.

6. Accept the asymmetry: People credit those who help them when they are conscious and emotional e.g. ICU = survival (blurred memory), Rehab = relationship + visible progress. You can mitigate this, not eliminate it.

If rehabilitation medicine is to be fully understood, it must not only deliver outcomes—but also ensure those outcomes are visible within the patient's story.

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History

Sister Kenny and the Origins of Rehabilitation: Lessons for Modern PMR Practice

Anand Raja D S[1]

Abstract

Sister Elizabeth Kenny was a pioneering figure in the management of poliomyelitis who challenged the prevailing practice of immobilization in the early twentieth century. Through her emphasis on pain relief, early mobilization, and functional recovery, she introduced principles that resemble modern rehabilitation approaches. Despite resistance from the medical establishment, her methods gained recognition and contributed to a shift in clinical practice. This article revisits her contributions and examines their relevance to contemporary Physical Medicine and Rehabilitation (PMR), highlighting lessons in clinical reasoning, patient-centred care, and innovation in rehabilitation practice.

Introduction

Medical practice evolves through cycles of acceptance and resistance. Innovations that challenge established norms often encounter scepticism, particularly when proposed by individuals outside traditional medical hierarchies. Sister Elizabeth Kenny's approach to poliomyelitis management represents one such turning point in the history of rehabilitation[2,3].

At a time when immobilization was considered standard care for poliomyelitis, Kenny advocated for an alternative approach centred on pain relief, muscle re-education, and early mobilization[2,4]. Her work, though controversial, contributed to a shift toward principles that align closely with modern PMR practice.

Beyond its historical significance, her work also illustrates how clinical insight and patient-centred observation can drive therapeutic innovation, even in the absence of formal scientific validation[3] . This makes her contributions particularly relevant in rehabilitation medicine, where individualized care and functional outcomes often guide practice.

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Historical Context: Poliomyelitis and Conventional Management

In the early twentieth century, poliomyelitis was a major public health concern with no effective treatment[3]. The prevailing medical approach emphasized immobilization of affected limbs, based on the belief that rest would prevent further damage[3,4].

However, this approach often resulted in persistent muscle stiffness, contractures, and long-term disability[4]. These limitations highlighted the need for alternative approaches and set the stage for innovation.

In retrospect, these complications reflect the consequences of prolonged disuse and lack of active rehabilitation, concepts that are now well understood in modern musculoskeletal and neurological care. The limitations of immobilization in polio management parallel similar challenges seen today in prolonged bed rest and critical illness-related deconditioning.

The Kenny Approach

Sister Kenny, an informally trained nurse from rural Australia, developed her approach based on clinical observation[2,3]. She observed that patients with poliomyelitis experienced significant pain and muscle spasm[2].

Her treatment approach included:

1. Application of hot moist packs
2. Early mobilization
3. Muscle re-education through active movement

This differed from conventional practice by emphasizing functional recovery and patient response rather than rigid immobilization[4]. Importantly, her approach prioritized restoration of movement over structural protection, reflecting an early understanding of functional rehabilitation. This shift from passive care to active engagement remains a cornerstone of contemporary rehabilitation strategies.

Relevance to Modern PMR Practice

Many principles underlying the Kenny method are now integral to contemporary rehabilitation:

1. Early Mobilization

Prevention of contractures and deconditioning through early movement[4]

2. Pain-Guided Therapy

Addressing pain and spasm to facilitate participation in rehabilitation

3. Functional Restoration

Focus on independence and meaningful activity

4. Patient-Centred Care

Individualized treatment guided by patient response. These principles are now widely applied across rehabilitation settings, including stroke and critical illness recovery[3]. Early mobilization is now routinely emphasized to reduce complications associated with prolonged immobility and deconditioning. Similarly, the emphasis on patient participation and restoration of function rather than passive care continues to influence modern rehabilitation approaches. These concepts remain central to activity-based and goal-oriented rehabilitation programs used in current clinical practice.

