International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347 -6435 (Online)), Volume 15, Issue 3, March 2026)

Management Strategies for Degenerative Musculoskeletal Disorders: An Integrated Clinical and Technological Framework

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***Abstract*—** Degenerative musculoskeletal disorders (DMSDs) encompassing osteoarthritis, degenerative disc disease, and chronic inflammatory rheumatic conditions constitute a leading cause of chronic pain, functional impairment, and disability in ageing populations worldwide. This cross-sectional observational study analysed data from 480 adult patients with confirmed DMSDs. Findings demonstrate that multidisciplinary care intensity ($\beta = -0.41$, $p < .001$), regenerative therapy utilisation ($\beta = -0.36$, $p < .001$), and psychosocial resilience ($\beta = -0.28$, $p < .01$) were significant negative predictors of chronic pain severity and functional impairment, while polypharmacy burden ($\beta = 0.33$, $p < .01$) positively predicted symptom persistence. The integrated model explained 65% of the variance in functional improvement outcomes ($R^2 = 0.65$). These findings validate contemporary integrated care models and precision medicine frameworks, supporting comprehensive, technologically augmented approaches including rehabilitation robotics, motion-controlled wearables, and AI-driven monitoring to sustainable musculoskeletal health management.

Keywords — *degenerative musculoskeletal disorders; chronic pain management; regenerative therapy; multidisciplinary care; polypharmacy; deprescribing; digital health; precision medicine; rehabilitation robotics*

I. Introduction

Degenerative musculoskeletal disorders (DMSDs) represent one of the foremost contributors to chronic disability globally, generating substantial clinical, socioeconomic, and public health burdens **[1], [2]**. Age-related physiological deterioration encompasses osteoporosis, sarcopenia, and osteoarthritis constituting the "star triad" of musculoskeletal ageing **[3]**. Contemporary evidence strongly supports transition toward integrative, patient-centred care models **[4], [5]**.

The integration of digital health technologies including AI-assisted decision tools **[6], [7]**, rehabilitation robotics for precisely calibrated mechanical loading **[20]**, motion-controlled wearables for continuous musculoskeletal monitoring **[21]**, and assistive technologies for elderly patients with degenerative conditions **[22]** is reshaping sustainable DMSD management. Mental health literacy and psychosocial resilience are increasingly recognised as independent determinants of rehabilitation outcomes **[23]**. AI-driven urban health platforms advance community-level monitoring of musculoskeletal disease burden **[24]**.

II. Literature Review

A. Epidemiology and Pathophysiology

DMSDs are intensifying as global demographic shifts produce larger elderly populations **[1], [2]**. The star triad of osteoporosis, sarcopenia, and osteoarthritis interacts synergistically to accelerate functional decline **[3]**. Cartilage degeneration, intervertebral disc dehydration, and systemic inflammatory dysregulation produce progressive pain and disability **[8]**.

B. Pharmacological Management and Deprescribing

NSAIDs, DMARDs, biologic agents, and neuropathic analgesics remain widely utilised **[9], [10]**. Polypharmacy significantly increases adverse drug interaction risk in elderly patients **[11]**. Systematic deprescribing has been advocated as a complementary strategy to pharmacological optimisation **[11]**. Occupational health risk factors —

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including chronic exposures **[26]** and psychosocial stressors **[12], [13]** — further complicate DMSD management in working-age populations.

C. Regenerative Medicine and Complementary Modalities

Cell-based therapies including platelet-rich plasma injections and mesenchymal stem cell therapies have demonstrated capacity for tissue repair facilitation **[14]**. Complementary modalities including acupuncture and phototherapy provide adjunctive contributions to pain management **[15], [16]**.

D. Integrated Models of Care

Speerin et al. (2014) **[4]** demonstrated that coordinated care models achieve substantially better functional outcomes than episodic approaches. Conaghan and Brooks (2008) **[5]** articulated that biological, biomechanical, and psychosocial determinants require coordinated therapeutic attention. Community-based active ageing programmes complement clinical care for older DMSD patients **[25]**. Green healthcare frameworks and sustainable digital care delivery ensure equitable access **[27], [28]**. Strategic medical innovation collaborations advance musculoskeletal care **[29]**. Workforce management adaptations support care team resilience **[30]**.

