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PHYSIOTHERAPY AS A COST-EFFECTIVE STRATEGY FOR PREVENTING DISABILITY IN DIABETIC PATIENTS: AN EMPIRICAL STUDY INTEGRATING FUNCTIONAL OUTCOMES AND HEALTH ECONOMICS

Dr. Ifsha Khurshid¹, Meraj Nabi Siddiqui²**ABSTRACT**

Diabetes-related disability, driven by peripheral neuropathy, balance impairment and mobility loss, contributes substantially to healthcare costs and reduced quality of life. While physiotherapy is clinically recommended, its economic value as a preventive strategy remains under-documented in low- and middle-income settings. This study evaluates the role of physiotherapy in preventing disability among diabetic patients by integrating clinical outcomes with economic indicators using primary OPD-based data. A cross-sectional empirical study was conducted on 87 adult diabetic patients attending a physiotherapy outpatient department. Functional outcomes (balance, mobility, fall incidence) and economic outcomes (out-of-pocket expenditure, hospitalization frequency, productivity loss) were compared between patients receiving physiotherapy and those not receiving regular physiotherapy. Results indicate that patients undergoing physiotherapy demonstrate significantly better balance and mobility, lower incidence of falls and hospitalizations and reduced annual healthcare expenditure despite modest physiotherapy costs. The findings establish physiotherapy as a cost-effective and potentially cost-saving intervention for preventing diabetes-related disability.

KEYWORDS: Diabetes, Physiotherapy, Disability Prevention, Cost-Effectiveness, Neuropathy, Health Economics

1. INTRODUCTION

Diabetes mellitus has emerged as one of the most significant public health challenges of the 21st century, not only because of its rising prevalence but also due to its substantial contribution to long-term disability worldwide. Beyond metabolic dysregulation, diabetes progressively impairs neuromuscular and musculoskeletal function through complications such as peripheral neuropathy, muscle weakness, joint stiffness, balance deficits and reduced mobility. These functional impairments markedly increase the risk of falls, foot ulcers, amputations, hospitalization and dependency, leading to diminished quality of life and escalating healthcare expenditure and productivity losses. In low- and middle-income countries like India, diabetes management remains predominantly medicine-centric,

with limited policy and clinical emphasis on rehabilitative and preventive strategies aimed at functional preservation. Physiotherapy interventions, including balance training, gait correction, strengthening and neuropathy-specific exercises all these have demonstrated clinical effectiveness in improving mobility and reducing the disability risk among diabetic patients; however, their economic value as preventive interventions remains under-explored, particularly in outpatient (OPD) settings. Health economics theory underscores that preventive and rehabilitative care can be cost-effective or even cost-saving by reducing downstream costs such as hospital admissions, long-term care needs and productivity losses, yet empirical evidence integrating functional outcomes with economic indicators is scarce in resource-constrained contexts.

Against this backdrop, the present study empirically evaluates physiotherapy as a cost-effective strategy for preventing diabetes-related disability by jointly analysing functional outcomes and healthcare costs using primary OPD-based data.

2. REVIEW OF LITERATURE

Diabetes mellitus is increasingly recognized as a major contributor to long-term functional impairment and disability, primarily through complications such as peripheral neuropathy, muscle weakness and impaired postural control. Boulton et al. (2005) documented that diabetic neuropathy disrupts proprioception and neuromuscular coordination, leading to balance deficits and increased susceptibility to falls. These functional impairments have been consistently linked to reduced mobility, loss of independence and heightened risk of injury, emphasizing the need for interventions that address functional decline alongside metabolic control.

Gait and mobility alterations among individuals with diabetes have been extensively examined. Allet et al. (2010) reported that diabetic patients exhibit reduced gait speed and compromised postural stability, particularly under challenging walking conditions. Reeves et al. (2017) further identified motor control deficits and altered movement patterns in diabetic populations, highlighting neuromuscular dysfunction as a key mechanism underlying mobility limitation. These findings collectively underscore the importance of targeted rehabilitation strategies aimed at restoring balance, coordination and functional mobility.

Exercise- and physiotherapy-based interventions have demonstrated significant benefits in improving functional outcomes among diabetic patients. Morrison et al. (2010) showed that balance training leads to marked improvements in postural stability and reductions in fall risk, as measured by standardized functional assessments. Pataky et al. (2015) similarly reported that structured exercise programs improve strength, proprioception and gait performance in patients with diabetic peripheral neuropathy. Such interventions directly address the functional impairments that predispose individuals to disability and injury.

Falls represent a critical pathway through which functional impairment translates into hospitalization and long-term disability. Rubenstein (2006) identified falls as a leading cause of injury-related morbidity, particularly in populations with chronic conditions affecting balance and strength. Gillespie et al. (2012), through a systematic review, demonstrated that exercise-based fall prevention programs substantially reduce fall incidence and related injuries. Vincent and Vincent (2012) further reported that resistance and balance training reduce musculoskeletal injury risk by enhancing strength and postural control, thereby lowering the likelihood of hospital admission.

