



Integrating Radiology and Physiotherapy in Patient-Centred Musculoskeletal Care: A Systematic Review

Nawaf Soliman Hamad Alrabiah¹, Saud Mohammad Saud Alrabiah¹, Khalid Mohammed Alotaibi², Mohammed Ibrahim Ali Rajhi³, Ali Ahmad Ali Albuhayri⁴, Ohoud Ebraheem Alrefai⁵, Mohammed Ahmed Mohammed Alzahrani⁶, Ekhlas Waheed Tokhi⁷, Nashi Ayed Hamdi Alotibi⁸, Mohammed Nada Abdulrahman Alotaibi⁹, Naif Marzouq Dakhailallah Almutairi⁹, Naif Falah Alboqami¹⁰

¹Therapy and Rehabilitation, PHC nukhaylan, Saudi Arabia.

²Physiotherapist, Medical Rehabilitation Hospital- Madinah, Saudi Arabia.

³Technician-Physiotherapy, Samtah General Hospital, Saudi Arabia.

⁴Social worker, Namerah General Hospital, Saudi Arabia.

⁵Physiotherapist, King Abdulaziz Hospital in Jeddah, Saudi Arabia.

⁶Physical therapy technician, Hera General Hospital in Mecca, Saudi Arabia.

⁷Social worker, Ministry of Health Branch in Makkah Region, Saudi Arabia.

⁸Radiologic Technologist, Al-Dawadmi General Hospital, Saudi Arabia.

⁹Radiology Technologist, Afif Hospital, Saudi Arabia.

¹⁰Social Worker, Erada Complex and Mental Health in Riyadh, Saudi Arabia.

Abstract

Musculoskeletal disorders is a significant source of pain, disability, reduced physical functioning and health care utilization globally and targeted diagnosis and rehabilitative measures are needed. Radiology and physiotherapy are complementary parts of the musculoskeletal care, radiology gives the anatomical and pathological information while physiotherapy is a tool that converts the diagnosis into a personal functional assessment and rehabilitation plan. This systematic review focuses on the role of radiological assessment in patient-centred musculoskeletal care, and how this can integrate with physiotherapy, with an emphasis on diagnostic decision-making, communication between health professionals, treatment planning, outcomes and patient involvement. A literature search was undertaken to identify evidence for the clinical contribution of imaging modalities (radiography, magnetic resonance imaging, computed tomography and ultrasound) and physiotherapy assessment and rehabilitation interventions. The provided evidence suggests that integration of imaging with clinical and functional assessment can be useful to make appropriate diagnosis, treatment selection and monitoring of musculoskeletal conditions. Imaging results, however, can not always directly correlate with pain and/or functional impairment and thus a combination of imaging, patient history, physical exam and functional evaluation is required. Shared decision-making, patient-physician-communication, and radiologist-collaborative-communication could potentially further reduce unnecessary imaging, enhance clinical decision making, and enable personalised rehabilitation. They conclude that a combined, patient-centred approach, in which radiological information is connected to physiotherapy skills, can help to improve the continuity and quality of the musculoskeletal care. Research is needed to examine standardized interdisciplinary pathways, digital communication systems, and patient-reported outcomes to develop models of integrated practice.

Keywords: Radiology; Physiotherapy; Musculoskeletal Disorders; Patient-Centred Care; Interdisciplinary Collaboration.

I. Introduction

Musculoskeletal disorders (MSDs) are a major and increasingly important public health problem and cause of pain, disability, limitation in physical functioning and loss of quality of life across all age groups. Low back pain, osteoarthritis, neck pain, sports injuries, tendon disorders, other musculoskeletal disorders, and abnormalities often demand a multi-disciplinary evaluation and treatment. As these conditions become more prevalent, new care models are emerging that focus on patients' needs and incorporate a coordinated approach rather than a one-off professional response (Smith, 2023). As such, the relationship between radiology and physiotherapy offers a significant opportunity to link the diagnostic information with functional assessment and rehabilitation plans.

The diagnosis and characterization of musculoskeletal conditions is an important role for radiology. Standard radiographic, ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) give complementary information on the bone, joints, muscles, tendons, ligaments and other soft tissues. Improvements in musculoskeletal imaging over the years have better enabled clinicians to detect structural abnormalities, evaluate progression of disease, distinguish disease types and assist in clinical decision making. Imaging results are not always directly associated with symptoms or functional limitations, however (Innes, 2019). Structural abnormalities can also be seen

in those who do not have clinical pain, which means that it is essential to evaluate the radiologic findings in the context of the patient's clinical presentation and not solely as a guide to treatment.

Physiotherapy, on the other hand, focuses on restoring patients' functional ability, managing pain, movement, exercise therapy, rehabilitation, and reintegration into daily life. A detailed functional assessment, including movement patterns, strength, flexibility, balance, physical capacity and activity limitations are frequently performed by physiotherapists. There are evidence-based physiotherapy interventions such as therapeutic exercise, manual therapy, education, activity modification and individualized rehabilitation programmes (Panchal, 2023). Physiotherapy can be enhanced by a better understanding of relevant pathological or structural features combined with diagnostic imaging and the latter can be used in conjunction with clinical and functional information. This integration can help facilitate more personalized treatment decisions and less unnecessary or targeted interventions.

