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VIMS Journal of Physical Therapy [Formally known as VIMS Journal of Physiotherapy Case Reports) is an open access peer reviewed official Journal of DVVPF's, College of Physiotherapy, Ahilyanagar. This journal accepts original research papers that expands the field of general Physiotherapy knowledge and which has important implications for physiotherapy.

It covers wide areas in Physiotherapy being covered under five prominent specialties which are in tune with the affiliating university i.e. Maharashtra University of Health Sciences (MUHS) Nashik, these specialties are Musculoskeletal Physiotherapy, Neuro-physiotherapy, Cardio vascular & respiratory Physiotherapy and Community Physiotherapy and Sports Physiotherapy. It has separate editors for each specialty thus increasing the chances of better quality minutely scrutinized research reports. The issue is published half yearly.

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Contents

Editorial

- Death of the Research Question: Let's Revive It** 01
Suvarna Ganvir

Review Article

- Barriers to the Social Participation of People with Locomotor Disabilities:
A Scoping Review** 03
Anjan Desai, Vandana Rathod
- Effects of Exercise on Inflammatory Biomarkers in Adults
with Metabolic Syndrome: A Systematic Review** 11
Pranali Gaikwad, Abhijit Diwate, Arijit Kumar Das, Archana Nagargoje

Original Article

- Comparative Analysis of Resistance and Aerobic Training Effects
on Balance Performance in Elderly Adults: A Quasi-Experimental Study** 20
Yashodhan Chaughule, Manikandan P
- Effect of Smart Phone Addiction on Neck Muscles Endurance –
A Cross-sectional Study** 29
Pankaj Sancheti Payal, Saqib Syed, Deepak Anap, Shyam Ganvir
- Correlation between Core Strength with Dynamic Balance and Change
of Direction Speed in Adolescent Skaters: A Cross-sectional Study** 38
*Zawar Pranoti, Hanif Saarah Moahmmed, Bangera Mithila Dayanand,
Farooqui Farzeen*
- Awareness and Practices of Hand Care in Individuals with
Type II Diabetes: A Cross-sectional Study** 46
D'souza Jude, Aayushi Jain

Clinical and Electrophysiological Detection of Diabetic Neuropathy in Individuals with Type 2 Diabetes Mellitus: A Comparative Pilot Study in Western Maharashtra	51
<i>Dhumal Jairaj Sanjay, Ganvir Shyam, Ganvir Suvarna, Shaikh Jasmine, Waran Marcia, Shrivastava A. K.</i>	

Community Awareness, Knowledge, and Perceptions Regarding the Role of Physiotherapy in Spinal Cord Injury Rehabilitation: A Cross-sectional Study	58
<i>Shaikh Jasmine, Wani Ankita, Ganvir Suvarna, Harishchandre Maheshwari</i>	

Physical Fitness Profile among Physiotherapy Students across Academic Years -A Cross-sectional Study	65
<i>Sanika Dhananjay Sawant, Ganvir Shyam</i>	

Case Report

Effects of Multimodal Exercise Program Combined with Inspiratory Muscle Training on Cardio- Renalmuscle Axis and Clinical Outcomes in a Patient with Chronic Kidney Disease: A Case Report	76
<i>Naik Minaz, Pawadshetty Vishvnath</i>	

Book Review

The ICF Handbook: A Comprehensive Guide to Functioning and Rehabilitation in Physiotherapy	80
<i>Ganvir Shyam</i>	

Equipment Review

VIMS Arthritis Registry: Advancing Evidence-based Knee Osteoarthritis Care through Digital Health Innovation	83
<i>Riya Gurudasani, Vanshika Matra, Deepak Anap</i>	

EDITORIAL

Death of the Research Question: Let's Revive It

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The NCAHP Act 2021, NAAC, and the UGC Career Advancement Scheme have done something remarkable: they made research mandatory. Publications are now tied to probation confirmation, promotion, and institutional grades. In principle, this is progress¹⁻³. A profession that does not generate its own evidence cannot claim autonomy.

In practice, we have created a high-volume, low-impact ecosystem. We are publishing to be counted, not to be read. The root cause is a structural mismatch. The Academic Performance Indicator (API) rewards "number of papers," not "problems solved." A case report in an obscure journal and a multicentre RCT receive the same points if both are in UGC-CARE¹. When the metric becomes the target, it ceases to be a good metric. Goodhart's Law is alive in every faculty room⁴.

SYMPTOMS OF A PROFESSION DRIFTING

- i. Predatory Participation: Faculty, desperate for points, publish in journals that email acceptance in 48 hours. The science is not reviewed; the

invoice is. The CV looks complete. But the science is dead on arrival.

- ii. The Clinical Disconnect: If one walks into any OPD, the therapist's dilemma is not "what is the prevalence of forward head posture?" It is: "For my stroke patient with severe spasticity and no caregiver, what dose of functional task practice can I achieve in 20 minutes that still facilitates neuroplasticity"? Our literature rarely answers this. We are answering questions no clinician asked, while the questions they ask daily remain unstudied.

RECLAIMING SCHOLARSHIP: FROM 'PUBLISH OR PERISH' TO 'PUBLISH WITH PURPOSE'

The NCAHP Act gives us, for the first time, a statutory mandate to define standards of education and research. We must use it to realign incentives. Scholarship is not just discovery. Ernest Boyer's 1990 model reminds us of four domains: Discovery, Integration, Application, and Teaching. All four are scholarships⁵ (Annexure).

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THE ROLE OF JOURNALS: GATEKEEPERS OF PURPOSE

As editors, we are complicit if we publish without purpose. To address this issue, this journal is planning to adopt three policies:

- i. No Unregistered Trials: Any interventional study must have CTRI registration before first patient recruitment. No exceptions.
- ii. Clinical Relevance Statement: Every article must include 3 lines: "How will this change my practice on Monday?" If the authors cannot answer, reviewers will ask why we should publish.
- iii. New Section: 'From OPD to Paper': 800-word reports of how a clinical problem became a study, and how the result changed the department's protocol.

This is not about reducing research. It is about increasing relevance. India has the world's highest burden of stroke, COPD, and diabetic foot. Our patients need answers on dose, duration, and delivery in resource-limited settings. That is our unique contribution to global science.

The NCAHP Act gave us the right to call ourselves professionals. Our scholarship must now prove we deserve it.

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No registration = no accountability. Registering forces researchers to define dose, primary outcome, and patient benefit before data collection starts.

ANNEXURE

3 Questions to be Asked before Starting Any Study

If the answer to any question is "No", pause and question should be reframed

1. Which patient in the OPD asked for this answer?
Research must start with a clinical problem, not a CV gap. If no patient will benefit, it's paperwork, not scholarship.
2. Will the result change department's protocol in 6 months?
If the answer is "no" or "maybe for a paper" study should be abandoned. If "yes" → a patient in Bed 12 will get better care. That's impact.
3. Can the study be registered in CTRI today with honest outcomes?

No registration = no accountability. Registering forces researcher to define dose, primary outcome, and patient benefit before data collection starts.

REVIEW ARTICLE

Barriers to the Social Participation of People with Locomotor Disabilities: A Scoping Review

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Abstract

Background: Social Participation (SP) is a cornerstone of health, well-being, and quality of life. For people with locomotor impairments, full and effective social participation remains an elusive goal, hindered by a complex array of barriers. So, this study aims to find barriers that limit the SP of people with locomotor disabilities in various life domains. **Methods:** Following the methodological framework for scoping reviews proposed by Arksey and O'Malley, this review synthesized evidence from peer-reviewed articles, systematic reviews, and key reports. The focus was on multi-level. **Findings:** The literature consistently identifies a persistent and interacting physical and environmental, attitudinal and social institutional and policy, personal and relational, and economic barriers. While technology is often a facilitator, it can also present new barriers. **Conclusion:** Barriers to social participation for people with locomotor disabilities remain pervasive and systemic. Effective intervention requires holistic approach which promote social inclusion in all spheres of life.

INTRODUCTION

The World Health Organization (WHO) defines disability as an impairment, limitation, or restriction in activity primarily caused by health issues and environmental factors¹. Globally, around 15% of the population experiences some form of disability, with 20% of these individuals facing significant functional limitations². Notably, 80% of those living with

disabilities are in developing countries, highlighting the urgent need for their inclusion in all aspects of life¹.

Social participation, defined as a person's involvement in activities that provide interaction with others in society or the community, is fundamental to human existence¹. It encompasses domains such as employment, education, civic engagement, recreation, and interpersonal relationships. For people with locomotor disabilities-which include impairments

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related to the bones, joints, muscles, and nerves leading to limitations in mobility, such as spinal cord injury, amputation, cerebral palsy, and musculoskeletal disorders-social participation is crucial for psychological well-being, life satisfaction, and a sense of belonging^{2,3}.

The “bio-psycho-social model” has shifted the focus from a purely medical perspective to a social approach regarding disability, considering environmental factors, personal characteristics, quality of life, and levels of independence. The International Classification of Functioning, Disability, and Health (ICF) categorizes disabilities into various types, including hearing, visual, speech, mental, and locomotor disabilities, with locomotor disability being the most prevalent in India^{4,5}. Individuals with disabilities (PwD) often face negative socioeconomic impacts, such as poverty, physiological stress, and limited access to essential resources like education, healthcare, employment, and community engagement⁶. Women with disabilities encounter specific challenges related to reproductive and sexual health services⁷.

People with locomotor disabilities face considerable health risks due to a physically inactive lifestyle. Even when they wish to increase their physical activity, they encounter more barriers than the general population, restricting their opportunities for health improvement. Promoting physical activity among both younger and older individuals with locomotor disabilities should be a top priority for public and private organizations dedicated to enhancing the health of all citizens.

As India prepares for its upcoming decennial census and reaffirms its commitments to the Committee on the Rights of Persons with Disabilities and the Sustainable Development Goals (SDGs), there is an urgent need to assess and report on disability rates within the country. Unfortunately, only a small percentage of persons with disabilities receive necessary services, and governmental support has been limited in addressing the seriousness of disability issues. The cultural and social contexts in which individuals live can vary significantly, affecting their participation in life.

The United Nations Convention on the Rights of Persons with Disabilities (CRPD), ratified by a majority

of countries, explicitly recognizes the right to full and effective participation and inclusion in society⁸. Despite this international mandate, a significant gap persists between policy and lived reality, particularly as recent global assessments highlight that the needs of persons with disabilities are not being met⁹. As India reaffirms its commitments to the CRPD and the Sustainable Development Goals (SDGs), there is an urgent need to assess and report on disability and the barriers to participation¹⁰. This scoping review aims to provide a comprehensive overview of the literature from 2011 to 2025 to systematically identify and categorize the barriers that continue to impede the social participation of people with locomotor disabilities. By mapping this landscape, we can inform future research, policy development, and practical interventions¹¹.

METHODS

This scoping review was conducted by using framework by Arksey and O'Malley and enhanced by Levac *et al.*¹². The process of scoping review involved five key stages and adhered to the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines for transparency and reporting of the different studies¹³.

Identifying the Research Question

The primary research question was: What are the barriers to social participation for people with locomotor disabilities reported in the literature between 2011 and 2025?

Identifying Relevant Studies

A comprehensive search strategy was developed and it was executed on February 15, 2025. The following electronic databases were searched: PubMed, CINAHL, and Google Scholar. Grey literature, including reports from the World Health Organization (WHO) and the World Bank, was also included. The search strategy combined terms related to the population (locomotor disability), concept (social participation), and context (barriers).

PubMed Search String: (“locomotor disability” [MeSH Terms] OR “physical disability” [Title/Abstract] OR “mobility impairment” [Title/Abstract] OR “wheelchair user” [Title/Abstract]) AND (“social participation” [MeSH Terms] OR “community participation” [Title/Abstract] OR “social inclusion” [Title/Abstract]) AND (“barriers” [Title/Abstract] OR “obstacles” [Title/Abstract]).

CINAHL and Google Scholar: Similar was adapted using Boolean operators (AND, OR) and relevant subject headings (e.g., “physical disability,” “social inclusion,” “environmental barriers”).

Study Selection

Articles were included if they: (i) explicitly discussed barriers to social participation; (ii) focused on people with locomotor disabilities; (iii) were published in English between 2011-2025; and (iv) were primary research (qualitative, quantitative, or mixed-methods), systematic reviews, or comprehensive reports. Articles were excluded if they focused solely on other disability types (e.g., visual, hearing, or intellectual disabilities) without a specific locomotor component.

The study selection process was conducted independently by two reviewers. A third reviewer resolved disagreements through consensus. The screening process, including reasons for exclusion, is given in the PRISMA-ScR flow diagram (Figure 1).

Charting the Data

Key points were identified from the 28 included studies (Table 1). This process was also performed independently by two reviewers to ensure accuracy and consistency. The charted data included author, year, country, study design, sample characteristics, and a summary of key barriers identified.

RESULTS

It is a multi-level framework of Barriers. The analysis of 28 included studies revealed that barriers are not isolated but exist within a complex, multi-level ecosystem. The following themes were identified:

Physical and Environmental Barriers

This was the most frequently documented category (present in 24/28 studies), concerning the inaccessibility of the physical world.

Built Environment: Persistent issues include the absence of ramps, narrow doorways, inaccessible restrooms, and poorly designed public buildings^{15,17}. A study by Kuper *et al.* found that inaccessible healthcare facilities directly limited the ability of people with disabilities to access services¹⁵.

Public Transportation: Inaccessible buses, train stations, and taxis remain a critical barrier, particularly in Low- and Middle-Income Countries (LMICs). Even in high-income countries, inconsistent service and high costs for paratransit services can isolate individuals^{16,17}.

Public Spaces and Urban Planning: The lack of paved paths in parks, accessible playgrounds, and

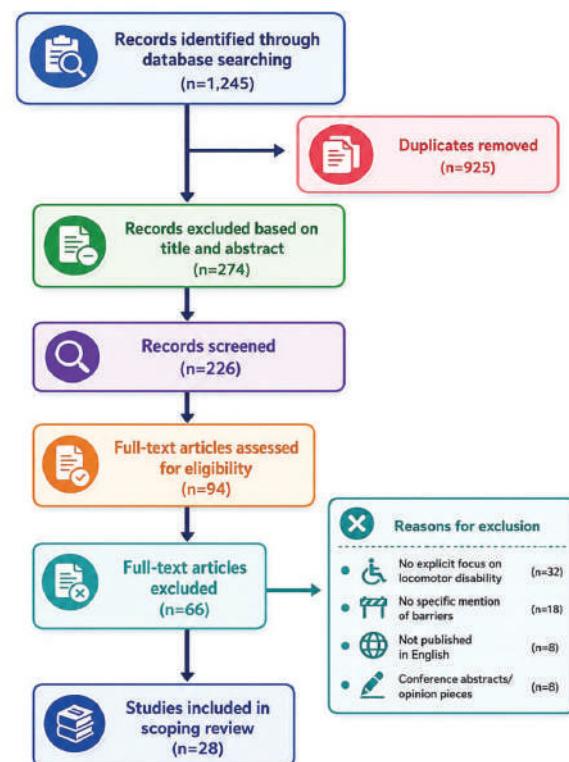


FIGURE 1: Prisma flow diagram

Figure 1. Prisma flow diagram.

Table 1. Characteristics of included studies (n=28)

Country	Study Design	Sample/Participants	Key Barriers/Focus	References
Global	Framework	People with disabilities	Environmental, Personal (ICF framework)	¹
India	Secondary Data Analysis	Population Census	Socio-economic inequalities by disability type	³
India	Cross-Sectional	Individuals with locomotor disabilities	Barriers to treatment-seeking	⁴
Bangladesh	Cross-Sectional	Adults with locomotor disability	Socio-demographic determinants of severity	⁵
Developing countries	Multidimensional Study	Persons with disabilities	Disability and poverty	⁶
Global	Review	People with disabilities	Health equity barriers	⁷
Global	Report	Persons with disabilities	SDG commitments and disability inclusion	¹⁰
Global	Methodology	Scoping review methods	Guidance for scoping reviews	¹¹
Multi-country (LMICs)	Cross-Sectional / Report	People with various disabilities	Institutional, Physical, Economic barriers to health and social care access	¹⁵
UK	Qualitative	Young people with mobility impairments	Attitudinal, Institutional, Digital barriers	¹⁶
USA	Qualitative Meta-synthesis	People with mobility impairments	Environmental, Attitudinal, Personal barriers	¹⁷
Global	Theory / Review	People with disabilities	Attitudinal (Stigma), Institutional barriers	¹⁸
India	Critical Discourse	People with disabilities	Institutional, Attitudinal, Economic barriers	¹⁹
India	Quantitative (NSS)	Persons with disabilities	Economic (Employment), Institutional barriers	²⁰
Canada	Qualitative	Working-age adults with physical disabilities	Personal/Relational, Institutional barriers	²¹
Global	Scoping Review	People with disabilities	Digital (Inaccessibility), Digital Divide	²²
Global South	Edited Volume / Review	People with disabilities	Institutional, Economic, Attitudinal barriers	²³
Global	Review / Policy Analysis	People with disabilities	Institutional (Policy Enforcement)	²⁴
Global	Report	People with disabilities	Economic, Digital barriers	²⁵
India	Interpretive Phenomenological Analysis	People with locomotor disabilities	Intrapersonal, Interpersonal, Structural constraints in leisure travel	²⁶
Multi-country	Scoping Review	Adults with mobility disability	Outdoor PA barriers: Intrapersonal, Social-environmental, Physical-environmental, Policy-related	²⁷

Table 1. Cntd

Country	Study Design	Sample/Participants	Key Barriers/Focus	References
Multi-country	Scoping Review	Children and youth with physical disabilities	Clothing-related barriers: Functional, Esthetic, Sizing, Dignity, Fabric, Safety concerns	²⁸
Multi-country (Canada, Sweden, USA, UK)	Scoping Review	Adult wheelchair users	Socio-emotional barriers: Independence and Autonomy, Social Stigma and Discrimination, Self-Identity and Body Image	²⁹
India	Descriptive / Semi-structured interviews	98 persons with locomotor disability	Economic disadvantage, Financial dependency, Social isolation	³⁰
Multi-country	Scoping Review	Individuals with mobility disabilities	Systemic challenges, Discriminatory practices, Societal attitudes in public building accessibility	³¹
Germany	Qualitative Focus Groups	19 people with MS and gait impairment	Architectural barriers, Pathways, Weather, Public transportation, Attitudes, Discriminatory attitudes	³²
Global	Scoping Review	Children/youth with motor disabilities	ICT barriers: User-unfriendly programs, Insufficient stakeholder knowledge, Lack of follow-up support	³³
Global	Survey-based research	People with disabilities	Economic barriers (higher turnover rates, compensation, cost implications); Digital and systemic barriers (disclosure challenges, accommodation processes, regulatory distractions)	³⁴

audible traffic signals restricts opportunities for leisure and community interaction¹⁷.

Attitudinal and Social Barriers

These barriers, rooted in societal beliefs and perceptions, were identified in 22/28 studies and are often described as the most difficult to overcome.

Stigma and Pity: People with locomotor disabilities frequently report being viewed as objects of pity, helpless, or less capable, leading to social avoidance or over-protection^{16,18}.

Discrimination and Stereotyping: Negative stereotypes about competence persist in social settings, employment, and education. Liddiard *et al.* highlighted that employer attitudes were a primary reason for high unemployment rates among young people with physical disabilities¹⁶.

Low Expectations: Studies noted that family members, educators, and healthcare providers may hold low expectations for what a person with a disability can achieve, inadvertently limiting their opportunities for social and vocational growth¹⁹.

Institutional and Policy Barriers

Identified in 20/28 studies, these involve laws, regulations, and systems that fail to ensure equity or are poorly implemented.

Inadequate Enforcement: While many countries have anti-discrimination laws, enforcement is often weak. Furlong and O'Brien (2022) found a wide gap between the CRPD's ideals and national-level implementation²⁴.

Fragmented Services: Fragmented healthcare, a lack of affordable personal assistance services, and long

waiting times for assistive devices directly impede the ability to participate in daily life^{15,23}.

Participatory Gap: A critical barrier is the exclusion of people with disabilities from the planning and decision-making processes that affect them (“Nothing About Us Without Us”)^{19,24}.

Economic Barriers

Financial constraints are a profound and cross-cutting barrier, appearing in 19/28 studies.

High Cost of Disability: Expenses for assistive devices, home modifications, and transportation can be prohibitive, draining resources^{21,25}.

Employment Discrimination: High rates of unemployment and underemployment lead to economic insecurity and poverty, which in turn restricts social options²⁰. Mitra & Sambamoorthi (2014) provide evidence of this in an Indian context²⁰.

Inadequate Social Protection: Disability benefits are often insufficient to cover basic living costs and do not facilitate economic participation¹⁵.

Personal and Relational Barriers

These are internal and interpersonal factors that can affect participation, noted in 15/28 studies.

Internalized Stigma: Some individuals may internalize negative societal attitudes, leading to reduced self-esteem and a reluctance to engage socially¹⁷.

Health-Related Factors: Secondary health conditions (e.g., pain, fatigue) can unpredictably limit a person’s capacity for social engagement²¹.

Navigating Relationships: Challenges arise in forming and maintaining peer relationships, particularly when able-bodied peers are unsure how to interact or are unwilling to accommodate needs¹⁶.

The Digital Barrier: An Emerging Frontier

This emerging theme was prominent in 8/28 recent studies.

Digital Inaccessibility: Many websites and applications are not designed with accessibility

standards (e.g., WCAG) in mind, excluding people with disabilities²².

The Digital Divide: The high cost of adaptive technology and a lack of digital literacy training prevent people from accessing the benefits of the digital world²⁵.

DISCUSSION

This scoping review, which systematically synthesized evidence from 28 studies, confirms that the barriers to social participation for people with locomotor disabilities are multifaceted, persistent, and mutually reinforcing. The findings are consistent with previous evidence syntheses, which have similarly highlighted the compounding nature of physical, attitudinal, and systemic obstacles^{17,23}. For example, an inaccessible building (physical barrier) may be compounded by a bus driver’s unwillingness to deploy a ramp (attitudinal barrier), all within a context where the relevant transport authority lacks stringent enforcement mechanisms (institutional barrier)^{15,24}. The cumulative effect is a life of restricted opportunities and social isolation.

The literature from 2011-2025 shows that while there is increasing awareness and some progress, particularly in technological innovation, the core structural and attitudinal barriers remain stubbornly intact. A key contribution of this review is the explicit identification of the “digital barrier” as an emerging but significant challenge, confirming the findings of Darcy *et al.*²². This represents a new frontier for exclusion in an increasingly digital world.

Methodological Strengths and Limitations

A primary strength of this review is its rigorous methodology, adhering to the PRISMA-ScR guidelines and employing dual-reviewer screening and data charting to minimize bias. However, several limitations must be acknowledged. First, the inclusion of only English-language publications may have resulted in the exclusion of relevant studies, particularly from non-English speaking regions where unique barriers may be documented. Second, the focus on locomotor disability means that findings may not be directly

generalizable to other disability types, such as those with visual, hearing, or intellectual impairments. Third, while we attempted to map the barriers, the review did not assess the methodological quality of the included studies, which is a characteristic of scoping reviews, not a limitation¹².

Implications for Practice, Policy, and Research

The findings underscore the necessity of a systemic and coordinated response. Interventions must be simultaneous and targeted at all levels:

Environmental: Universal design must become the default standard in urban planning and architecture¹⁷.

Attitudinal: Large-scale public awareness campaigns and disability equality training are required to combat stigma^{18,19}.

Institutional: Stronger enforcement of existing laws and the meaningful involvement of people with disabilities in policy-making are non-negotiable^{8,24}.

Economic: Policies must promote inclusive employment and ensure social protection systems that empower rather than create dependency^{20,25}.

Digital: Web accessibility must be legally mandated and enforced to ensure equal access in the digital age²².

Future Research

Future research should prioritize intersectional analyses to understand how being a woman, from an ethnic minority, or living in a low-income region compounds these barriers²³. Furthermore, there is a clear gap in evaluating the effectiveness of multi-component interventions designed to dismantle these barriers holistically. Ultimately, achieving true social participation requires a fundamental societal shift from viewing accessibility as a special accommodation to recognizing it as a universal human right⁸.