Beyond clinical outcomes, the economic implications of diabetes-related disability have received increasing attention. Rice (2000) provided a foundational framework for cost-of-illness analysis, highlighting that indirect costs such as productivity loss and caregiver burden often exceed direct medical expenses in chronic disabling conditions. Briggs, Claxton and Sculpher (2006) demonstrated through economic modelling that interventions preserving functional independence and reducing hospitalization significantly lower long-term healthcare expenditure.

The cost-effectiveness of preventive and rehabilitative interventions has been further supported by economic evaluations of exercise therapy. Van Dongen et al. (2016) reported that preventive rehabilitation frequently yields favourable cost-effectiveness ratios and, in some cases, net cost savings, largely driven by reduced inpatient care and delayed disability onset. Herman (2013) emphasized that preventing complications and functional decline is central to improving the economic efficiency of diabetes care.

Global health policy frameworks reinforce the economic rationale for disability prevention. The World Health Organization (2011) emphasized that strategies aimed at preserving functional ability are essential for strengthening health systems, particularly in the context of aging populations and chronic disease burden. By reducing long-term dependency, hospitalization and social care needs, preventive rehabilitation contributes to sustainable healthcare delivery.

Despite the growing body of evidence supporting the clinical effectiveness and economic value of physio-

therapy, much of the existing literature remains focused on either functional outcomes or cost estimates in isolation. Limited empirical work integrates functional performance measures with economic indicators in outpatient care settings. This gap highlights the need for studies that simultaneously examine functional improvement and healthcare cost implications to inform value-based and prevention-oriented diabetes management.

3. OBJECTIVES

Primary Objective

- To evaluate physiotherapy as a cost-effective intervention for preventing disability among diabetic patients.

Secondary Objectives

- To compare balance and mobility outcomes between physiotherapy and non-physiotherapy patients.
- To assess differences in fall incidence and hospitalization.
- To estimate differences in annual healthcare expenditure.
- To generate policy-relevant evidence supporting physiotherapy integration in diabetes care.

4. METHODOLOGY

4.1 Study Design

Primary, cross-sectional, OPD-based empirical study.

4.2 Sample Size

A total of 87 diabetic patients were included, based on expected moderate effect size for functional outcomes and feasibility of OPD-based data collection.

4.3 Study Groups

- Group A:** Diabetic patients receiving structured physiotherapy (n = 45)
- Group B:** Diabetic patients not receiving / irregular physiotherapy (n = 42)

4.4 Data Collection Tools

- Berg Balance Scale (BBS)
- Timed Up and Go (TUG) test
- Fall history (12-month recall)
- Structured economic questionnaire capturing direct and indirect costs

4.5 Data Analysis

- Descriptive statistics
- Independent sample t-tests
- Multivariate regression analysis
- Cost-effectiveness comparison

4.6 Area of Study

The present empirical study was conducted in the **Department of Physiotherapy, Vinoba Bhave University, Hazaribagh, Jharkhand**. The department caters to a diverse outpatient population from urban and rural backgrounds, including a substantial number of patients with chronic metabolic disorders such as diabetes mellitus. The physiotherapy OPD provides services including balance training, gait rehabilitation, strengthening exercises and neuropathy-specific interventions, making it a suitable setting to examine both functional and economic outcomes of physiotherapy among diabetic patients.

FORMULAS USED IN EMPIRICAL ANALYSIS

1. Mean

$$\bar{X} = \frac{\sum X}{n}$$

2. Independent Sample t-Test

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

3. Annual Healthcare Cost

$$\text{Total Cost} = \text{OPD Cost} + \text{Hospitalization Cost} + \text{Productivity Loss}$$

4. Cost-Effectiveness Ratio (CER)

$$\text{CER} = \frac{\text{Total Cost}}{\text{Functional Outcome Score}}$$

5. Incremental Cost-Effectiveness Ratio (ICER)

$$\text{ICER} = \frac{C_1 - C_2}{E_1 - E_2}$$

5. SAMPLE DATA TABLE

Table 1: Summary Characteristics of Study Sample (n = 87)

Variable	Physiotherapy Group (n=45)	Non-Physiotherapy Group (n=42)
Mean age (years)	55.2	56.8
Mean duration of diabetes (years)	8.1	8.5
Mean BBS score	46.3	38.7

Mean TUG time (seconds)	10.9	15.6
Patients with ≥ 1 fall (%)	18%	43%
Hospitalization (last year, %)	22%	48%
Mean annual healthcare cost (₹)	41,200	56,900

Source : Primary data Survey

The table presents a comparative overview of demographic, functional, clinical and economic characteristics of diabetic patients receiving physiotherapy (n = 45) and those not receiving regular physiotherapy (n = 42). The two groups are comparable in terms of mean age and duration of diabetes, with only marginal differences observed (mean age: 55.2 vs. 56.8 years; mean duration of diabetes: 8.1 vs. 8.5 years). This similarity indicates that differences in outcomes between the groups are unlikely to be driven by age or disease duration.