Lessons for Rehabilitation Practice

This historical perspective offers important lessons:

- Innovation may arise outside traditional academic pathways
- Clinical observation remains valuable in developing therapeutic approaches
- Resistance to new ideas is a recurring feature of medical progress (3)
- Functional outcomes should remain central to patient care

Additionally, the story of Sister Kenny highlights the importance of interdisciplinary collaboration and adaptability in clinical practice. Rehabilitation medicine often requires integration of multiple therapeutic approaches, and openness to evolving methods remains essential for improving patient outcomes.

Discussion

Sister Kenny's contribution extends beyond poliomyelitis management. Her emphasis on movement, function, and patient experience anticipated key principles of modern rehabilitation[3,4]. While not all aspects of her method were scientifically validated, her work helped shift attention toward active rehabilitation and functional recovery[4]. Her story also highlights the importance of questioning established practices and integrating clinical insight with evolving evidence.

From a contemporary perspective, her work can be seen as an early challenge to rigid, protocol-driven care. Modern rehabilitation increasingly recognizes the need for individualized, adaptive approaches that respond to patient variability rather than relying solely on standardized protocols.

Conclusion

Sister Kenny's work represents an important chapter in the evolution of rehabilitation medicine. Her emphasis on early mobilization, pain management, and functional recovery continues to resonate with contemporary PMR practice.

Revisiting her contributions underscores the importance of open-mindedness, clinical observation, and patient-centred care in advancing rehabilitation.

Her legacy also serves as a reminder that meaningful advances in medicine often emerge from challenging established norms and rethinking conventional approaches in light of patient-centred outcomes.

Disclosure

This article is adapted and expanded from a previously published narrative on Sister Kenny in Hektoen International (2021), with substantial modification and additional focus on rehabilitation practice[1].

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Cervicogenic Vertigo Associated with Cervical Osteophytes: A Case Report and Rehabilitation Approach

Akshay Kumar K[1], Santhosh K Raghavan[2], Sindhuja NS[3]

Abstract

Cervicogenic vertigo is a clinical condition characterized by dizziness associated with cervical spine dysfunction. It is often under-recognized and may mimic vestibular disorders. We report a case of a 57-year-old female presenting with chronic vertigo, neck pain, and postural instability, unresponsive to vestibular suppressants. Imaging revealed cervical spondylotic changes with posterior uncovertebral osteophytes. The patient was managed with a structured rehabilitation program including cervical proprioceptive training, strengthening exercises, and vestibular rehabilitation. Significant improvement in symptoms was observed. This case highlights the importance of considering cervicogenic causes in persistent vertigo and the role of targeted rehabilitation.

Introduction

Vertigo is a common clinical complaint encountered in rehabilitation and general medical practice, with a wide range of potential aetiologies including vestibular, neurological, cardiovascular, and cervical causes. While vestibular disorders remain the most frequently identified source, a subset of patients present with persistent dizziness in whom standard vestibular and neurological evaluations are inconclusive. In such cases, cervicogenic vertigo should be considered as a possible diagnosis.[1,2]

Cervicogenic vertigo is believed to arise from abnormal proprioceptive input originating from the cervical spine, particularly from the upper cervical segments. The cervical spine contains a high density of mechanoreceptors that contribute to head–eye coordination and postural control. Disruption of this proprioceptive input due to pain, muscle dysfunction, or degenerative changes can lead to a mismatch between cervical, vestibular, and visual sensory inputs, resulting in symptoms of dizziness, imbalance, and disorientation[2,3,4].