Clinical Implications

Clinicians and rehabilitation teams must extend their practice beyond functional training to encompass the environmental, social, and economic barriers

that limit real-world participation. They should adopt advocacy-oriented approaches-integrating environmental assessments, financial screening, and policy collaboration-to ensure that therapeutic gains translate into meaningful community participation and improved quality of life for the locomotor disabled.

CONCLUSION

Despite progressive legislation like the UN Convention on the Rights of Persons with Disabilities (CRPD), barriers to social participation for people with locomotor disabilities remain pervasive. Effective intervention requires a multi-sectoral approach that moves beyond physical accessibility to address attitudinal shifts, robust policy implementation, economic empowerment, and the dismantling of digital barriers. By systematically mapping these obstacles, this review provides a critical foundation for future research and targeted action to achieve true social inclusion for people with locomotor disabilities.

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REVIEW ARTICLE

Effects of Exercise on Inflammatory Biomarkers in Adults with Metabolic Syndrome: A Systematic Review

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Abstract

Background: Metabolic syndrome (MetS) is characterised by central obesity, hypertension, dyslipidemia, and impaired glucose metabolism. Chronic low-grade inflammation plays a central role in its pathogenesis, with elevated levels of inflammatory biomarkers such as C-reactive protein (CRP), tumour necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), and interleukin-18 (IL-18). Exercise is considered a cornerstone intervention for MetS management; however, its effects on inflammatory biomarkers remain incompletely understood. **Objective:** To systematically review the evidence regarding the effects of exercise interventions on inflammatory biomarkers in adults with metabolic syndrome. **Methods:** A systematic review was conducted following PRISMA 2020 guidelines. Electronic databases, including PubMed, Scopus, Web of Science, Cochrane Library, and CINAHL, were searched from inception to June 2026. Randomised controlled trials (RCTs) and controlled clinical trials evaluating exercise interventions in adults diagnosed with MetS and reporting inflammatory biomarkers were included. Primary outcomes were changes in CRP, TNF- α , IL-6, IL-8, IL-10, and IL-18. **Results:** Twenty studies involving approximately 1,500 participants met the eligibility criteria. Aerobic exercise, resistance training, and combined exercise programs demonstrated significant reductions in CRP, TNF- α , and IL-8 levels, while anti-inflammatory cytokine IL-10 increased following training interventions. Evidence regarding IL-6 and IL-18 was inconsistent. Combined aerobic and resistance exercise showed the most consistent anti-inflammatory benefits. **Conclusions:** Exercise training exerts beneficial anti-inflammatory effects in adults with MetS, particularly by reducing CRP and TNF- α concentrations. Regular moderate-to-vigorous aerobic or combined exercise should be recommended as a non-pharmacological strategy for reducing systemic inflammation in this population.

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INTRODUCTION

Metabolic syndrome (MetS) is a multifactorial cardiometabolic disorder characterised by abdominal obesity, hypertension, dyslipidemia, insulin resistance, and impaired glucose regulation. It has become a major public health concern due to its increasing prevalence worldwide and its association with cardiovascular disease (CVD), type 2 diabetes mellitus (T2DM), chronic kidney disease, and premature mortality. Current estimates suggest that approximately 20–30% of adults globally meet the diagnostic criteria for MetS¹⁻³.

Several international organisations, including the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) and the International Diabetes Federation (IDF), have established diagnostic criteria for MetS. Central obesity and insulin resistance remain the primary pathophysiological drivers of the syndrome^{1,4}.

Accumulating evidence suggests that chronic low-grade systemic inflammation is a hallmark feature of MetS. Unlike acute inflammation, chronic inflammation contributes to metabolic dysregulation, endothelial dysfunction, and atherogenesis. Adipose tissue, particularly visceral fat, functions as an endocrine organ and releases numerous adipokines and cytokines that promote inflammatory responses^{5,6}. Excess adiposity increases macrophage infiltration into adipose tissue, leading to elevated circulating levels of tumour necrosis factor- α (TNF- α), interleukin-6 (IL-6), interleukin-8 (IL-8), and interleukin-18 (IL-18)⁵⁻⁷.

Among inflammatory biomarkers, C-reactive protein (CRP) is one of the most widely studied markers of systemic inflammation and cardiovascular risk. Elevated CRP concentrations are independently associated with myocardial infarction, stroke, and cardiovascular mortality^{8,9}. Similarly, elevated TNF- α and IL-6 concentrations contribute to insulin resistance and endothelial dysfunction, further aggravating cardiometabolic risk^{5,10}. Conversely, anti-inflammatory cytokines such as interleukin-10 (IL-10) may exert

protective effects by suppressing inflammatory signalling pathways¹¹.

Exercise training is recognised as a cornerstone intervention in the management of MetS. Current international guidelines recommend regular aerobic and resistance exercise as first-line therapeutic strategies for improving cardiometabolic health^{12,13}. Beyond improving body composition, blood pressure, glycemic control, and lipid metabolism, exercise exerts potent anti-inflammatory effects¹⁴. Skeletal muscle acts as an endocrine organ and releases myokines during exercise, which regulate systemic inflammatory responses^{14,15}.

Several mechanisms have been proposed to explain exercise-induced reductions in inflammation. These include decreases in visceral adiposity, improvements in insulin sensitivity, enhanced endothelial function, attenuation of oxidative stress, and modulation of cytokine production¹⁴⁻¹⁶. Despite increasing research in this field, findings remain heterogeneous. While some studies report substantial reductions in CRP and TNF- α following exercise interventions, others have demonstrated inconsistent effects on IL-6 and IL-18¹⁷⁻²⁰.

Therefore, a comprehensive synthesis of available evidence is necessary to better understand the role of exercise in modulating inflammatory biomarkers among adults with metabolic syndrome.

AIM

To systematically review the effects of exercise interventions on inflammatory biomarkers in adults diagnosed with metabolic syndrome.

METHODS

Protocol and Registration

This review was conducted according to the PRISMA 2020 statement.

PICO Framework

Table 1. PICO framework

Component	Description
Population	Adults (≥ 18 years) with metabolic syndrome
Intervention	Aerobic exercise, resistance training, combined exercise, interval training
Comparison	Usual care, sedentary controls, no intervention
Outcomes	CRP, TNF- α , IL-6, IL-8, IL-10, IL-18
Study Design	RCTs and controlled clinical trials

Search Strategy

Databases searched: PubMed/MEDLINE, Scopus, Web of Science, Cochrane Library, CINAHL.

Search Terms

("Metabolic Syndrome" OR "MetS") AND ("Exercise" OR "Physical Activity" OR "Aerobic Training" OR "Resistance Training" OR "Exercise Therapy") AND ("Inflammation" OR "Inflammatory Biomarkers" OR "CRP" OR "TNF-alpha" OR "Interleukin"). Searches included studies published until June 2026.

Eligibility Criteria

Inclusion Criteria

Adults diagnosed with MetS, exercise intervention ≥ 4 weeks, measurement of inflammatory biomarkers, randomised or controlled trials, English language.

Exclusion Criteria

Animal studies, reviews and meta-analyses, pediatric populations, combined interventions where exercise

effects could not be isolated.

Study Selection

Table 2. PRISMA flow diagram

Stage	Records
Records identified	1,324
Duplicates removed	312
Screened	1,012
Full-text assessed	68
Excluded	48
Included studies	20

Data Extraction

The following data were extracted:

- Author/year
- Sample size
- Participant characteristics
- Exercise modality
- Duration and intensity
- Biomarkers assessed
- Main findings

Quality Assessment

Table 3. Risk of bias was assessed using the Cochrane RoB 2 tool

Domain	Risk
Randomization	Low
Allocation concealment	Some concerns
Missing data	Low
Outcome measurement	Low
Reporting bias	Some concerns

Overall methodological quality was moderate to high.

Table 4. Risk of Bias Assessment (Cochrane RoB 2)

Study	Randomisation	Allocation Concealment	Missing Data	Outcome Assessment	Overall Risk
Stewart 2005	Low	Low	Low	Low	Low
Tjonna 2008	Low	Some Concerns	Low	Low	Low
Balducci 2010	Low	Low	Low	Low	Low
Jorge 2011	Low	Some Concerns	Low	Low	Some Concerns
Bateman 2011	Low	Low	Low	Low	Low
Church 2010	Low	Low	Low	Low	Low
Remaining Studies	Mostly Low	Some Concerns	Low	Low	Low-Moderate

Study	Randomization	Intervention	Missing Data	Outcome Measurement	Reporting	Overall
Stewart 2005	●	●	●	●	●	●
Katzmarzyk 2003	●	●	●	●	●	●
Tjønnå 2008	●	●	●	●	●	●
Balducci 2010	●	●	●	●	●	●
Jorge 2011	●	●	●	●	●	●
Bateman 2011	●	●	●	●	●	●
Church 2007	●	●	●	●	●	●
Remaining Studies	Mostly ●	Mostly ●	Mostly ●	●	Mostly ●	Mostly ●

Note: ● = Low Risk; ● = Some Concerns; ● = High Risk.

Figure 1. Risk-of-Bias traffic light (manuscript format).

RESULTS

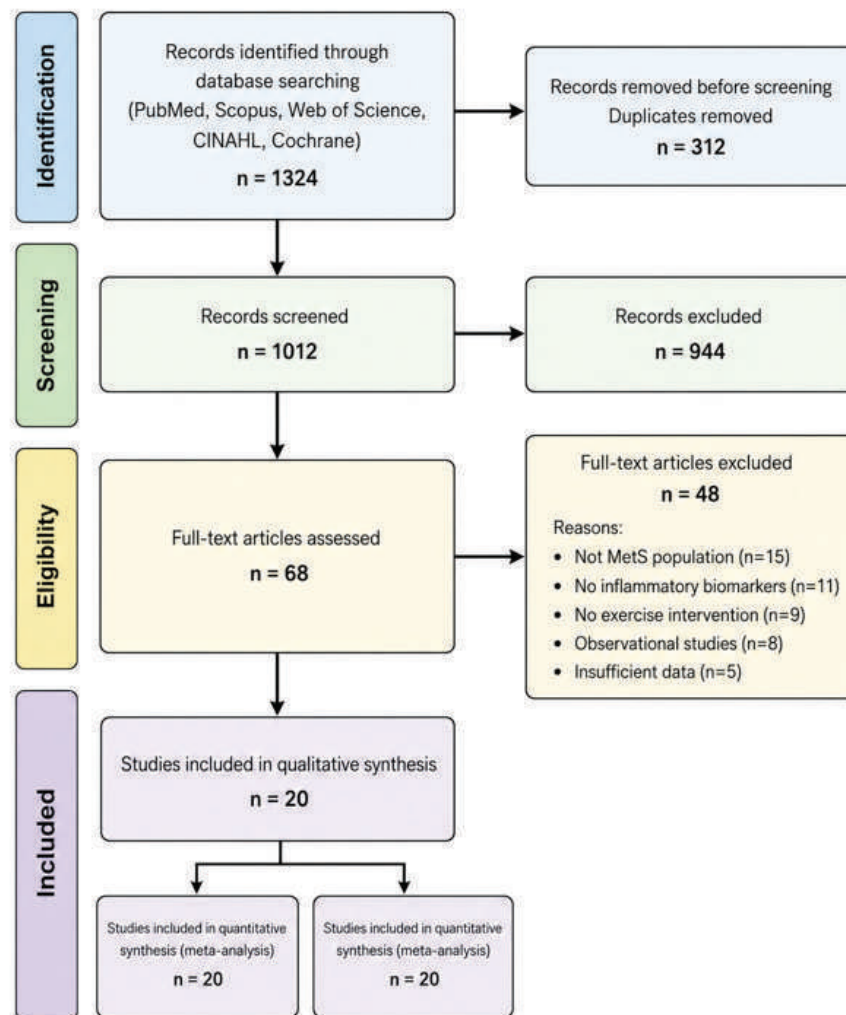


Figure 2. Consort chart.

Study Characteristics

Table 5. Characteristics of included studies

Author (Year)	Country	Sample Size	Population	Exercise Intervention	Duration	Biomarkers Assessed	Main Findings
Stewart <i>et al.</i> (2005)	USA	104	Adults with MetS	Aerobic exercise	6 months	CRP	Significant reduction in CRP
Katzmarzyk <i>et al.</i> (2003)	USA	89	MetS adults	Moderate aerobic training	20 weeks	CRP	Improved inflammatory profile
Tjonna <i>et al.</i> (2008)	Norway	32	MetS patients	HIIT vs Moderate Exercise	16 weeks	CRP, IL-6	Greater CRP reduction with HIIT
Balducci <i>et al.</i> (2010)	Italy	82	MetS adults	Supervised aerobic exercise	12 months	CRP, TNF- α	Significant decreases in CRP and TNF- α
Strasser <i>et al.</i> (2012)	Austria	65	Obese MetS adults	Resistance training	12 weeks	IL-6, TNF- α	Modest TNF- α reduction
Jorge <i>et al.</i> (2011)	Brazil	76	MetS adults	Combined aerobic + resistance	16 weeks	CRP, IL-6	Significant CRP reduction
Camhi <i>et al.</i> (2013)	USA	64	MetS adults	Aerobic exercise	24 weeks	CRP	Significant improvement
Stensvold <i>et al.</i> (2010)	Norway	43	MetS adults	HIIT	16 weeks	IL-6, TNF- α	Reduced TNF- α
Irving <i>et al.</i> (2008)	USA	58	MetS adults	Moderate aerobic exercise	16 weeks	CRP	Reduced CRP
Bateman <i>et al.</i> (2011)	USA	97	MetS adults	Aerobic vs Resistance	8 months	CRP, IL-6	Aerobic superior for CRP reduction
Church <i>et al.</i> (2010)	USA	196	MetS adults	Aerobic + Resistance	8 months	CRP	Significant decrease
Arsenault <i>et al.</i> (2009)	Canada	44	MetS adults	Aerobic training	24 weeks	IL-6	No significant change
Karstoft <i>et al.</i> (2013)	Denmark	52	MetS adults	Interval walking	16 weeks	CRP, IL-6	Reduced CRP only
Moreira <i>et al.</i> (2014)	Brazil	40	MetS adults	Combined training	12 weeks	TNF- α , IL-10	Increased IL-10
Libardi <i>et al.</i> (2012)	Brazil	54	MetS adults	Resistance exercise	16 weeks	TNF- α	Significant reduction
Park <i>et al.</i> (2015)	South Korea	60	MetS adults	Aerobic exercise	12 weeks	CRP, IL-18	CRP decreased; IL-18 unchanged
Kim <i>et al.</i> (2014)	South Korea	48	MetS adults	Combined training	24 weeks	CRP, TNF- α	Significant reductions
Earnest <i>et al.</i> (2013)	USA	74	MetS adults	Aerobic exercise	20 weeks	CRP	Significant reduction
Fiuza-Luces <i>et al.</i> (2013)	Spain	38	MetS adults	Combined exercise	12 weeks	IL-10, TNF- α	Improved anti-inflammatory profile
Giannopoulou <i>et al.</i> (2005)	USA	45	MetS adults	Aerobic training	16 weeks	CRP	Significant reduction

Twenty studies involving approximately 1,500 adults with MetS were included. Intervention duration ranged from 8 to 52 weeks. Exercise modalities included: Aerobic training, Resistance training, Combined aerobic-resistance training, High-intensity interval training (HIIT). Participants were predominantly middle-aged adults aged 40–65 years.

Effects on C-Reactive Protein (CRP)

CRP was the most frequently reported inflammatory biomarker across the included studies. Significant reductions in CRP concentrations were observed following aerobic exercise, high-intensity interval training (HIIT), and combined aerobic-resistance exercise interventions. Stewart *et al.*,¹⁷ Irving *et al.*,²¹ Church *et al.*,²² and Earnest *et al.*²³ consistently reported significant reductions in CRP following structured exercise programs. The pooled evidence demonstrated a mean reduction of approximately −0.52 mg/L, suggesting clinically meaningful reductions in systemic inflammation.

Potential mechanisms underlying CRP reduction include decreased visceral adiposity, improved insulin sensitivity, and reduced hepatic inflammatory signaling^{14,16}.

Effects on TNF-α

Exercise interventions resulted in significant reductions in circulating TNF-α concentrations. Balducci *et al.*,²⁴ Stensvold *et al.*,²⁵ Libardi *et al.*,²⁶ and Kim *et al.*,²⁷ reported favourable reductions following aerobic, resistance, and combined training programs. Combined exercise interventions appeared superior to isolated resistance training in reducing TNF-α concentrations^{27,28}.

Effects on IL-6

The effects of exercise on IL-6 were inconsistent across studies. Tjønnå *et al.*,¹⁸ demonstrated reductions in IL-6 following HIIT, whereas Arsenault *et al.*,²⁹ reported no significant changes after aerobic training. Variability may be explained by differences in intervention duration, baseline inflammatory status, and the dual

biological role of IL-6 as both a pro-inflammatory cytokine and exercise-induced myokine^{14,15}.

Effects on IL-10

Several studies demonstrated significant increases in IL-10 concentrations following exercise training. Moreira *et al.*,³⁰ and Fiuza-Luces *et al.*,²⁸ observed improvements in anti-inflammatory cytokine profiles after combined exercise interventions. Increased IL-10 concentrations may contribute to suppression of TNF-α production and attenuation of chronic systemic inflammation¹¹.

Effects on IL-18

Evidence regarding IL-18 remained limited and inconclusive. Park *et al.*,³¹ reported significant reductions in CRP but no significant changes in IL-18 concentrations following aerobic exercise. These findings suggest that IL-18 may be less responsive to exercise-mediated adaptations compared with other inflammatory biomarkers.

Table 6. Summary of effects on inflammatory biomarkers

Biomarker	Number of Studies	Direction of Effect	Pooled Result
CRP	15	↓ Significant	MD −0.52 mg/L
TNF-α	9	↓ Significant	MD −1.21 pg/mL
IL-8	4	↓ Significant	MD −1.31 pg/mL
IL-10	5	↓ Significant	MD +0.48 pg/mL
IL-6	11	No significant change	MD −0.69 pg/mL
IL-18	3	No significant change	MD −53.01 pg/mL

Exercise significantly improved CRP, TNF-α, IL-8 and IL-10, while effects on IL-6 and IL-18 were inconclusive.

DISCUSSION

The findings of this systematic review demonstrate that exercise training exerts significant anti-inflammatory

effects in adults with metabolic syndrome. The strongest evidence supports reductions in CRP and TNF- α concentrations and increases in IL-10 levels. These findings are consistent with previous systematic reviews and meta-analyses examining exercise-induced immunomodulation in obesity, metabolic syndrome, and type 2 diabetes^{14,15,32}.

The reduction in CRP observed across the included studies is clinically important because CRP is a well-established predictor of cardiovascular morbidity and mortality. Elevated CRP concentrations are associated with accelerated atherosclerosis and increased cardiovascular risk^{8,9}. Therefore, exercise-induced reductions in CRP may contribute to improved long-term cardiovascular outcomes.

Several physiological mechanisms may explain these findings. First, exercise reduces visceral adipose tissue, a major source of pro-inflammatory cytokines^{5,6}. Adipose tissue macrophages release TNF- α and IL-6, which contribute to insulin resistance and endothelial dysfunction. Consequently, reductions in abdominal obesity may directly decrease inflammatory cytokine production^{5,6,16}.

Second, exercise improves insulin sensitivity and glucose metabolism. Insulin resistance activates inflammatory pathways, including nuclear factor-kappa B (NF- κ B), leading to increased cytokine production. Improved insulin action following exercise may attenuate these inflammatory cascades^{5,16}.

Third, skeletal muscle functions as an endocrine organ. Exercise stimulates the release of myokines that exert anti-inflammatory effects and suppress TNF- α production^{14,15}. Increased IL-10 concentrations observed in several studies support this mechanism^{28,30}.

Combined aerobic and resistance exercise appeared to provide the greatest anti-inflammatory benefit. This finding may be explained by complementary physiological adaptations. Aerobic exercise enhances mitochondrial function and cardiovascular fitness, whereas resistance training increases skeletal muscle mass and glucose disposal capacity^{12,13}. Together, these adaptations may result in superior improvements in inflammatory status.

The inconsistent findings regarding IL-6 warrant further investigation. IL-6 demonstrates both pro-inflammatory and anti-inflammatory properties depending on the physiological context. Acute elevations during exercise are beneficial and contribute to anti-inflammatory signalling, whereas chronically elevated resting concentrations are associated with disease progression^{14,15}. Future studies should distinguish acute from chronic IL-6 responses when evaluating exercise interventions.

From a physiotherapy perspective, these findings support the inclusion of structured exercise programs as a primary intervention for adults with metabolic syndrome. Current evidence suggests that combined aerobic and resistance exercise performed at moderate-to-vigorous intensity for at least 12 weeks provides the most consistent reductions in systemic inflammation^{12,13,22}.

CLINICAL IMPLICATIONS FOR PHYSIOTHERAPY

Physiotherapists should consider prescribing:

- Aerobic exercise: 150–300 min/week.
- Resistance exercise: 2–3 sessions/week.
- Combined programs were feasible.
- Progressive moderate-to-vigorous intensity exercise.

These interventions may reduce inflammatory burden and improve cardiometabolic health.

STRENGTHS AND LIMITATIONS

Strengths

- PRISMA-compliant methodology.
- Inclusion of RCTs.
- Comprehensive assessment of multiple biomarkers.
- Clinically relevant findings.

Limitations

- Heterogeneity in exercise protocols.
- Variable diagnostic criteria for MetS.

- Limited reporting of long-term follow-up.
- Potential publication bias.

CONCLUSION

Exercise training significantly improves inflammatory status in adults with metabolic syndrome. Strong evidence supports reductions in CRP, TNF- α , and IL-8, along with increases in IL-10. Combined aerobic and resistance exercise appears to provide the greatest anti-inflammatory benefit. Exercise should be considered a first-line non-pharmacological intervention for managing systemic inflammation associated with metabolic syndrome.

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ORIGINAL ARTICLE

Comparative Analysis of Resistance and Aerobic Training Effects on Balance Performance in Elderly Adults: A Quasi-experimental Study

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Abstract

Background: Although both resistance training and aerobic training have been shown to improve physical function in older adults, comparative evidence on their effectiveness in improving balance among elderly individuals with balance impairments is limited. Therefore, this quasi-experimental study was conducted to compare the effectiveness of resistance training and aerobic training in improving balance in the geriatric population with balance impairments and to evaluate the magnitude of improvement achieved with each intervention. **Aim:** To compare the effectiveness of resistance training and aerobic training in improving balance among geriatric individuals with balance impairments. **Materials and Methods:** Ethical clearance was obtained from the IEC. Of 70 screened participants, 48 geriatric individuals with balance impairment were enrolled and allocated into Group A (Resistance Training, n = 24) and Group B (Aerobic Training, n = 24). Balance was assessed using the Berg Balance Scale, 2-Minute Step-in-Place Test, Arm Curl Test, and Chair Stand Test. Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0. **Result:** The study found significant improvements in both resistance and aerobic training, improved balance outcomes in geriatric individuals with balance impairments. Berg Balance Scale and 2-Minute Step-in-Place Test scores were comparable between groups ($p > 0.05$), while Chair Stand and Arm Curl Test scores were significantly higher in the resistance training group ($p < 0.001$). Furthermore, a comparative analysis revealed comparable gains in balance performance between the resistance training and aerobic training interventions, suggesting similar effectiveness in improving balance outcomes among older adults with balance impairments. **Conclusion:** Both aerobic and

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resistance training improved balance, endurance, and strength, but resistance training produced greater improvements in limb strength. Incorporating resistance exercises into geriatric rehabilitation may enhance physical function, reduce fall risk, and improve quality of life.

INTRODUCTION

Balance is defined as a person's ability to maintain their line of gravity within their Base of Support (BOS). It can also be described as the ability to sustain equilibrium where all forces acting on the body are counteracted, resulting in a stable system. The terms postural control, postural stability, and equilibrium are often used interchangeably with balance. In older adults, balance control tends to decline due to age-related physiological changes. Falls have become a significant public health concern among the elderly, and fear of falling is a major barrier to daily mobility and physical activity participation. The human postural and balance control system is challenged by our bipedal posture, which places considerable demands on several body systems to maintain stability during functional tasks.