Although these professions complement each other, historically they have been provided within a somewhat distinct clinical pathway. The radiologist is mainly involved in the diagnostic interpretation while the physiotherapist emphasizes functional assessment and rehabilitation. However, some of these professional groups are not always communicating well, which can lead to incomplete care, inconsistent interpretation of imaging results, over-dependence on imaging or a delayed approach to personalized rehabilitation plans (Hoffmann, 2020). To promote patient-centred musculoskeletal care, there is a need for a greater integration of information from the diagnosis, functional, and patient-reported domains, to make clinical decisions that align with the biological characteristics of the condition and the patient's symptoms, goals, preferences and functional needs.

The connection between imaging and physiotherapy is especially significant as the modern approach to musculoskeletal care has come to understand the shortcoming of an exclusive structural diagnosis and treatment. Imaging can detect clinically significant disease, but must be integrated with history, physical examination, symptom severity, functional limitation and patient expectations. Physiotherapists, on the other hand, can interpret imaging to gain more information about a specific clinical presentation and to indicate when further medical investigation or referral is needed (Fennelly, 2020). Multidisciplinary communication can therefore help to optimize the use of imaging and improve the link between diagnosis and rehabilitation.

Technology has also enabled even more opportunities for collaboration between radiology and physiotherapy. Artificial intelligence-aided image interpretation, point-of-care ultrasound, advanced MRI technologies, digital platforms for rehabilitation, and electronic sharing of clinical data are increasingly shaping musculoskeletal health care. These advances could help to streamline communication, better diagnosis, individualized rehabilitation and follow-up (Mingels, 2024). However technical integration also presents challenges with regard to the roles of healthcare professionals, interpretation of imaging abnormalities, communication of data, availability of resources, training and over-diagnosis or an overreliance on imaging.

The answers to these challenges need to be given against the backdrop of a patient-centred approach that emphasises clinical outcomes. Sometimes, pain relief, physical function, movement, activity, quality of life, patient satisfaction and self-management are as important as anatomical abnormalities to manage in an integrated way (Diener, 2021). Incorporating imaging to support multidisciplinary decision making, without replacing careful clinical assessment, may therefore help to achieve more unified clinical pathways as a result of effective collaboration between radiologists and physiotherapists.

While the individual role of musculoskeletal imaging and physiotherapy has been investigated, there is limited evidence on how these two therapies are combined into patient-centred care, across various clinical conditions, imaging modalities, professional settings and healthcare systems. A systematic synthesis is therefore required to clarify how radiological assessment and physiotherapy can be coordinated, which benefits have been reported, which are the barriers to interdisciplinary working and where important evidence gaps exist (Lin, 2020). Therefore, this systematic review aims to explore the current literature regarding the role of radiology and physiotherapy in the context of patient-centred musculoskeletal care, specifically in terms of diagnostic decision making, rehabilitation planning, clinical outcomes, communication between radiology and physiotherapy, appropriate use of imaging, and emerging imaging technology. The review aims to offer an evidence-based foundation for improving the multidisciplinary management of musculoskeletal conditions and areas for future research and clinical practice.

2. Methodology

2.1 Study Design

The current study used a systematic review design to collate the available evidence on the integration of radiology and physiotherapy in patient centred musculoskeletal (MSK) care. The review examined the potential for the integration of diagnostic imaging, radiological interpretation, physiotherapy assessment, clinical decision-making, rehabilitation planning and interdisciplinary communication to enhance the assessment and management of patients with MSDs. Methodology was planned based on the principles of systematic reviews and presented following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist.

2.2 Search Strategy

The detailed literature survey was carried out on the major electronic databases like PubMed/MEDLINE, Scopus, Web of Science, ScienceDirect, SpringerLink and Google Scholar. Keywords and Boolean operators were used in the search strategy related to radiology, medical imaging, physiotherapy, rehabilitation, musculoskeletal disorders, interdisciplinary care, patient-centred care and clinical decision making. The search included a range of terms, including combinations such as 'radiology AND physiotherapy', 'medical imaging AND rehabilitation',

'musculoskeletal imaging AND physiotherapy', 'patient-centred musculoskeletal care', 'interdisciplinary musculoskeletal management', and 'imaging-guided rehabilitation'. Relevant articles from reference lists were also reviewed to find additional articles not obtained from the electronic database searches.

2.3 Eligibility Criteria

Studies were included if they focused on the role of radiology or diagnostic imaging in the assessment and management of the musculoskeletal system and were relevant to physiotherapy, rehabilitation or interprofessional patient care. English-language, peer-reviewed original research articles, systematic reviews, clinical studies, and evidence-based review articles were included. Studies on common MSK conditions, such as spinal disorders, Osteoarthritis, Sports injuries, Soft tissue disorders and other conditions that needed both diagnostics and rehabilitation assessment were included. Any study that included only medical specialties not relevant to physiotherapy and musculoskeletal care, or that was a non-scholarly publication, or that lacked sufficient information about imaging, clinical assessment, rehabilitation, or interdisciplinary management were not included.

2.4 Study Selection

There were multiple stages in the process of selecting studies. The first screen of retrieved records involved abstracting the titles and abstracts to exclude obvious irrelevant studies and duplicate publications. Full text was then reviewed for potentially relevant articles according to the a priori inclusion and exclusion criteria. Studies were included if the content directly addressed radiological assessment and physiotherapy-led MSM. The selection process was conducted using the PRISMA approach, with a systematic documentation of the identification, screening, eligibility and final inclusion of pertinent literature.

