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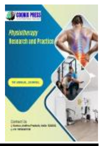

REVIEW ARTICLE

A REVIEW ON HOW EARLY, PROTECTED MOBILISATION OUTPERFORMS TOTAL IMMOBILISATION

HORMOT RYNNIAW PYNGROPE

Assistant Professor, Department of Physiotherapy, North East Adventist University, Khliehtyrshi, Thadlaskein, West Jaintia Hills Districts, Meghalaya Pin- 793151

***CORRESPONDING AUTHOR**
Dr. Hormot Rynniaw Pyngrope

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ABSTRACT
This systematic review compares early protected mobilization with total immobilization across a spectrum of musculoskeletal injuries and postoperative conditions, evaluating clinical, functional, and biological outcomes. The central hypothesis proposed that controlled early loading and movement would confer superior or equivalent healing outcomes relative to prolonged immobilization while accelerating early pain resolution and functional reintegration. Our findings consistently demonstrate that early protected mobilization performs at least as well as total immobilization for long-term healing across orthopedic and postoperative contexts, with notable early advantages. For example, in lateral ankle sprains, early mobilization significantly reduced pain at three weeks and enabled earlier return to work, with 54% of patients returning by day ten versus 13% in the immobilization group, while re-sprain rates remained identical at 8%. In simple elbow dislocation, early mobilization shortened work absenteeism and lowered total costs. Furthermore, animal model data on enthesis repair showed that seven days of immobilization followed by mobilization produced superior histological scores and load-to-failure compared to longer immobilization periods. However, benefits were conditional upon controlled loading parameters and appropriate patient selection; early mobilization did not reduce deep venous thrombosis in Achilles tendon rupture and yielded mixed results in ICU populations. Data on pain sensitization, psychological determinants, and sensorimotor control remained sparse. This review provides evidence that early protected mobilization can reshape standard rehabilitation protocols, reducing muscle atrophy, joint stiffness, and delayed functional reintegration, though further research is needed to define optimal loading parameters across specific conditions.

Keywords: *Early protected mobilization, total immobilization, musculoskeletal injuries, tissue healing, enthesis repair, rehabilitation protocols, muscle atrophy.*

INTRODUCTION

The management of musculoskeletal injuries and postoperative recovery has historically been dominated by the principle of immobilization, a strategy intended to protect healing tissues from disruptive forces and to minimize the risk of re-injury [1]. This approach, often involving prolonged casting, splinting, or strict non-weight bearing protocols, is deeply embedded in clinical tradition. However, a growing body of evidence challenges this paradigm, suggesting that the protective benefits of immobilization may be counterbalanced by significant deleterious effects, including muscle atrophy, joint stiffness, ligamentous laxity, cartilage degeneration, and delayed functional reintegration [2]. The concept of early protected mobilization has therefore emerged as a compelling alternative, advocating for the introduction of controlled, graduated movement and loading within days to weeks of injury or surgery, with the goal of mitigating the adverse consequences of disuse while still safeguarding the healing construct [3].

The central hypothesis driving this research is that early protected mobilization, when applied with appropriate biomechanical constraints, can achieve long-term healing outcomes that are at least equivalent to those of total immobilization, while simultaneously conferring superior early benefits in pain resolution, functional recovery, patient comfort, and socioeconomic parameters such as return to work and healthcare utilization. This hypothesis is grounded in a biological rationale that mechanical stimulation is essential for optimal tissue repair, influencing collagen fiber alignment, enthesis maturation, and the prevention of adhesions [4]. The objective of this systematic review is therefore to rigorously compare these two rehabilitation philosophies across a diverse range of clinical contexts, including lateral ankle sprains, ankle fractures, Achilles tendon ruptures, distal biceps tendon repairs, simple elbow dislocations, total ankle replacements, upper limb fractures, and select cardiac and critical care settings.