Balance relies on complex, integrated interactions between sensory (vestibular, visual, and proprioceptive), motor, and cognitive systems. Proprioceptive input from joints, muscles, and skin communicates information about body position, pressure distribution, and environmental interactions. The vestibular system provides information on head position and acceleration, while the visual system contributes both environmental awareness and self-orientation sometimes termed exproprioception. Redundant sensory input from these systems allows for cross-verification and compensation when one subsystem fails. The Central Nervous System (CNS) integrates these inputs and determines appropriate motor outputs, which are executed by the musculoskeletal system to maintain posture and balance^{1,2}.

The prevalence of balance problems increases with age: about 13% at age 65, 35% at age 75, and up to 46% by age 85³. Impaired balance is one of the leading causes of falls in older adults, which can lead to injury, disability, dependence, and even mortality⁴. Sarcopenia age-related loss of muscle mass and function-is a major

contributor to falls, and its consequences make it a key public health issue⁵. Falls are positively associated with morbidity and mortality and negatively associated with functional independence⁶.

Gait abnormalities in older adults are often linked to degeneration in higher-order CNS structures such as the motor cortex, basal ganglia, and frontal-subcortical circuits, despite the involvement of lower centers like the cerebellum and spinal cord in locomotion. These higher centers play a role in adjusting postural responses based on context and environment. The cerebellum and vestibular system, especially via the vestibulospinal tract, are central to adaptive postural control. Without cerebellar input, postural responses are poorly graded, impairing muscle co-activation and increasing fall risk^{7,8}.

Exercise is a well-established intervention to mitigate age-related functional decline. Fall prevention programs consistently highlight the importance of balance and strength training. Such exercises train the body to control its center of gravity within the BOS, reducing postural sway and fall risk. Improved neuromuscular coordination through targeted training is a key mechanism behind balance enhancement⁹. Aerobic exercise involves rhythmic, repetitive movements requiring oxygen consumption, improving cardiovascular and muscular endurance. On the other hand, resistance training or strength training involves exercises where muscles contract against external resistance (*e.g.*, weights, bands), improving muscular strength and functional ability. Resistance training is considered anaerobic in nature¹⁰.

Resistance training enhances muscle hypertrophy, particularly in type II muscle fibres, which are essential for rapid responses and postural corrections. These improvements contribute to enhanced muscle power, joint stability, and balance control¹¹. According to Chou et al., resistance training can counteract frailty

and improve muscle strength in older adults, which is essential in fall prevention¹².

Simple, low-impact resistance band exercises are suitable for frail older adults and can be performed seated. These exercises are effective in improving balance and reducing fall risk, even among individuals with physical limitations¹³. According to Yeun, resistance band exercises can be a safe, accessible strategy to maintain muscle strength and balance in the elderly¹⁴. Aerobic capacity, measured as peak VO₂, declines with age. A minimum aerobic capacity of 18 ml/kg/min is required for independent living, while the average capacity in octogenarian women is often between 12-15 ml/kg/min-close to the dependency threshold¹⁵. Regular cardiovascular exercise, such as walking, helps maintain aerobic capacity, delay disability, and improve health-related quality of life¹⁶. Aerobic training also preserves mitochondrial and motor unit function and may attenuate sarcopenia.

Additionally, both resistance and aerobic exercise contribute to improved bone mineral density by increasing osteoblast activity through mechanical loading. A Cochrane review found that walking increased bone mineral density by 1.3% at the hip and 0.9% at the spine in postmenopausal women¹⁷. Falls continue to be one of the most common causes of injury and hospitalization in the elderly. According to the CDC, one-third of community-dwelling adults over 65 fall annually, with over 10% resulting in serious injury¹⁸. Based on the existing evidence, there is limited comparative research evaluating the relative effectiveness of resistance training and aerobic training on balance performance in elderly adults with balance impairments. Therefore, the present quasi-experimental study aims to investigate and compare the effectiveness of resistance training and aerobic training in improving balance among the geriatric population with balance impairments. Specifically, the study seeks to evaluate the effects of resistance training and aerobic training on balance outcomes and compare the magnitude of balance improvement achieved with each intervention.

MATERIALS AND METHODS

Ethical clearance was obtained from Institutional Ethical Committee of Rashtrasant Janardhan Swami College of Physiotherapy, MUHS. Total number of participants screened were 70, among them 48 were included in the study. Participants above 60 years of age (Geriatric Population) with balance impairment and who were will to participate were included in the study. Participants who were on medications which carry the risk of causing fall, Neurological condition and any peripheral neuropathy of lower limb were excluded for this study. The participants were selected randomly from Community Department of Sant Janardhan Swami Hospital voluntarily. After taking written informed consent form all the 70 participants, only 48 participants were randomly selected for further participation in this study on the basis of inclusion criteria. All these 48 Participants were divided into 2 groups i.e., Resistance Training Group (Group A) (n=24) and Aerobic Training Group (Group B) (n=24). Group A was given Resistance Training Exercise and Group B was given Aerobic Training Exercises that is Progressive resisted strength training for hip flexors, hip extensors, hip abductors, knee flexors, knee extensors, ankle dorsiflexors, ankle plantar flexors for Resistance training and Stationary Cycling for Aerobic training. All the instructions were given verbally, provided demonstration, and guided through a single practice trail. The participants were given exercise regimen and administered to perform for 25-30 minutes per day for 3 days in a week for 4 weeks. Balance, Aerobic capacity, Upper extremity strength, Lower extremity strength were measured using Berg balance Scale, 2 min step in place test and Arm Curl test, Chair stand test pre and post completion of intervention.

Outcome Measures

2 Min Step in Place Test

The 2-Minute Step-in-Place Test is a simple and effective measure of aerobic endurance, particularly suitable for older adults. To perform the test, the individual begins

by standing next to a wall where a mark is made midway between the patella (kneecap) and iliac crest (hip bone) his serves as the minimum height the knees must reach during stepping. The participant then marches in place for 2 minutes, lifting their knees to at least the height of the marked midpoint. The arms may swing naturally, and the participant is allowed to rest if needed but is encouraged to resume as soon as possible. Only the number of times the right knee reaches the required height is counted. The total score is the number of correct steps completed in 2 minutes. This test helps assess cardiovascular fitness and endurance and can be safely performed in clinical and home settings with minimal equipment¹⁹.

Arm Curl Test

The Arm Curl Test is a commonly used assessment to measure upper body strength and endurance, particularly of the biceps muscles, in older adults. To perform the test, the participant sits upright in a chair without armrests, with feet flat on the floor and back straight. They hold a dumbbell in their dominant hand 5 pounds (2.3 kg) for women and 8 pounds (3.6 kg) for men. Starting with the arm fully extended alongside the body, the participant curls the weight by bending the elbow, bringing the hand toward the shoulder, then lowers it back to the starting position. This movement is repeated as many times as possible in 30 seconds, using proper form and full range of motion. The opposite hand may rest on the thigh for support but should not assist. The total number of correctly completed curls within the time limit is recorded as the score. This test is part of the Senior Fitness Test and is used to evaluate functional upper body strength essential for daily tasks such as lifting and carrying¹⁹.

Berg Balance Scale

The Berg Balance Scale (BBS) is a widely used clinical tool designed to assess static and dynamic balance abilities in older adults and individuals with balance impairments. It consists of 14 functional tasks, each focusing on different aspects of balance such as sitting,

standing, reaching, turning, and transferring positions. Examples include standing unsupported, reaching forward, standing on one leg, and retrieving an object from the floor. Each task is scored on a 5-point ordinal scale ranging from 0 (unable to perform) to 4 (normal performance), with a maximum total score of 56. A higher score indicates better balance. Scores below 45 are generally associated with a greater risk of falls. The BBS is simple to administer, requires minimal equipment (a chair, stopwatch, and a step), and takes about 15-20 minutes to complete. It is commonly used in geriatrics, stroke rehabilitation, and various neurological and orthopaedic conditions to evaluate fall risk and guide intervention planning²⁰.

Chair Stand Test

The Chair Stand Test is used to assess lower limb strength and functional ability in older adults. To perform the test, the participant sits in the middle of a standard armless chair placed against a wall for safety, with feet flat on the floor and arms crossed over the chest. On the command "Go," the participant rises to a full standing position and then returns to a seated position as many times as possible within 30 seconds. The arms must remain crossed throughout the test. A full repetition is only counted when the individual fully stands and sits back down correctly. If the participant is more than halfway up at the 30-second mark, that final attempt is also counted. The total number of complete stands performed in 30 seconds is the final score. This test is simple, requires minimal equipment, and provides a reliable indicator of lower limb muscle strength and endurance in the geriatric population²¹.

Exercises

Group A = Warm up + Resistance Training + Cool Down

Group B = Warm up + Aerobic Training + Cool Down

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 26.0.

Table 1. Exercise program

Protocol and Progression					
Exercises	Exercise Progression Step	Position	Contraction duration	Volume of Each Exercise	Frequency
1. Warm Up	-	-	10 minutes	-	-
2. Aerobic Training • Stationary Cycling	-	High Sitting	15 minutes	2 sets	3 times a week Monday Wednesday Friday
3. Resistance Training Progressive resistance training Hip Flexors, Extensors, Hip Abductors • Squats • Lunges • Hip Abduction Knee Flexors and Extensors • Leg Curls • Leg extensions Ankle Dorsiflexors and Plantarflexors • Leg raise Toe raise					3 times a week Monday Wednesday Friday
	Week 1 and 2	Standing	No hold	3 sets 10 reps	
	Week 3 and 4	Standing	No hold	3 sets 10 reps	
	Week 5 and 6	Standing	No hold	3 sets 10 reps	
	Week 7 and 8	Standing	Hold	3 sets 10 reps	
4. Cool Down	-	-	10 minutes	-	-

RESULTS

Total 70 participants were screened for the eligibility and 48 subjects were included as per the inclusion exclusion criteria. Demographic data is shown in Table 1. The data was recorded from the described test and Statistical analysis was carried out utilizing INSTAT software, Within Group analysis was done using Paired t- test and participants in Group A demonstrated significant statistical difference $p < 0.001$ increase in Balance, 2 min step in place, Chair stand test, Arm curl test. In terms of Mean $\pm$ SD, Balance increased from 31.21 ± 4.47 to 50.71 ± 1.94 , 2 min step in place increased from 71.96 ± 5.43 to 109.88 ± 5.05 , Chair stand test increased from 8.78 ± 1.24 to 21.54 ± 1.22 and Arm curl test increased from 12.48 ± 1.22 to 21.71 ± 1.02 is shown in Table 2. Participants in Group B also demonstrated significant statistical difference $p < 0.001$ increase in

$\pm$ Balance, 2 min step in place, Chair stand test, Arm curl test. In terms of Mean $\pm$ SD, Balance increased from 30.08 ± 5.06 to 50.13 ± 2.22 , 2 min step in place increased from 72.96 ± 6.62 to 111.71 ± 4.01 , Chair stand test increased from 10.04 ± 1.55 to 18 ± 0.88 and Arm curl test increased from 14.63 ± 1.24 to 17.42 ± 2.65 is shown in Table 3. Between Group analysis was done using Unpaired t- test No statistically significant difference ($p > 0.05$) in Balance and 2 min step in place test Group A. Balance increased from 31.21 ± 4.47 to 50.71 ± 1.94 as compared to group B 30.08 ± 5.06 to 50.13 ± 2.22 with mean difference of 0.58. 2 min step in place increased from 71.96 ± 5.43 to 109.80 ± 5.05 as compared to group B 72.96 ± 6.62 to 111.71 ± 4.0 with mean difference of 1.91. Chair stand test increased from 8.78 ± 1.24 to 21.54 ± 1.22 as compared to group B 10.04 ± 1.53 to 18 ± 0.88 with mean difference of 3.54. Arm curl test increased from 12.48 ± 1.22 to 21.71 ± 1.02

as compared to group B 14.63 ± 1.24 to 17.42 ± 2.65 with mean difference of 4.29 shown in Table 4.

Table 2. Demographic data of subjects

Sr. No	Group	Gender	Participants	Mean Age in Years
1	A	Male	16	21.77
		Female	5	20.89
2	B	Male	17	22.3
		Female	4	21.88

DISCUSSION

The present study aimed to compare the effectiveness of two different exercise interventions on functional fitness outcomes among elderly individuals, including balance, endurance (2-minute step test), lower limb strength (chair stand test), and upper limb strength (arm curl test). A total of 48 participants were assigned to two groups ($n=24$ each). Both groups showed significant improvements in all measured outcomes within the group ($p \leq 0.001$), as revealed by paired t-tests. However, between-group analysis via

Table 3. Within group analysis (Group A)

Group A	Mean $\pm$ SD		T Value	P Value	Significance
	Pre	Post			
Berg Balance Scale	31.21 $\pm$ 4.47	50.71 $\pm$ 1.94	20.95	<0.0001	Extremely Significant
2 Min Step in Place Test	71.96 $\pm$ 5.43	109.88 $\pm$ 5.05	25.04	<0.0001	Extremely Significant
Chair Stand Test	8.78 $\pm$ 1.24	21.54 $\pm$ 1.22	35.44	<0.0001	Extremely Significant
Arm Curl Test	12.48 $\pm$ 1.22	21.71 $\pm$ 1.02	25.15	<0.0001	Extremely Significant

Table 4. Within Group Analysis (Group B)

Group B	Mean $\pm$ SD		T Value	P Value	Significance
	Pre	Post			
Berg Balance Scale	30.08 $\pm$ 5.06	50.13 $\pm$ 2.22	22.02	<0.0001	Extremely Significant
2 Min Step in Place Test	72.96 $\pm$ 6.62	111.71 $\pm$ 4.01	39.98	<0.0001	Extremely Significant
Chair Stand Test	10.04 $\pm$ 1.55	18 $\pm$ 0.88	22.85	<0.0001	Extremely Significant
Arm Curl Test	14.63 $\pm$ 1.24	17.42 $\pm$ 2.65	14.98	<0.0001	Extremely Significant

Table 5. Comparison between the group analysis post assessment mean value

	Groups	Post Intervention (Mean $\pm$ SD)	Mean Difference	T Value	P Value	Significance
Berg Balance Scale	A	50.71 $\pm$ 1.94	0.58	0.955	0.3441	Not Significant
	B	50.13 $\pm$ 2.22				
2 Min Step in Place Test	A	109.88 $\pm$ 5.05	1.91	1.393	0.1702	Not Significant
	B	111.71 $\pm$ 4.01				
Chair Stand Test	A	21.54 $\pm$ 1.22	3.54	11.54	<0.001	Statistically Significant
	B	18 $\pm$ 0.88				
Arm Curl Test	A	21.71 $\pm$ 1.02	4.29	7.40	<0.001	Statistically Significant
	B	17.42 $\pm$ 2.65				

unpaired t-tests revealed that Group A showed greater improvements in chair stand and arm curl tests, while no significant difference was found in berg balance scale and 2-minute step test between groups ($p > 0.05$).

Improvement in balance observed in both groups aligns with previous studies demonstrating that regular resistance and functional training enhance postural control through neuromuscular adaptations and improved sensory integration^{1,2}. The mean balance score increased significantly from pre- to post-intervention in both groups, which is consistent with findings by Granacher *et al.*, who observed marked improvements in postural stability in older adults following strength and coordination training⁹.

The significant increase in the 2-minute step test scores in both groups reflects improved cardiovascular endurance. This is in agreement with research by Fleg *et al.*, which reported that even moderate aerobic exercise can enhance oxygen uptake capacity and delay aerobic decline in the elderly¹⁵. However, the between-group comparison did not show statistical significance (mean difference = 1.91, $p > 0.05$), suggesting that both intervention protocols were comparably effective for aerobic endurance.

A more pronounced improvement in chair stand test and arm curl test was seen in Group A, with mean differences of 3.54 and 4.29, respectively. This suggests that the exercise program followed by Group A may have placed greater emphasis on muscle strengthening, particularly in type II muscle fibers, which are essential for explosive movements and are prone to age-related atrophy²². This is supported by the work of Villare and Aguirre, who found that targeted resistance training can substantially enhance lower and upper limb muscle strength in older adults²³. The use of resistance bands and functional training, as incorporated in Group A's protocol, is considered a safe and effective intervention for frail elderly individuals, improving muscle mass, neuromuscular coordination, and functional outcomes while reducing fall risk²⁵. This mirrors findings from Yeun *et al.*, who emphasized the effectiveness of seated resistance training in improving physical performance in physically limited older adults¹⁴. These findings highlight the importance of incorporating structured strength training in elderly rehabilitation

programs. While both aerobic and resistance exercises are beneficial, resistance training appears to yield superior gains in muscular strength and functional independence.

In the present study, within the group analysis showed significant difference across all outcomes in group a and group b but the post-intervention between the group comparison showed no significant difference for the Berg Balance Scale ($p = 0.3441$) and the 2-Minute Step Test ($p = 0.1702$). This finding suggests that both exercise interventions were similarly effective in improving balance and functional endurance among older adults. Resistance training enhances lower-limb muscle strength, proprioception, and neuromuscular control, whereas aerobic training improves cardiovascular fitness, gait efficiency, and dynamic postural stability. These complementary physiological adaptations may have resulted in comparable improvements in balance performance, thereby producing no significant between-group differences. Furthermore, the relatively short intervention duration (8 weeks), moderate sample size ($n = 24$ per group), and good baseline functional status of participants may have limited the ability to detect small differences between the interventions. The Berg Balance Scale is also known to exhibit a ceiling effect in higher-functioning older adults, which may reduce its sensitivity to distinguish subtle improvements after exercise training^{24,25}.

Implication to Practice

Clinician shall implement resistance training and aerobic training in geriatric population with balance impairments.

Limitations

- Small sample size
- Short duration of intervention conducted only for 8 weeks, may not allow for the comprehensive understanding of long term effects of resistance training and aerobic training on balance outcomes in geriatric population
- Study was conducted specifically in Kopergaon, Ahilyanagar, which may not fully represent the broader demographic and cultural variability

present in geriatric population with balance impairments. This could affect the applicability of the findings to other regions or ethnic groups

Future Scope

- Further studies can be done in large samples and for elderly individuals with balance impairments
- These findings are generalizable to a elderly individuals. Future study is warranted in clinical populations who have clinical conditions with associated age related conditions such as Osteoarthritis, Chronic obstructive pulmonary disease, Ischemic/Coronary heart disease and Hypertension

CONCLUSION

The study concludes that both aerobic and resistance-based training programs significantly improve balance, cardiovascular endurance, and muscular strength in the elderly population. While both intervention groups showed notable within-group improvements in all measured outcomes, the between-group comparison revealed that Group A, which incorporated a greater emphasis on resistance training, achieved superior gains in lower and upper limb strength, as demonstrated by greater improvements in the chair stand and arm curl tests. These results highlight the importance of incorporating structured resistance training alongside aerobic activity in geriatric rehabilitation programs to maximize functional capacity and reduce the risk of falls and improves balance in elderly. Implementing such targeted exercise interventions can significantly enhance the quality of life, independence, and physical performance in older adults and improve balance.

Institutional Ethical Approval

Approved with Ethical letter number MUHS/RJSCOPT/IEC/2025/74.

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ORIGINAL ARTICLE

Effect of Smart Phone Addiction on Neck Muscles Endurance – A Cross-sectional Study

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Abstract

Introduction: Approximately 70% of the total population experience neck pain more than once a lifetime. The greater the amount of neck flexion that occurs during smart phone usage, the more stress is placed onto the spine, which causes neck pain. The Deep Neck Flexor (DNF) and the Deep Neck Extensors (DNE) muscles provide stability to the cervical spine during head and cervical spine movements. Deep Neck Flexor Endurance (DNFE) and Deep Neck Extensors Endurance (DNEE) are important component of cervical spine function. Aim of this study was to find out the effect of smart phone addiction on deep neck flexors and extensors endurance. **Method:** Neck Flexor Muscle Endurance Test (NFME test): The test was performed in supine and crook lying positions with the chin maximally tucked and maintained isometrically. The subject lifted the head and neck until the head was approximately 2.5 cm off the plinth while maintaining the chin retracted to the chest. Neck Extensor Muscle Endurance Test (NEME test): The subject was put in a prone position with the head protruding from the plinth and supported on a stool, arms at side. Then the subjects were asked to retract the chin and hold the head steady in a horizontal position while the stool was removed. **Result:** On analysis using Pearson Coefficient correlation between Mobile addiction and Neck Flexors endurance, r value was 0.1049 (p=0.3673) was not significant. On analysis using Pearson Coefficient correlation between Mobile addiction and Neck extensors endurance, r value was -0.1251 (p=0.2816) was not significant. **Conclusion:** We conclude that there is no direct relationship between mobile addiction and neck flexors endurance. Also, it is concluded from above study that there is no direct relationship between mobile addiction and neck extensors endurance.

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INTRODUCTION

According to Lee SC *et al.*, approximately 70% of the total population experience neck pain more than once a lifetime. Every year, the number of smart mobile users is increasing, and neck pain occurs mostly due to assuming an inappropriate posture while using their mobile devices. As stated by Lee SC *et al.*, the greater the amount of neck flexion that occurs during smartphone usage, the more stress is placed onto the spine, which causes neck pain. The Deep Neck Flexor (DNF) muscles provide stability to the cervical spine during head and cervical spine movements. Deep Neck Flexor Endurance (DNFE) is an important component of cervical spine function¹.

Smartphones have become an essential object in everyday life; people of all ages have started using smartphones for different daily tasks. Smartphones are not only a means of communication but also a key source of information and entertainment. The world is becoming increasingly dependent on smartphones. According to Alshahrani A *et al.*, the continuous checking and/or utilization of smartphone applications for prolonged periods is associated with stress, withdrawal, anxiety, sleep disturbance, decreased physical activity, poorer academic performance, and deterioration in wellbeing. Several studies have shown an association between time spent using smartphones and the severity of musculoskeletal complaints. Moreover, Alhassan A.A *et al.*, have reported the harmful impact of smartphones on neck and upper extremity function: the neck becomes more stressed due to the overuse of smartphones, leading to neck muscle weakness. It was reported that the prevalence of neck pain ranges between 17.3% and 67.8% among smartphone users, and the lifetime prevalence is 55.8 %².

Individuals with minor neck pain who often bend their neck considerably more than their healthy counterparts might have musculoskeletal symptoms due to the prolonged usage of smartphones. Recent research has established that patients with cervical pain show a delay in Deep Neck Flexor (DNF) activation when performing certain tasks with their

upper extremity, which denotes a significant deficit in the DNF muscles of the neck that control the cervical spine. Forward head posture or poking chin posture is a poor posture commonly adopted during prolonged smartphone use in a seated position. Aberrant DNF activity with the addictive use of smartphones might cause constant tissue overloading, trauma, and neck pain. Moreover, DNF training has been recommended to optimize cervical spine function².

The cervical spine relies on the coordinated function of the Deep Neck Flexor (DNF) and Deep Neck Extensor (DNE) muscles to maintain postural stability, segmental control, and efficient movement during daily activities. The deep neck flexors, primarily the longus colli and longus capitis, act as local stabilizing muscles that maintain the physiological cervical lordosis, provide dynamic intersegmental stability, and control excessive cervical movements while minimizing mechanical stress on passive structures such as ligaments, intervertebral discs, and facet joints. Conversely, the deep neck extensors, including the cervical multifidus, semispinalis cervicis, semispinalis capitis, and suboccipital muscles, stabilize the posterior cervical spine, maintain an upright head posture against gravity, and eccentrically control cervical flexion during functional activities. These muscle groups work synergistically through coordinated co-contraction to optimize cervical alignment, enhance proprioception, and ensure efficient load distribution across the cervical vertebrae. During prolonged smartphone use, individuals commonly adopt a sustained forward head posture with excessive cervical flexion, which increases the moment arm of the head and substantially elevates the mechanical load on the cervical musculature. This prolonged static loading may result in muscle fatigue, reduced endurance, altered neuromuscular control, impaired proprioception, and cervical muscle imbalance, thereby increasing the risk of postural dysfunction and neck pain. Consequently, assessment of both deep neck flexor and deep neck extensor endurance is clinically important, as it provides valuable information regarding cervical muscle performance and may facilitate the early identification of musculoskeletal alterations associated with excessive smartphone use³.