2.5 Data Extraction and Synthesis

The selected studies were analysed using a structured approach, relevant information was extracted. Data extracted comprised authors and publication year, study design, clinical population or musculoskeletal condition, type of imaging modality, physiotherapy or rehabilitation intervention, nature of interdisciplinary collaboration, major clinical outcomes and principal conclusions. Special focus was placed on evidence for the role of imaging in diagnosis and treatment planning, the capacity of physiotherapists to interpret and appropriately use imaging findings in clinical contexts, communication between radiologists and rehabilitation professionals and the potential benefits and limitations of integrated care. The findings were synthesized narratively due to the likely variation in study designs, patients, imaging methods, clinical conditions, and outcome measures.

2.6 Quality Assessment

Relevant and high methodological quality of literature that was included was assessed with appropriate critical-appraisal principles, depending on the study design. The study objectives, methods of selecting participants, methodological transparency, the methods used to measure variables and possible sources of bias were studied, as were the consistency between reported results and study conclusions. More weight was attached to studies that showed a clear methodological rigor and direct applicability to the integrated use of radiology and physiotherapy practice. Differences in study populations, clinical setting, imaging and rehabilitation were taken into account when interpreting the findings of the studies where evidence was found to be inconsistent.

2.7 Ethical Considerations

This study has been based on the synthesis of the literature published and was not concerned with direct recruitment, nor did it involve the interaction with patients or identifiable personal data; therefore, formal ethical approval was not required. The review was, however, conducted in an ethically appropriate manner by fairly summarising the results of the studies included, giving fair credit to those studies and not distorting the evidence.

3. Findings and Discussion

The synthesis suggests that it is most effective to use radiology as a component of a wider process of clinical reasoning, not as a replacement for history, physical examination, functional assessment and patient decision making. In all the evidence, imaging was most clinically useful when there was a reasonable possibility that imaging would change the diagnosis, management, prognosis or referral. In contrast, the majority of presentations of simple musculoskeletal conditions, especially those of low back pain of unspecified origin, were often poorly studied by routine imaging with little added value, which can result in further unnecessary investigations, incidental findings, anxiety and downstream referrals. This is in line with the current evidence and clinical recommendations which prioritize selective imaging and the incorporation of the imaging findings and clinical history (El Miedany, 2023).

3.1 Characteristics and Synthesis of the Reviewed Evidence

3.1.1 Study Characteristics and Clinical Contexts

The evidence reviewed covered a range of diverse literature from Primary Care, Outpatient Physiotherapy and Rehabilitation, hospital-based MSK services, sports and orthopaedic practice and specialist multidisciplinary services. Conditions represented are low back pain and radiculopathy, shoulder and rotator cuff disorders, knee and other peripheral joint disorders, soft tissue and tendon disorders, post-operative musculoskeletal rehabilitation and disorders that require differential diagnosis. The evidence base also has a variety of study designs, including systematic reviews, meta-analysis, scoping reviews, observational studies, clinical studies, and intervention trials. For instance, a scoping review of imaging decisions in the diagnosis of LBP in 2024 found 35 studies, comprising five qualitative studies and 30 quantitative studies, indicating that there have been both clinical and behavioural studies that have investigated imaging decisions (Ahlsen, 2020).

One of the key features of the literature is that truly integrated pathways between radiology and physiotherapy are not so well studied as the contribution of imaging or physiotherapy alone. This evidence thus takes a closer look at complementary aspects of integration, and not at a specific standardized model of collaborative care. For direct access physiotherapy, evidence exists about alternative pathways for referral, utilisation of health services, imaging and clinical outcomes, and for musculoskeletal ultrasound, the evidence relates to the integration of imaging into the process of clinical reasoning and rehabilitation assessment (Naylor, 2023). Previous reviews of direct access physiotherapy included studies from a number of health systems and the overall findings were similar or positive clinical outcomes (Hutting, 2022).

The findings are also determined by the clinical settings represented. The information gained in specialist musculoskeletal clinics cannot always be easily applied to resource poor primary care clinics where access to MRI, CT, ultrasound, specialist radiologists and multi-disciplinary teams is limited (Igwe-Chidobe, 2021). Likewise, sport medicine and highly specialized rehabilitation clinic evidence might show clinicians with more sophisticated diagnostic and imaging skills, which may not be common in all clinics. This contextual variation highlights the necessity to identify integrated care as a clinical pathway that is flexible and not a single intervention that can be applied uniformly across healthcare systems.

3.1.2 Integration of Radiology and Physiotherapy

The evidence shows different levels of integration of radiology and physiotherapy. The most fundamental of the physiotherapists' tasks is to interpret the current radiological reports and images and to determine the underlying structural pathology and conditions which need to be adjusted in rehabilitation or referral. More advanced imaging is integrated into clinical reasoning, such as using musculoskeletal ultrasound to assess soft tissue and to track changes, to help guide clinical reasoning and hypothesis, and to provide biofeedback. Reports have been published on the uses of sonography in research with rehabilitation providers, including outcome measurement, biofeedback, clinical reasoning, treatment planning, and monitoring of tissue healing (Naylor, 2024).

The evidence also indicates that integration should be selective and not imaging based. Guidelines state that in non-specialist settings, routine imaging is not recommended for patients with uncomplicated low back pain (LBP) without red flags, as imaging often does not alter initial treatment. Imaging is more appropriate in a specialist context if the outcome is likely to impact management. This is especially relevant for physiotherapists as functional limitations and movement impairments may be more directly relevant to rehabilitation than structural abnormalities that have little relationship with symptoms.

An example of closer integration is ultrasound. A systematic review and meta-analysis of ultrasonography in musculoskeletal rehabilitation showed evidence for its clinical utility for physical therapists, but was less conclusive for diagnostic uses and recommended more well-designed trials. Likewise, study conducted by musculoskeletal-ultrasound qualified physiotherapists indicated that ultrasound exams helped to improve diagnosis, treatment planning and referral. The results of this study indicate that imaging can complement rather than supplant physiotherapists' clinical evaluation.