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Conflict of Interest : Nil

Degenerative changes of cervical spine, such as spondylosis and osteophyte formation, may further contribute to symptom generation through altered biomechanics, restricted mobility, and, in some cases, mechanical compression of adjacent vascular structures such as the vertebral artery. Although vascular compromise is less commonly demonstrated, it remains a potential contributing factor in selected patients. [4]

The diagnosis of cervicogenic vertigo is primarily clinical and remains one of exclusion[6]. It requires careful evaluation to rule out primary vestibular disorders, central neurological causes, and other systemic conditions. A thorough history, focused clinical examination, and appropriate imaging studies can aid in identifying cervical spine involvement. Recognition of this condition is important, as it has implications for targeted rehabilitation strategies and improved functional outcomes.[3,5]

Case Presentation

A 57-year-old woman presented with a two-year history of recurrent vertigo associated with neck pain, cervical stiffness, postural instability, and recurrent falls. One of the falls had previously resulted in bilateral forearm fractures. She had received multiple courses of vestibular suppressants over this period with minimal symptomatic improvement. Persistent symptoms despite medical therapy prompted further evaluation for possible non-vestibular causes of dizziness. There was no significant past medical history or major comorbidity.

On clinical examination, cervical range of motion was notably restricted, particularly during neck rotation and extension. No focal neurological deficits were identified. Cerebellar signs were absent, and Spurling's test was negative. Dix–Hallpike manoeuvre was not performed because of severe cervical spondylotic changes and concern regarding symptom exacerbation with neck positioning.

Routine blood investigations, electrocardiogram, and pure tone audiometry were within normal limits. Imaging of the cervical spine revealed degenerative changes. Plain radiographs demonstrated cervical spondylosis, while CT imaging showed anterior marginal and bridging osteophytes extending from C3 to C5 along with posterior uncovertebral osteophytes from C4 to C6 [Fig. 1]. MRI of the brain and spinal cord did not reveal any significant abnormality. CT angiography could not be performed because of a documented contrast allergy.

Based on the clinical presentation, imaging findings, and exclusion of vestibular and central neurological causes, a diagnosis of cervicogenic vertigo secondary to cervical spondylosis with osteophyte formation was made.

The patient underwent a structured rehabilitation program. Initial management included short-term use of a soft cervical collar, nonsteroidal anti-inflammatory drugs, vestibular suppressants, patient education, and reassurance. Vestibular suppressants were gradually tapered during the course of rehabilitation.

The rehabilitation program focused on postural correction, cervical proprioceptive retraining, strengthening exercises, and vestibular rehabilitation. Postural and ergonomic interventions included correction of forward head posture and modification of aggravating activities. Cervical proprioceptive training involved laser pointer-based joint position sense retraining exercises. Strengthening exercises targeted the deep neck flexors and scapular stabilizers to improve cervical stability and posture. Vestibular rehabilitation consisted of habituation exercises and gaze stabilization training.

Over the course of rehabilitation, the patient reported a significant reduction in vertigo episodes along with improvement in balance and neck pain. No further falls were reported during follow-up.

Discussion

Cervicogenic vertigo remains a diagnosis of exclusion and is often underdiagnosed. This is partly due to the overlap of symptoms with vestibular and central causes of dizziness, as well as the absence of definitive diagnostic tests[2,3].

The pathophysiology is believed to involve altered cervical proprioceptive input affecting vestibular processing. The upper cervical spine, rich in mechanoreceptors, plays a crucial role in sensorimotor integration, and dysfunction in this region can lead to a mismatch between cervical, visual, and vestibular inputs, resulting in dizziness and imbalance[2,3,4].

In this case, degenerative changes and osteophytes likely contributed to abnormal sensory input and postural instability. Restricted cervical mobility and chronic neck pain may have further impaired joint position sense and neuromuscular control, thereby exacerbating symptoms. Additionally, although not confirmed in this patient, osteophytic changes have been postulated to contribute to symptoms through possible mechanical effects on adjacent vascular structures[4].

The patient's improvement with a multimodal rehabilitation approach supports the role of cervical proprioceptive retraining, strengthening with postural correction, and combined vestibular rehabilitation in the management of cervicogenic vertigo.

Figure 1. Plain radiograph and computed tomography (CT) images of the cervical spine demonstrating multilevel cervical spondylotic changes with prominent anterior osteophyte formation and uncovertebral osteophytes involving the mid-cervical vertebrae (predominantly C3 to C6), consistent with degenerative cervical spondylosis associated with cervicogenic vertigo

Cervical proprioceptive training, particularly using joint position sense exercises, may help restore sensorimotor integration. Strengthening of deep neck flexors and scapular stabilizers contributes to improved cervical stability and posture. Vestibular rehabilitation, including habituation and gaze stabilization exercises, complements cervical interventions by addressing associated balance and visual–vestibular deficits[3,5]).