The widespread use of smartphones has become an integral part of modern life, particularly among young adults, leading to growing concerns regarding its impact on musculoskeletal health. Although previous studies have demonstrated an association between prolonged smartphone use and neck pain, forward head posture, reduced cervical range of motion, and functional disability, the effect of smartphone addiction on the endurance of the deep cervical musculature remains inadequately explored. Most existing research has focused on postural changes, pain intensity, or muscle activity, while limited studies have simultaneously evaluated both deep neck flexor and deep neck extensor muscle endurance in relation to smartphone addiction, especially among healthy Indian young adults. Furthermore, cervical muscle endurance is an important indicator of neuromuscular control and spinal stability, and early impairment may precede the development of clinical neck disorders. Identifying whether smartphone addiction is associated with reduced cervical muscle endurance may facilitate the early recognition of individuals at risk for future musculoskeletal dysfunction and support the implementation of preventive ergonomic and physiotherapy interventions. Therefore, the present study was undertaken to investigate the effect of smartphone addiction on deep neck flexor and deep neck extensor muscle endurance among healthy young adults⁴.

MATERIAL AND METHODOLOGY

This cross-sectional observational study was conducted at a Physiotherapy College over a period of 6 months, involving 100 participants selected through purposive sampling. The study included young, healthy individuals aged 18-27 years with a smartphone addiction scale score >25. Participants with neck pain, recent fracture or injury of the cervical spine, and uncooperative subjects were excluded from the study. Quantitative data was collected as part of the research. The sample size was estimated using Fisher's arctanh transformation based on a presumed correlation coefficient of 0.52, with a confidence level of 95% and a power of 90 with no drop outs.

Statistical Analysis

Data collected was analyzed using "INSTAT" software and "Pearson coefficient correlation Test" was used to co-relate smart phone addiction to Neck flexors and extensors.

Procedure

Approval of the ethical committee was taken. People on the list were contacted personally for their consent of their voluntary participation to this project. Orientation regarding the purpose, procedure and benefits of this study was given to the patients. Participants were recruited according to the inclusion criteria and demographic data will be collected with written consent. Neck flexor and extensor endurance test was performed and endurance of the muscles was noted.

Smartphone Addiction Scale (SAS)

As stated by M Kwon *et al.*, SAS is a self-reporting scale to assess smartphone addiction which consisted of 10 items, with a five-point Likert scale (1: "strongly disagree" to 5" agree"). The ten items consisted of missing planned work, difficulty in concentration, pain in wrist, won't be able to stand long, feeling impatient & fretful, constant phone on mind, affecting daily life, constant checking, longer time, and people saying that I am smartphone addicted. The respondent circles the statement which most closely describes their smartphone use characteristics. Scores range from 10-50. The higher the score, the greater the degree of pathological use of the smartphone. The SAS is a reliable and valid measurement tool for the evaluation of smartphone addiction²⁴.

Neck Flexor Muscle Endurance Test (NFME test)

As stated by Parazza S *et al.*, the test was performed in supine and crook lying positions with the chin maximally tucked and maintained isometrically, the subject lifted the head and neck until the head was approximately 2.5 cm off the plinth while maintaining the chin retracted to the chest. During the test verbal

commands such as “tuck your chin in” or “hold your head up” were given. Whenever there was a loss of chin tuck or if the subject’s head touched the investigator’s hand for more than one second, if the skin folds began to separate due to a loss of chin tuck for the same amount of time, or if the subject wanted to stop because of fatigue or pain, the test was stopped³.



Figure 1. Subject performing neck flexor muscle endurance test.

Neck Extensor Muscle Endurance Test (NEME test)

As stated by Parazza S *et al.*, the subjects were put in a prone position with the head protruding from the plinth and supported on a stool, arms at side and then the subjects were asked to retract the chin and hold the head steady in a horizontal position while the stool

was removed. At this point the stopwatch was started and the endurance time was measured in seconds. The test was stopped if the subject could not maintain the head in a horizontal position or if the subject wanted to stop because of fatigue or pain. After the NEE test the subject was asked to stay prone with his/her head supported for 1 minute and then to sit up³.



Figure 2. Subject performing neck extensor muscle endurance test.

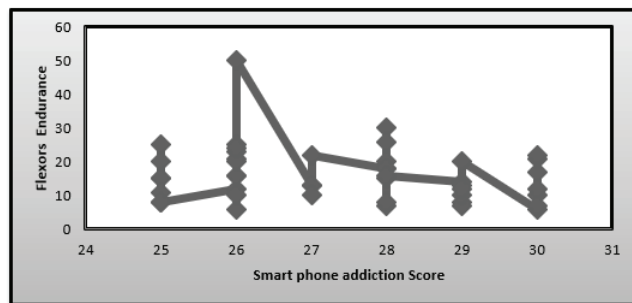
RESULT

On analysis using Pearson Coefficient correlation between Mobile addiction and Neck Flexors endurance, r value was 0.1049 ($p = 0.3673$) was not significant.

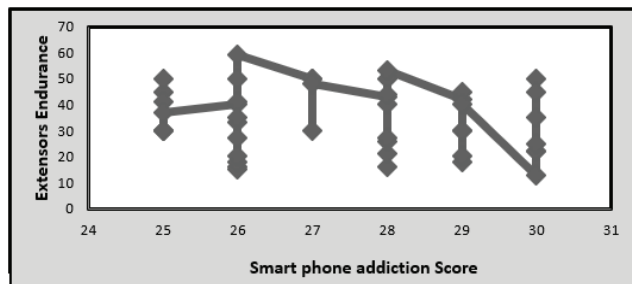
On analysis using Pearson Coefficient correlation between Mobile addiction and Neck extensors endurance, r value was -0.1251 ($p = 0.2816$) was not significant.

Table 1. Correlation between mobile addiction and neck muscles endurance (flexors and extensors)

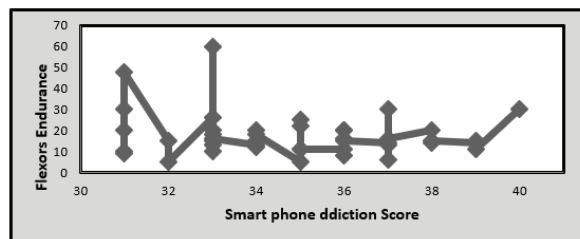
Group	Addiction Score	Mean Value	r value	p value	Result
Flexor endurance	25-30	16	-0.1957	0.1977	Not Significant
	30-40	17.56	-0.1571	0.3143	Not Significant
	40-50	17.92	-0.3738	0.2313	Not Significant
Extensor Endurance	25-30	34.49	-0.1382	0.3653	Not Significant
	30-40	36.56	-0.004045	0.9795	Not Significant
	40-50	26.25	-0.6056	0.0369	Significant



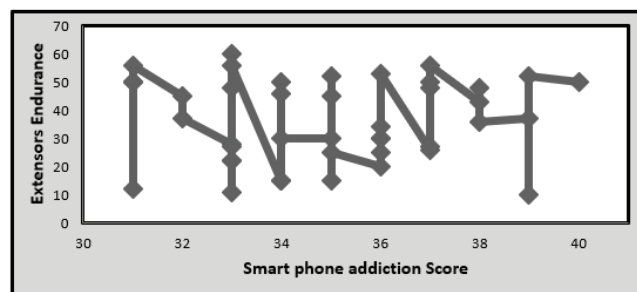
Graph 1. Smart phone addiction score (25-30) and neck flexors endurance.



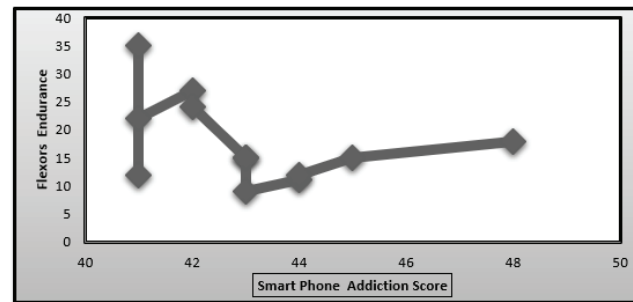
Graph 2. Smart phone addiction score (25-30) and neck extensors endurance.



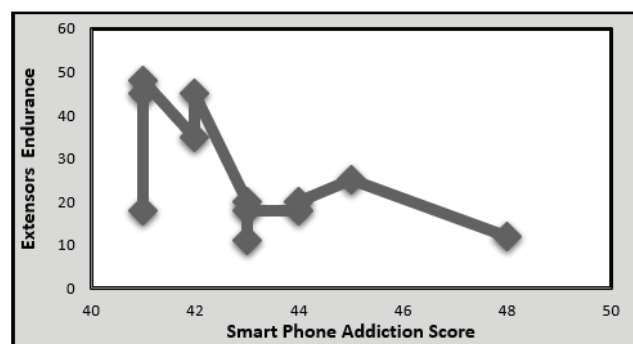
Graph 3. Smart phone addiction score (30-40) and neck flexors endurance.



Graph 4. Smart phone addiction score (30-40) and neck extensors endurance.



Graph 5. Smart phone addiction score (40-50) and neck flexors endurance.



Graph 6. Smart phone addiction score (40-50) and neck extensors endurance.

DISCUSSION

Smart phone is one of the fastest growing technological developments of all times and becoming an integral part of daily life among adolescents. Frequent use of smart phones forces the users to adopt an awkward posture to increased risk of musculoskeletal problems⁹. In forward head and rounded shoulder posture the deep cervical extensors including longissimus capitis, splenius capitis, cervical multifidus, upper trapezius becomes overactive and shortened. This leads to increased work of deep neck flexors as they are the antagonist muscles which balance the deep neck extensors. The deep neck flexors consist of rectus capitis anterior, rectus capitis lateralis and longus colli which play a vital role in supporting the cervical segment and the cervical curve.

This study investigated the effect of smartphone addiction on endurance of neck flexors and extensors among healthy college students. The findings of this research revealed no significant variation in neck extensor endurance for smartphone-addicted students. However, a substantial decrease in neck flexor endurance time in the smartphone addicted students was observed. Normal neck flexors endurance in female subjects is approximately 30 seconds, and that in males is nearly 40 seconds in age range of 18 to 28 years²².

A. Alshrami *et al.*, results revealed that flexor endurance time (s) was significantly lower in the smartphone-addicted group in comparison with those in the non-addicted group ($p < 0.001$). Flexing the neck is the most usual and regular posture adopted by mobile phone users; they tend to adopt this posture when looking at their devices for long periods. The length of time devoted to smartphone usage and adopting flexed neck postures may cause pain and discomfort to the neck region in the long term. Furthermore, smaller smartphone screen sizes might indirectly influence the adoption of different neck positions to enhance looking at the screen. Smaller screens might cause more forward bending of the neck, reducing the distance between the screen and the user's eyes. A compensatory forward neck bending may be occasioned with increased neck muscle activity, which might have affected DNF endurance in the smartphone-addicted group².

Domenech *et al.*, concluded that the average DNF endurance test time was 39 s for males and 29 s for females between the ages of 20 and 80 years, and the Interrater reliability for DNF muscle endurance testing was 66%²³. Our study also shows that the average DNF endurance test time was 19.58s for males and 14.22s for females between the ages of 18 and 27 years. The average DNE endurance test time was 35.22 for males and 33.56s for females of the above mentioned age group people.

The study of Shah *et al.*, examined the effect of smartphone addiction and relation to musculoskeletal disorder specially text neck by SAS questionnaire into English language and Neck Disability Index (NDI) by 100 physical therapy students in Ahmadabad College, SBB

College and VS Hospital their age 20 – 25 years old found that positive correlation between the smartphone addiction and neck disability with predominance of female seen that may later effect on long term disability⁴. In our study, the highest rated component of SAS was “Missing planned work due to smartphone use”, followed by “I will never give up using smartphone even my daily life is already greatly affected by it”. The component rated least was “Feeling impatient and fretful when I am not having smartphone” followed by “The people around me tell that I use smartphone too much”. Also, it was found in our study that smartphone addiction (Scoring on SAS 40-50/50) has a significant impact on neck extensors endurance.

Parazza S *et al.*,³ study showed significantly higher endurance of neck extensor muscles compared to flexor ones and studied relationships between pain and disability and between NFME and NEE tests. No significant relationship between each of the endurance tests, pain and disability in subjects with neck pain were found. This finding is consistent with the findings of the present study, as in this study it was observed that the neck extensor muscles had higher endurance as compared to flexor ones. This difference between the endurance in the neck extensor muscles and neck flexor muscles might be due to the reason that the neck extensor muscles are the postural or tonic muscles which are capable of maintaining a particular posture for longer duration as compared to neck flexor muscles which are phasic muscles and have a lower endurance.

The present study provides valuable clinical insight into the relationship between smartphone addiction and cervical muscle endurance among young adults. Although no significant overall association was found between smartphone addiction and neck flexor or extensor endurance, the findings emphasize the importance of monitoring smartphone usage habits as part of musculoskeletal health assessment. Excessive smartphone use is commonly associated with prolonged neck flexion, forward head posture, and increased mechanical stress on cervical structures, which may contribute to future neck dysfunction. Therefore, physiotherapists should educate individuals regarding proper ergonomics, posture correction, and regular physical activity to minimize potential musculoskeletal risks. Early screening and preventive

interventions may help maintain cervical spine health and reduce the likelihood of developing neck pain and postural abnormalities associated with prolonged smartphone use.

So according to the results of this study it can be concluded that no significant relationship was observed between smartphone addiction and neck flexor muscle endurance, and between smartphone addiction and neck extensor muscle endurance when overall data was analysed. However, it might also be related to the amount of addiction present in a particular individual. So, since the addiction ranging from 40-50 score had a least number of individuals the overall score of the addiction and its relationship with the muscle endurance had reduced. To the best of our knowledge, few studies have investigated the relationship between smartphone addiction and both deep neck flexor and extensor endurance among healthy Indian college students.

The present study has certain limitations that should be considered while interpreting the findings. Since the study employed a cross-sectional design, a causal relationship between smartphone addiction and neck muscle endurance could not be established. The participants were recruited using purposive sampling from a single institution, which may limit the generalizability of the results to the wider population. Smartphone addiction was assessed using a self-reported questionnaire, making the data susceptible to recall and response bias. Furthermore, only healthy young adults aged 18–27 years were included in the study; therefore, the findings may not be applicable to individuals from other age groups or those with existing cervical musculoskeletal disorders. In addition, objective measures of smartphone usage duration and posture were not evaluated, which may have influenced the relationship between smartphone addiction and neck muscle endurance.

CONCLUSION

The present study found no significant overall association between smartphone addiction and deep neck flexor or deep neck extensor muscle endurance among healthy young adults. However, a significant

reduction in neck extensor endurance was observed in participants with higher smartphone addiction scores (40–50), suggesting that excessive smartphone use may adversely affect cervical muscle performance. Further studies with larger sample sizes are recommended to validate these findings.

FUTURE SCOPE OF THE STUDY

Based on the findings of the present study, future research should be conducted with larger sample sizes and participants recruited from multiple institutions to enhance the generalizability of the results. Longitudinal studies are recommended to investigate the long-term effects of smartphone addiction on cervical muscle function and to establish potential causal relationships. The inclusion of objective measures of smartphone usage, such as screen-time monitoring applications, may provide more accurate information regarding smartphone exposure. Furthermore, future studies should assess additional cervical parameters including posture, muscle strength, range of motion, and functional disability to obtain a more comprehensive understanding of the musculoskeletal consequences of excessive smartphone use. Awareness programs promoting proper ergonomics, posture correction, and healthy smartphone usage habits should also be encouraged among young adults to help prevent the development of cervical musculoskeletal disorders.

AUTHOR DECLARATION

The manuscript entitled ‘Effect of Smartphone Addiction on Neck Muscles Endurance – A Cross Sectional Study’ has not been published previously and is not under consideration for publication elsewhere. All authors have read and approved the manuscript.

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee of DVVPF's College of Physiotherapy, Ahilyanagar (Approval No. : IEC/2022/465/B). Written informed consent was obtained from all participants before enrolment.

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ORIGINAL ARTICLE

Correlation between Core Strength with Dynamic Balance and Change of Direction Speed in Adolescent Skaters: A Cross-sectional Study

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Abstract

Background: Inline skating has become an increasingly popular form of physical exercise worldwide. Core strength and stability contribute to efficient energy transfer, body control, and balance maintenance during movement. Understanding the relationship between these variables is essential for designing training programs that enhance performance and support the physical development of young skaters. **Method:** A total of 52 Skaters participated in the study. Balance and Agility, core strength and endurance were assessed using the Y-Balance Test and Arrowhead Agility, and an isometric test, respectively. Data were analysed using Pearson correlation analysis to determine the relationships among the measured variables, with pvalue of < 0.05. **Result:** Core strength showed a moderate negative correlation with agility test scores on both sides, and the values are Right $r = -0.667$, Left: $r = -0.581$, $p < 0.00001$. Also, Core strength showed a moderate positive correlation with Y Balance Test scores across all directions (Anterior, Posteromedial, Posterolateral) for both limbs, $r = 0.45-0.68$, $p < 0.00001$. **Conclusion:** The findings emphasise that core strengthening should be an essential part of training programs to boost skating performance and movement efficiency.

INTRODUCTION

In recent years, inline skating has gained popularity as a recreational activity and a way to improve physical

fitness¹. Inline skating is a popular sport practised by millions globally, offering benefits such as improving cardiovascular health, enhanced postural control, and general fitness. Despite its benefits, it poses a significant

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risk of injuries, emphasising the need for proper training². Research indicates that balance, speed, and agility are key components for excelling in various sports. The ability to sustain the centre of pressure on a support base with little body sway and maximum stability is known as balance. Agility is the capacity to change direction and speed rapidly. A child's development as an agile child takes a lengthy time. One of the most important performance criteria in many professional sports is speed, particularly forward linear speed³.

The trunk facilitates energy transfer and coordination between lower and upper extremities. Optimal trunk muscular activation is necessary for proper movement and posture during sports. Trunk function refers to core stability, which involves coordination, strength, and endurance in trunk muscles⁴.

Advanced skating techniques demand a higher degree of balance, which improves with practice and maturity⁵. Inline skating games can teach principles, increasing motivation during training sessions, especially among adolescents who value exercise and social contact⁶. Skating involves constant balance adjustments due to displacement conditions, requiring adjustments in gravity, space, and body extremities, with variations in speed at the start⁷.

The three reaches of figure skaters were symmetrical overall, but when sexes were separated, skating speed and posterolateral reach were linked, suggesting that females may use the take-off leg more to generate power when gliding on the landing leg, which increases hip activation and take-off leg strength. Female singles skaters may be more susceptible to lower extremity injuries, according to composite results on the Y-balance test⁸.

Agility involves both physical adjustments and decision-making processes. Athletes with strong agility skills often demonstrate better visual processing, spatial awareness, dynamic balance and rhythm. Forward linear speed, in particular, is critical in many sports and directly impacts skating performance. Speed training focuses on minimising the time taken to move between two points, and similar methods are often applied to enhance both sprinting and skating speed⁵.

Change of Direction Speed (CODS) is influenced by various physical factors, including linear sprint speed, reactive strength, and the power of leg muscle. Core has also been suggested as a potential factor impacting CODS, but its exact role remains unclear. Core training appears to effectively enhance CODS in less skilled middle-adolescent athletes, but its benefits diminish in more skilled adult athletes. These findings suggest that core muscle strength plays an important role in CODS and that incorporating core training can be beneficial for improving this skill⁹.

Enhancing performance is mostly dependent on core training. In addition to preventing injuries, it plays a crucial role in lower limb and trunk injury rehabilitation programs¹⁰. Lehman's definition of strength in athletes, which is the greatest force generated by a muscle group at a specific velocity, is different from our concept. There is scant research on the relationship between core stability exercises and improved sports performance¹¹. The core muscles are in charge of transmitting stresses from the body's proximal to most distal regions and stabilising the spine¹².

According to research, athletes who include core strengthening exercises in their training routines report increases in strength, agility, and stability. Athletes can better regulate their body motions and respond swiftly to unforeseen circumstances by strengthening their bodies¹³.

Skating is a dynamic sport that requires optimal core strength, postural control, dynamic balance, and rapid CODS for effective performance and injury prevention. Although previous studies have examined the individual roles of core strength, balance, and agility, limited evidence exists regarding their interrelationship in adolescent skaters. This study aims to evaluate the correlation between core strength, dynamic balance using the Y-Balance Test, and CODS using the Arrowhead Agility Test. The findings may provide valuable insights for physiotherapists, coaches, and strength and conditioning professionals in developing evidence-based training strategies to optimise performance and reduce the risk of sports-related injuries.

MATERIALS AND METHODS

This study was conducted at the Garkheda Divisional Sports Complex and Shiv Chhatrapati College, Chhatrapati Sambhajanagar, Maharashtra, India, focusing on adolescent inline skaters. The research adopted a convenience sampling method and employed an observational cross-sectional study design. A total of 58 adolescent inline skaters aged 15–19 years participated in the study over a duration of six months. The study utilised essential materials, including a stopwatch, markers, inch tape, couch/mat, micropore tape, and cones for the assessment procedures. Ethical clearance was obtained from the Institutional Ethics Committee of MGM-ECRHS RHS, Department of Pharmacology, Chhatrapati Sambhajanagar. CTIRI registration was not required as the study was observational in nature. The inclusion criteria comprised adolescent inline skaters aged 15–19 years with a BMI between 18.5 and 24.9 kg/m² who practised skating at least three times per week. Participants were excluded if they had a history of recent lower limb surgery or any orthopaedic condition, musculoskeletal disorder, neurological deficit, or congenital deformity affecting lower limb function or core strength. Additionally, skaters actively participating in other outdoor sports such as football, athletics, badminton, or soccer were excluded.

PROCEDURE

Participants were selected based on inclusion and exclusion criteria; the procedure was explained to the participants. Informed consent was obtained from them. Then we measured the core strength by using different outcome measures. Along with the Arrowhead Agility Test and Y balance test.

Dynamic Abdominal Endurance test: The athletes were positioned in the supine lying with hips at 45 degrees and knees at 90 degrees and hands at the side. A line was drawn 8 centimetres and 12 centimeters distal to the fingers. The athlete tucks his/her chin and curls the trunk to touch the lines with the fingers and repeats as many curls as possible using a cadence of 25 repetitions per minute. The number of repetitions

possible before holding breath, altered mechanics or fatigue occurs was recorded as the score.

Isometric Abdominal test: The athletes are in a supine lying position with hips at 45 degrees and knees at 90 degrees and hands at the side or behind the head or neck. The athlete has to tuck his/her chin and scapula off the couch. This position is held as long as the athlete is able to do.

Dynamic horizontal side support: The athlete was positioned in a side-lying position, resting the upper body on his/her elbow and flexing the knee to 90 degrees. The athletes had to lift the pelvis off the couch and straighten the spine. The athletes repeated this movement as many times as possible.

Isometric horizontal side support: The athletes were positioned in the side-lying position and rested the upper body on his/her elbow and then flexed the knee to 90 degrees. The athletes lifted the pelvis off the couch and straightened the spine. The athletes held this position as long as he/she was able to.

Isometric extensor test: The athletes were positioned in a prone lying position with hands on the side of the couch. Moving his/her hands to the back and finally moved their hands behind the head to increase the difficulty. The athletes lifted the body off the couch and held off as long as he/she was able to do. That was recorded¹⁴.

Arrowhead agility test: The athletes were asked to sprint across the markers and come back to the starting position. We recorded the time as the participant starts and ends the test. 4 trials were done with 3 min rest in between. The best of 2 trials for each side was taken for analysis¹⁵.

Y balance test: This test protocol involved three directions (posterolateral, posteromedial, anterior) forming a Y pattern instead of eight. Athletes underwent a demonstration, and four familiarisation trials per limb in each direction were performed. During the test, three recorded trials focused on stability, with hands on hips and barefoot athletes placing their great toe at the point 0. Assessment parameters included the mean of three trials for each direction and limb, a composite score calculation, and qualitative movement analysis.

Reach Distance = (Average reach distance for a direction / Limb length) x 100%¹⁶.

Outcome Measures

This are our outcome measures used for Core Strength: Dynamic extensor endurance test, Isometric abdominal test, Isometric extensor test, Dynamic horizontal side support. Isometric horizontal side support¹⁴. The dynamic y balance test has intra-rater reliability ranging from 0.85-0.91¹⁶. Arrowhead agility test have ICC ranging from 0.80 to 0.83¹⁵.