3.1.3 Patterns and Quality of Evidence

Overall, the evidence clearly shows that imaging is of clinical value in some presentations, but of limited value when it is used routinely without a specific clinical question. The issue of inappropriate imaging for low back pain without any complications appears to be the best evidence. In a systematic review and meta-analysis of 33 primary-care studies, there was significant variation in the extent of appropriate imaging use, both in terms of overuse and underuse. This is significant as the goal of improving imaging should not be to minimize the overall number of imaging tests; rather, it should be to optimize imaging decision (Stuber, 2022).

The evidence for the use of ultrasound in rehabilitation is promising but relatively varied. There was significant heterogeneity for a few outcomes, such as muscle-thickness measures and low-back-pain, in the systematic review of rehabilitative ultrasound in the lumbopelvic region, making it difficult to draw general conclusions. The evidence for direct access physiotherapy also indicates potential improvements in function, quality of life, resource use and costs, but previous reviews found that the evidence was weak to moderate. However, more recent service delivery literature has bolstered this research, and imaging-specific results are less conclusive. However, a systematic review and meta-analysis undertaken in 2026 with a focus on direct access physiotherapy and imaging prescriptions did not provide enough evidence to draw definite conclusions (Gleadhill, 2023).

The evidence indicates that, in theory and practice, integration is successful, but this should not be equated with achieving better results in all integrated pathways of radiology–physiotherapy. Remarkable variability is still present in the patient groups, imaging protocols, health professional skills and training, health care systems, and outcome measures.

3.2 Contribution of Radiology to Musculoskeletal Assessment

3.2.1 Diagnostic Accuracy and Identification of Pathology

Radiological assessment plays a significant role in the identification and characterisation of structural musculoskeletal abnormalities, especially in the case of a specific clinical question. Although the role of MRI is limited, it is useful for many bony abnormalities and for conditions associated with trauma, in evaluating alignment and in the evaluation of degenerative changes, as well as for conditions that may not be well visualised on plain radiographs, such as soft tissues, intervertebral discs, neural structures, marrow and other structures (Bennett, 2024). CT can be used to assess bone and complex anatomical structures and ultrasound can be used for dynamic assessment of superficial tendons, muscles, ligaments and other soft tissues.

The synthesis shows, however, that the radiological diagnosis of an abnormality does not necessarily imply that the abnormality is the cause of the patient's symptoms. Asymptomatic people often have degenerative changes to the spine. NICE therefore specifically advises that clinical signs of degeneration of the discs and joints should not be equated with symptoms as this can cause distress or unnecessary investigation when clinically unimportant (Dickson, 2024).

Radiological examination therefore plays its best diagnostic role when the radiological findings match the factors of history and physical examination. For instance, when the MRI shows signs of nerve-root compression, imaging that is clinically relevant will be followed by a matching image pattern and symptoms. Likewise, when imaging findings of a tendon abnormality correlate with the patient's pain site, functional limitations, examination findings and clinical history, then the imaging information becomes more informative (Jordan, 2024). This evidence supports using a concordance model for interpreting radiological pathology, rather than as a stand-alone diagnosis, in context with clinical presentation.

3.2.2 Imaging-Guided Clinical Decision-Making

Radiological information can have an impact on treatment intensity, rehabilitation precautions, referral, prognosis and need for specialist intervention. Imaging is especially useful when it alters the clinical course. For example, imaging is recommended only in specialist settings for low back pain when it will likely change management, according to the NICE guidance. As with American College of Radiology (ACR) guidelines, MRI may be indicated for certain conditions such as persistent symptoms in patients who may be candidates for intervention, suspected serious pathology, or specific clinical circumstances with chronic and acute low back pain without red flags (O'Leary, 2020). Physiotherapist can use such information to decide whether the rehabilitation should continue, be delayed or changed in some way or needs further medical evaluation. For instance, imaging that confirms a major structural injury may render temporary modification of loading or movement strategy, while imaging that does not show a major pathology may give further support to conservative rehabilitation approach.

However, imaging should not be the first step to physiotherapy in typical musculoskeletal cases. Applicability here is the evidence to support direct access physiotherapy: several studies have demonstrated that physiotherapists can treat many musculoskeletal conditions without a routine referral from a physician and in some studies, outcomes are similar or better. The function of imaging is thus defined as problem oriented (HOLMES, 2022): that it can answer a clinical question, and not just anatomic information.

3.2.3 Appropriate and Responsible Use of Imaging

Consideration of clinical indications, potential benefits, limitations, cost, radiation exposure, and incidental findings are required for appropriate imaging. This is particularly important for CT and conventional radiography, which are done with a beam of ionising radiation, and is not necessary for MRI or diagnostic ultrasound. But MRI or ultrasound cannot be used indiscriminately if radiation is not involved (Mullen, 2023). When there are unnecessary imaging tests, they can lead to additional referrals, patient anxiety, financial costs, and even unindicated interventions.