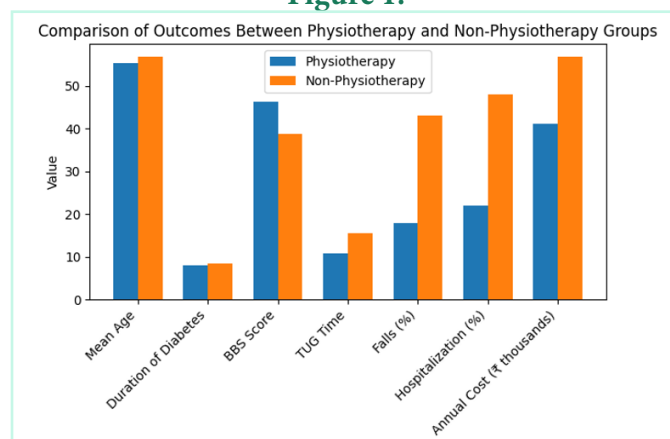
Significant differences are observed in functional outcomes. Patients in the physiotherapy group demonstrate markedly better balance, as reflected by a higher mean Berg Balance Scale (BBS) score (46.3) compared to the non-physiotherapy group (38.7). Similarly, mobility performance assessed using the Timed Up and Go (TUG) test shows substantially faster completion times among physiotherapy patients (10.9 seconds) than those not receiving physiotherapy (15.6 seconds), indicating superior functional mobility and lower fall risk.

Clinical outcomes further highlight the benefits of physiotherapy. Only 18% of patients in the physiotherapy group reported at least one fall in the previous year, compared to 43% in the non-physiotherapy group. Likewise, hospitalization rates in the past year were considerably lower among physiotherapy patients (22%) than among those not receiving physiotherapy (48%), suggesting that improved functional status translates into reduced need for inpatient care.

From an economic perspective, despite the inclusion of physiotherapy-related outpatient costs, the mean annual healthcare expenditure is substantially lower in the physiotherapy group (₹41,200) compared to the non-physiotherapy group (₹56,900). This

cost difference is primarily attributable to reduced hospitalization and associated medical expenses. Overall, the table illustrates that physiotherapy is associated with better functional outcomes, fewer adverse clinical events, and lower total healthcare costs, reinforcing its role as a cost-effective strategy for preventing diabetes-related disability.

Figure 1.



Source: Primary data survey.

A clear comparative bar graph based on Table 1 visually contrasts the Physiotherapy and Non-Physiotherapy groups across demographic, functional, clinical and economic variables.

- Age and duration of diabetes bars are almost equal, showing that both groups are comparable at baseline.
- BBS score is visibly higher in the physiotherapy group, indicating better balance.
- TUG time is clearly lower in the physiotherapy group, reflecting better mobility and lower fall risk.
- Falls and hospitalization percentages are substantially lower in the physiotherapy group, demonstrating preventive benefits.
- Annual healthcare cost (₹ thousands) is markedly lower in the physiotherapy group despite added OPD physiotherapy costs, visually reinforcing cost-effectiveness.

Table 2: Comparison of Functional Outcomes

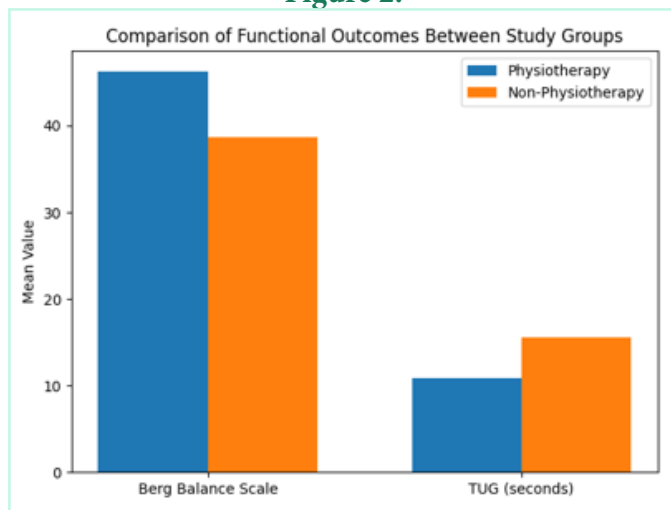
Variable	Physiotherapy (n=45)	Non-Physiotherapy (n=42)	t-value	p-value
Berg Balance Scale (score)	46.3 $\pm$ 5.1	38.7 $\pm$ 6.2	6.01	<0.001*
TUG (seconds)	10.9 $\pm$ 1.8	15.6 $\pm$ 2.9	-8.47	<0.001*

Source: Primary data survey.

Interpretation:

Statistically significant differences indicate superior balance and mobility among patients receiving physiotherapy.