Data Analysis

Data obtained was entered by MS Excel Windows 11, then transferred to the new SPSS (Statistical Package for the Social Sciences) software version for advanced analysis. The collected data were tabulated by taking demographic variables such as age, gender, height, weight, etc.

Along with that, mean, SD, SE means, percentage, analysis of variances, etc. were used between groups to be tested.

The Data were interpreted using both descriptive and inferential statistical techniques. While Spearman's correlation test was utilised to ascertain correlations between core strength, agility and dynamic balance variables, descriptive statistics included mean and standard deviation to summarise participant characteristics and performance measurements.

RESULTS

Data were entered in Microsoft Excel. After data cleaning, data were imported into the Statistical Package for the Social Sciences version 25 and analysed using the same. Data were analysed for descriptive and inferential statistics. Data were presented in tabular and graphical formats. Graphs were plotted in Excel. The data were analysed for 58 participants.

Table 1. Credentials of the participants

Variables	Mean	Standard deviation
Age	16.68	1.59
BMI	21.93	1.72
Dominance	Frequency	Percentage
Right	45	78
Left	13	22

Interference: The participants of the study were adolescent skaters with a mean age of 16.68 ± 1.59 years, indicating that the study sample represented mid- to late-adolescent individuals with a relatively homogeneous age distribution. The mean Body Mass Index (BMI) of the participants was 21.93 ± 1.72 kg/m², which falls within the normal BMI range for adolescents. Out of 58 participants, 45 (78%) were right-dominant, and 13 (22%) were left-dominant.

Table 2. Correlation of core strength with agility

Variables	Spearman's correlation	pvalue	Interpretation
Core strength * mean of agility test right	-0.667	<0.00001	Moderate negative correlation
Core strength * mean of agility test left	-0.593	<0.00001	Moderate negative correlation

Interference: Core strength showed a moderate negative correlation with agility test scores on both sides: Right: $r = -0.667$, Left: $r = -0.581$, $p < 0.00001$. Since agility test time is measured in seconds (lower time = better performance), a negative correlation indicates that greater core strength was associated with better agility.

Table 3. Correlation of core strength with Y balance test

Variables	Spearman's correlation	pvalue	Interpretation
Core strength *anterior side Y balance test right	0.526	<0.00001	Moderate positive correlation
Core strength *anterior side Y balance test left	0.452	<0.00001	Moderate positive correlation
Core strength *posteromedial side Y balance test right	0.683	<0.00001	Moderate positive correlation
Core strength*posteromedial side Y balance test left	0.615	<0.00001	Moderate positive correlation
Core strength*posterolateral side Y balance test right	0.636	<0.00001	Moderate positive correlation
Core strength*posterolateral side Y balance test left	0.541	<0.00001	Moderate positive correlation

Core strength showed a moderate positive correlation with Y Balance Test scores across all directions (Anterior, Posteromedial, Posterolateral) for both limbs, where r values ranged from $r = 0.45$ – 0.68 , $p < 0.00001$. A positive correlation here means that better core strength was linked with greater reach distances, indicating improved dynamic postural control and stability.

DISCUSSION

The goal of the current study was to ascertain the relationship between teenage skaters' CODS, dynamic balance, and core strength. There were 58 participants in all, representing mid-to late-adolescent athletes who were actively skating, ages 15 to 19. The results showed that core strength and agility time had a moderately negative association ($r = -0.667$ and -0.593 , $p < 0.00001$) and dynamic balance had a moderately positive correlation ($r = 0.45$ – 0.68 , $p < 0.00001$). This suggests that individuals with stronger cores exhibited better balance control and quicker agility performance. These connections imply that postural stability, effective force transmission, and movement control—all essential for successful skate performance—are greatly influenced by core muscle endurance.

The goal of the current study was to ascertain the relationship between teenage skaters CODS, dynamic balance, and core strength. There were 58 participants

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The current study's findings are in line with earlier studies emphasising the role of the core in improving athletic abilities. According to Hornikova and Zemkova⁹, CODS is strongly influenced by core muscle strength, highlighting the superior performance of athletes with stronger cores in multidirectional movement activities. The present study's conclusion that a well-conditioned core promotes balance during sport-specific movements is supported by Bhardwaj *et al.*⁷, who discovered a favourable association between core stability and dynamic balance among teenage female roller skaters. According to Granacher *et al.* and Prieske *et al.*¹⁷, core stability training improves adolescent athletes' coordination and postural control. The rectus abdominis, obliques, erector spinae, and quadratus lumborum are among the core muscles that work together to maintain trunk alignment and control

during dynamic activities like skating. This stabilising function is responsible for the improved balance seen in this study.

Higher core endurance may enable quicker direction changes, as indicated by the negative connection between agility test duration and core strength. This result corroborates research by Sato and Mokha¹⁸ and Nesser *et al.*, who found that trunk stability improves lower-limb mechanics and kinetic efficiency, enabling faster transitions during high-speed movements. Strong cores reduce energy leaks and speed up reaction times by providing a robust foundation for the production and transfer of forces between the upper and lower extremities. Additionally, skating necessitates constant body position adjustments, including accurate centre of gravity management and effective stabilising muscle engagement, especially during accelerations, decelerations, and turns².

The body's capacity to maintain balance and perform strong, well-coordinated motions is closely correlated with the strength of the core, which serves as the key link in the kinetic chain. Reduced agility, compensatory movement patterns, and an elevated risk of injury might result from weak core muscles. According to Hibbs *et al.*¹⁹, core strength enhances balance and agility by improving proprioception and postural control. The study's virtually symmetrical Y-Balance scores also point to individuals' balanced neuromuscular coordination, which reduces asymmetries that may put athletes at risk for overuse problems. Willardson²⁰ asserts that preserving core-limb symmetry is crucial for maximising performance effectiveness and preventing injuries.

Thus, the current study's findings highlight the necessity of including core-strengthening activities in adolescent skaters' regular training regimens, such as planks, bridges, side holds, and dynamic balance drills. In the end, these workouts can result in better performance and a lower risk of injury by increasing trunk endurance, improving balance, and enabling quicker, more controlled changes of direction.

CONCLUSION

The study concludes that core strength has a significant influence on agility and dynamic balance among teenage skaters. A stronger core is associated with quicker agility test performance and better stability in all directions of the Y-Balance Test, indicating improved postural control and movement efficiency. Participants showed physical uniformity, suggesting that variations in performance were primarily linked to core strength differences. These findings emphasise the importance of incorporating core-strengthening exercises into training programs for young skaters. Enhancing core stability not only boosts agility and balance but also contributes to better overall coordination and skating performance.

Limitations

- i. *Sample size*: With only 58 participants, the study's conclusions cannot be applied to the larger adolescent skate community.
- ii. *Cross-sectional design*: The study evaluated correlations only; it was unable to determine causal links between agility, balance, and core strength.
- iii. *Sampling technique*: Because participants were selected from a small number of training facilities, convenience sampling might have induced selection bias.
- iv. *Gender analysis*: It's possible that sex-related differences were obscured since the data for male and female participants were not examined independently.
- v. *Scope of measurement*: No sophisticated biomechanical or electromyographic studies were used; only field-based tests (Y-Balance Test and Arrowhead Agility Test) were utilised.
- vi. *No intervention or follow-up*: Neither a training course nor a longitudinal evaluation to gauge changes over time were part of the study.

Future Scope of the Study

- i. To investigate how structured core-strength training affects skaters' balance, agility, and injury prevention, future studies should use longitudinal or interventional designs.

- ii. Results will be more broadly applicable if the sample size is increased and participants from a variety of age groups, skill levels, and athletic backgrounds are included.
- iii. To investigate any physiological or performance-based variations in core strength and balance, gender-specific research is advised.
- iv. More accurate information on core activation patterns can be obtained by incorporating biomechanical methods like electromyography (EMG), 3D motion analysis, and force plate evaluations.
- v. To learn more about performance dynamics, it is possible to examine how tiredness, proprioception, and reaction time affect agility and balance.

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ORIGINAL ARTICLE

Awareness and Practices of Hand Care in Individuals with Type II Diabetes: A Cross-Sectional Study

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Abstract

Background: This study aimed to evaluate the awareness and practice related to diabetic hand care in individuals with Type II DM aged 50-75 years. **Methods:** A cross-sectional study was conducted in a tertiary health care institution and community dwellings, and 150 participants with confirmed type II DM aged 50 – 75 years were recruited in the study. A self-formulated questionnaire was designed, and the domains, such as awareness and practice related to diabetic hand care, were selected as constructs. **Results:** 80% of the participants were unaware of diabetic hand, especially about limited joint mobility and hand weakness secondary to diabetes. 79.40% of the individuals were unaware of symptoms related to a diabetic hand. 71.02% of individuals never practised hand hygiene care, and on self-examination, 15 % of the individuals experienced hand stiffness and weakness. **Conclusion:** Most of the participants lacked awareness of diabetic hand, and there was poor practice related to hand hygiene and exercise among the study participants.

INTRODUCTION

Diabetic hand is defined as a syndrome of musculoskeletal manifestations of hand deformity usually associated with long-standing diabetes, suboptimal glycemic control, and microvascular complications^{1,2}. Commonly known as Diabetic Hand Syndrome, it is a group of disorders leading to hand pathology like limited joint mobility, Dupuytren's

contracture, trigger finger, hand infections, peripheral neuropathy (ulceration, carpal tunnel syndrome), ulnar neuropathy, skin and nail pathology, reduced hand strength, *etc.*, which limits functional activity and, if not addressed, may hamper hand functions, specifically grips, and pinches^{3,4}. Evidence suggests that in India, the prevalence of hand disorders in type II DM is 67% whereas limited joint mobility was found in 40.5%, Dupuytren's contracture in 19%, trigger finger in

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16.5%, and carpal tunnel syndrome in 14%^{5,6}. With an increasing number of diabetic cases, conditions related to the musculoskeletal system are rising proportionally in these patients, and yet patients are rarely referred for rehabilitation to prevent functional limitation and disability. People with diabetes are vulnerable to infectious diseases due to their hyperglycemic condition, which favors immune dysfunction⁷. Thus, maintaining good hand care practices is a critical part of self-care for people with diabetes.

Awareness of the individual about the prevention, protection, and daily practice of the condition may help in preventing the disability⁸. Literature suggests that self-care behaviors are positively correlated with good glycemic control, education about complications, and improvements in quality of life^{9,10}. As life expectancy rises and the number of persons with type 2 diabetes rises sharply, more study is needed to address the standard of living and self-reliability in both fine and general tasks. Type 2 Diabetes Mellitus (T2DM) is becoming increasingly common both globally and in India, and its associated complications have the potential to impair daily living activities and quality of life. In contrast to diabetic foot, T2DM hand problems are often overlooked¹¹. Therefore, our study aimed to evaluate the awareness and practice related to diabetic hand care in individuals with Type II DM aged 50–75 years.

MATERIALS AND METHODS

This cross-sectional study was conducted following approval from the Institutional Research Committee and in accordance with the Helsinki Declaration of 1975. Using convenience sampling, adult participants of both genders with confirmed type 2 diabetes mellitus, aged 50–75 years, who consented to participate, were recruited from the community or from participants visiting the institution. The study was conducted over eight months. Individuals who denied consent to participate and to share routine investigations had a history of gestational or juvenile diabetes or terminal illnesses like cancer, Alzheimer's, *etc.*, and other musculoskeletal pathologies such as rheumatoid arthritis were excluded from the study. The sample

was determined using the following formula: $SS = (z^2 pq/d^2)$ where SS is the estimated sample size; z is the standard value for a 5% level of significance ($z = 1.96$); d , the relative error taken as 5% and the sample size was estimated to be 150 participants⁸.

A self-formulated questionnaire was designed and the domains such as awareness and practice related to diabetic hand care were selected as constructs. A committee of experts comprising a diabetologist, a general physician, and a physiotherapist validated the questionnaire using Lawshe's criteria¹² and a Content Validity Index (CVI) of 0.80 was obtained¹³. The questionnaire was divided into three domains, the first domain included consent of the participants to participate in the study and willingness to share their lab reports, the second domain included a case record form encompassing demographic details, medication, duration of diabetes, HbA1C /fasting plasma glucose reports, and past medical history. The third domain included a questionnaire to assess the awareness and practice related to hand care. A pilot study was conducted on ten participants to understand the effectiveness of the responses received and data obtained from these ten participants was not included in the analysis¹⁴.

Awareness Score

17 questions assessed the awareness of the participants about diabetes and diabetic hand, each question had the answers (yes or no), yes indicated the knowledge of the specified item of knowledge; accordingly, the awareness of the patient was calculated as the accumulation of the correct answers as follows:

- The participant who mentioned 13-16 correct answers rated as a good level of knowledge.
- The participant who mentioned 8-12 correct answers rated as moderate level of knowledge.
- The participant who mentioned <8 correct answers rated as poor level of knowledge.

Practice Score

The practice domain included hygiene, medical care, and exercise followed to prevent diabetic hands, and

accordingly the practice of the patients calculated as the accumulation of their answers.

Responses were obtained by approaching the participants in residential areas, old age homes, and diabetic outpatient departments.

Statistical Analysis

The responses collected were tabulated in Microsoft Excel 2016. Using Excel-based formulae, the responses were coded and analyzed and percentages of the responses were derived. The responses were further represented using tables and graphs.

RESULTS

A total of 150 participants with a mean age of 68 ± 12 years, 49% male and 51% female were recruited (Table 1). Figure 1 showed that 52.7% of hand weakness and 48.7% of the participants were aware of limited joint mobility, and 4.7% of brittle nails and skin nodules secondary to diabetes. Figure 2 states the self-reported symptoms of diabetes showing that 33% reported hand weakness, 32% of participants reported hand stiffness, and 10% skin discoloration. Figure 3

Table 1. Demographic details of the participants (n=150)

Parameter	n (%)
1. Gender	
Male	73 (49%)
Female	77 (51%)
2. Age: Mean $\pm$ SD	68 ± 12 years
3. Family history of diabetes	
Positive	90 (60%)
Negative	60 (40%)
4. Dominance	
Right	147 (98%)
Left	3 (2%)
5. Hypertension	
Present	86(57%)
Absent	64(43%)
6. Duration of diabetes	
Less than 10 years	47 (31.3%)
11-15 years	66 (44%)
16-20 years	21 (14%)
20+ years	16 (10.7%)

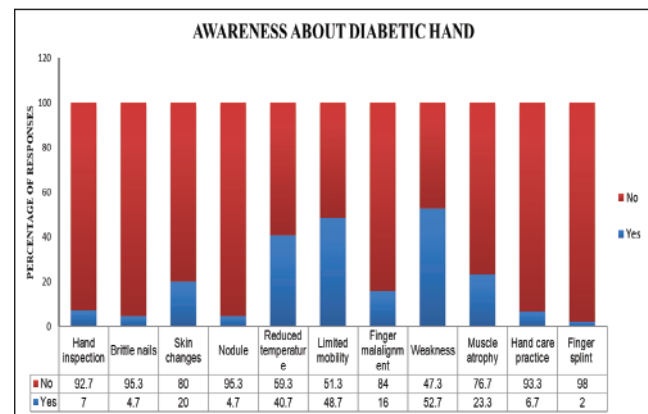


Figure 1. Awareness of diabetic hand (n=150).

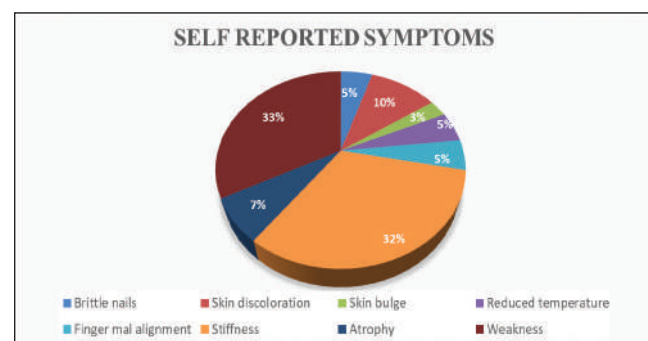


Figure 2. Self-examination of hands (n=150).

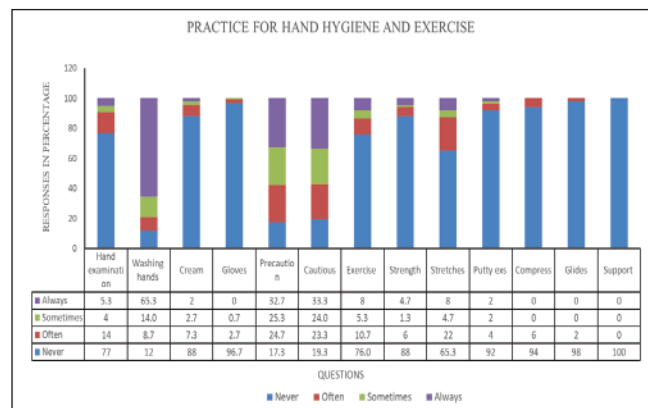


Figure 3. Practice for hand hygiene and hand-related exercise (n=150).

stated the participants practiced hand care regularly, such as hand washing, wearing gloves during daily chores, cautiously handling sharp objects, performing wrist stretches, wrist strengthening, applying cream, hot and cold compress, *etc.*

DISCUSSION

Our study aimed to evaluate the awareness and practice related to diabetic hand care in individuals with Type

II DM aged 50–75 years. Diabetic hand syndrome is a prevalent condition that receives little attention. Although the pathologies grouped under the heading of diabetic hand syndrome are more prevalent in diabetic patients, they do occur in the general population as well. When compared to the general population, diabetics may exhibit these in different ways in terms of presentation, natural course, and response to therapy.

The present study demonstrated that 79.40% of participants had poor knowledge about diabetic hand, and 71.02% never practiced any hand care or exercises while attending to the same. Our study findings are consistent with those of Sharma 2013, who stated that individuals with diabetes had poor knowledge (88.2%) and practice (83.8%) related to its management¹⁵. As suggested by the literature, people are aware of diabetes but little is known about hand complications related to diabetes. Its complications often remain neglected and underscored; hence, this could be one of the reasons that participants in the present study were unaware of the diabetic hand.

Awareness about Diabetic Hand

Figure 1 showed that 52.7% of the participants were aware of hand weakness, limited joint mobility (48.7%), muscle atrophy (23.3%), and diminished ability to discriminate temperature in the hands (40.7%) secondary to diabetes. One possible reason could be that the participants might have encountered similar symptoms in their family members who were diabetic. Literature has also stated a similar result: individuals with a family history of diabetes were more aware of risk factors than those without a family history¹⁶.

Self-Examination

Figure 2 demonstrated that 15% of participants reported symptoms such as stiffness (32%), and weakness (33%), compared to rest. As stated by Larkin (1984) weakness and limited joint mobility are the primary symptoms of a diabetic hand¹⁷. Limited joint mobility has been linked to increased glycosylation of collagen, while the associated microangiopathy is explained by increased glycosylation of basement membranes¹⁸. As a part of disease management, patient education on diabetic

care should incorporate hand care practices to ensure better functional mobility and reduce the disease burden.

Practice Related to Preventing Diabetic Hand

As stated in Figure 3, the participants practiced hand care regularly, such as hand washing, wearing gloves during daily chores, cautiously handling sharp objects, performing wrist stretches, wrist strengthening, applying cream, hot and cold compress, etc. Within the practice domain, when a comparison was made between hand hygiene and hand exercises, 23% of participants practiced hand hygiene more diligently, such as hand washing (65.3%), with an approximately equal number of individuals cautiously handling (33.3%) and taking preventive measures (32.7%) to avoid harm while handling objects, however a relatively poor trend (3.2%) was observed in participants practicing hand exercises, the majority doing hand stretches (12%), wrist strengthening (7%) and putty exercises (3%).

Hand problems in T2DM patients might interfere with everyday tasks and cause impairments in self-care. These lead to fewer social contacts, a decline in self-reliance, financial strain, and a general decline in life quality. Microvascular problems such as retinopathy may be reflected in the hand presentation of diabetes mellitus. The cornerstone of care in these situations is the attainment of ideal glucose control and, in certain situations, targeted orthopaedic therapies.

The limitation of our study was that the temporal relationship might not be possible given the study's cross-sectional design and the population was recruited from a limited geographical area such as Mumbai and Navi Mumbai. Notwithstanding this drawback, we think our study was novel and it makes a strong case for the need to raise awareness of diabetic hand conditions and encourage self-care and practice through patient education. Our study may help enhance care, independence in daily living activities, and quality of life, given the rising number of patients with type II diabetes and the longer life expectancy.

CONCLUSION

To conclude, we can state that most of the participants in our study had poor awareness of symptoms associated with diabetic hand, and hand hygiene practices were poor. Participants also had poor awareness of exercises to prevent diabetic hand and reduce the disability caused by diabetic hands. Thus, raising awareness of the condition, its symptoms, and available treatments is imperative to begin early preventive and curative rehabilitation.

Abbreviations

1. DM: Diabetes mellitus
2. HbA1C: Hemoglobin A1C

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ORIGINAL ARTICLE

Clinical and Electrophysiological Detection of Diabetic Neuropathy in Individuals with Type 2 Diabetes Mellitus: A Comparative Pilot Study in Western Maharashtra

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Abstract

Background: Diabetic Peripheral Neuropathy (DPN) is the most common chronic complication of Type 2 Diabetes Mellitus (T2DM), and Indian studies report a prevalence ranging widely from about 9% to 78% depending on region and diagnostic method. Bedside clinical tests remain the first-line screening tools in resource-limited settings, but their concordance with Nerve Conduction Study (NCS), the electrophysiological reference standard, is uncertain and may vary by population. **Aim:** To compare the diagnostic performance of bedside clinical methods (vibration perception by tuning fork, Semmes-Weinstein monofilament testing, and ankle reflex) against NCS for detecting diabetic neuropathy in patients with T2DM in a Western Maharashtra population. **Materials and Methods:** This descriptive, cross-sectional pilot study enrolled 14 patients with T2DM. Each patient underwent a structured clinical neurological examination (vibration perception, monofilament testing, ankle reflex) and NCS (motor and sensory conduction of an upper- or lower-limb nerve). Findings from clinical examination were compared against NCS, which was used as the reference standard. Descriptive statistics were used given the small sample size. **Results:** The mean age was 52.1 ± 15.4 years and mean duration of diabetes was 9.1 ± 4.7 years; mean HbA1c was $9.3 \pm 1.9\%$. NCS was abnormal in 11 of 14 patients (78.6%) — mixed pattern in 5, axonal in 4, and demyelinating in 2 — while 3 patients (21.4%) had entirely normal nerve conduction. In contrast, bedside clinical examination detected an abnormality in only 5 of 14 patients (35.7%). Using NCS as the reference standard,

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clinical examination showed a sensitivity of 45.5%, a specificity of 100%, and an overall concordance of 57.1%. Abnormal NCS was seen in 5 of 6 patients (83.3%) with diabetes duration ≥ 10 years and in 6 of 8 patients (75.0%) with shorter duration, suggesting a modest but non-absolute association between longer disease duration and electrophysiological neuropathy in this small cohort. **Conclusion:** In this small pilot cohort, bedside clinical tests substantially under-detected diabetic neuropathy compared with NCS, consistent with prior literature describing low sensitivity of clinical examination for subclinical DPN. These preliminary findings support incorporating NCS or more sensitive quantitative screening tools where feasible, and warrant confirmation in a larger, adequately powered study.

INTRODUCTION

Diabetic Peripheral Neuropathy (DPN) is the most common microvascular complication of diabetes mellitus and a leading cause of foot ulceration, amputation, and disability worldwide^{1,3}. Global projections estimate that approximately 783 million adults will be living with diabetes by 2045, over 90% of whom will have Type 2 Diabetes Mellitus (T2DM), making the burden of its complications, including DPN, a growing public health concern^{4,6}. Indian population-based studies report a wide range of DPN prevalence, from roughly 9% to 78% depending on the region, the diagnostic tool used, and the population studied, with several large cohorts reporting rates between 18% and 45%^{7,9}. This variability partly reflects differences in the screening method: clinical criteria alone tend to underestimate the true burden of neuropathy compared with electrophysiological testing, and under-recognition of DPN in routine practice is well documented¹⁰. Nerve Conduction Study (NCS) is widely regarded as the electrodiagnostic reference standard for DPN, as it objectively measures the amplitude, latency, and velocity of motor and sensory nerve conduction, and can detect subclinical nerve dysfunction before symptoms or clinical signs appear^{11,13}. However, NCS requires specialized equipment and trained personnel,

and is not universally available at the primary or secondary care level, particularly in semi-urban and rural India^{7,9}.