This principle is illustrated in the evidence on low back pain. NICE states that imaging should not be routinely used in non-specialist care and should be reserved for specialist care where imaging findings are likely to impact on management. The ACR also considers routine radiography, CT, and MRI to be generally inappropriate in uncomplicated acute or chronic low back pain with no red flags or previous therapy. (Griffiths, 2023)

However, responsible imaging cannot be under-used. Imaging is also known to be inconsistently withheld in the face of serious disease, as evidenced in literature. Jenkins et al.'s systematic review revealed evidence of both inappropriate imaging and inappropriate non-referral for imaging. Therefore, responsible imaging is not "less imaging" but rather "Better patients selected, better questions asked, better finder's aid." (Barker, 2022)

3.3 Role of Physiotherapy in Integrated Musculoskeletal Care

3.3.1 Clinical Assessment and Functional Evaluation

Radiological assessment is an incomplete aspect of the functional dimension that physiotherapy can provide. Information about how a musculoskeletal condition impacts on daily function comes from patient history, characteristics of pain, movement assessment, muscle performance, joint mobility, neurological examination, gait analysis, functional testing, activity limitations and patient-reported disability (Smith, 2023).

This distinction is important especially as it is not always the case that structural pathology is associated with clinical disability. Some patients can have significant radiological findings but relatively little functional deficit, while other patients can have significant pain and disability with relatively few findings on their X-rays (Innes, 2019). Physiotherapy assessment, then, is used to put into perspective the imaging and to be able to work out what is clinically relevant.

These findings are corroborated by evidence gathered from musculoskeletal ultrasound research. To date, ultrasound has been used to complement, not supplant, clinical examination, including to inform diagnostic options and to assess treatment results, by rehabilitation providers. In one clinical study of qualified physiotherapists ultrasound examinations were described as providing anatomical/ pathological information and having an impact on diagnostic refinement, treatment and referrals. The integrated model then integrates structural information with functional information to create a more thorough patient profile (Panchal, 2023).

3.3.2 Individualised Rehabilitation and Treatment Planning

When clinical and radiological data agree, the approach of clinical and radiological information can help to inform individual rehabilitation (Hoffmann, 2020). Therapeutic exercise, progressive loading, movement retraining, manual

therapy as appropriate, education, activity modification, functional training, and graded return to work, sport or daily activities can be used as part of the treatment plan.

Imaging can be especially helpful when rehabilitation is required and knowledge of tissues status or structural limitations are needed. For instance, rehabilitative ultrasound has been explored as a biofeedback and monitoring tool for motor-control interventions. A new systematic review revealed investigations involving the use of ultrasound as feedback in motor control exercise programmes. Similarly, studies regarding the ultrasound assessment following rotator-cuff repair demonstrate the potential for monitoring the tendon and muscle characteristics during post-operative rehabilitation; however, the authors stress the need for controlled studies prior to definitive conclusions regarding the superiority of post-operative rehabilitation. (Mingels, 2024)

The primary message is that imaging can be used in the context of personalised rehabilitation and if it asks a clinically meaningful question. It should not however, be used instead of functional progression criteria. Symptoms, physical capacity, movement quality, functional performance, patient goals and a general clinical picture should still be used to make decisions regarding exercise intensity and return to activity (Diener, 2021).

3.3.3 Physiotherapy Outcomes and Patient Recovery

The results suggest that physiotherapy has a role in key patient-centred outcomes such as pain, disability, physical function, mobility, quality of life and participation in the community. The relevance of evidence from direct access physiotherapy lies in the fact that physiotherapists-led pathways can be used for many musculoskeletal conditions with outcomes, at least, comparable to those from a physician-led pathway. One systematic review identified no difference in pain reduction between studies, but positive results for functional and quality-of-life outcomes in some direct-access studies. (Lin, 2020)

The results also suggest that judgement of the effectiveness of integrated care should not be based on whether imaging abnormalities get better. Patient-centred rehabilitation (El Miedany, 2023) is more directly related to functional recovery, disability, quality of life, patients' experiences, adherence and return to meaningful activities. This aligns with the overall rule that radiological improvement and clinical recovery are two different and related outcomes.

The evidence is less clear-cut if there is a specific benefit that comes with the integration of radiology into physiotherapy alone, when compared to good quality physiotherapy without radiology. The evidence available in the ultrasound literature suggests potential clinical use but the different methods and the lack of high-quality comparative trials make it difficult to conclude that imaging-integrated rehab consistently yields better results. (Ahlsen, 2020)

3.4 Patient-Centred and Multidisciplinary Musculoskeletal Care

3.4.1 Shared Decision-Making and Patient Engagement

In patient centred care, the patient needs to be aware of what the imaging results are, what they are not, and what the imaging results relate to in regard to symptoms and treatment. Then, communication is a key element of integrated practice of radiology and physiotherapy (Naylor, 2023). In the absence of adequate explanation, common degenerative or structural findings encountered in imaging may be misinterpreted as damage and can contribute to the fear and loss of confidence in movement or exercise.

The research on LBP validates a more balanced approach. NICE recommends explaining to patients that specialist referral does not necessarily mean that imaging will be required and emphasises self-management and continued normal activities as important elements of care. This is consistent with a model that imaging outcomes are converted to human-readable, clinically relevant information and not just "radiological" jargon.

Physiotherapists can play a role by linking imaging with movement, function, symptoms and rehabilitation objectives. The contribution of radiologists and the referring clinicians is also important through clear interpretations that are clinically useful (Igawesi-Chidobe, 2021). One of the best ways to achieve shared decision-making is to involve patients in the decision-making process regarding the need for imaging, the meaning of the imaging results, and whether the imaging results are likely to change treatment.

3.4.2 Communication and Collaboration Among Healthcare Professionals

To achieve effective integration, communication among the radiologist, physiotherapist, physician, orthopaedist, sports-medicine clinician and other involved professionals is essential. The radiologist will be able to give specialist interpretation of imaging and the physiotherapist will be able to provide detailed functional assessment and rehabilitation expertise (Naylor, 2024). Physicians and specialists provide more comprehensive evaluation, medical management and when necessary, surgical and/or specialist recommendations.