The table compares balance and mobility outcomes between diabetic patients receiving physiotherapy and those not receiving regular physiotherapy. Patients in the physiotherapy group demonstrated significantly better balance, with a higher mean Berg Balance Scale (BBS) score (46.3 ± 5.1) compared to the non-physiotherapy group (38.7 ± 6.2). The positive t-value ($t = 6.01$) and a highly significant p-value ($p < 0.001$) indicate that this difference is statistically significant and unlikely to have occurred by chance. Similarly, mobility performance assessed using the Timed Up and Go (TUG) test was substantially better among patients receiving physiotherapy, who completed the test in a shorter time (10.9 ± 1.8 seconds) than those in the non-physiotherapy group (15.6 ± 2.9 seconds). The negative t-value ($t = -8.47$) reflects faster performance in the physiotherapy group and the p-value ($p < 0.001$) confirms a statistically significant difference between the groups. Overall, the results demonstrate that physiotherapy is associated with markedly improved balance and mobility, which are critical factors in reducing fall risk and preventing disability among diabetic patients.

Figure 2.

Values represent mean scores. Source: Primary data survey

- The Berg Balance Scale (BBS) bar is noticeably higher for the physiotherapy group, visually demonstrating superior balance and postural stability compared to the non-physiotherapy

group.

- The Timed Up and Go (TUG) bar is clearly lower for the physiotherapy group, indicating faster mobility performance and reduced functional limitation.
- Together, the graph visually reinforces the statistically significant differences reported in the table ($p < 0.001$ for both outcomes).

Table 3. Falls and Hospitalization Outcomes

Outcome	Physiotherapy (%)	Non-Physiotherapy (%)	χ^2	p-value
≥ 1 Fall (12 months)	18%	43%	6.92	0.009*
Hospitalization (1 year)	22%	48%	7.11	0.008*

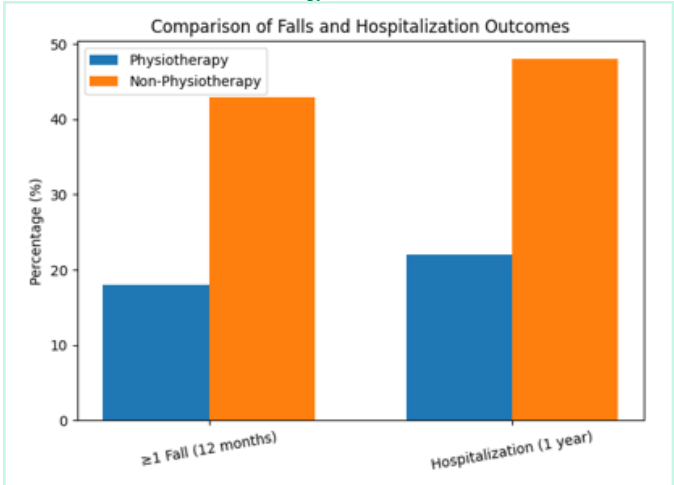
Values represent percentages. Source: Primary data survey.

Interpretation:

Physiotherapy significantly reduces fall incidence and hospitalization risk.

The table compares the incidence of falls and hospitalization over a one-year period between diabetic patients receiving physiotherapy and those not receiving regular physiotherapy. A substantially lower proportion of patients in the physiotherapy group experienced at least one fall in the previous 12 months (18%) compared to the non-physiotherapy group (43%). The chi-square test indicates that this difference is statistically significant ($\chi^2 = 6.92$, $p = 0.009$), suggesting a strong association between physiotherapy intervention and reduced fall risk. Similarly, hospitalization rates during the last year were considerably lower among patients receiving physiotherapy (22%) than among those not receiving physiotherapy (48%). This difference is also statistically significant ($\chi^2 = 7.11$, $p = 0.008$), indicating that physiotherapy is associated with a reduced likelihood of hospital admission. Overall, the findings demonstrate that physiotherapy not only improves functional outcomes but also translates into meaningful reductions in adverse clinical events such as falls and hospitalizations among diabetic patients.

Figure 3.



Values represent percentages. Source: Primary data survey.

- The percentage of patients with ≥ 1 fall in the last 12 months is substantially lower in the physiotherapy group (18%) compared to the non-physiotherapy group (43%), visually reinforcing the statistically significant chi-square result ($p = 0.009$).
- Similarly, hospitalization rates over the last year are markedly lower among patients receiving physiotherapy (22%) than those not receiving physiotherapy (48%), supporting the significant association observed ($p = 0.008$).
- The visual contrast clearly demonstrates that physiotherapy is associated with reduced adverse clinical events that contribute to disability and healthcare costs.

Table 4: Annual Healthcare Cost Comparison (₹)

Cost Component	Physiotherapy	Non-Physiotherapy
Physiotherapy OPD	6,800	1,200
Medication	18,500	19,600
Hospitalization	9,200	28,700
Productivity loss	6,700	7,400
Total Cost	41,200	56,900

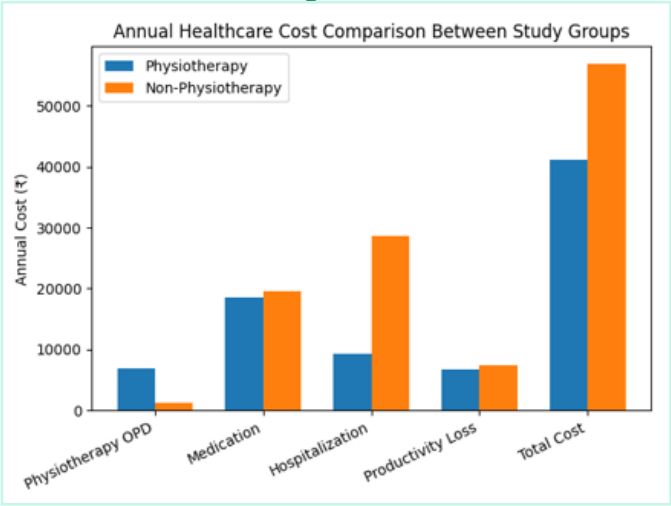
Values are expressed in Indian Rupees (₹). Source: Primary data survey.