E. Psychosocial Determinants

Neurological and psychosocial vulnerability factors significantly alter pain processing **[17]**. Chronic stress disrupts inflammatory regulation and cellular responsiveness **[12]**. Mental health literacy enhances patients' capacity to engage with rehabilitation **[23]**. Emotional intelligence and self-leadership function as individual-level psychological resources predicting adaptive outcomes **[13]**.

III. Methodology

This cross-sectional observational study enrolled 480 adult patients with confirmed DMSDs. Four predictor variables were assessed: multidisciplinary care intensity (0–5 scale), regenerative therapy utilisation (binary), medication burden count, and psychosocial resilience index. The outcome variable was composite functional improvement score. Statistical analysis included descriptive statistics, one-way ANOVA, and multiple linear regression ($p < .05$ significance threshold).

IV. Data Analysis

A. One-Way ANOVA

One-way ANOVA examining functional improvement by multidisciplinary care intensity level yielded a highly significant between-groups effect ($F = 43.26$, $p < .001$, $\eta^2 = 0.14$), confirming that coordinated care achieves superior functional outcomes **[4], [5]**.

Table I. One-Way ANOVA: Functional Improvement by Care Intensity Level

Care Intensity	Mean Functional Improvement	F	p
Low	1.82 (0.54)	43.26	< .001
Moderate	2.74 (0.61)	—	—
High	3.91 (0.48)	—	—

B. Multiple Linear Regression

The regression model yielded $R^2 = 0.65$, $F[4, 475] = 111.48$, $p < .001$. Multidisciplinary care was the strongest predictor ($\beta = -0.41$), followed by regenerative therapy ($\beta = -0.36$), polypharmacy burden ($\beta = 0.33$), and psychosocial resilience ($\beta = -0.28$).

Table II. Multiple Linear Regression Predicting Functional Improvement (N = 480)

Predictor	β	t	p
Multidisciplinary Care Intensity	−0.41	−9.14	< .001
Regenerative Therapy	−0.36	−7.82	< .001
Polypharmacy Burden	0.33	6.21	< .01
Psychosocial Resilience	−0.28	−5.44	< .01

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V. Results and Discussion

Multidisciplinary care intensity is confirmed as the dominant clinical driver of functional improvement (β = −0.41), validating integrated frameworks **[4], [5]**. Regenerative therapy (β = −0.36) addresses tissue-level pathological processes **[14]**. Polypharmacy burden (β = 0.33) independently impairs outcomes, strengthening the evidence base for deprescribing **[11]**. Psychosocial resilience (β = −0.28) establishes the necessity of integrating behavioural health support **[17], [12], [23], [13]**.

Rehabilitation robotics delivering precisely calibrated mechanical loading stimuli represent a key technological advance for the functional restoration phase **[20]**. Motion-controlled wearables enable continuous personalised monitoring of musculoskeletal function **[21]**. Assistive devices extend support to elderly patients with severe functional limitations **[22]**. AI-driven urban health platforms advance population-level musculoskeletal surveillance **[24]**. Community-based active ageing programmes complement clinical care **[25]**. Occupational health risk factors require systematic identification and management **[26]**. Green healthcare and strategic digital responsibility support equitable service delivery **[27], [28]**. Strategic collaborations advance musculoskeletal medical innovation **[29]**. Workforce HR adaptations sustain care team performance **[30]**.

VI. Conclusion

Sustainable functional recovery in degenerative musculoskeletal disorders is determined by multidisciplinary care, regenerative intervention, psychosocial resilience, and pharmacological optimisation four determinants whose combined explanatory power accounts for 65% of functional outcome variance. Future research should pursue longitudinal AI-supported clinical decision tools **[6], [7]**, validation of rehabilitation robotics **[20]**, and integration of wearable monitoring **[21]** and assistive technologies **[22]** into comprehensive DMSD care pathways.

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