The use of a structured, multimodal approach is important, as isolated interventions may not adequately address the complex interplay of factors contributing to cervicogenic vertigo. These findings are consistent with previous literature suggesting that targeted rehabilitation can significantly improve symptoms in cervicogenic vertigo, although high-quality evidence remains limited[4,5].

Clinical Relevance to Rehabilitation Practice

Persistent vertigo not responding adequately to vestibular medications should prompt evaluation for possible cervical causes. Rehabilitation plays a central role in management, particularly through a multimodal approach combining cervical proprioceptive retraining, postural correction, strengthening exercises, and vestibular rehabilitation. Such combined interventions are often more effective than isolated treatment strategies in addressing the complex mechanisms contributing to cervicogenic vertigo.

Conclusion

Cervicogenic vertigo is an important and often overlooked cause of dizziness. This case demonstrates that an individualized rehabilitation program focusing on cervical proprioception, strength, and vestibular adaptation can lead to significant clinical improvement. Early involvement of rehabilitation specialists is essential for optimal outcomes.

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Dr. Shahin K. E.

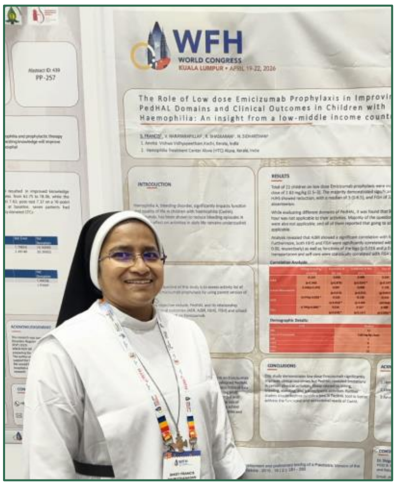
Dr. Shahin K. E., Specialist in Charge, Department of Physical Medicine and Rehabilitation, KIMS Al Shifa Super Speciality Hospital, Perinthalmanna, received the Award for Excellence in Stroke Rehabilitation Leadership at the National Stroke Conclave 2026 held in New Delhi.

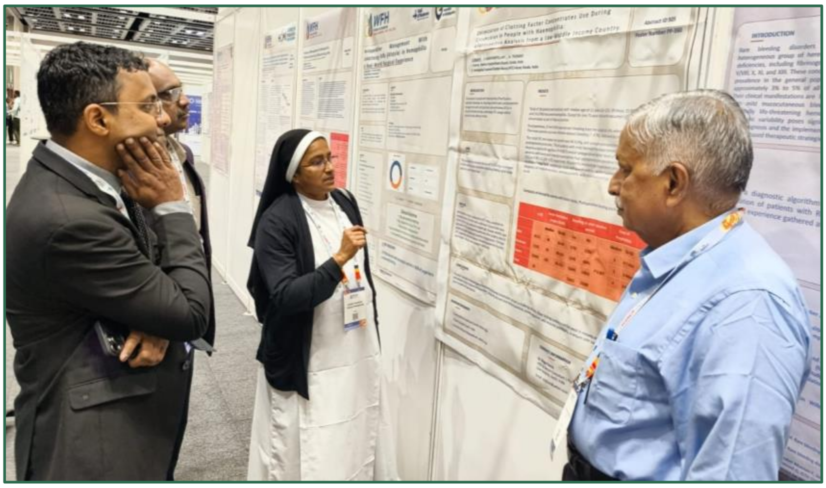
The award, presented during the Stroke Innovations & Excellence Awards 2026 organized by Voice of Health Care and endorsed by the. Indian Stroke Association, recognized his contributions to stroke rehabilitation and multidisciplinary neurorehabilitation care

Dr. Shigy Francis

Dr. Shigy Francis, Head of the Department of Physical Medicine and Rehabilitation, Lisie Hospital, Kochi, presented two scientific posters at the World Congress of Hemophilia 2026 held in Kuala Lumpur, Malaysia, organized by the World Federation of Hemophilia, highlighting rehabilitation and clinical outcomes in haemophilia care.