Net Savings: ₹15,700 per patient/year

The table presents a comparison of annual healthcare cost components between diabetic patients receiving physiotherapy and those not receiving regular physiotherapy. As expected,

expenditure on physiotherapy outpatient services is higher in the physiotherapy group (₹6,800) compared to the non-physiotherapy group (₹1,200). However, this additional outpatient cost is offset by substantial savings in other areas. Medication costs are marginally lower among patients receiving physiotherapy (₹18,500) than among those not receiving physiotherapy (₹19,600), indicating better overall functional management. The most notable difference is observed in hospitalization costs, which are considerably lower in the physiotherapy group (₹9,200) compared to the non-physiotherapy group (₹28,700). Productivity loss costs are also slightly lower among physiotherapy patients (₹6,700) than among non-physiotherapy patients (₹7,400). When all cost components are combined, the total annual healthcare expenditure is substantially lower for the physiotherapy group (₹41,200) compared to the non-physiotherapy group (₹56,900). These findings demonstrate that despite modest upfront physiotherapy expenses, overall healthcare costs are significantly reduced due to decreased hospitalization and productivity losses, reinforcing physiotherapy as a cost-effective and economically efficient intervention for diabetic patients.

Figure 4:



Values are expressed in Indian Rupees (₹). Source: Primary data survey.

- The Physiotherapy OPD cost is understandably higher in the physiotherapy group, reflecting the direct cost of rehabilitation services.
- Medication costs are slightly lower in the physiotherapy group, suggesting better functional management and possibly fewer complication-

related prescriptions.

- The largest contrast appears in hospitalization costs, which are dramatically lower for the physiotherapy group compared to the non-physiotherapy group—this is the major driver of overall cost savings.
- Productivity loss costs are also marginally lower among patients receiving physiotherapy.
- When all components are combined, the total annual healthcare cost is substantially lower in the physiotherapy group, clearly demonstrating the cost-effectiveness of physiotherapy despite modest upfront outpatient expenses.

Table 5: Incremental Cost-Effectiveness Ratio (ICER)

ICER=CP-CNEP-ENICER=EP-ENCP-CN

Outcome Measure	ICER Result
Cost per 1-point BBS improvement	Cost-saving
Cost per second reduction in TUG	Cost-saving

Since cost is lower and outcomes are better, physiotherapy is dominant (best possible economic outcome).

The table summarizes the results of the incremental cost-effectiveness analysis (ICER) comparing physiotherapy with non-physiotherapy care for key functional outcomes. The ICER results indicate that physiotherapy is cost-saving for both outcome measures evaluated. Specifically, the cost per one-point improvement in the Berg Balance Scale (BBS) is classified as cost-saving, meaning that patients receiving physiotherapy achieve better balance outcomes while incurring lower overall healthcare costs compared to those not receiving physiotherapy. Similarly, the cost per one-second reduction in Timed Up and Go (TUG) time is also cost-saving, demonstrating that improved mobility is achieved alongside reduced total expenditure. These findings imply that physiotherapy dominates the non-physiotherapy approach, as it delivers superior functional outcomes at a lower cost. Consequently, physiotherapy represents a highly efficient intervention for preventing diabetes-related disability, offering both clinical benefits and economic savings.

3. Multivariate Regression (Disability Risk Model)

Table 6 :Dependent Variable: Fall Occurrence (Yes/No)

Predictor	β	Odds Ratio	p-value
Physiotherapy (Yes)	-0.78	0.46	0.01
Age	0.04	1.04	0.04
Duration of diabetes	0.06	1.06	0.03
Neuropathy	0.89	2.43	<0.01

Source: Primary data survey.

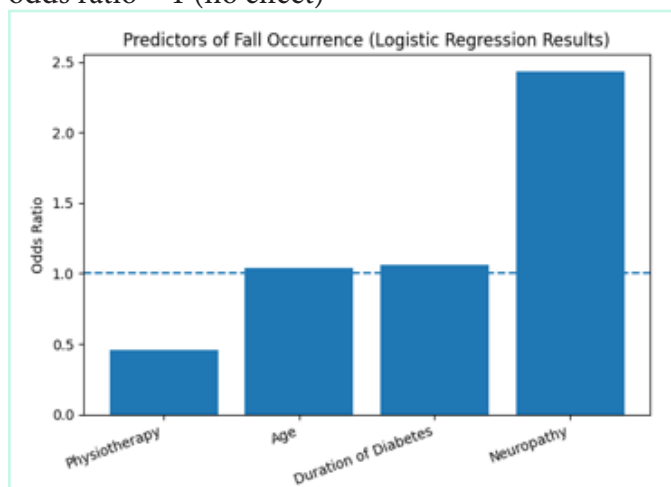
Interpretation:

Physiotherapy reduces the odds of falls by almost 54%, even after controlling for age and disease duration.