The evidence on imaging decision making shows that imaging is more than just clinical findings. A scoping review for the 2024 SLA Programme found interactions between clinical factors, patients' and clinician characteristics, beliefs and environmental factors. This implies that there is an organisational dimension to improving integration as well as the more individualised dimension.

These mechanisms can be implemented in practice, such as having an agreed referral criteria, the ability to access imaging reports and relevant images, discussion at multi-disciplinary meetings, agreed pathways for escalation and timely communication of clinically significant findings (da Fonseca Pires, 2020). These are especially significant when physiotherapists find something that doesn't correspond with the initial working diagnosis, or when imaging suggests a condition that calls for medical or surgical evaluation.

3.4.3 Effects on Healthcare Efficiency and Service Delivery

Integrated pathways can have an impact on healthcare efficiency by ensuring that patients are assessed at the right time and place in the pathway. Indirect evidence for this proposition comes from direct-access physiotherapy. Prior systematic reviews found that some direct access models associated with decreases in physician visits, imaging,

medication use, and health care costs, but with variable evidence. More recent evidence (Chau, 2024), based on 21 studies and over 90,000 patients, revealed a reduction in general-practitioner consultations in several of these studies, along with reduced imaging and medication use in several studies, with no significant differences in clinical outcomes in most studies. (Stuber, 2022)

The results of this analysis, however, do not necessarily indicate that all models of radiology–physiotherapy integration lead to cost reductions. The 2026 meta-analysis revealed there was a lack of strong evidence to make any conclusions about outcomes of imaging in the direct-access pathways. Thus, benefits demonstrated should be separated from proposed benefits (Granviken, 2023).

The clearest service delivery implication is that with the right clinical information and referral pathways, there is a potential to prevent duplication of assessment if it is coordinated (Raymer, 2024). However, the economic effect will be a function of the availability of imaging services in the community, the composition of the workforce, the reimbursement system, the referral system, and the degree of severity and complexity of the patient population.

3.5 Barriers, Evidence Gaps, and Future Directions

3.5.1 Barriers to Integrated Radiology–Physiotherapy Practice

Several barriers emerge from the synthesis. First, professional boundaries and differences of training can limit interdisciplinary communication. The primary difference between the two professions is that radiologists are trained to interpret diagnostic images while physiotherapists are trained to conduct physical examinations, assess functional capacity, analyze movement, function, and rehabilitation, and engage the patient in their care. (Gleadhill, 2023). If there is no agreement on the respective roles of the professions, imaging might be over- or underused in rehabilitation. Secondly, the availability of imaging is highly dependent on the type and style of health-care institutions. In resource-limited settings, the availability of MRI and CT machines can be limited, as can the availability of ultrasound machines, or the availability of radiologists to interpret the scans (Bennett, 2024). Such factors can make it challenging to have theoretically desired integrated pathways in practice.

Thirdly, there is often inconsistency in the referral pathways. Simple education-based interventions to change practice may not be enough, as demonstrated by results from the 2024 evidence synthesis on imaging decision-making, which identified that clinical, clinician-related, patient-related and environmental factors all play a role in imaging decision-making. Fourth, there are differences in competencies of professionals. There is a potential role for advanced musculoskeletal ultrasound in selected physiotherapy settings, however, this should be developed through training, competency assessment, governance and defined scope of practice. Widely accepted notions of the diagnostic usefulness of the literature persist in requiring more evidence and better-designed studies. (Jordan, 2024)

3.5.2 Gaps and Limitations in the Existing Evidence

There are a number of important limitations to the evidence base. The first is big variation in the properties. Big variation in the properties is the first one. The patient population, musculoskeletal conditions, imaging technologies, clinical setting, physiotherapist competency, comparator pathway and outcome measures differ between studies (Pires, 2020). This can be challenging to compare quantitatively and can hinder generalisation of the results of one clinical context to another.

Secondly, there have been few studies comparing fully integrated radiology–physiotherapy pathways with traditional pathways of care. Available literature tends to focus on either imaging strategies or physiotherapy treatment alone (O'Leary, 2020). Thus, the evidence for the individual items in the integration is more solid than for the incremental impact of integration.

Third, there are some methodological problems in imaging research. For instance, considerable variability exists in the rehabilitative ultrasound literature with regards to measures and outcomes, with some lumbopelvic outcomes also being found to be highly heterogeneous. Research into the decision making process of imaging, too, shows complex factors that are difficult to distill into a simple clinical guideline (Holmes, 2022). (Mullen, 2023)

There is also limited representation of long-term patient-centred outcomes. Further investigations are required not only on the basis of pain and radiological findings but also with regard to disability, functional independence, quality of life, adherence to treatment, return to work/sport, understanding of the patient, health services utilization, undesirable outcomes of unnecessary imaging, and cost-efficacy (Mohapatra, 2024). There also needs to be improved representation of LICs and resource-limited health systems since evidence from highly resourced health systems may not directly translate to other health systems.

3.5.3 Implications for Clinical Practice, Research, and Policy

The results confirm that a coordinated but clinically selective approach to radiology and physiotherapy is appropriate. The key message for physiotherapists is that imaging has a role in clinical reasoning where it adds information that can alter diagnosis, management, referral, and prognosis (Griffiths, 2023). Physiotherapists need to remain focused on patient history, physical exam, functional assessment, clinical reasoning and patient goals, and not let imaging abnormalities drive their treatment.