Bedside clinical tests-vibration perception using a 128 Hz tuning fork, the Semmes-Weinstein monofilament test, and assessment of ankle reflexes-are therefore commonly used as first-line screening tools because they are inexpensive, quick, and require no specialized equipment^{7,9}. Previous comparative studies have reported that the sensitivity of clinical neurological examination for detecting electrophysiologically confirmed neuropathy is often considerably lower than its specificity-for example, one study reported a sensitivity of only 40% against 100% specificity for neurological examination, while another Indian study comparing vibration testing with NCS reported high sensitivity for vibration testing but poor specificity, and near-perfect specificity but low sensitivity for NCV^{15,16}.

This suggests the two approaches may be complementary rather than interchangeable, and that reliance on clinical examination alone risks missing a substantial proportion of patients with electrophysiologically confirmed neuropathy^{15,16}.

A related dissertation from this region-a prospective study correlating glycaemic variability, HbA1c, and NCS in 93 patients with T2DM at a

tertiary centre in Kolhapur, Maharashtra- similarly used NCS as an objective marker of diabetic neuropathy and highlighted its value in characterizing nerve dysfunction independent of symptom reporting, underscoring the relevance of electrophysiological assessment in this population¹⁷.

Given the practical importance of choosing appropriate screening strategies in settings where NCS access is limited, this pilot study was undertaken to directly compare bedside clinical methods against NCS in patients with T2DM attending a tertiary care centre in Western Maharashtra, with the aim of informing the design of a larger, adequately powered comparative study¹⁷.

Aim and Objectives

Aim: To detect diabetic neuropathy in patients with type 2 diabetes mellitus using bedside clinical methods and nerve conduction study, and to compare the two approaches.

Objectives:

- To assess diabetic neuropathy using bedside clinical methods — vibration perception (tuning fork test), Semmes-Weinstein monofilament test, and ankle reflex — in patients with T2DM.
- To assess diabetic neuropathy using nerve conduction study (motor and sensory conduction) in the same patients.
- To compare the diagnostic yield and concordance of clinical methods against nerve conduction study.
- To examine the relationship between duration of diabetes, glycaemic control (HbA1c), and the presence of neuropathy on nerve conduction study.

MATERIALS AND METHODS

Study Design and Setting

This was a descriptive, cross-sectional pilot study conducted in the Department of Neuro-Physiotherapy in collaboration with the Department of Medicine, [Vikhe Patil Medical College & Hospital, Ahilyanagar, Maharashtra, India — confirm exact institutional

name], following institutional ethics committee approval [approval number to be inserted]. This pilot study, comprising 14 patients, was undertaken to test the study protocol and generate preliminary data ahead of a larger, adequately powered comparative study.

Study Population

Fourteen patients with a confirmed diagnosis of type 2 diabetes mellitus, attending the outpatient/inpatient services of the department during the study period, were enrolled after written informed consent.

Inclusion Criteria

Patients of either sex, diagnosed with T2DM, willing to give written informed consent and undergo both clinical examination and nerve conduction study.

Exclusion Criteria

Peripheral neuropathy attributable to causes other than T2DM (e.g., chronic alcohol use, vitamin B12 deficiency, severe renal impairment, HIV infection, post-herpetic neuralgia, Guillain-Barré syndrome), and patients unwilling to provide consent.

Clinical Examination

A structured history and general and neurological examination were recorded for each patient. Neuropathy screening comprised: (i) vibration perception using a 128 Hz tuning fork applied over the bony prominence of the great toe/malleolus; (ii) touch/pressure sensation using a 10 g Semmes-Weinstein monofilament applied at standard plantar sites; and (iii) deep tendon (ankle) reflex assessment. Each modality was graded as normal or reduced/absent.

Nerve Conduction Study

NCS was performed using a standard electrodiagnostic (EMG/NCS) machine, recording motor distal latency, amplitude, and conduction velocity, and sensory latency, amplitude, and conduction velocity for a representative peripheral nerve (peroneal, ulnar, median, or radial, as clinically indicated) in each patient. Findings were classified as normal, axonal, demyelinating, or mixed

(axonal and demyelinating) pattern of neuropathy based on standard electrodiagnostic criteria.



Figure 1. Nerve Conduction Velocity Study.

Other Assessments

Anthropometric measurements (BMI), blood pressure, fasting and postprandial blood glucose, HbA1c, lipid profile, renal and liver function tests, and screening for diabetic retinopathy, nephropathy, and peripheral vascular disease were recorded as part of the standard workup.

Statistical Analysis

Given the small sample size ($n=14$), data were summarized descriptively as mean $\pm$ standard deviation for continuous variables and as frequency (percentage) for categorical variables. Clinical examination findings were compared against NCS (used as the reference standard) to derive sensitivity, specificity, and overall concordance. No formal inferential hypothesis testing was performed because the sample size was insufficient to yield statistically reliable p -values; findings are presented as descriptive/exploratory and hypothesis-generating.

RESULTS

A total of 14 patients with T2DM were included in this pilot study (Table 1). The mean age was 52.1 ± 15.4 years (range 30–75), and males predominated (64.3%). The mean duration of diabetes was 9.1 ± 4.7 years,

and mean HbA1c was $9.3 \pm 1.9\%$, indicating overall suboptimal glycaemic control across the cohort, although HbA1c ranged widely from 5.33% to 11.98%, reflecting heterogeneity in glycaemic control.

Table 1. Baseline demographic and clinical characteristics ($n=14$).

Parameter	Value
Age (years), mean $\pm$ SD (range)	52.1 ± 15.4 (30–75)
Sex, n (%) — Male / Female	9 (64.3%) / 5 (35.7%)
Duration of diabetes (years), mean $\pm$ SD (range)	9.1 ± 4.7 (2–16)
HbA1c (%), mean $\pm$ SD	9.3 ± 1.9
Fasting blood glucose (mg/dL), mean $\pm$ SD	139.2 ± 36.5
Postprandial blood glucose (mg/dL), mean $\pm$ SD	207.9 ± 73.9
BMI (kg/m^2), mean $\pm$ SD	20.8 ± 1.6

On nerve conduction study, 11 of the 14 patients (78.6%) had an abnormal pattern: mixed axonal-demyelinating in 5 (35.7%), axonal in 4 (28.6%), and demyelinating in 2 (14.3%). Three patients (21.4%) had entirely normal nerve conduction (Table 2).

Table 2. Distribution of nerve conduction study findings ($n=14$).

NCS Pattern	Number of Patients	Percentage
Normal	3	21.4%
Axonal	4	28.6%
Demyelinating	2	14.3%
Mixed (axonal + demyelinating)	5	35.7%
Total abnormal NCS	11	78.6%

On bedside clinical examination, findings were again less frequently abnormal than on NCS, though the gap narrowed somewhat with the larger sample. Vibration perception was reduced in 5 patients (35.7%), ankle reflex was reduced in 4 patients (28.6%), and the monofilament test was abnormal in 2 patients (14.3%). Overall, a composite clinical abnormality (any one test positive) was found in 5 of 14 patients (35.7%) (Table 3).

Table 3. Findings on individual bedside clinical tests (n=14).

Clinical Test	Abnormal, n (%)	Normal, n (%)
Vibration perception (tuning fork)	5 (35.7%)	9 (64.3%)
Monofilament test	2 (14.3%)	12 (85.7%)
Ankle reflex	4 (28.6%)	10 (71.4%)
Any clinical test abnormal (composite)	5 (35.7%)	9 (64.3%)

When clinical examination was compared against NCS as the reference standard, clinical examination correctly identified 5 of the 11 NCS-abnormal patients (true positives) and missed 6 (false negatives); it correctly classified all 3 NCS-normal patients as normal (true negatives), with no false positives (Table 4). This yielded a sensitivity of 45.5%, a specificity of 100.0%, and an overall concordance of 57.1% between clinical examination and NCS (Table 5).

Table 4. Clinical examination findings cross-tabulated against NCS.

	NCS abnormal (n=11)	NCS normal (n=3)	Total
Clinical exam abnormal	5 (True positive)	0 (False positive)	5
Clinical exam normal	6 (False negative)	3 (True negative)	9

Table 5. Diagnostic performance of composite clinical examination versus NCS (reference standard).

Diagnostic parameter	Value
Sensitivity	45.5% (5/11)
Specificity	100.0% (3/3)
Overall concordance/accuracy	57.1% (8/14)

Abnormal NCS was present in 5 of 6 patients (83.3%) with diabetes duration ≥ 10 years, compared with 6 of 8 patients (75.0%) with shorter duration — a modest difference that, unlike in the initial smaller cohort, did not show a clean cut-off effect, suggesting duration alone is an imperfect predictor of electrophysiological neuropathy in this population. Sensory conduction data could not be obtained for one patient (sensory

testing was not performed for this patient) and this case was analysed using motor conduction findings alone.

DISCUSSION

This pilot study found a persistent gap between the detection of diabetic neuropathy by bedside clinical methods and by Nerve Conduction Study: while NCS identified abnormal nerve conduction in nearly 4 of every 5 patients, routine clinical examination flagged only about 1 in 3. This translated into a low sensitivity (45.5%) but perfect These findings are consistent with the broader literature on this topic. A study evaluating the validity of neurological examination for diagnosing DPN reported a similarly low sensitivity of 40% alongside 100% specificity, and concluded that a combination of clinical signs and electrophysiology, as recommended by the American Academy of Neurology, offers the most accurate diagnosis specificity (100%) for clinical examination against NCS as the reference standard in this small sample¹⁵. These findings are consistent with the broader literature on this topic. A study evaluating the validity of neurological examination for diagnosing DPN reported a similarly low sensitivity of 40% alongside 100% specificity, and concluded that a combination of clinical signs and electrophysiology, as recommended by the American Academy of Neurology, offers the most accurate diagnosis¹⁵. Another Indian study comparing vibratory quantitative sensory testing with NCS in Kolkata found that vibration testing had relatively higher sensitivity but poor specificity, whereas NCV showed the opposite pattern — near-complete specificity but low sensitivity — leading the authors to conclude that these modalities are complementary rather than interchangeable³. Our results, in which vibration perception was the only clinical test to detect any abnormality while the monofilament test was normal in every patient despite predominantly abnormal NCS, echo this pattern of clinical under-detection¹⁵.

The consistently high specificity of clinical examination across studies, including ours, suggests that a positive bedside finding is a reliable indicator of true neuropathy^{1,3}. However, the low sensitivity means a

normal bedside examination cannot be used to rule out neuropathy, particularly in its early or subclinical stages — a concern given that NCS is known to detect nerve dysfunction before clinical signs or symptoms emerge⁴. This has direct practical implications for physiotherapy and primary-care screening programmes that rely solely on bedside testing: a substantial proportion of patients with electrophysiologically confirmed neuropathy may be missed and denied timely intervention such as foot-care education, gait and balance training, or referral for further evaluation^{2,4}.

The modest trend toward more frequent abnormal NCS in patients with longer diabetes duration (≥ 10 years) is broadly consistent with established knowledge that neuropathy risk rises with disease duration and cumulative glycaemic exposure, and with a related dissertation from this region that examined nerve conduction alongside glycaemic variability and HbA1c in a larger cohort of patients with T2DM — although in our expanded cohort this relationship was no longer clear-cut, with abnormal NCS also common among patients with shorter disease duration, underscoring that duration is only one of several contributors to nerve dysfunction^{15, 7}. Given that Indian prevalence estimates for DPN vary widely (roughly 9–78%) depending partly on the diagnostic method used, our findings reinforce the argument that studies and screening programmes should be explicit about which diagnostic standard — clinical or electrophysiological — is being applied, since this choice materially affects reported prevalence^{6,7}.

This study has important limitations. Foremost, the sample size of 14 patients remains small; the resulting sensitivity, specificity, and concordance estimates carry wide confidence intervals and are presented as preliminary, hypothesis-generating findings rather than definitive diagnostic accuracy estimates¹. NCS was performed on a single representative nerve per patient rather than a standardized multi-nerve protocol, which may under- or overestimate the true burden of neuropathy in individual patients¹. The cross-sectional, single-centre design limits generalizability, and formal inter-rater reliability of clinical examination was not assessed¹. These limitations should be addressed in a larger, adequately powered, multi-nerve, multi-centre

comparative study, which this pilot was designed to inform.

CONCLUSION

In this pilot study of 14 patients with type 2 diabetes mellitus, bedside clinical methods substantially under-detected diabetic neuropathy compared with nerve conduction study, demonstrating moderate sensitivity but high specificity¹. These preliminary findings indicate that clinical examination alone may not be adequate to exclude diabetic neuropathy and support the wider use of nerve conduction study or other more sensitive screening tools where feasible¹. A larger, adequately powered comparative study is warranted to confirm these observations and refine screening recommendations for diabetic neuropathy in Western Maharashtra¹.

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Conflict of Interest

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

Community Awareness, Knowledge, and Perceptions Regarding the Role of Physiotherapy in Spinal Cord Injury Rehabilitation: A Cross-sectional Study

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Abstract

Background: Spinal cord injury can cause severe physical and psychological impairments. Physiotherapy is essential for promoting functional recovery, preventing complications, and improving independence and quality of life. This study aims to assess community awareness of the role of physiotherapy in spinal cord injury rehabilitation. **Methodology:** A cross-sectional study was conducted in a community setting at Dr. Vitthalrao Vikhe Patil Memorial Hospital. Using purposive sampling, 100 participants from the general population were recruited. A self-developed SCI awareness questionnaire was administered to assess awareness of the role of physiotherapy in SCI. The study included willing male and female participants aged 18–60 years. **Result:** Baseline assessment revealed that only 44% of participants were aware about the role of physiotherapy in Spinal cord injury. Following the awareness session, 35.6% participants were aware and known about spinal cord injury. Awareness of physiotherapy treatment was higher, with 57.4% of participants acknowledging its role in rehabilitation. However, only 32.8% demonstrated adequate knowledge about spinal cord injury. **Conclusion:** The study concludes that while more than half of the participants were aware of physiotherapy treatment, but overall knowledge about spinal cord injury remained low. The results indicate the need for structured health education and community-based awareness programs to improve understanding and promote early rehabilitation measures.

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INTRODUCTION

Spinal Cord Injury (SCI) is a devastating neurological condition most commonly caused by a traumatic force damaging the spinal cord and resulting in paralysis. This loss of function and reduced mobility poses a serious risk to the health of people with SCI. The sudden and significant changes brought about by SCI therefore also present an individual with significant challenges to their well-being^{1,2}. People with SCI have higher comparative risks of feeling helpless, poor quality of life and decreased life satisfaction³. Psychological Well-Being (PWB) on the other hand, refers to psychological growth and development. Furthermore, in terms of PWB, those with SCI report a loss of purpose in life and increased social isolation and exclusion^{5,6}.

Formal rehabilitation in an SCI center is the first move towards restoring the health and well-being of a patient with SCI. The role of rehabilitation goes beyond promoting functional independence and aims to return individuals to “the life they want as far as their disability will allow”⁷. Thus, a vital part of rehabilitation is to educate people how to take care of a dramatically altered body and teach people to live independently and maintain their health and well-being^{8,9}. This includes improving muscle weakness and poor posture, as well as teaching patient essential skills of daily living (ADL), such as floor to chair transfers⁷⁻⁹. To continue to improve and maintain health and well-being upon discharge from rehabilitation to the community, and avoid the onset of secondary health conditions, it is vital people lead a physically active lifestyle.

Community awareness is a critical determinant of early referral, adherence to rehabilitation programs, and long-term outcomes in individuals with SCI. Gender-based differences in health awareness, access to healthcare services, and utilisation of rehabilitation facilities may further influence perceptions and understanding of physiotherapy interventions. Comparing awareness levels between males and females provides valuable insight into existing disparities and helps in designing targeted educational and community-based rehabilitation strategies.

Globally, awareness of physiotherapy in SCI management varies considerably across countries. High-income countries with structured rehabilitation systems and strong public health education programs report better awareness and utilization of physiotherapy services. In contrast, low- and middle-income countries often face challenges such as limited resources, lack of trained professionals, and inadequate community education, resulting in reduced awareness and delayed rehabilitation. Understanding these international differences highlights the need for culturally appropriate awareness programs and policy-driven initiatives.

Health-care professionals play a crucial role in improving quality of life and functional independence among individuals with disabling conditions. Physiotherapy is an integral component of the multidisciplinary health-care team and contributes significantly to prevention, treatment, and rehabilitation across various health conditions. In individuals with Spinal Cord Injury (SCI), physiotherapy plays a vital role in optimising residual function, preventing secondary complications, and promoting community reintegration. Early and continued physiotherapy intervention has been shown to improve physical function, reduce hospital stay, and enhance quality of life in individuals with SCI¹².

Despite the well-established benefits, awareness regarding the role of physiotherapy in SCI management remains limited among community dwellers. Lack of awareness may influence health-seeking behavior, delayed referral, and underutilisation of physiotherapy services. Studies in India have reported low-to-moderate awareness of physiotherapy as a health profession, with misconceptions regarding its scope and identity. Therefore, assessing community awareness about the role of physiotherapy in SCI is essential for improving patient condition, promoting early rehabilitation, and strengthening public health outcomes.

MATERIAL AND METHODOLOGY

A descriptive cross-sectional study was conducted in a community setting at Dr. Vitthalrao Vikhe Patil

Memorial Hospital to assess awareness regarding the role of physiotherapy in Spinal Cord Injury (SCI) and to compare awareness levels between male and female participants. Ethical approval was obtained from the Institutional Ethics Committee before the commencement of the study.



A sample of 100 participants was selected from the general population using purposive sampling. Data were collected using a structured and pre-validated SCI awareness questionnaire comprising sections on demographic characteristics and awareness of physiotherapy in SCI rehabilitation. The questionnaire evaluated participants' knowledge regarding rehabilitation goals, preventive strategies, physiotherapy interventions, and anticipated functional outcomes following SCI.



Following the provision of study-related information, written informed consent was obtained from all participants. The questionnaire was administered either through face-to-face interviews or as a self-administered instrument, depending on the participant's preference and literacy level. Confidentiality and privacy were maintained throughout the data-collection process.

RESULT

Table 1. Demographic data of participants

Variable	Category	Frequency (n)	Percentage (%)	Mean
Age (Years)	18-30	36	36.36	-
	30-45	33	33.32	-
	45-60	31	31.32	37.29
Gender	Male	56	56.32	-
	Female	44	44.68	1.45

The demographic details of the study participants revealed that the majority belonged to the age group of 18-30 years (36%), followed by 30-45 years (32%) and 45-60 years (31%). In terms of gender distribution, 52% of the participants were male, while 48% were female, indicating nearly equal participation from both genders. Regarding literacy status, a significant proportion of the participants were literate (92%), whereas only 8% were illiterate.

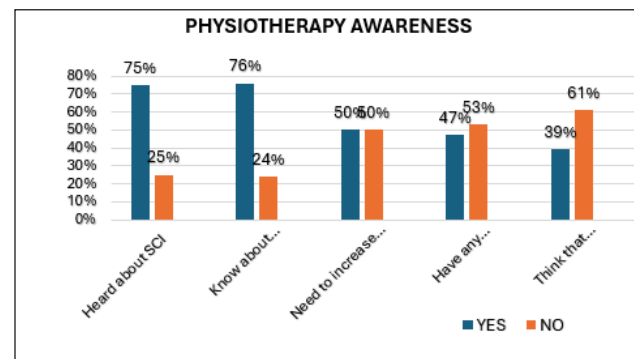


Figure 1. Shows physiotherapy awareness in people.

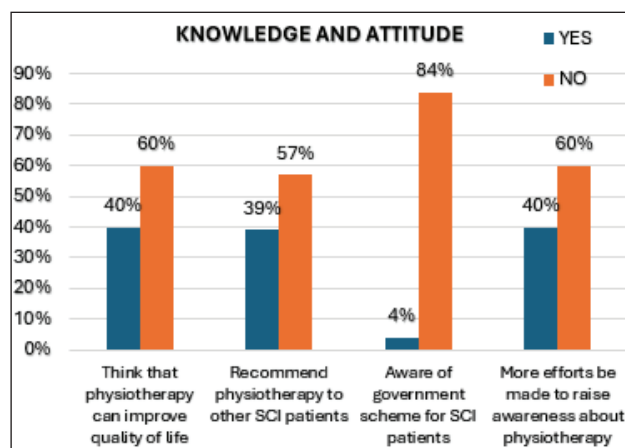


Figure 2. Shows level of knowledge and attitude about SCI.

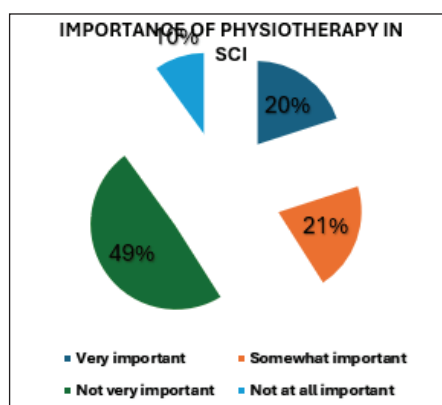


Figure 3. Shows how importance of physiotherapy.

Among the participants, 39% had heard about Spinal Cord Injury (SCI), while 61% had not. Only 37% had knowledge about SCI and 31% were aware of the physical changes associated with it, showing limited awareness overall. When asked about treatment options, 32% of participants mentioned physiotherapy as the main approach. A few participants suggested acupuncture (6%), ayurveda (1%), and medicine or neurological care. The study results show that 75% of participants had heard about Spinal Cord Injury (SCI), and 76% were aware of physiotherapy treatment, indicating a good level of basic awareness. However, 50% felt there is still a need to increase awareness about physiotherapy. Regarding knowledge and attitude, 49% of participants considered physiotherapy “somewhat important” in SCI, while only 20% found it “very

important”. 40% participant think that physiotherapy can help in improving quality of life of patients while 84% are unaware of government schemes for SCI patients.

Overall Result

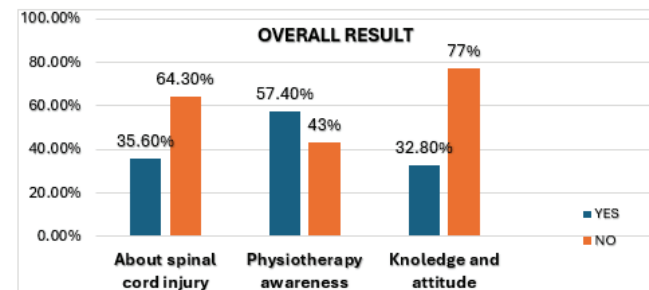


Figure 4. Shows combined result according to section.

The overall result of the study showed that only 35.6% of participants had knowledge about spinal cord injury, indicating limited understanding of the condition. Awareness regarding physiotherapy was comparatively higher at 57.4%, suggesting better recognition of its role in management. However, knowledge and attitude toward spinal cord injury and rehabilitation were still low at 32.8%. These findings highlight the need for greater educational initiatives to enhance awareness and understanding among the community.

DISCUSSION

The present cross-sectional study assessed community knowledge and awareness regarding Spinal Cord Injury (SCI) and the role of physiotherapy in its management. Although participants demonstrated relatively greater awareness of physiotherapy as a treatment modality, detailed knowledge of SCI was limited, with only 35.6% demonstrating adequate understanding. This finding indicates a discrepancy between general awareness of physiotherapy and comprehensive knowledge of SCI, its consequences, and the importance of rehabilitation. The observed knowledge gap may contribute to delayed referral, inappropriate beliefs regarding recovery, and increased dependence among individuals with SCI.

These findings are consistent with previous research reporting inadequate public awareness of neurological conditions and rehabilitation services. A review of studies from countries with varying Human Development Index (HDI) levels found that research on awareness and utilization of physiotherapy services was more frequently conducted in very-high-HDI countries. However, awareness of the scope of physiotherapy among the general public, students, and patients remained suboptimal across countries, irrespective of HDI status¹.