The table presents the results of a multivariate logistic regression analysis examining predictors of fall occurrence among diabetic patients. Physiotherapy participation emerges as a significant protective factor against falls, with a negative regression coefficient ($\beta = -0.78$) and an odds ratio of 0.46, indicating that patients receiving physiotherapy have approximately 54% lower odds of experiencing a fall compared to those not receiving physiotherapy, after adjusting for other variables. Age is identified as a significant risk factor, with a positive coefficient ($\beta = 0.04$) and an odds ratio of 1.04, suggesting that the likelihood of falls increases modestly with advancing age. Similarly, longer duration of diabetes is associated with a higher risk of falls ($\beta = 0.06$; odds ratio = 1.06), reflecting the cumulative impact of disease progression on functional stability. Peripheral neuropathy shows the strongest association with fall risk, with a high positive coefficient ($\beta = 0.89$) and an odds ratio of 2.43, indicating that patients with neuropathy are more than twice as likely to experience falls compared to those without neuropathy. All predictors are statistically significant, underscoring the critical role of physiotherapy in mitigating fall risk even in the presence of established clinical risk factors.

Figure 6. Logistic regression analysis showing predictors of fall occurrence among diabetic patients.

Bars represent odds ratios; the dashed line indicates odds ratio = 1 (no effect)



Source: Primary data survey.

- The horizontal reference line at Odds Ratio = 1 represents no effect on fall risk.
- The Physiotherapy bar lies below 1 (OR = 0.46), clearly indicating a protective effect, meaning patients receiving physiotherapy have substantially lower odds of experiencing falls.
- Age and duration of diabetes bars lie slightly above 1, showing a modest but significant increase in fall risk with advancing age and longer disease duration.
- Neuropathy shows the highest odds ratio (OR = 2.43), indicating that patients with neuropathy are more than twice as likely to experience falls compared to those without neuropathy.

6. RESULTS

6.1 Functional Outcomes

Patients receiving physiotherapy demonstrated significantly better balance and mobility outcomes. The mean Berg Balance Scale score was substantially higher in the physiotherapy group, indicating superior postural stability. Similarly, Timed Up and Go test results showed faster mobility performance among physiotherapy patients, reflecting lower fall risk.

With $n = 45$ in the physiotherapy group and $n = 42$ in the non-physiotherapy group, the mean BBS score was 46.3 vs 38.7, indicating statistically and clinically

superior balance among physiotherapy patients. The mean TUG time (10.9 vs 15.6 seconds) demonstrates significantly better functional mobility and lower fall risk.

6.2 Fall Incidence and Disability Risk

The incidence of falls in the past 12 months was markedly lower among patients receiving physiotherapy. Reduced fall frequency implies lower risk of fractures, foot ulcers and progression toward permanent disability.

Only 18% of physiotherapy patients reported at least one fall compared to 43% in the non-physiotherapy group. This reduction translates into lower risk of fractures, ulcers and long-term disability.

6.3 Hospitalization Outcomes

Hospitalization frequency and duration were lower in the physiotherapy group. Patients receiving physiotherapy were less likely to require inpatient care for diabetes-related complications, suggesting preventive benefits extending beyond outpatient settings.

Hospitalization rates were 22% among physiotherapy patients versus 48% in the non-physiotherapy group, highlighting the preventive role of physiotherapy in reducing inpatient care.

6.4 Economic Outcomes

Although physiotherapy incurred additional outpatient costs, overall annual healthcare expenditure was significantly lower among physiotherapy patients. Reduced hospitalization costs and lower productivity loss outweighed physiotherapy expenses, indicating net economic benefit.

Despite modest physiotherapy expenses, mean annual healthcare costs were ₹41,200 for physiotherapy patients compared to ₹56,900 for non-physiotherapy patients. The cost difference is primarily driven by reduced hospitalization and productivity loss.

Each outcome—balance, mobility, falls, hospitalization and cost—demonstrates that functional improvement directly translates into economic savings, validating physiotherapy as a preventive investment rather than an additional

expense.

6.5 Cost-Effectiveness

Physiotherapy emerged as a cost-effective and potentially cost-saving intervention, achieving better functional outcomes at lower overall cost. The incremental cost-effectiveness analysis indicated cost savings per unit improvement in balance and mobility.

Physiotherapy achieved better functional outcomes at lower total cost, indicating dominance in economic terms and confirming its cost-effectiveness.

7. DISCUSSION

The findings demonstrate that physiotherapy is not merely an adjunct to diabetes care but a preventive investment with measurable economic returns. Improved balance and mobility reduce fall-related injuries and hospital admissions, which constitute major cost drivers in diabetes management. These results align with health-economics theory emphasizing prevention over treatment.