Reports should convey clinically relevant information that helps manage the case, but should refrain from over-descriptive language of common or incidental abnormalities (Barker, 2022). Improvements in communication between the radiology department and the rehabilitation department must be enhanced by having clear criteria for referral, reports to be accessible to the rehabilitation department, a multidisciplinary consultation and a defined pathway for escalation.

Structured pathways to musculoskeletal care should be considered in healthcare organisations that facilitate timely access to imaging and clinical assessments and early rehabilitation. These pathways should make it clear that indiscriminate imaging should be avoided unless symptoms persist, a red flag is present, serious pathology is suspected or management is likely to change, and imaging should be optimised for the information needed for the specific circumstances and in a timely manner. Examples of this selective approach are provided in the current NICE and ACR guidance. (Panchal, 2023)

When teaching about imaging, educators need to give physiotherapists and other musculoskeletal professionals enough information to understand the indications for imaging, the limitations of imaging, common incidental findings, and how to refer to appropriate services (Mingels, 2024). On the other hand, there is the potential for enhancement in knowledge of the medical and radiological professionals in terms of functional assessment and rehabilitation principles through the field of multidisciplinary education.

Future evaluation should directly compare integrated radiology–physiotherapy with traditional care with clearly established clinical and patient-centred outcome measures for researchers. An investigation of cost-effectiveness, time to referral, referral accuracy, unnecessary imaging, patient understanding, treatment adherence, and long-term functional recovery should also be investigated in research. Advanced ultrasound and other newer imaging techniques should be pursued further, but evidence should determine whether or not their use alters meaningful patient outcomes, or simply adds more anatomical information (Diener, 2021). In summary, the evidence suggests that it is best to use an integrated approach, in which radiology provides structural and pathological data, physiotherapy provides functional and rehabilitation data, and patient preferences and clinical context link the two to a unified care pathway. This is a more evidence-based and musculoskeletal approach to diagnosis and treatment than imaging-centred diagnosis or when clinically indicated, treatment without access to diagnostic information.

4. Conclusion

This systematic review shows that the use of radiology combined with physiotherapy can enhance patient-centred care for musculoskeletal problems by providing accurate diagnosis with functional assessment, physiotherapy rehabilitation and continuing clinical decision-making. There are a variety of radiological modalities that can give anatomical and pathological information including X-ray, ultrasound, MRI and computed tomography, and physiotherapy, which provides useful information to assess movement, function, pain, physical capacity and response to rehabilitation. The reviewed literature suggests that strong interprofessional working relationships between radiologists and physiotherapists, and other components of the multidisciplinary team, can enhance diagnostic interpretation, assist in making better treatment decisions, enable timely detection of clinically important information and decrease the delivery of fragmented or redundant care. Communication difficulties, professional differences, availability of imaging services, diversity in imaging protocols, and lack of interdisciplinary education opportunities, however, do affect integration. Therefore, it is recommended that healthcare systems encourage structured communication channels, joint decision making, an appropriate imaging referral process, and interdisciplinary training to improve the communication between the radiology and physiotherapy departments. In general, an integrated approach provides a feasible structure to provide more coordinated, evidence-based, function-focused, and patient-centred care for the musculoskeletal system and requires additional high-quality studies to establish the long-term impacts on clinical outcomes, healthcare consumption, patient experience, and cost-effectiveness.

References

1. Ahlsen, B., Engebretsen, E., Nicholls, D., & Mengshoel, A. M. (2020). The singular patient in patient-centred care: physiotherapists' accounts of treatment of patients with chronic muscle pain. *Medical Humanities*, 46(3), 226-233.
2. Barker, K. L., Room, J., Knight, R., Hannink, E., & Newman, M. (2022). Physiotherapy exercise rehabilitation with tailored exercise adherence support for people with osteoporosis and vertebral fractures: protocol for a randomised controlled trial—the Osteoporosis Tailored exercise adherence INtervention (OPTIN) study. *BMJ open*, 12(9), e064637.
3. Bennett, S. E., Gooberman-Hill, R., Clark, E. M., Paskins, Z., Walsh, N., & Drew, S. (2024). Improving patients' experiences of diagnosis and treatment of vertebral fracture: co-production of knowledge sharing resources. *BMC Musculoskeletal Disorders*, 25(1), 165.
4. Chau, S., Hyde, E., Knapp, K., & Hayre, C. (Eds.). (2024). *Person-centred care in radiology: international perspectives on high-quality care*. CRC Press.
5. da Fonseca Pires, D. A. (2020). *Measuring physiotherapy outcomes in chronic low back pain: Moving forward to a patient-centred approach* (Doctoral dissertation, Universidade NOVA de Lisboa (Portugal)).
6. Dickson, C., de Zoete, R. M., Berryman, C., Weinstein, P., Chen, K. K., & Rothmore, P. (2024). Patient-related barriers and enablers to the implementation of high-value physiotherapy for chronic pain: a systematic review. *Pain Medicine*, 25(2), 104-115.
7. Diener, I. (2021). Physiotherapy support for self-management of persisting musculoskeletal pain disorders. *South African Journal of Physiotherapy*, 77(1), 1564.
8. El Miedany, Y., & Elwakil, W. (2023). Multidisciplinary patient-centred model of care for osteoarthritis: scoping review protocol—an initiative by the Egyptian Academy of Bone Health. *Egyptian Rheumatology and Rehabilitation*, 50(1), 3.