She also delivered a paper on Acute bleed management in haemophilia during a masterclass for DM Clinical Haematology students at St. John's Medical College, Bangalore, organized by the Indian Association of Haemophilia and Allied Disorders.

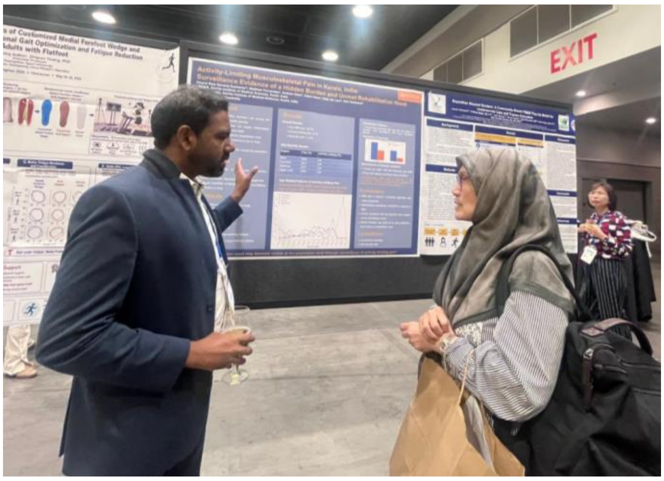


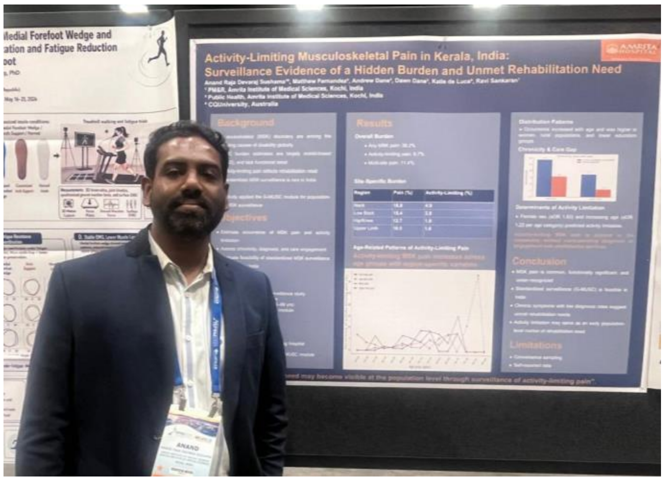


In addition, Dr. Shigy Francis participated as a panellist on Acute and Chronic Complications of Radiotherapy at the World Cancer Summit 2026 held at Kochi, contributing rehab perspectives to multidisciplinary oncology care.

Dr. Anand Raja

Dr. Anand Raja, Assistant Professor, Department of Physical Medicine and Rehabilitation, Amrita Institute of Medical Sciences, Kochi, presented a scientific poster at the ISPRM World Congress 2026 held in Vancouver, Canada, from May 18–21, 2026. The poster highlighted findings from a musculoskeletal pain surveillance study in Kerala and focused on the hidden burden of activity-limiting musculoskeletal pain and unmet rehabilitation needs at the community level





Dr. Razy Hassan and Dr. Masna Majeed

Dr. Razy Hassan and Dr. Masna Majeed, specialists in Physical Medicine and Rehabilitation, have started ReLiv Centre for Physical Medicine and Rehabilitation, Kozhikode, a dedicated private rehabilitation centre focused on evidence-based, non-surgical management of musculoskeletal and pain conditions.

The centre emphasizes function-oriented and personalized rehabilitation care through exercises, rehabilitation therapies, regenerative medicine approaches, and medical management, with the goal of achieving meaningful long-term recovery while reducing unnecessary surgical interventions. ReLiv also offers specialized services in PRP therapy, fibromyalgia care, lymphedema management, cancer rehabilitation, and geriatric rehabilitation. Their initiative reflects the growing role of PM&R in delivering evidence-based, function-oriented, & non-surgical rehabilitation care.