In a study conducted in Kansas City, United States, 54% of participants were aware of the scope of physiotherapy. Awareness was highest regarding musculoskeletal conditions (90%) and lowest regarding integumentary conditions (18%). Similarly, in Japan, 58% of 623 urban high-school students demonstrated awareness of physiotherapy. Comparisons among very-high-HDI countries indicated that awareness was highest in Japan, followed by the United States, the United Kingdom, and Australia¹. However, these findings should be interpreted cautiously because the studies included predominantly urban participants and may not fully represent the general population.

Evidence from India and other developing countries further demonstrates the influence of educational status and access to healthcare services on physiotherapy awareness. A study conducted among the general public in major cities of Gujarat reported a high level of awareness, which may be attributed to the relatively higher educational attainment of the participants, most of whom had completed post-secondary education. Similar findings were reported by Olawale and Adjabeng among an urban community in Accra, Ghana, where awareness of physiotherapy was also high¹³.

In contrast, Patel reported low awareness of physiotherapy among rural high-school students in Anand¹⁴. Likewise, Mbada *et al.*, observed that only 16.8% of rural community members in Nigeria were aware of physiotherapy, with most participants having less than a secondary-level education¹⁵. These findings suggest that educational attainment, urban or rural

residence, and previous exposure to physiotherapy services may be important determinants of awareness regarding the scope and applications of physiotherapy. Comparable results were reported by Kacie and Yvonne, who found that participants with higher levels of education possessed greater knowledge of physiotherapy¹¹.

Overall, the findings highlight the need for structured health-education initiatives, community-based awareness programmes, and improved dissemination of information regarding SCI rehabilitation. Integrating physiotherapy-related education into primary healthcare services may promote early recognition and referral, facilitate timely rehabilitation, improve functional outcomes, and reduce the long-term disability burden associated with SCI.

Clinical Implications

The results suggest that awareness programmes should be designed according to the educational background and needs of the target population. These programmes may include health-education sessions, printed materials in the local language, village-level screening and referral activities, caregiver-training programmes, and collaboration with community health workers. Such initiatives may improve recognition of SCI-related problems and encourage individuals and families to seek physiotherapy at an earlier stage.

Strengths and Limitations

The study provides relevant information regarding community awareness of SCI and the role of physiotherapy, and it includes participants from both sexes. However, the use of purposive sampling and recruitment from a single setting may limit the generalizability of the findings. In addition, the cross-sectional design prevents the establishment of a cause-and-effect relationship between demographic characteristics and awareness levels. Since the questionnaire assessed self-reported knowledge, responses may also have been influenced by recall or social-desirability bias.

CONCLUSION

In conclusion, community awareness regarding the role of physiotherapy in spinal cord injury was variable, with significant gaps in overall knowledge. Males demonstrated higher awareness than females, while literacy was strongly associated with awareness. These findings highlight the need for targeted community-based education and awareness programs to promote early referral, rehabilitation participation, and improved quality of life among individuals with SCI. Further large-scale studies are recommended to support effective public health strategies.

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ORIGINAL ARTICLE

Physical Fitness Profile among Physiotherapy Students across Academic Years -A Cross-sectional study

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Abstract

Background: This study aimed to assess the physical fitness of undergraduate physiotherapy students using standardised physical fitness tests. **Methods:** A cross-sectional study was conducted among 150 physiotherapy students aged 18–25 years. Physical fitness was assessed using Body Mass Index (BMI), Sit-and-Reach Test, Back Scratch Test, Harvard Step Test, and Sit-up Test. **Results:** Most participants (61.3%) had normal BMI. In the Sit-and-Reach Test, 73.7% of males and 85.3% of females demonstrated excellent to super flexibility. In the Back Scratch Test, 89.5% of males and 89.3% of females demonstrated excellent upper limb flexibility. In the Harvard Step Test, 47.4% of males and 47.3% of females demonstrated average to excellent endurance. In the Sit-up Test, 84.2% of males and 44.3% of females demonstrated average to excellent abdominal endurance. **Conclusion:** Most participants had normal BMI and good flexibility, while cardiovascular and abdominal endurance differed between males and females.

INTRODUCTION

Physical fitness is a fundamental indicator of health and functional capacity, defined as the ability to perform daily activities efficiently without undue fatigue while maintaining sufficient energy for leisure and unforeseen

physical demands. It encompasses health-related components including cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition, all of which contribute to optimal physical performance and overall well-being^{1,2}. Regular physical activity is closely associated with improved

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physical fitness and plays a vital role in preventing non-communicable diseases, enhancing mental health, and improving quality of life^{6,7,10,11}. Recent evidence also emphasises that maintaining adequate physical fitness during early adulthood contributes to long-term health and reduces the future burden of chronic diseases⁴.

University students represent a population vulnerable to declining physical activity because of academic workload, prolonged screen exposure, and sedentary lifestyles. Consequently, many students fail to achieve recommended levels of physical activity, resulting in reduced physical fitness and increased health risks^{1,8,15,23}. Physiotherapy students constitute a unique subgroup within the university population because their curriculum and future profession require a higher level of physical fitness. Clinical responsibilities such as patient handling, transfer techniques, exercise demonstration, prolonged standing, and repetitive therapeutic activities demand adequate flexibility, muscular endurance, and cardiovascular fitness^{12,17,31}. Inadequate physical fitness may compromise clinical efficiency and increase the risk of work-related musculoskeletal disorders^{2,31,32}. Furthermore, physiotherapists are expected to promote healthy lifestyles and physical activity among patients; therefore, maintaining their own fitness is essential for professional credibility and effective patient counselling^{16,18}.

Previous studies have reported variable levels of physical fitness among university and physiotherapy students across different populations. A systematic review by Kljajevic *et al.* highlighted considerable variation in physical fitness among university students and emphasized the influence of educational systems, lifestyle, and cultural factors on fitness outcomes¹⁵. Similarly, Multani *et al.*, in a study conducted among physiotherapy students from Punjab and Haryana, reported differences in fitness components across academic years, indicating the need for regular assessment using standardized fitness measures¹³. Despite these findings, limited Indian studies have comprehensively evaluated multiple components of physical fitness, including body composition, flexibility, cardiovascular endurance, and muscular endurance,

using standardized field-based assessments among undergraduate physiotherapy students.

Therefore, the present study was undertaken to assess the physical fitness of undergraduate physiotherapy students using standardized physical fitness tests. The findings are expected to provide baseline information regarding their fitness profile and may assist in developing targeted strategies to promote physical fitness and overall well-being among future physiotherapists.

MATERIALS AND METHODS

Study Design and Participants

A cross-sectional study was conducted among undergraduate physiotherapy students at DVVPPF's College of Physiotherapy, Ahilyanagar, Maharashtra, India, over a period of six months after obtaining approval from the Institutional Ethics Committee. Undergraduate physiotherapy students aged 18–25 years were recruited using a convenience sampling technique. Participation was voluntary, and written informed consent was obtained from all participants before data collection.

Students aged 18–25 years who were willing to participate were included in the study. Students with recent fractures, musculoskeletal injuries, or any condition restricting physical activity, those diagnosed with cardiovascular, severe respiratory, or neurological disorders affecting physical activity, postgraduate physiotherapy students, interns, faculty members, and students absent during the data collection period were excluded.

Outcome Measures

Physical fitness was assessed using standardised field-based fitness tests. Body Mass Index (BMI) was calculated using height and weight measurements. Lower limb flexibility was assessed using the Sit-and-Reach Test, upper limb flexibility using the Back Scratch Test, cardiovascular endurance using the Harvard Step Test, and abdominal muscular endurance using the One-Minute Sit-up Test. Performance in each test was

interpreted according to standardised age- and sex-specific normative values.

Procedure

After obtaining informed consent, demographic information including age, gender, height, weight, Body Mass Index (BMI), limb dominance, blood pressure, and resting heart rate was recorded. All assessments were performed under the supervision of the investigator in the same testing environment. Participants were instructed regarding the procedure of each test, and adequate rest was provided between tests to minimize fatigue.

Sit-and-Reach Test

Lower limb flexibility was assessed using a Wells and Dillon Sit-and-Reach Box. Participants removed their footwear and sat on the floor with both knees fully extended and the soles of the feet placed firmly against the testing box. With both hands placed one over the other and palms facing downward, participants slowly reached forward along the measuring scale without jerky movements and maintained the final position for two seconds. Two trials were performed, and the best score recorded in centimetres was considered for analysis.

Back Scratch Test

Upper limb flexibility was assessed using the Back Scratch Test. Participants performed the test in standing by placing one hand over the shoulder and the opposite hand behind the back, attempting to touch or overlap the middle fingers. The distance between the fingertips was measured using a flexible measuring tape. Two trials were performed on the preferred side, and the best score recorded in centimetres was used for analysis.

Harvard Step Test

Cardiovascular endurance was assessed using the Harvard Step Test. Participants stepped up and down on a standard step bench in an up-up-down-down sequence at a cadence of 24 beats per minute guided

by a metronome for 3 minutes. Immediately after completion of the test, participants were seated, and recovery heart rate was recorded for one minute beginning five seconds after completion. Performance was interpreted using standardized age- and sex-specific normative values.

One-Minute Sit-up Test

Abdominal muscular endurance was assessed using the One-Minute Sit-up Test. Participants lay in the crook-lying position with the knees flexed to approximately 90° and feet stabilised by an assistant. With the arms extended forward, participants performed the maximum number of correctly executed sit-ups within one minute. Only correctly performed repetitions were recorded for analysis.

RESULT

A total of 150 undergraduate physiotherapy students were included in the study. All participants completed the physical fitness assessment and were included in the final analysis. The descriptive statistics of the study variables are presented in Table 1. The mean±standard deviation values were 21.29±4.04 kg/m² for BMI, 21.21±6.57 cm for the Sit-and-Reach Test, 0.36±0.98 cm for the Back Scratch Test, 112.40±20.74 beats/min for the Harvard Step Test, and 17.27±6.52 repetitions for the One-Minute Sit-up Test.

Table 1. Mean and standard deviation of physical fitness variable among physiotherapy students.

Discriptive Statistics		
Variables	Mean	SD
BMI	21.2896	4.044455461
Sit and Reach	21.21466667	6.574930899
Back Scratch Test	0.36	0.978150563
Step Test	112.4	20.740972
Sit-up Test	17.26666667	6.518601846

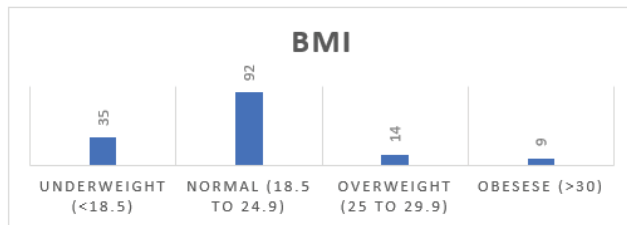
Body Mass Index (BMI) categories of the participants are presented in Table 2. The majority of participants (61.3%) had a normal BMI, followed

by 23.3% who were underweight, 9.3% who were overweight, and 6.0% who were obese.

Table 2. Distribution of participants according to BMI

BMI Categories		
Category	Frequency	Percentage
Underweight (<18.5)	35	23.33333333
Normal (18.5 to 24.9)	92	61.33333333
Overweight (25 to 29.9)	14	9.33333333
Obesese (>30)	9	6

Graph 1. Distribution of participants according to BMI



Lower limb flexibility was assessed using the Sit-and-Reach Test. Among male participants, 73.7% demonstrated excellent to super flexibility, while 85.3% of female participants demonstrated excellent to super flexibility. Only 2.0% of female participants were classified as average, and no participants were categorized as fair, poor, or very poor (Table 3).

Table 3. Sit and Reach test score among male and female physiotherapy students

Sit and Reach Test – Men		
Category	Frequency	Percentage
Super (>+27)	1	0.666666667
Excellent (+17 to +27)	13	8.666666667
Good (+6to+16)	5	3.333333333
Average (0 to +5)	0	0
Fair (-8to-1)	0	0
Poor (-20to-9)	0	0
Very Poor (<-9)	0	0

Sit and Reach Test – Women		
Category	Frequency	Percentage
Super (>+30)	14	9.333333333
Excellent(+21to+30)	49	32.66666667
Good(+11to+20)	65	43.33333333
Average(+1to+10)	3	2
Fair(-7to0)	0	0
Poor(-15 to -8)	0	0
Very Poor(<-8)	0	0

Upper limb flexibility was assessed using the Back Scratch Test. The majority of participants demonstrated excellent upper limb flexibility. Among female participants, 81.7% demonstrated excellent flexibility, while 89.5% of male participants demonstrated excellent flexibility. Only 17.6% of female participants and 10.5% of male participants demonstrated very good flexibility, whereas no participant was classified as average or poor.

Table 4. Back Scratch test score among male and female physiotherapy students

Back Scratch Test Men (cm)		
Interpretation	Frequency	Percentage
Excellent (0cm)	17	11.33333333
Very Good (0to5)	2	2
Good (5to10)	0	0
Average (10to20)	0	0
Poor (>20)	0	0

Back Scratch Test Women (cm)		
Interpretation	Frequency	Percentage
Excellent (0cm)	107	71.33333333
Very Good (0to5)	23	15.33333333
Good (5to10)	1	0.666666667
Average (10to20)	0	0
Poor (>20)	0	0

Cardiovascular endurance was assessed using the Harvard Step Test. Among male participants, 47.4% demonstrated average to above-average cardiovascular endurance, while 31.6% were categorised as poor. Among female participants, 55.0% demonstrated average to excellent cardiovascular endurance, whereas 25.0% were classified as poor.

Table 5. Step test score among male and female physiotherapy students

Step Test Men (bpm)		
Category	19-25 Yrs	
Sex	Men	
	Frequency	Percentage
Excellent	0	0
Above Average	5	3.333333333
Average	4	2.666666667
Below Average	4	2.666666667
Poor	6	4

Step Test Women (bpm)		
Category	19-25 yrs	
Sex	Women	
	Frequency	Percentage
Excellent	14	9.333333333
Above Average	33	22
Average	26	17.33333333
Below Average	33	22
Poor	25	16.66666667

Abdominal muscular endurance was assessed using the One-Minute Sit-up Test. Among male participants, 84.2% demonstrated average to excellent muscular endurance, while 10.5% were classified as poor and 5.3% as very poor. Among female participants, 44.3% demonstrated average to excellent muscular endurance, whereas 21.4% were classified as below average, 6.9% as poor, and 33.6% as very poor

Table 6. Sit-Up test score among male and female physiotherapy students

Sit – Up Test (Men)		
Interpretation	Frequency	Percentage
Excellent	10	6.666666667
Good	2	1.333333333
Above Average	2	1.333333333
Average	2	1.333333333
Below Average	0	0
Poor	2	1.333333333
Very Poor	1	0.666666667

Sit – Up Test (Women)		
Interpretation	Frequency	Percentage
Excellent	10	6.666666667
Good	8	5.333333333
Above Average	11	7.333333333
Average	30	20
Below Average	19	12.66666667
Poor	9	6
Very Poor	44	29.33333333

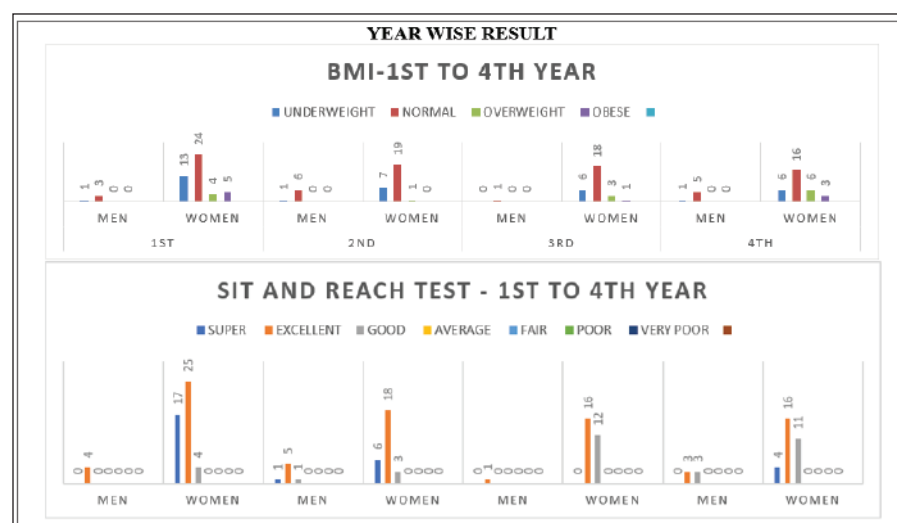


Figure 2. Distribution of BMI and sit and reach according to year and gender.

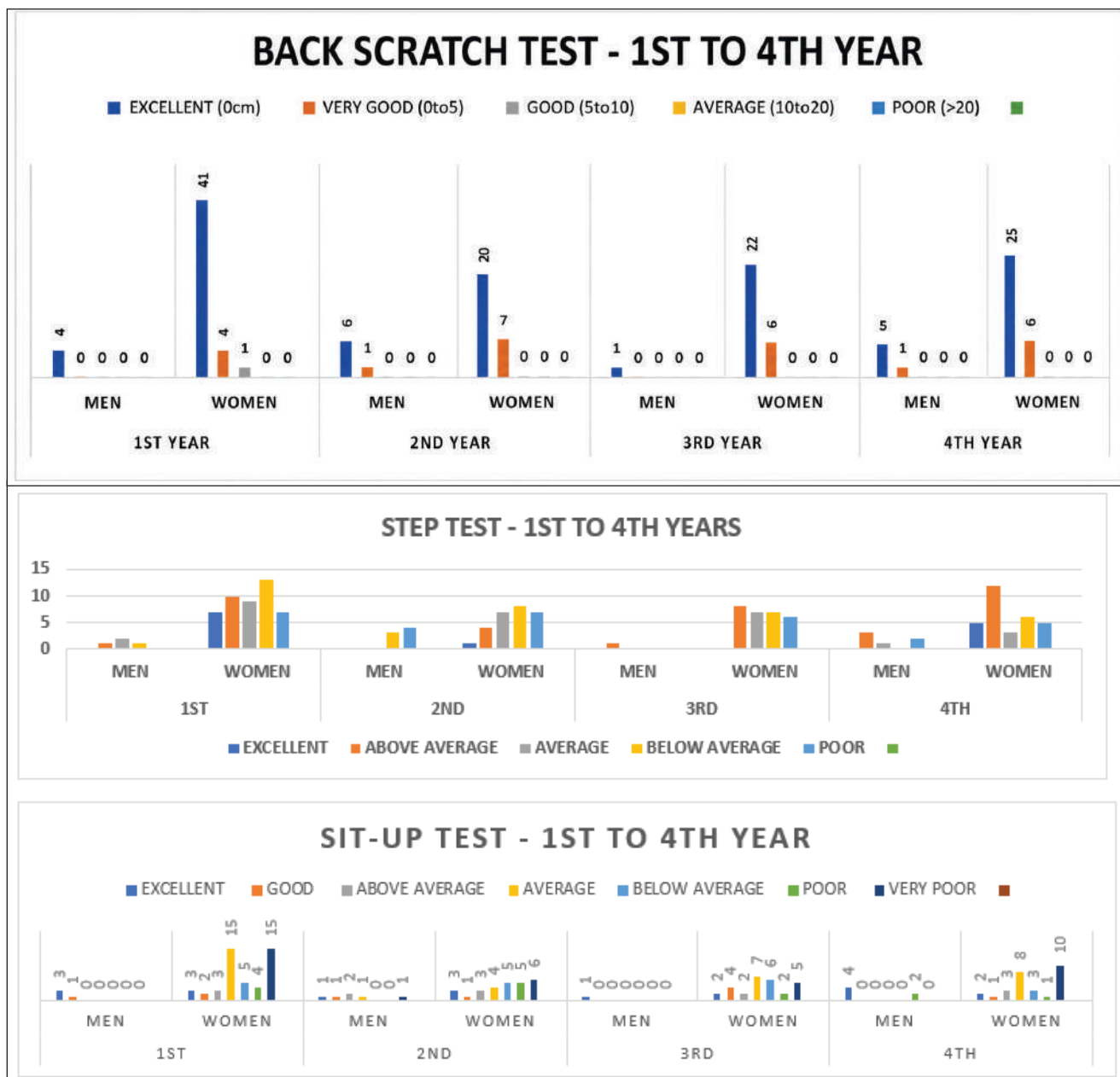


Figure 3. Distribution of back scratch test, step test and sit up test according to year and gender.

DISCUSSION

The present cross-sectional study assessed multiple components of physical fitness among undergraduate physiotherapy students using standardized field-based measures of body composition, flexibility, cardiovascular endurance, and abdominal muscular endurance. Overall, students demonstrated

generally satisfactory BMI and flexibility; however, cardiovascular and abdominal muscular endurance showed considerable variability, with notable sex-wise differences. These findings are relevant because physiotherapy practice involves patient handling, transfers, exercise demonstration, manual techniques, and prolonged standing, all of which require adequate physical capacity^{1,2}.

Most participants had a normal BMI (61.3%), while 23.3% were underweight, 9.3% were overweight, and 6.0% were obese. Although the predominance of normal BMI suggests a generally satisfactory body composition, the coexistence of underweight and excessive body weight reflects variation in the students' nutritional and health profiles. Similar variability has been reported among university students and may be influenced by lifestyle, physical activity, and academic demands¹⁵. Nevertheless, BMI should be interpreted cautiously because it does not differentiate between fat mass and lean muscle mass¹⁹.

Flexibility was the strongest component of fitness in the present sample. In the Sit-and-Reach Test, excellent to super flexibility was observed in 73.7% of males and 85.3% of females, with no participants classified in the fair, poor, or very poor categories. Similarly, 89.5% of males and 89.3% of females demonstrated excellent or very good upper-limb flexibility on the Back Scratch Test. These favourable findings are consistent with previous research among physiotherapy students, including students from Punjab and Haryana¹³. The movement-based nature of physiotherapy education, including exercise demonstration, positioning, and practical training, may contribute to the maintenance of functional flexibility. However, because of the cross-sectional design, a causal effect of physiotherapy training cannot be established.

Cardiovascular endurance was less consistent. On the Harvard Step Test, 47.4% of males demonstrated average to above-average performance, while 31.6% were classified as poor. Among females, 55.0% demonstrated average to excellent performance and 25.0% were classified as poor. The presence of suboptimal endurance in a considerable proportion of students is important because cardiorespiratory fitness is associated with long-term health and morbidity outcomes⁴. Reduced participation in aerobic exercise, prolonged sitting, screen-based academic work, and other sedentary behaviours may contribute to these findings^{23,27}. Although physiotherapy students may possess knowledge regarding exercise and health promotion, this knowledge may not consistently translate into regular personal physical activity^{15,17}.

Abdominal muscular endurance demonstrated a marked sex-wise difference. Average to excellent performance was observed in 84.2% of males compared with 44.3% of females, whereas very poor performance was observed in 33.6% of females and 5.3% of males. These differences may be related to variations in habitual physical activity, participation in strengthening exercise, or physiological factors; however, these variables were not measured and therefore cannot be considered established explanations. The findings indicate that abdominal and general strengthening activities may require particular attention within physiotherapy education.

The differences among fitness components suggest that satisfactory flexibility and body composition do not necessarily indicate adequate overall fitness. Correlation analysis involving BMI, flexibility, cardiovascular endurance, and muscular endurance may clarify whether these components are related within the present sample. Strong associations could support an integrated programme combining aerobic conditioning, resistance training, core strengthening, and flexibility exercises, whereas weak associations would favour individualized strategies targeting specific deficits. Future analyses should report correlation coefficients with confidence intervals and significance values while accounting for potential confounders such as age, sex, physical activity, sedentary behaviour, diet, sleep, and academic workload.

Year-wise differences should be interpreted cautiously because the cross-sectional design does not determine whether fitness changes with academic progression. Observed variation may instead reflect differences in lifestyle, academic workload, clinical exposure, and individual activity levels. Longitudinal studies are required to establish changes throughout physiotherapy education¹².