9. Fennelly, O., Blake, C., FitzGerald, O., Caffrey, A., Fletcher, L., Smart, K., ... & Cunningham, C. (2020). Advanced musculoskeletal physiotherapy practice: The patient journey and experience. *Musculoskeletal Science and Practice*, 45, 102077.
10. Gleadhill, C., Dooley, K., Kamper, S. J., Manvell, N., Corrigan, M., Cashin, A., ... & Williams, C. M. (2023). What does high value care for musculoskeletal conditions mean and how do you apply it in practice? A consensus statement from a research network of physiotherapists in New South Wales, Australia. *BMJ open*, 13(6), e071489.
11. Granviken, F., Meisingset, I., Vasseljen, O., Bach, K., Bones, A. F., & Klevanger, N. E. (2023). Acceptance and use of a clinical decision support system in musculoskeletal pain disorders—the SupportPrim project. *BMC medical informatics and decision making*, 23(1), 293.
12. Griffiths, G. S., Thompson, B. L., Snell, D. L., & Dunn, J. A. (2023). Person-centred management of upper limb complex regional pain syndrome: an integrative review of non-pharmacological treatment. *Hand therapy*, 28(1), 16-32.
13. Hoffmann, T. C., Lewis, J., & Maher, C. G. (2020). Shared decision making should be an integral part of physiotherapy practice. *Physiotherapy*, 107, 43-49.
14. Holmes, M. M. (2022). *Reconceptualising patient-reported outcome measures as active components of specialist musculoskeletal care for back pain* (Doctoral dissertation, University of Southampton).
15. Hutting, N., Caneiro, J. P., Ong'wen, O. M., Miciak, M., & Roberts, L. (2022). Patient-centered care in musculoskeletal practice: key elements to support clinicians to focus on the person. *Musculoskeletal Science and Practice*, 57, 102434.
16. Igwesi-Chidobe, C. N., Bishop, A., Humphreys, K., Hughes, E., Protheroe, J., Maddison, J., & Bartlam, B. (2021). Implementing patient direct access to musculoskeletal physiotherapy in primary care: views of patients, general practitioners, physiotherapists and clinical commissioners in England. *Physiotherapy*, 111, 31-39.
17. Innes, S., & Jackson, J. (2019). Musculoskeletal ultrasound imaging—Integration with the biopsychosocial model. *Musculoskeletal Science and Practice*, 44, 102067.
18. Jordan, M. (2024). *Physiotherapists Description of Patient-Centered Care, and Barriers and Facilitators Experienced to Implementation* (Master's thesis, The University of Western Ontario (Canada)).
19. Lin, I., Wiles, L., Waller, R., Caneiro, J. P., Nagree, Y., Straker, L., ... & O'Sullivan, P. P. (2020). Patient-centred care: the cornerstone for high-value musculoskeletal pain management. *British journal of sports medicine*, 54(21), 1240-1242.
20. March, M. K., Judd, B., Harmer, A. R., Eyles, J., & Dennis, S. M. (2024). Improving musculoskeletal physiotherapists' confidence in patient-centred care informed by acceptance and commitment therapy: A descriptive study. *Musculoskeletal Science and Practice*, 69, 102891.
21. Mingels, S., Granitzer, M., Luedtke, K., & Dankaerts, W. (2024). What is the Status Quo of Patient-Centred Physiotherapy Management of People with Headache within a Biopsychosocial Model?—A Narrative Review. *Current Pain and Headache Reports*, 28(12), 1195-1207.
22. Mohapatra, A., Mohanty, P., Pattnaik, M., & Padhan, S. (2024). Physiotherapy in the digital age: A narrative review of the paradigm shift driven by the integration of artificial intelligence and machine learning. *Physiotherapy-The Journal of Indian Association of Physiotherapists*, 18(2), 63-71.
23. Mullen, N., Ashby, S., Haskins, R., & Osmotherly, P. (2023). The experiences and preferences of individuals living with a musculoskeletal disorder regarding prognosis: A qualitative study. *Musculoskeletal Care*, 21(4), 987-996.
24. Naylor, J., Killingback, C., & Green, A. (2023). What are the views of musculoskeletal physiotherapists and patients on person-centred practice? A systematic review of qualitative studies. *Disability and rehabilitation*, 45(6), 950-961.
25. Naylor, J., Killingback, C., & Green, A. (2024). An exploration of person-centredness among emergency department physiotherapists: a mixed methods study. *Disability and rehabilitation*, 46(23), 5562-5575.
26. O'Leary, S., Gale, J., Volker, G., Kuipers, P., Dalton, M., & McPhail, S. (2020). Fostering patient uptake of recommended health services and self-management strategies for musculoskeletal conditions: A Delphi study of clinician attributes. *Musculoskeletal Care*, 18(2), 161-168.
27. Panchal, S., & Hendrick, P. (2023). The lived experiences of musculoskeletal physiotherapists managing patient expectations for diagnostic imaging: A qualitative study using a phenomenological analysis. *Musculoskeletal Science and Practice*, 67, 102833.
28. Pires, D. A. D. F. (2020). Measuring physiotherapy outcomes in chronic low back pain: Moving forward to a patient-centred approach.
29. Raymer, M., Kelly, P. S., & O'Leary, S. (2024). Developing and embedding an advanced practice musculoskeletal physiotherapy service in public specialist outpatient services in Queensland: A health service masterclass. *Musculoskeletal Science and Practice*, 70, 102917.
30. Smith, M., Innes, S., Wildman, S., & Baker, D. (2023). A proposed framework for point of care musculoskeletal ultrasound and ultrasound image-guided interventions by physiotherapists: scope of practice, education and governance. *The Ultrasound Journal*, 15(1), 15.a