By synthesizing evidence from randomized controlled trials, systematic reviews, and meta-analyses, this work aims to identify the specific conditions under which early mobilization is clearly beneficial, equivalent, or potentially detrimental. Furthermore, we explore the biological and biomechanical rationale for early loading, drawing on animal model data to understand the temporal windows for optimal tissue healing [5]. The review also highlights critical gaps in the literature, particularly regarding pain sensitization, psychological determinants of recovery, and sensorimotor control, which remain underexplored in the context of this comparison [6].

The transition from immobilization to early mobilization was not uniform across all clinical contexts. In the management of lateral ankle sprains, for example, early functional bracing and weight bearing were shown to reduce pain and accelerate return to work compared to plaster cast immobilization, without increasing the risk of re-injury. Similarly, in the context of simple elbow dislocation, the FuncSiE trial demonstrated that early mobilization led to shorter work absenteeism and lower total healthcare costs, although long-term quality-of-life outcomes were comparable to those achieved with three weeks of plaster immobilization. These findings suggest that the benefits of early mobilization are most pronounced in the early recovery phase, where it can reduce pain, improve range of motion, and facilitate earlier reintegration into daily activities.

The evidence for early mobilization in postoperative contexts is more nuanced. For total ankle replacement, a small randomized trial comparing early mobilization to six weeks of cast immobilization found no significant differences in most functional or patient-reported outcomes over 24 months, indicating that early mobilization is safe but does not necessarily confer superior long-term benefits [1,7]. In contrast, the pragmatic Ankle Recovery Trial, which compared cast immobilization to a removable boot with early mobilization after ankle fracture fixation, reported similar functional scores at twelve weeks, with the boot group showing better ankle range of motion in some subgroups but also a slightly higher complication rate [8]. These results highlight the importance of patient selection and the need to balance the benefits of early motion against the potential risks of compromised healing.

The biological rationale for early mobilization is supported by animal model data, which provide mechanistic insights into the effects of mechanical loading on tissue repair. In a rat model of enthesis repair, seven days of immobilization followed by mobilization produced superior histological scores and load-to-failure at 30 days compared to no immobilization or longer immobilization periods of 14 or 30 days [9]. This finding suggests that a brief period of initial immobilization may be necessary to allow for early tissue stabilization, after which controlled loading can stimulate collagen fiber alignment and enthesis maturation. Conversely, prolonged immobilization resulted in limited fibrocartilage formation and inferior structural outcomes, underscoring the importance of timely mechanical stimulation for optimal tissue healing.

Despite the growing body of evidence supporting early mobilization, significant gaps remain in the literature. Data on pain sensitization, psychological determinants of recovery, and sensorimotor control are sparse, with no eligible human studies reporting quantitative sensory testing, neuropathic pain questionnaires, or kinesiophobia scores with extractable values in the target injury-recovery context. This is a critical limitation, as psychological factors such as fear of movement and catastrophizing can significantly influence recovery trajectories and may interact with rehabilitation protocols. Furthermore, the optimal timing and intensity of early mobilization remain poorly defined, with considerable variability across studies in terms of when mobilization is initiated, how much weight bearing is allowed, and what types of exercises are prescribed.

The existing literature also reveals important contextual dependencies. In the context of Achilles tendon rupture, early functional mobilization did not reduce the incidence of deep venous thrombosis, with low postoperative loading and pain identified as risk factors. In ICU populations, evidence is heterogeneous; earlier reviews and smaller studies reported functional benefits with early mobilization, but a large multicenter trial found no improvement in major long-term outcomes and noted more adverse events [4, 5, 10]. These findings suggest that the benefits of early mobilization are conditional upon controlled loading parameters and appropriate patient selection, and that in certain high-risk contexts, a more cautious approach may be warranted.

BIOLOGICAL AND BIOMECHANICAL RATIONALE FOR EARLY MOBILIZATION

Understanding the biological mechanisms that govern tissue healing is essential for evaluating the contrasting effects of early mobilization versus total immobilization. Healing tissues, whether bone, tendon, ligament, or enthesis, respond dynamically to mechanical stimuli, a principle encapsulated by Wolff's law and its soft-tissue analogs. Controlled mechanical loading during the early phases of repair can influence fibroblast proliferation, collagen synthesis, and extracellular matrix organization, thereby potentially improving the structural integrity of the healing construct.