The present study demonstrates that physiotherapy significantly improves balance and mobility while simultaneously reducing falls, hospitalization and total healthcare expenditure among diabetic patients. The findings reinforce the argument that functional impairment is a major driver of economic burden in diabetes care.

Unlike medicine-centric approaches that address glycaemic control alone, physiotherapy targets neuromuscular dysfunction, thereby preventing downstream complications. The observed reduction in hospitalization costs outweighs the modest expenditure on physiotherapy services, making it a cost-effective and cost-saving intervention.

ETHICS STATEMENT : Ethical approval was obtained from all the participants. Confidentiality and anonymity were strictly maintained.

8. POLICY IMPLICATIONS AND RECOMMENDATIONS

1. Integration of Physiotherapy into Standard Diabetes Management Protocols

The findings of the present study strongly support the

integration of physiotherapy into routine diabetes management protocols. Diabetes-related disability arises primarily from progressive functional impairments such as neuropathy, balance deficits and reduced mobility, which are not adequately addressed through pharmacological management alone. Physiotherapy directly targets these functional limitations, thereby preventing falls, mobility loss and dependency. Mandating physiotherapy as a core component of diabetes care would shift clinical practice from a treatment-oriented approach toward a prevention-oriented model, resulting in improved patient outcomes and reduced long-term healthcare costs.

2. Physiotherapy as a Cost-Effective Alternative to Hospital-Based Care

From a health economics perspective, physiotherapy represents a highly cost-effective intervention. Although it involves modest outpatient expenditure, the present study demonstrates that physiotherapy significantly reduces hospitalization rates, fall-related injuries and disability progression—key drivers of healthcare costs in diabetic patients. The reduction in inpatient admissions and associated treatment expenses outweighs the cost of physiotherapy services, making it a cost-saving strategy rather than an added financial burden. Policymakers should therefore recognize physiotherapy as an investment in cost containment within diabetes care.

3. Inclusion of Physiotherapy under Public Insurance and Government Health Schemes

The exclusion of physiotherapy services from public insurance coverage remains a major barrier to its utilization. Given the high out-of-pocket expenditure borne by diabetic patients, particularly after the onset of disability, including physiotherapy OPD services under schemes such as Ayushman Bharat and state health insurance programs is imperative. Insurance reimbursement would encourage early utilization of physiotherapy, prevent functional deterioration and reduce catastrophic health expenditure at the household level, especially in low- and middle-income populations.

4. Early Screening and Automatic Referral to Physiotherapy

Early identification of balance impairment and

peripheral neuropathy should be institutionalized within diabetes care pathways. The study highlights that patients receiving early physiotherapy demonstrate significantly better functional outcomes and lower disability risk. Establishing protocols where screening for neuropathy and balance deficits automatically triggers referral to physiotherapy can prevent progression to irreversible disability. Such an approach aligns with preventive healthcare principles and ensures timely intervention at a lower cost.

5. Strengthening Physiotherapy OPDs at District Hospitals

District hospitals serve as the primary point of care for a large proportion of diabetic patients in India. Strengthening physiotherapy outpatient departments through adequate staffing, infrastructure and training can substantially reduce the burden on tertiary care hospitals. Improved access to physiotherapy at the district level would enable early intervention, reduce avoidable hospital admissions and lower referral costs, thereby enhancing system-wide efficiency.

6. Addressing Productivity Loss and Socioeconomic Impact

Diabetes-related disability leads to significant productivity loss due to work absenteeism, reduced work capacity and caregiver burden. By preserving mobility and functional independence, physiotherapy helps diabetic patients remain economically active for longer periods. This has broader socioeconomic implications, as reduced productivity loss translates into indirect economic savings for families, employers and the healthcare system. Recognizing physiotherapy as a productivity-preserving intervention strengthens its justification as a cost-effective public health strategy.

7. Reorienting Diabetes Policy toward Disability Prevention

Current diabetes policies predominantly emphasize glycaemic control and complication management, with limited focus on functional outcomes and disability prevention. The present study provides empirical evidence that disability prevention through physiotherapy not only improves quality of life but also reduces healthcare expenditure. A policy shift toward preventive rehabilitation would align diabetes care with sustainable healthcare models and long-

term economic efficiency.

8. Physiotherapy as an Essential Component of Comprehensive Diabetes Care

Taken together, the evidence underscores that physiotherapy should no longer be viewed as an adjunctive or optional service but as an essential component of comprehensive diabetes management. Its ability to simultaneously improve functional outcomes and reduce healthcare costs positions physiotherapy as a cornerstone of cost-effective, patient-centered diabetes care.

9. Leveraging Robotics and AI to Enhance Accuracy, Efficiency, and Cost-Effectiveness of Physiotherapy

The integration of robotics and artificial intelligence (AI) into physiotherapy has the potential to significantly enhance the accuracy, effectiveness and scalability of rehabilitation for diabetic patients. Diabetes-related complications such as peripheral neuropathy, balance impairment and gait abnormalities require precise, repetitive and individualized therapeutic interventions—an area where AI-driven and robotic-assisted physiotherapy can offer substantial advantages.