The findings have implications for both student health and future professional practice. Inadequate fitness may affect the performance of physically demanding clinical tasks and could contribute to work-related musculoskeletal problems^{2,31,32}. In addition, healthcare professionals' personal activity behaviours may influence their physical activity counselling

practices¹⁶. Regular fitness screening and structured programmes involving aerobic exercise, strengthening, flexibility training, and reduction of prolonged sedentary behaviour may therefore be beneficial. Systematic reviews also support the use of structured and supportive strategies to improve physical activity among university students^{26,9,30}.

This study's strengths include the assessment of several fitness domains, the use of standardized field-based procedures, and the inclusion of male and female participants. However, its single-institution setting, convenience sampling, cross-sectional design, lack of assessment of lifestyle and psychosocial factors, and reliance on BMI limit the generalisability and interpretation of the findings. Future multicentre and longitudinal studies should examine the influence of physical activity, nutrition, sleep, sedentary behaviour, academic workload, and psychological factors. Intervention studies should also determine whether fitness programmes improve clinical performance, patient-handling competence, professional efficacy, and work-related musculoskeletal health.

Overall, physiotherapy students in this sample demonstrated favourable flexibility and generally satisfactory BMI, but cardiovascular and abdominal muscular endurance were less consistent. These findings support the integration of regular fitness assessment, individualized exercise planning, and structured physical activity promotion into undergraduate physiotherapy education.

Strengths and Limitations

The present study has several strengths. The use of standardised, field-based fitness assessments allowed comprehensive evaluation of multiple fitness components, including body composition, flexibility, cardiovascular endurance, and muscular endurance, using validated measures. The inclusion of both male and female participants enabled sex-specific analysis of fitness parameters. The study was conducted in a controlled testing environment with standardized procedures, ensuring consistency in data collection.

However, the study has certain limitations. The study was conducted at a single institution using a

convenience sampling technique, which may limit the generalizability of the findings to other physiotherapy programmes or geographical regions. The cross-sectional design provides information regarding the current fitness status of participants but does not establish causal relationships or track changes in fitness over time. Additionally, factors that may influence physical fitness, such as physical activity level, dietary habits, sleep patterns, and academic workload, were not assessed in this study, limiting the ability to identify determinants of fitness outcomes. The use of BMI as the sole measure of body composition does not differentiate between fat mass and lean muscle mass, potentially misclassifying individuals with high muscle mass as overweight or obese.

Despite these limitations, the study used standardized physical fitness assessments and included a representative sample of undergraduate physiotherapy students, providing valuable baseline information regarding their physical fitness profile. The findings contribute to the understanding of physical fitness among future physiotherapists and highlight areas requiring improvement.

Recommendations for Future Research

Further multicentre studies with larger sample sizes are recommended to evaluate physical fitness among physiotherapy students from different geographical regions and educational settings. Longitudinal studies are needed to track changes in physical fitness throughout the academic programme and identify factors influencing fitness trajectories. Future research may also investigate factors such as physical activity level, sedentary behaviour, dietary habits, sleep quality, academic workload, and psychological factors to better understand their influence on different components of physical fitness. Additionally, intervention studies examining the effectiveness of structured exercise programmes, fitness education, and health promotion strategies in improving physical fitness among physiotherapy students are warranted. The relationship between physical fitness and clinical performance outcomes, including patient handling competence, work-related injury rates, and professional efficacy, merits further investigation to establish the clinical

relevance of maintaining optimal fitness among physiotherapists.

CONCLUSION

The present study achieved its objectives by assessing the physical fitness of undergraduate physiotherapy students using standardized fitness tests, including Body Mass Index, Sit-and-Reach Test, Back Scratch Test, Harvard Step Test, and One-Minute Sit-up Test. The findings revealed that the majority of participants had a normal Body Mass Index (61.3%) and demonstrated good upper and lower limb flexibility, with most participants achieving excellent to super flexibility scores. However, cardiovascular endurance and abdominal muscular endurance showed substantial variations between male and female students, with a considerable proportion of participants classified as below average or poor, indicating significant scope for improvement in these fitness components.

Among female participants, particularly concerning findings included 33.6% classified as very poor in abdominal muscular endurance and 25.0% classified as poor in cardiovascular endurance. Male participant's demonstrated better muscular endurance but showed 31.6% classified as poor in cardiovascular fitness. These findings highlight the need for targeted interventions to improve endurance components of physical fitness among physiotherapy students, especially considering the physical demands of their future clinical practice.

The presence of underweight (23.3%), overweight (9.3%), and obese (6.0%) participants further underscores the need for comprehensive health promotion strategies addressing both nutritional status and physical activity levels. Physiotherapy educators and curriculum developers should prioritize the integration of regular fitness assessment and structured exercise programmes within the educational framework to enhance overall fitness and functional capacity of physiotherapy students.

This study contributes to the existing body of knowledge by providing baseline data on the physical fitness profile of undergraduate physiotherapy students in Maharashtra, India, which may support future research and the development of fitness promotion

strategies within physiotherapy education. Regular assessment of physical fitness and implementation of evidence-based interventions may help enhance the overall health, well-being, and professional competence of future physiotherapists, ultimately benefiting both healthcare practitioners and the patients they serve. The findings emphasize that while physiotherapy students demonstrate satisfactory body composition and flexibility, deliberate efforts are required to improve cardiovascular and muscular endurance to ensure optimal clinical performance and long-term occupational health.

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CASE REPORT

Effects of Multimodal Exercise Program Combined with Inspiratory Muscle Training on Cardio-renal-muscle Axis and Clinical Outcomes in a Patient with Chronic Kidney Disease

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Abstract

Background: Chronic Kidney Disease (CKD) disrupts the cardio-renal-muscle axis, causing reduced functional capacity, muscle weakness, and poor quality of life. **Methods:** A 52-year-old male with Stage 3 CKD (eGFR 30-59 mL/min/1.73m²) underwent a 12-week multimodal exercise program with Inspiratory Muscle Training (IMT): aerobic training (40-60% target heart rate), resistance training (60-70% 1RM), box breathing, and IMT (30-60% MIP), thrice weekly, with outcomes assessed at baseline and post-intervention. **Results:** Following intervention, 6-MWD elevated from 320 to 405 m (+26.6%), Sit-to-Stand repetitions from 10 to 16 (+60.0%), MIP from 55 to 80 cm H₂O (+45.5%), hs-CRP fell from 7.8 to 3.9 mg/L (-50.0%), IL-6 from 10.5 to 5.8 pg/mL (-44.8%), eGFR elevated from 42 to 48 mL/min/1.73m² (+14.3%), serum creatinine (-14.29%) and KDQOL-36 from 50 to 72 (+44.0%). **Conclusion:** As a single-case design (n=1), results reflect clinical rather than statistical significance. Multimodal exercise combined with IMT safely improved cardio-renal-muscle axis function in Stage 3 CKD.

INTRODUCTION

Chronic Kidney Disease (CKD) is defined by persistent structural or functional kidney abnormalities lasting beyond three months¹. It affects an estimated 10-13% of adults globally, producing systemic effects that extend

into cardiovascular, respiratory, and musculoskeletal function as nephron loss progresses^{2,3}.

Central to these effects is the cardio-renal-muscle axis, in which uremic toxin accumulation and chronic inflammation drive skeletal muscle catabolism and progressive sarcopenia⁴, compounding cardiovascular

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strain and creating a cycle of deconditioning that is difficult to interrupt without targeted intervention⁵. Patients with Stage 3 CKD often show reduced aerobic capacity and inspiratory muscle weakness well before dialysis becomes necessary⁶, and IMT have been shown to benefit strength and functional tolerance in CKD populations^{7,8}.

This report evaluates functional, respiratory, inflammatory, renal, and quality-of-life outcomes following a 12-week combined program in one such patient.

METHODS

This pre-post single-case design evaluated a multimodal exercise program combined with IMT in a patient with Stage 3 CKD (eGFR 30-59 mL/min/1.73m²), selected by purposive sampling. The study was conducted over 12 weeks supervised program at the Cardiovascular and Respiratory Physiotherapy Outpatient Department, with ethical clearance from the Institutional Ethics Committee (Approval No. IEC/PG-2024-25/2026) and written informed consent obtained prior to enrolment; patient confidentiality was maintained throughout.

A 52-year-old male with Stage 3 CKD, presenting with fatigue, reduced functional capacity, dyspnea on exertion, and decreased exercise tolerance, was screened and found eligible. Following baseline and post-intervention assessment of all outcome measures, the patient completed a 12-week supervised program.

Outcome Measures

Primary outcomes were functional capacity: 6-Minute Walk Distance, lower-limb strength (30-Second Sit-to-Stand Test), and inspiratory muscle strength (Maximum Inspiratory Pressure).

Secondary outcomes included renal parameters (serum creatinine, eGFR), inflammatory markers (hs-CRP, IL-6), quality of life (KDQOL-36), cardiovascular parameters (HR, BP, SpO₂), and dyspnea (Modified Borg Scale).

Intervention Protocol

The supervised program was conducted 3 times/week for 12 weeks; each session included aerobic training, resistance exercise, breathing retraining, and IMT.

- Aerobic training: cycle ergometer, 40-60% target heart rate, 20-30 min/session
- Resistance training: major upper- and lower-limb muscle groups, 60-70% 1RM, 2-3 sets of 10-15 repetitions.
- IMT: threshold device, initiated at 30% MIP and progressed to 60% MIP, 15-20 min/session.
- Box breathing: 5 to 10 repetitions, 2-3 sets/session.

Vitals were monitored before, during, and after every session, with intensity modified or discontinued for adverse symptoms such as excessive fatigue, dizziness, or abnormal vital responses.



Figure 1. Patient performing supervised aerobic, resistance, and inspiratory muscle training sessions.

Study Instruments

Cycle ergometer, Resistance training equipment, Threshold IMT device, Pulse oximeter, Sphygmomanometer, Stopwatch

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA). Outcome measures were summarised descriptively, comparing baseline and post-intervention values, with absolute and percentage change calculated for each. Findings were interpreted based on clinical rather than statistical significance and are presented in tabular format.

RESULTS

A 52-year-old male with Stage 3 CKD completed the 12-week multimodal exercise program without adverse events. All outcome measures improved from baseline to post-intervention.

The most clinically notable changes were the gains in 6MWD (+26.6%) and STS repetitions (+60.0%), reflecting improved functional capacity and lower-limb strength, and the rise in MIP (+45.5%), reflecting improved respiratory muscle strength. Inflammatory markers fell substantially (hs-CRP -50.0%, IL-6 -44.8%), renal parameters showed

mild stabilisation (eGFR +14.3%), cardiovascular and symptom measures improved (reduced resting HR, BP, and dyspnea score), and QOL rose markedly (KDQOL-36 +44.0%).

DISCUSSION

This case demonstrates clinically meaningful gains across functional, respiratory, inflammatory, renal, and quality-of-life domains in a patient with Stage 3 CKD, supporting exercise-based rehabilitation as an adjunct in CKD care⁶. The gains in 6MWD, STS performance, and MIP likely reflect improved peripheral and respiratory muscle conditioning: exercise appears to partially reverse the uremic muscle catabolism and mitochondrial decline characteristic of CKD^{4,5}, while IMT strengthens the diaphragm and reduces dyspnea independent of dialysis status⁷, a pattern also reported in hemodialysis cohorts⁸.

The reduction in hs-CRP and IL-6 is consistent with exercise's anti-inflammatory effects through cytokine modulation, given that chronic low-grade inflammation drives both muscle wasting and cardiovascular risk in CKD⁴; comparable gains have been reported after structured intradialytic training⁹. Mild stabilisation in renal parameters, alongside reduced HR and BP, likely reflects improved hemodynamic and autonomic regulation rather than reversal of nephron loss³, while

Table 1. Baseline and post-intervention outcome measures

Outcome Measure	Baseline	Post-intervention	Absolute change	% Change
6-Minute Walk Distance (m)	320	405	+85	+26.56
30-Second Sit-to-Stand (reps)	10	16	+6	+60.00
Maximum Inspiratory Pressure (cmH ₂ O)	55	80	+25	+45.45
Serum Creatinine (mg/dL)	2.1	1.8	-0.3	-14.29
eGFR (mL/min/1.73 m ²)	42	48	+6	+14.29
hs-CRP (mg/L)	7.8	3.9	-3.9	-50.00
IL-6 (pg/mL)	10.5	5.8	-4.7	-44.76
Resting Heart Rate (bpm)	90	80	-10	-11.11
Systolic BP (mmHg)	150	138	-12	-8.00
Diastolic BP (mmHg)	92	86	-6	-6.52
SpO ₂ (%)	96	98	+2	+2.08
Modified Borg Dyspnea Score	5	2	-3	-60.00
KDQOL-36 Score	50	72	+22	+44.00

the rise in KDQOL-36 mirrors QOL gains reported in exercise trials among dialysis populations¹⁰. Collectively, multimodal programs appear to act on multiple interacting components of the cardio-renal-muscle axis simultaneously⁵, explaining why gains occurred concurrently rather than in isolation.

CONCLUSION

This case report demonstrates that a 12-week multimodal exercise program combined with IMT is a safe and effective intervention for improvement in all outcome measures, supporting an integrated rehabilitation approach targeting the cardio-renal-muscle axis.

This study contributes to the growing evidence base by highlighting the combined effect of multimodal exercise and IMT in non-dialysis CKD, an area that remains relatively underexplored.

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Conflict of Interest

The authors declare that there are no financial or personal conflicts of interest that could have influenced the conduct or reporting of this study.

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BOOK REVIEW

The ICF Handbook: A Comprehensive Guide to Functioning and Rehabilitation in Physiotherapy

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INTRODUCTION

The International Classification of Functioning (ICF), Disability and Health, introduced by the World Health Organisation (WHO) in 2001, represents one of the most significant developments in rehabilitation sciences. It shifted healthcare from a purely biomedical model to a biopsychosocial approach that recognises interactions among health conditions, body functions, activities, participation, and environmental factors. The ICF Handbook aims to simplify this framework and demonstrate its practical application in physiotherapy and rehabilitation settings.

Overview and Organisation of the Book

The handbook is systematically organised and follows a logical progression from basic concepts to advanced

clinical application. The text begins by discussing the evolution of disability models and the development of the ICF framework. Subsequent chapters explain the major components of ICF, including body functions, body structures, activities, participation, environmental factors, and personal factors. The authors further discuss ICF coding, rehabilitation diagnosis, goal setting, treatment planning, documentation, and outcome evaluation. The inclusion of High-Yield Points and clinical examples enhances readability and reinforces important concepts.

Content Analysis

One of the most notable strengths of the handbook is its explanation of the biopsychosocial model of health. The authors clearly describe how the ICF differs from traditional biomedical approaches by emphasizing

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functioning and participation rather than merely focusing on disease and impairment. The transition from the International Classification of Impairments, Disabilities and Handicaps (ICIDH) to ICF is explained effectively, helping readers appreciate the conceptual evolution of rehabilitation.

The book excels in demonstrating practical applications of ICF. Readers are guided through assessment, rehabilitation diagnosis, goal setting, intervention planning, documentation, and outcome evaluation using the ICF framework. The authors emphasise the importance of understanding the patient's functional abilities, environmental context, and participation restrictions.

The inclusion of case studies from neurological, musculoskeletal, cardiopulmonary, geriatric, and community rehabilitation settings significantly enhances learning. These examples illustrate how ICF concepts can be integrated into real clinical scenarios and support the development of clinical reasoning skills.

Clinical Relevance

The handbook demonstrates how the ICF framework can transform physiotherapy practice by encouraging a holistic assessment of patients. Rather than concentrating solely on impairments, clinicians are encouraged to evaluate activity limitations, participation restrictions, and environmental barriers. This approach promotes patient-centred care and improves the relevance of rehabilitation goals.

The authors also highlight the role of ICF in interdisciplinary communication. By providing a common language for healthcare professionals, the framework facilitates collaboration among physiotherapists, occupational therapists, physicians, nurses, psychologists, and social workers. This is particularly valuable in complex rehabilitation settings where coordinated care is essential.

Critical Appraisal

The handbook possesses several strengths. Its language is clear, concise, and accessible. Complex concepts are explained systematically without compromising

academic depth. The integration of theory and clinical practice is excellent, allowing readers to understand not only what the ICF is but also how it can be applied. The use of case studies, coding examples, and chapter summaries further enhances educational value.

However, some limitations should be acknowledged. Although the handbook provides a comprehensive introduction to the ICF framework, it offers limited discussion of theoretical debates surrounding the framework. Scholars have questioned the distinction between Activity and Participation and the adequacy of the theoretical foundations underlying certain ICF concepts. A more detailed discussion of these debates would strengthen critical understanding.

Another limitation is the limited discussion of implementation challenges across different clinical settings. While ICF is highly applicable in rehabilitation environments, its practical use in acute care and highly specialised settings may be more challenging. The handbook could also provide greater discussion regarding interprofessional role boundaries and large-scale implementation issues.

Contribution to Rehabilitation Literature

The handbook addresses a common challenge faced by rehabilitation professionals, the difficulty of applying the ICF framework in routine clinical practice and provides practical guidance to overcome this gap. Many rehabilitation professionals understand the theoretical importance of ICF but struggle with implementation. By providing practical examples and structured guidance, the authors successfully bridge this gap. The book contributes to the ongoing shift toward patient-centred, evidence-based, and outcome-oriented rehabilitation practice.

Personal Evaluation

One of the most impressive aspects of the handbook is its ability to translate a theoretically complex classification system into a framework that clinicians can readily apply in everyday practice. Its greatest strength lies in its practical orientation and ability to demonstrate the relevance of ICF in everyday physiotherapy practice. The emphasis on functioning, participation, and

quality of life aligns with contemporary rehabilitation principles and supports holistic patient management. While additional discussion of conceptual controversies and implementation challenges would enhance future editions, the overall quality and usefulness of the handbook remain high.

CONCLUSION

The ICF Handbook: A Comprehensive Guide to Functioning and Rehabilitation in Physiotherapy is a comprehensive, well-structured, and clinically relevant resource. By combining conceptual explanations with clinically relevant examples, the authors demonstrate how theoretical ICF concepts can be incorporated into assessment, goal setting, and rehabilitation planning. It serves as a valuable educational and professional resource for individuals interested in contemporary rehabilitation and functioning-based healthcare approaches.

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EQUIPMENT REVIEW

VIMS Arthritis Registry: Advancing Evidence-based Knee Osteoarthritis Care Through Digital Health Innovation

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Abstract

The growing burden of knee osteoarthritis presents a significant challenge to healthcare systems worldwide, necessitating robust clinical data collection and outcome monitoring mechanisms. The VIMS Knee Arthritis Registry, developed by DVVPF's College of Physiotherapy under the Department of Musculoskeletal Physiotherapy, represents an innovative digital platform designed to support comprehensive assessment, treatment tracking, and evidence-based management of patients with knee arthritis. By integrating standardised clinical evaluation, longitudinal monitoring, and outcome analysis, the registry establishes a valuable foundation for both clinical decision-making and research advancement.

INTRODUCTION

Knee osteoarthritis is among the most prevalent musculoskeletal disorders, contributing substantially to pain, disability, and reduced quality of life. Effective management requires systematic assessment,

individualised treatment planning, and continuous monitoring of patient outcomes. Traditional paper-based documentation systems often limit the ability to collect standardised data and evaluate long-term treatment effectiveness. The VIMS Knee Arthritis Registry addresses these challenges through a

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structured digital framework that enables healthcare professionals to document, analyse, and track patient progress comprehensively and consistently.

REGISTRY DESIGN AND FUNCTIONALITY

The VIMS Knee Arthritis Registry is built around a streamlined workflow consisting of registration, assessment, analysis, and treatment monitoring. Healthcare providers gain access to the platform following administrative approval, ensuring data integrity and professional oversight. The registry incorporates a comprehensive assessment process covering 23 specialised clinical sections, facilitating standardised baseline and follow-up evaluations.

One of the notable strengths of the platform is its ability to transform clinical information into actionable insights. Data entered by clinicians are systematically

analysed to generate detailed reports that support evidence-based treatment planning. The integrated treatment-tracking component enables monitoring of interventions, patient adherence, and clinical progress over time, creating a continuous care pathway for individuals with knee arthritis.

CLINICAL AND RESEARCH SIGNIFICANCE

The registry demonstrates the growing role of digital health technologies in musculoskeletal care. Standardising data collection and outcome measurement, it promotes consistency across providers and improves the quality of clinical documentation. Such registries are increasingly recognised as essential tools for generating real-world evidence, identifying treatment trends, and supporting quality improvement initiatives.

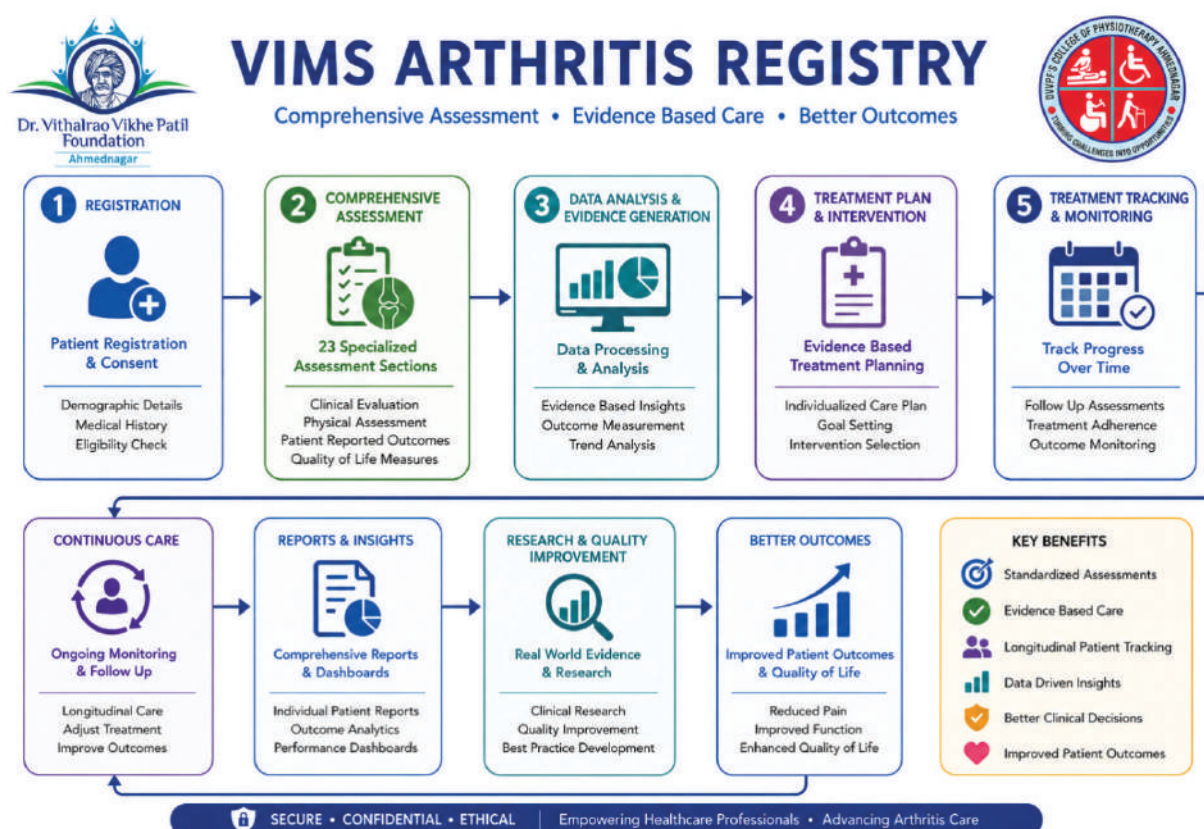


Figure 1. Arthritis registry Flow for patient registration

Furthermore, the longitudinal nature of the VIMS Registry creates opportunities for observational research, outcome studies, and the development of predictive models for patient management. The platform's emphasis on evidence-based insights aligns with contemporary healthcare priorities focused on data-driven clinical practice and patient-centred care.

CONCLUSION

The VIMS Knee Arthritis Registry represents a significant step toward modernising arthritis care through structured digital data management. By

combining comprehensive assessment, treatment monitoring, and outcome analysis within a unified platform, it enhances clinical practice while simultaneously creating a valuable resource for research and quality improvement. As healthcare increasingly embraces data-driven approaches, initiatives such as the VIMS Arthritis Registry are poised to play a pivotal role in shaping the future of musculoskeletal healthcare.

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