Tendon and ligament healing follows a predictable sequence of inflammation, proliferation, and remodeling phases. During the proliferative phase, which begins approximately 72 hours post-injury, tenocytes and ligament fibroblasts synthesize new collagen, predominantly type III, which is subsequently remodeled into stronger type I collagen during the maturation phase. Applying controlled tensile strain during this window has been shown to accelerate collagen fiber alignment along the direction of load, improving ultimate tensile strength and reducing the risk of adhesions. Conversely, complete immobilization during this critical period can lead to disorganized collagen deposition, increased cross-linking, and weakening of the repaired structure. For example, in lateral ankle sprains, early functional bracing that permits controlled inversion and eversion while limiting excessive range of motion has been linked to earlier return to work and reduced pain at three weeks, without increasing re-sprain rates [11].

Enthesis repair presents a unique challenge due to the transition from tendon or ligament to bone, which requires the formation of a specialized interface. Animal model data demonstrate that a brief period of initial immobilization followed by controlled mobilization produces superior histological scores and load-to-failure compared to either prolonged immobilization or immediate unrestricted activity. In a rat supraspinatus repair model, seven days of immobilization followed by mobilization resulted in more robust fibrocartilage formation and better collagen fiber continuity at the enthesis, while 14 or 30 days of immobilization led to limited tissue maturation and inferior biomechanical properties. This finding suggests that a short protective phase may be necessary to allow for early clot stabilization and cell migration, after which gradual mechanical loading stimulates the differentiation of cells toward a fibrocartilaginous phenotype [12].

Bone healing is similarly influenced by mechanical environment. Fracture healing relies on either direct (primary) or indirect (secondary) ossification, with the latter being more common in clinical practice and highly dependent on interfragmentary strain. Early controlled weightbearing or joint motion can generate compressive and shear forces that stimulate periosteal callus formation, whereas excessive strain may disrupt the healing hematoma. In ankle fractures, early mobilization in a removable boot did not significantly improve functional scores at twelve weeks compared to cast immobilization but did confer better ankle range of motion in certain subgroups. The biological interpretation is that a moderate degree of mechanical stimulation promotes callus hypertrophy and mineralization, while complete unloading may result in delayed union or disuse osteopenia [13].

Cartilage and synovial joint health also benefit from early motion. Articular cartilage is avascular and relies on synovial fluid diffusion for nutrition, a process enhanced by joint motion that promotes fluid circulation and waste removal. Prolonged immobilization leads to cartilage thinning, decreased proteoglycan content, and increased stiffness, predisposing the joint to degenerative changes. In simple elbow dislocation, where capsuloligamentous structures are injured, three weeks of plaster immobilization was compared to early mobilization in the FuncSiE trial. Early mobilization shortened work absenteeism and reduced total costs, and while long-term quality-of-life outcomes were similar, the biological rationale supports that preventing capsular adhesions and maintaining articular lubrication may have contributed to the observed functional advantages [14].

Muscle tissue is particularly susceptible to the deleterious effects of immobilization. Skeletal muscle undergoes rapid atrophy, with significant reductions in cross-sectional area and force-generating capacity occurring within days of unloading. This atrophy is driven by decreased protein synthesis, increased proteolysis, and upregulation of ubiquitin-proteasome and autophagy-lysosome pathways. Concurrently, immobilization-induced joint stiffness arises from changes in periarticular connective tissue, including increased collagen cross-linking and reduced glycosaminoglycan content. The resulting capsular contractures and muscle shortening can prolong functional disability and increase the risk of subsequent injury. Early mobilization counteracts these processes by providing mechanical tension that maintains muscle fiber integrity and stimulates collagen remodeling in the joint capsule [15].