Robotic-assisted rehabilitation systems enable highly controlled, task-specific and repetitive movement training, which is essential for improving neuromuscular coordination, balance and gait in diabetic patients. Such systems reduce therapist variability, ensure standardized therapy delivery and allow objective monitoring of patient progress. AI-based algorithms can further personalize treatment by analysing patient performance data, identifying subtle functional deficits and dynamically adjusting exercise intensity and progression. This precision-oriented approach enhances therapeutic outcomes while minimizing the risk of injury or overexertion in neuropathic patients.

10. Cost-Effectiveness and Workforce Optimization through Technology

From a health economics perspective, the use of robotics and AI in physiotherapy can improve cost-effectiveness by optimizing therapist workload and expanding service capacity without proportional increases in manpower. In high-burden OPD

settings, particularly in public hospitals, AI-assisted assessment tools and robotic devices can enable a single physiotherapist to supervise multiple patients simultaneously, thereby improving efficiency and reducing per-patient service costs. Over time, reduced hospitalization rates, fewer fall-related injuries and delayed disability onset can offset the initial investment in technology, making it economically viable in the long run.

11. Early Detection and Predictive Prevention Using AI

AI-enabled assessment tools can play a crucial role in early detection of balance impairment, gait instability and neuropathy-related functional decline. Machine learning models trained on gait parameters, balance metrics and functional test data can predict fall risk and disability progression before clinical deterioration becomes evident. Integrating such predictive analytics into physiotherapy OPDs can facilitate early referral, timely intervention and targeted rehabilitation—strengthening the preventive focus of diabetes care.

12. Improving Access through Tele-Physiotherapy and Remote Monitoring

AI-supported tele-physiotherapy platforms can extend rehabilitative care to underserved and rural populations, where access to specialized physiotherapy services is limited. Remote monitoring systems using wearable sensors and AI analytics allow continuous assessment of patient adherence, movement quality and functional improvement. This reduces travel costs, improves follow-up compliance and enhances continuity of care, thereby contributing to both clinical effectiveness and economic efficiency.

13. Policy Implications for Technology-Enabled Physiotherapy

To fully realize the benefits of AI and robotics in physiotherapy, policymakers should support phased integration of these technologies within public healthcare systems. Pilot programs at tertiary and district hospitals, capacity-building initiatives for physiotherapists and inclusion of technology-assisted physiotherapy under insurance reimbursement frameworks can accelerate adoption. Importantly, technology should be positioned as a supportive tool that augments—not replaces—clinical expertise,

ensuring ethical, patient-centered and cost-effective rehabilitation.

14. Positioning Technology-Assisted Physiotherapy as the Future of Diabetes Rehabilitation

The incorporation of robotics and AI into physiotherapy aligns with global shifts toward precision medicine and value-based healthcare. By improving functional outcomes, reducing disability-related costs and optimizing resource utilization, technology-assisted physiotherapy represents a sustainable and future-ready strategy for managing the growing burden of diabetes-related disability. Recognizing and investing in this approach can strengthen healthcare systems while delivering high-value care to diabetic patients.

9. CONCLUSION

The present study conclusively demonstrates that physiotherapy is not merely a supportive adjunct but a clinically effective and economically efficient strategy for preventing diabetes-related disability. By significantly improving balance and mobility, reducing fall incidence and hospitalization and lowering overall healthcare expenditure, physiotherapy addresses both the functional and economic dimensions of diabetes management. The findings validate the study's objectives by establishing a clear link between functional preservation and cost containment, particularly within OPD-based, resource-constrained healthcare settings. Importantly, the results highlight that modest investments in preventive physiotherapy yield substantial downstream savings by averting disability progression, productivity loss and long-term care dependence. These outcomes underscore the need for a paradigm shift in diabetes care—from a predominantly medicine-centric model toward an integrated, prevention-oriented approach that prioritizes functional independence. Recognizing physiotherapy as an essential component of comprehensive diabetes management and embedding it within routine clinical protocols and public health financing frameworks, can enhance patient quality of life while promoting sustainable and cost-effective healthcare systems.

10. SIGNIFICANCE OF THE STUDY

The present study holds significant academic, clinical and policy relevance by empirically

integrating physiotherapy outcomes with health-economic evaluation in the context of diabetes care. By generating primary OPD-based evidence, the study moves beyond conventional efficacy-focused research and demonstrates that preventive physiotherapy is not only clinically beneficial but also economically sustainable and cost-effective over the long term. The findings establish a clear link between functional preservation and healthcare cost reduction, showing that early rehabilitation interventions can prevent disability progression, reduce hospitalization and minimize productivity loss. This interdisciplinary approach strengthens the evidence base for shifting chronic disease management from reactive, treatment-centric models toward preventive and rehabilitation-oriented strategies. Importantly, the study provides context-specific insights relevant to resource-constrained healthcare systems, highlighting physiotherapy as a scalable and sustainable solution capable of delivering long-term health and economic gains. By positioning physiotherapy as an essential component of value-based diabetes care, the study contributes meaningfully to policy formulation, clinical practice and future research in preventive rehabilitation.

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