Jubilee Mission Medical College & Research Institute, Thrissur

The Department of Physical Medicine and Rehabilitation, Jubilee Mission Medical College & Research Institute, Thrissur, organized the Thrissur Pooram Exhibition Fall Prevention Initiative 2026, a community outreach programme focused on fall-risk screening, public education, and preventive rehabilitation during the Thrissur Pooram Exhibition.

Conducted under the leadership of the Departments of PM&R and Geriatrics, the initiative integrated rapid fall-risk assessment, balance and vision screening, exercise promotion, and public awareness activities within a large public gathering setting. The programme emphasized early identification of individuals at risk for falls and highlighted the importance of preventive rehabilitation and healthy ageing.

The initiative demonstrated an innovative community-oriented model combining geriatric rehabilitation, public health outreach, and preventive care, while also showcasing the expanding role of PM&R in community engagement and disability prevention.

Defying the Decline: A Multidisciplinary Approach to Sarcopenia

Sir,

We read with great interest the comprehensive article by Dr. Lakshmi[1] bringing this critical issue to the forefront and outlining essential guidelines for the screening and management of sarcopenia. The progressive loss of skeletal muscle mass and function is a formidable challenge in the landscape of modern critical care and rehabilitation. Dr. Lakshmi's work provides a vital framework for clinicians to identify and reverse this condition, mitigating the risks of prolonged hospital stays, cognitive decline, and increased mortality.

We appreciate the advocacy for the systematic integration of the European Working Group on Sarcopenia in Older People (EWGSOP2) guidelines into routine clinical practice[2]. The highlighted transition from the SARC-F questionnaire to objective clinical assessments using dynamometers, the 6-Minute Walk Test (6MWT), and the Short Physical Performance Battery (SPPB) is highly practical[3]. Additionally, the inclusion of definitive imaging modalities like DEXA, MRI, and BIA ensures diagnostic precision across patient populations.

Regarding management, the emphasis on targeted physical activity and nutritional optimization is highly relevant. Positioning resistance training—specifically a minimum of twice-weekly progressive strength training—as the cornerstone of rehabilitation, along with joint preservation and balance training, is vital and aligns with international consensus guidelines[4]. Furthermore, addressing the prevalent issue of protein deficiency in the Indian diet with specific targets of 1-1.2 g/kg daily (and up to 1.5 g/kg for critically ill patients) alongside Leucine supplementation provides excellent, actionable goals supported by established geriatric nutritional guidelines[5].

Ultimately, this article serves as a timely reminder that addressing sarcopenia requires a proactive, multidisciplinary approach starting in mid-life. By integrating physiatrists, physiotherapists, dietitians, and nursing staff, we can effectively transition from merely managing the symptoms of aging to actively preserving the functional vitality of our patients.

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* * * * *

Expanding Sarcopenia and Physical activity Guidelines

Sir,

We read with great interest the recent article on ‘ Sarcopenia and Physical activity Guidelines’ and would like to highlight certain evolving aspects regarding its assessment and management. Sarcopenia is characterized by progressive loss of skeletal muscle mass, strength, and physical performance and is now officially recognized as a muscle disease with ICD-10 code M62.84[2]. While earlier approaches primarily focused on quantification of muscle mass, recent evidence emphasizes that evaluation of muscle quality is equally important.

Muscle quality represents the relative composition of muscle fibres, vascular tissue, fibrous tissue, and adipose infiltration within muscle tissue. Conventional modalities such as Dual-Energy X-ray Absorptiometry and Bioimpedance Analysis mainly estimate muscle quantity, with limited information regarding muscle quality[1]. Although CT and MRI can assess both muscle quantity and quality, standardized cut-off values are yet to be universally established.