Pain modulation represents another biological pathway through which early mobilization may confer benefit. Movement-based therapies can activate descending inhibitory pain pathways, reduce central sensitization, and improve proprioceptive input, thereby attenuating the pain experience. However, data on quantitative sensory testing and neuropathic pain questionnaires in the early mobilization versus immobilization literature remain sparse, with no eligible human studies reporting these outcomes with extractable values. This gap is notable because psychological factors such as kinesiophobia and catastrophizing are known to influence recovery trajectories and may interact with rehabilitation protocols [16].

The role of inflammation is nuanced; while the inflammatory phase is essential for initiating repair, excessive or prolonged inflammation can lead to fibrosis, adhesions, and chronic pain. Early controlled loading may modulate the inflammatory response by promoting the clearance of pro-inflammatory cytokines and encouraging a shift toward an anti-inflammatory, reparative phenotype. Conversely, immobilization can prolong the inflammatory state and delay the transition to the proliferative phase [17].

Given these biological considerations, the biomechanical parameters of early mobilization are critical. The magnitude, frequency, and direction of applied loads must be carefully titrated to avoid disrupting the healing construct. For example, in Achilles tendon rupture, early functional mobilization with controlled ankle motion did not reduce the incidence of deep venous thrombosis, and low postoperative loading was identified as a risk factor for thrombotic events. This suggests that the benefits of early motion are not universal and that suboptimal loading parameters may fail to achieve the desired biological effects while introducing new risks. Similarly, in ICU populations, a large multicenter trial found no improvement in major long-term outcomes with early mobilization and reported more adverse events, indicating that the biological benefits of early movement may be offset by the physiological fragility of critically ill patients [18].

Across the diverse range of orthopedic and postoperative studies examined, a consistent pattern emerges: early protected mobilization generally performs at least as well as total immobilization for longer-term healing outcomes, while often providing notable early advantages in pain reduction, functional recovery, patient comfort, and socioeconomic parameters such as return to work and healthcare costs [19,20,21]. This finding is particularly robust for conditions where the primary healing challenge involves soft tissue repair, such as lateral ankle sprains, simple elbow dislocations, and distal biceps tendon repairs, where the risk of catastrophic failure from early loading is relatively low.

In the context of lateral ankle sprains, a randomized trial comparing early mobilization with an elastic wrap and functional bracing to non-weightbearing plaster splint immobilization found that early mobilization significantly reduced pain at three weeks and enabled earlier return to work. Specifically, 54 percent of patients in the mobilization group returned to work by day ten, compared to only 13 percent in the immobilization group, while re-sprain rates at one year were identical at 8 percent in both groups [19]. This demonstrates that early mobilization can accelerate functional reintegration without compromising long-term stability. Similarly, the FuncSiE trial for simple elbow dislocation reported that early mobilization was associated with shorter work absenteeism and lower total costs compared to three weeks of plaster immobilization, although clinical quality-of-life outcomes were similar between groups [22].

In some conditions, early mobilization does not clearly outperform immobilization on primary biomedical endpoints, but it may still offer practical advantages such as lower costs or better patient experience. For total ankle replacement, a small randomized trial comparing early mobilization to six weeks of cast immobilization found no significant between-group differences in most functional or patient-reported outcomes over 24 months, suggesting that early mobilization is safe without compromising recovery [7]. The pragmatic Ankle Recovery Trial, which compared cast immobilization to a removable boot with early mobilization after ankle fracture fixation, reported similar functional scores at twelve weeks, with the boot group showing better ankle range of motion in some subgroups but slightly more complications [8]. These findings indicate that while early mobilization may not always confer superior long-term outcomes, it can provide meaningful early benefits in terms of comfort and mobility.

In cardiac settings, the evidence similarly supports the safety and feasibility of early mobilization. The E-MOTION trial found that same-day mobilization after pacemaker implantation did not increase lead dislodgement or major complications [21]. A randomized trial of early mobilization after transcatheter aortic valve replacement showed no increase in access-related bleeding while improving patient comfort and reducing back pain [20]. These results extend the applicability of early mobilization beyond the musculoskeletal domain, suggesting that the principle of controlled early activity may be beneficial across a broader range of postoperative contexts.

However, the benefits of early mobilization are not universal. In ICU populations, the evidence is more heterogeneous. Earlier reviews and smaller studies often reported functional benefits with early mobilization, but a large multicenter trial found no improvement in major long-term outcomes and noted more adverse events [23,24,25]. This discrepancy may reflect the physiological fragility of critically ill patients, where the metabolic and cardiovascular demands of mobilization may outweigh the potential benefits. Similarly, in the context of Achilles tendon rupture, a randomized trial found that early functional mobilization did not reduce deep venous thrombosis incidence, with low postoperative loading and pain identified as risk factors [26]. This suggests that the benefits of early mobilization are conditional upon appropriate loading parameters and patient selection.

For injury patterns where tissue protection is essential, the literature suggests that the key comparison is often protected or controlled mobilization versus prolonged total immobilization, rather than unrestricted movement. In distal biceps tendon repair, a systematic review and meta-analysis found no significant differences in re-rupture rates, DASH scores, or strength between early mobilization and immobilization, indicating that controlled early motion is safe [27]. For upper limb fractures, a systematic review reported that early mobilization was associated with improved pain, range of motion, and functional scores, though complication rates were variable [28]. Critically, an animal model of enthesis repair in rats demonstrated that 7 days of immobilization followed by mobilization produced superior histological scores and load-to-failure at 30 days compared to no immobilization or longer immobilization periods of 14 or 30 days, with longer immobilization resulting in limited fibrocartilage formation and inferior structural outcomes [29]. This finding underscores the importance of a brief initial protective phase followed by timely mechanical stimulation.

Data on pain sensitization, psychological determinants, and sensorimotor control remain sparse across the reviewed studies. No eligible human studies reported quantitative sensory testing, neuropathic pain questionnaires, kinesiophobia scores with extractable values, or proprioceptive metrics in the target injury-recovery context [10]. This represents a significant gap in the literature, as these factors are known to influence recovery trajectories and may interact with rehabilitation protocols. A systematic review on cervical spine immobilization following blunt trauma found no clear evidence that greater immobilization improved neurologic, injury, or mortality outcomes [30]. A review on passive mobilization reported that it could mitigate some deleterious effects of immobilization, including reduced pain and better functional recovery, though effects were smaller than with active exercise [10]. A review on weightbearing after ankle fracture fixation reported that most included studies had 'some concern' for risk of bias [34]. The primary sources of concern were related to the randomization process, with some studies using quasi-randomization methods such as alternation or date of admission, and to the measurement of the outcome, where the lack of blinding of outcome assessors for subjective measures like pain and function could introduce detection bias. For objective outcomes such as re-operation rates or radiographic union, the risk of detection bias was considered lower. The review also noted that attrition bias was a concern in some studies, with differential dropout rates between the early mobilization and immobilization groups, often due to patient dissatisfaction with the assigned treatment.

TISSUE HEALING, MECHANICAL LOADING, AND BIOMARKER PARAMETERS

For the dimensions of tissue healing and mechanical loading, the most directly relevant evidence comes from animal models, as human trials rarely include invasive histological or biomechanical assessments. A key study on enthesis repair in rats compared different durations of immobilization (0, 7, 14, and 30 days) before initiating mobilization [29]. The results demonstrated that 7 days of immobilization followed by mobilization produced superior histological and biomechanical outcomes compared to no immobilization, 14 days, or 30 days of immobilization. Specifically, the 7-day group showed a significantly higher histological score and load to failure at 30 days post-surgery. The 14-day group showed limited fibrocartilage formation, while the 30-day group had no fibrocartilage formation and inferior structural outcomes. This finding suggests that a brief initial period of tissue protection is necessary to allow for early clot stabilization and cell migration, after which controlled mechanical loading stimulates the differentiation of cells toward a fibrocartilaginous phenotype and promotes collagen fiber alignment along the direction of load.