In recent years, musculoskeletal ultrasonography has emerged as a reliable, reproducible, and easily accessible modality in Physical Medicine and Rehabilitation practice. The SARCUS (Sarcopenia Through Ultrasound) recommendations advocate documentation of ultrasound parameters including muscle thickness, pennation angle, fascicle length, echo intensity, and cross-sectional area. Measurement of muscle cross-sectional area in muscles such as the quadriceps, rectus abdominis, gastrocnemius, biceps femoris may provide a practical outpatient-based approach for quantification of muscle mass and assessment of sarcopenia. These recommendations currently serve as a foundational framework and require further large-scale multicentric studies to facilitate the development of universally accepted global guidelines.

Anabolic resistance is commonly observed in older adults, wherein muscle protein synthesis response to dietary protein intake is diminished compared with younger individuals[3]. Hence, adequate nutrition with sufficient intake of high-quality protein, essential amino acids (leucine rich) assumes major importance.

In addition, multicomponent exercise programs combining resistance, balance, and aerobic exercises for a minimum duration of 12 weeks have demonstrated significant benefits in improving muscle strength, physical performance, and overall functional status[4]

We believe that incorporation of muscle quality assessment, particularly through ultrasonography, along with targeted nutritional and exercise interventions, may further enhance early diagnosis and comprehensive management of sarcopenia.

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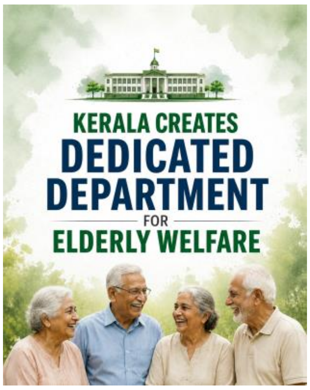
■

A FINAL WORD

LOOKING AHEAD - NEXT ISSUE

As this edition of KJPMR draws to a close, we hope you enjoyed this issue themed on “Movement Analysis”. This naturally sets us thinking about the theme for the September edition.

The recent initiative of the Government of Kerala to establish a dedicated department for senior citizens reflects a growing recognition of the challenges and opportunities associated with population ageing. This landmark step underscores the need for comprehensive strategies that promote healthy, active, and dignified ageing.



Rehabilitation has a pivotal role in this endeavour. As longevity increases, healthcare priorities must extend beyond disease management to encompass the preservation of function, independence, mobility, participation, and quality of life.

At this juncture we are pleased to announce “Geriatric Rehabilitation” as the theme for our next issue. We look forward to exploring this vital and evolving field with our readers in the forthcoming issue of KJPMR. Expecting your continued support and valuable contributions.

NATIONAL PMR DAY

“Rehabilitation is Essential, Not Optional”

National PMR Day is observed on 6th July every year, as spearheaded by the Indian Association of Physical Medicine and Rehabilitation. This year's theme, “Rehab is Essential, Not Optional,” is both a statement of fact and a call to action.

As specialists in Physical Medicine and Rehabilitation, we witness daily the profound impact of rehabilitation on function, participation, and quality of life. Yet, access to comprehensive rehabilitation services remains limited for many who need them. The challenge before us is not only to expand access, but also to ensure the availability of high-quality, evidence-based, physiatrist-led multidisciplinary rehabilitation services that address the complex needs of individuals with chronic diseases and disability.

National PMR Day provides an opportunity to reaffirm our commitment to advancing rehabilitation across the continuum of care, strengthening awareness, promoting research and innovation, and advocating for policies that support equitable access to rehabilitation services.

As we observe National PMR Day 2026, let us collectively champion the message that rehabilitation is an essential service and strive together to ensure that every individual has access to genuine, PMR led comprehensive rehabilitation, enabling the best possible functional outcomes and quality of life.

REVIEWER POOL

KJPMR CALL FOR SUBMISSIONS

KJPMR invites submissions from physiatrists, residents, researchers, and medical practitioners who are interested in rehabilitation medicine. We welcome:

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- Innovation & Technology Briefs
- Humanities & Reflections
- Resident Forum Articles
- Community Stories
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