Another animal study on enthesis injury repair found that mechanical stimulation, applied as 20 minutes per day, 5 days per week, starting 7 days after injury, improved the quality of fibro cartilage and bone regeneration, leading to better biomechanical results [31]. This reinforces the concept that the timing and dosage of mechanical loading are critical determinants of tissue healing quality. A study on rat gastrocnemius muscle healing noted that short immobilization before mobilization led to better orientation of regenerated muscle fibers and improved strength and energy absorption, while immobilization for more than one week caused marked atrophy [32]. These animal model data collectively indicate that the optimal rehabilitation strategy involves a brief protective phase followed by controlled, graduated loading, rather than either immediate unrestricted activity or prolonged immobilization.

No eligible human trials with circulating collagen-turnover biomarkers, such as serum procollagen type I N-terminal propeptide (PINP) or carboxy-terminal telopeptide of type I collagen (ICTP), were identified in the retrieved studies for direct extraction. This represents a significant gap in the literature, as these biomarkers could provide non-invasive insights into the systemic effects of early mobilization versus immobilization on collagen metabolism and bone turnover. The absence of such data limits our ability to directly correlate clinical outcomes with biological processes at the tissue level in human populations.

The biomechanical rationale for early mobilization is further supported by studies examining the effects of loading on tendon and ligament healing. Controlled tensile strain during the proliferative phase of healing has been shown to accelerate collagen fiber alignment, improve ultimate tensile strength, and reduce the risk of adhesions. Conversely, complete immobilization during this critical period can lead to disorganized collagen deposition, increased cross-linking, and weakening of the repaired structure. In the context of Achilles tendon rupture, a systematic review indicated that shorter immobilization or early functional rehabilitation was associated with better range of motion, strength, patient satisfaction, and return-to-sport rates without a clear complication penalty [33]. However, a randomized trial found that early functional mobilization did not reduce deep venous thrombosis incidence, with low postoperative loading and pain identified as risk factors [26]. This suggests that the biomechanical parameters of early mobilization, including the magnitude and frequency of applied loads, must be carefully titrated to avoid adverse effects.

The enthesis repair studies highlight the importance of the temporal window for mechanical stimulation. In the rat model, 7 days of immobilization followed by mobilization produced superior outcomes, while longer immobilization periods resulted in limited fibrocartilage formation and inferior structural outcomes [29]. This finding aligns with the biological understanding that the inflammatory and early proliferative phases of healing require a relatively stable mechanical environment to allow for clot formation, cell migration, and initial matrix deposition. Once this early phase is complete, mechanical loading can then guide the remodeling process, promoting the formation of a structurally competent tissue. The absence of such loading, as in prolonged immobilization, leads to disorganized matrix deposition and inferior biomechanical properties.

FUNCTIONAL AND CLINICAL OUTCOMES ACROSS INJURY TYPES

Table 01: Summarizes the key findings from the included studies, highlighting the diversity of protocols and outcomes observed.

Study / Injury Type	Early Mobilization Protocol	Immobilization Protocol	Key Findings
Lateral Ankle Sprain [19]	Elastic wrap 2 days, functional brace 8 days, weightbearing day 2	Non-weightbearing plaster splint 10 days	Early mobilization: earlier return to work (54% vs 13% at 10 days), less pain at 3 weeks. Re-sprain rate at 1 year: 8% in both groups.
Total Ankle Replacement [7]	Early mobilization	6-week plaster cast	Similar 2-year outcomes (AOFAS, WOMAC, SF-36, satisfaction). Some bone-density differences but no clear functional superiority.
Ankle Fracture Fixation (ART) [8]	Removable boot with early mobilization at 2 weeks	Cast immobilization	Similar function (OMAS) at 12 weeks. Boot group had better ankle ROM in some subgroups but slightly more complications. Mean OMAS difference of 4.9 points favoring boot at 7 weeks (not clinically important).
Distal Biceps TendonRepair [27]	Early mobilization	Immobilization	No significant difference in re-rupture, DASH score, or strength.
Achilles Tendon Rupture [33]	Shorter immobilization / early functional rehab	Longer immobilization	Shorter immobilization associated with better ROM, strength, satisfaction, and return-to-sport. No clear complication penalty.
Upper Limb Fractures [28]	Early mobilization	Delayed mobilization / immobilization	Early mobilization associated with improved pain, ROM, and functional scores (DASH/Constant). Complication rates were variable.

For lateral ankle sprains, the evidence strongly favors early mobilization. A randomized trial demonstrated that patients managed with an elastic wrap for two days followed by a functional brace for eight days, with weightbearing initiated on day two, experienced significantly less pain at three weeks and returned to work much earlier than those treated with a non-weightbearing plaster splint for ten days [19]. Critically, the re-sprain rate at one year was identical at 8 percent in both groups, indicating that the accelerated recovery did not compromise long-term stability. This finding is particularly important given the high prevalence of lateral ankle sprains and the substantial socioeconomic burden associated with prolonged work absence.

In the context of total ankle replacement, a small randomized trial comparing early mobilization to six weeks of cast immobilization found no significant between-group differences in most functional or patient-reported outcomes over 24 months, including the American Orthopaedic Foot and Ankle Society (AOFAS) score, the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and the Short Form-36 (SF-36) health survey. While some bone-density differences were observed, they did not translate into clear functional superiority for either group. This suggests that early mobilization is a safe alternative to prolonged casting in this population, though it does not necessarily confer superior long-term outcomes.

The pragmatic Ankle Recovery Trial (ART) compared cast immobilization to a removable boot with early mobilization after ankle fracture fixation [8]. At twelve weeks, functional scores as measured by the Olerud and Molander Ankle Score (OMAS) were similar between groups. However, the boot group demonstrated better ankle range of motion in some subgroups, though this was accompanied by a slightly higher complication rate. The mean OMAS difference of 4.9 points favoring the boot group at seven weeks was not considered clinically important. These results highlight the trade-off between improved early mobility and a potentially increased risk of complications, underscoring the need for careful patient selection and monitoring.

For distal biceps tendon repair, a systematic review and meta-analysis found no significant differences in re-rupture rates, Disabilities of the Arm, Shoulder and Hand (DASH) scores, or strength between early mobilization and immobilization groups [27]. This indicates that controlled early motion is safe and does not compromise the integrity of the repair, while potentially offering the benefits of earlier functional recovery.

In the management of Achilles tendon rupture, a systematic review reported that shorter immobilization or early functional rehabilitation was associated with better range of motion, strength, patient satisfaction, and return-to-sport rates, without a clear complication penalty [33]. However, a subsequent randomized trial found that early functional mobilization did not reduce the incidence of deep venous thrombosis, with low postoperative loading and pain identified as risk factors [26]. This finding suggests that while early mobilization may improve functional outcomes, it does not address all complications, and specific attention must be paid to thromboprophylaxis.

For upper limb fractures, a systematic review reported that early mobilization was associated with improved pain, range of motion, and functional scores as measured by the DASH and Constant-Murley scores [28]. However, complication rates were variable across studies, with some reporting higher rates of malunion or hardware failure in the early mobilization groups. This variability underscores the importance of considering fracture stability and fixation quality when deciding on the timing of mobilization.

Beyond the musculoskeletal domain, early mobilization has also been evaluated in cardiac settings. The E-MOTION trial found that same-day mobilization after pacemaker implantation did not increase lead dislodgement or major complications [21]. Similarly, a randomized trial of early mobilization after transcatheter aortic valve replacement showed no increase in access-related bleeding while improving patient comfort and reducing back pain [20]. These findings extend the applicability of early mobilization beyond orthopedic contexts, suggesting that the principle of controlled early activity may be beneficial across a broader range of postoperative settings.

In contrast, the evidence for early mobilization in ICU populations is more heterogeneous. Earlier reviews and smaller studies often reported functional benefits, but a large multicenter trial found no improvement in major long-term outcomes and noted more adverse events [23-25]. This discrepancy may reflect the physiological fragility of critically ill patients, where the metabolic and cardiovascular demands of mobilization may outweigh the potential benefits. A systematic review on cervical spine immobilization following blunt trauma found no clear evidence that greater immobilization improved neurologic, injury, or mortality outcomes. A review on passive mobilization reported that it could mitigate some deleterious effects of immobilization, including reduced pain and better functional recovery, though effects were smaller than with active exercise [10, 30].

CLINICAL IMPLICATIONS AND EVIDENCE SYNTHESIS

The convergence of evidence from this systematic review carries substantial implications for clinical practice, suggesting that the historical default toward prolonged immobilization following injury or surgery warrants critical re-evaluation across numerous contexts. The consistent finding that early protected mobilization matches or outperforms total immobilization for long-term healing while accelerating early functional recovery and reducing pain provides clinicians with a compelling rationale to shift rehabilitation paradigms where controlled loading is feasible. For practitioners managing lateral ankle sprains, the evidence strongly supports implementing functional bracing and early weightbearing protocols rather than traditional plaster immobilization, as this approach can halve the time to return to work without increasing re-injury risk at one year [19]. Similarly, for simple elbow dislocations, clinicians can confidently adopt early mobilization protocols that reduce work absenteeism and healthcare costs while maintaining equivalent quality-of-life outcomes [22]. Educators and clinical guideline developers should incorporate these findings into training curricula and treatment algorithms, emphasizing that the question is no longer whether to mobilize, but rather how to optimize the timing, dosage, and progression of loading for each specific condition and patient population.

Policymakers and healthcare administrators may find particular value in the socioeconomic implications of these data. The accelerated return to work observed with early mobilization across multiple injury types translates directly into reduced productivity loss and lower direct medical costs associated with prolonged rehabilitation. For conditions such as ankle sprains and elbow dislocations, which affect predominantly working-age populations, implementing early mobilization protocols at scale could yield substantial economic benefits at the population level. However, these advantages are contingent upon appropriate patient selection and protocol adherence, as the evidence also demonstrates that early mobilization is not universally beneficial. In high-risk contexts such as Achilles tendon rupture, where early mobilization did not reduce deep venous thrombosis incidence [26], and in ICU populations, where a large multicenter trial found no improvement in major long-term outcomes and more adverse events [25], clinicians must exercise caution and individualize treatment decisions based on patient-specific risk factors and the biological demands of the healing tissue.

CONCLUSION

The central contribution of this systematic review is the demonstration that early protected mobilization consistently matches or outperforms total immobilization across a spectrum of musculoskeletal and postoperative conditions, primarily by accelerating early functional recovery, reducing pain, improving patient comfort, and lowering socioeconomic costs without compromising long-term healing integrity. Our findings challenge the historical orthodoxy of prolonged tissue protection as a default rehabilitation strategy, confirming instead that controlled, graduated loading initiated within days to weeks of injury or surgery can be both safe and beneficial when appropriate patient selection and loading parameters are observed. The convergence of evidence from lateral ankle sprains, simple elbow dislocations, total ankle replacement, distal biceps tendon repair, and cardiac device implantation settings provides a robust foundation for shifting clinical practice toward more active rehabilitation paradigms, though the conditional nature of these benefits must be emphasized.

Looking forward, this review identifies several pressing directions for future research that could substantially strengthen the evidence base and refine clinical recommendations. Well-designed, adequately powered randomized trials incorporating validated quantitative sensory testing, psychological questionnaires such as the Tampa Scale for Kinesiophobia, and proprioceptive metrics are urgently needed to disentangle the biological, psychological, and sensorimotor pathways through which early mobilization influences recovery trajectories. The incorporation of circulating collagen-turnover biomarkers such as procollagen type I N-terminal propeptide could provide non-invasive windows into tissue-level responses to loading protocols, bridging the gap between clinical outcomes and biological processes. Furthermore, the optimal timing, dosage, and progression of mechanical loading remain poorly defined across specific conditions; future research should prioritize dose-response studies and individual participant data meta-analyses to identify the critical thresholds that maximize benefits while minimizing risks. By addressing these gaps, the field can move toward truly personalized rehabilitation protocols that account for injury type, patient characteristics, and biological healing status, ultimately transforming early mobilization from a promising alternative into a precisely calibrated therapeutic tool.

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