Musculoskeletal ultrasound imaging - an exploration of physiotherapists' interests and use in practice

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Abstract:

Background:

Musculoskeletal ultrasound imaging, (MSKUSI) is an appealing modality for many professions and professionals. There are indications that physiotherapists have tried to access MSKUSI but the evidence base exploring their interests and clinical use is extremely limited.

Aim:

To explore physiotherapists' interest and use of MSKUSI in practice.

Method:

A questionnaire was developed and distributed to gain initial information relating to physiotherapists' interest and use of MSKUSI. 75 responses were received, analysis informed topic-guide development for in-depth interviews and enabled a purposeful sampling strategy. 11 in-depth interviews explored physiotherapists' interests, education and clinical use of MSKUSI.

Results:

Thematic analysis of the interview data identified 5 themes:

1. Professional skill set – physiotherapists' suitability for MSKUSI
2. Factors that have impacted physiotherapists' ability to use MSKUSI

3. Physiotherapists' motivation to use ultrasound - improving patient focused care
4. Quality assurance strategies
5. Application of biopsychosocial model

These themes revealed links between physiotherapists' core skills, knowledge and professional experiences that align well to the requirements of MSKUSI. Some participants reported support whilst accessing education but many described challenges that had influenced their ability to use MSKUSI. A common challenge was accessing mentorship responsive to physiotherapists' requirements. Participants observed the variation in their practice when compared to other professionals was not always reflected in education. Application of clinical reasoning processes to ensure scanning was responsive to individual patient's requirements was emphasised.

Conclusion:

Physiotherapists are amongst a number of professional groups interested in MSKUSI. Proposed roles include verification of clinical assessment findings for diagnosis and facilitation of patient education. The potential to reduce patient attendances, streamline management pathways and optimise resource management warrants further investigation. Professional and regulatory issues need evaluation to support physiotherapists' use of MSKUSI. Professional organisations including the Chartered Society of Physiotherapy should extend current guidance to protect professionals and patients.

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Chapter 1 Background to the Study

1.1: Introduction:

Ultrasound imaging is a modality that has traditionally been performed by radiologists and sonographers. Historically, X-Rays have been the imaging modality most commonly used for musculoskeletal presentations and relatively few radiologists or sonographers have chosen the musculoskeletal field as an area of specialisation. There has recently been a development of interest in musculoskeletal ultrasound imaging, (MSKUSI) from several health professionals including physiotherapists, sports physicians and rheumatologists, (Edwards 2010). The history and development of MSKUSI has been explored to provide the background to the current interest from physiotherapists.

1.2: History of Musculoskeletal Ultrasound

The history of ultrasound imaging can be traced back to the work of two brothers; Jacques and Pierre Curie who, in 1880 documented the piezoelectric effect for the first time, (Manbachi & Cobbold 2011). The piezoelectric effect and converse piezoelectric effect relate to solid materials’ property to produce electricity under pressure and for mechanical strain to result from applied electrical force. The subsequent contraction and expansion of material when a voltage is applied produces vibration that causes sound waves to be produced, (Venables 2011). The application of these ultrasound producing properties was not initially in the medical domain, but in the measurement of very small electrical currents and later in submarine detection. Paul Langevin and Constantin Chilowsky filed two US patents in 1916 and 1917 detailing their underwater sound detector including the process for generation and detection of ultrasonic waves. The pulse-echo principle used to construct an object's image can be compared with the echo-location system used by bats, (Venables 2011). Langevin's work was developed by Cody, who in 1921 presented the first piezoelectric crystal oscillator (Kane et al 2004a, Manbachi & Cobbold 2011). The role of ultrasound as a medical diagnostic tool was explored by Karl Dussik, a neurologist in Vienna who attempted to scan the head. A paper published in 1942 outlines his investigations over 5 years and his intention to locate brain tumours with ultrasound, (Dussik 1942). Whilst the validity of Dussik's early findings have been questioned, his work resulted in a surge of advancements in the field. In 1958 Dussik published the first report of MSKUSI and described the acoustic attenuation of articular and peri-articular tissues, (Kane et al 2004a). This report of the distinctive properties of varying musculoskeletal tissues including muscle, tendon, cartilage, capsule and bone is hugely significant in the development of ultrasound as a musculoskeletal imaging modality.

Technical advancements improved both the imaging quality and potential to view more diverse structures. A key development was in 1952 with the introduction of B-mode ultrasound; the combination of a high-frequency transducer with a mechanical scanning system that creates two-dimensional pictures, (Wild & Reid 1952). Holmes and Harry contributed 'Pan scanners' to the development process, these enabled generation of accurate and reproducible images but with the inconvenience and discomfort of the patient being partially immersed in a water tank, (Kane et al 2004a). Studies exploring muscle tissue were undertaken in the 1960's and in 1968 authors attempted to make a link between muscle size, as witnessed with ultrasound and muscle strength, (Ikai & Fukunaga 1968). The first publication of B-mode images of a joint was in 1972, where the ability to distinguish ‘between thrombophlebitis and irritation or rupture of a Baker's cyst’ was reported (McDonald & Leopold 1972). This innovative study highlights the clinical potential of ultrasound as a musculoskeletal imaging modality as it is a ‘simple, rapid, non-invasive technique’. Another noteworthy milestone was the first documentation of a bony erosion in the rheumatoid hand accompanied by synovitis and tenosynovitis (De Flaviis et al 1988). This scanning procedure required probe precision and sufficient signal processing technology that had previously been unattainable, enabling the clinician to gain clinically useful information from small joints. Power Doppler became an additional tool for the scanning clinician in the late 1990’s following the first report of soft tissue hyperaemia, (Newman 1994). The last forty years have witnessed remarkable technical improvements in all aspects of ultrasound systems; probes, computer processing, power Doppler and monitor resolution have all enhanced the ability to differentiate abnormal from normal tissues, but the application of the modality to musculoskeletal medicine has lagged behind its use in other specialties e.g. gynaecology, obstetrics and cardiology, (Kane et al 2004a).

1.3: Modern Day Musculoskeletal Ultrasound Imaging Applications

The traditional role of MSKUSI has been to assist the assessment process and enable diagnosis. The evidence base that explores diagnostic musculoskeletal scanning protocols is extensive and reflects the suitability of the modality for imaging musculoskeletal tissues, (Lew et al 2007, Chew et al 2008, Hashefi 2011, Patil & Dasgupta 2012, Russell & Crawford 2013). Image formation is dependent on tissue's ability to reflect the ultrasound beam, consequently a large proportion of the musculoskeletal system can be viewed. Strong reflectors of the beam such as bone and tendon appear as a bright white image and are termed 'hyperechoic', medium reflectors such as muscle and fat are grey and termed 'hypoechoic' and non-reflectors such as fluids are black and called 'anechoic', (Venables 2011). Normal tissue can be differentiated from abnormal by changes in echogenicity within a structure as well as changes to shape, size and boundaries. A summary of musculoskeletal structures and their capacity to be visualised with ultrasound will now follow.

Bone presents a highly reflective acoustic interface and is hyperechoic. The ultrasound beam is reflected so bone cortex presents as a well-defined smooth line and the image beyond this interface is black (Smith & Finnoff 2009a). Superficial bone is usually accessible but deeper or structures inaccessible by prove may be more challenging to visualise,for instance the 4th metacarpalphalangeal joint (Patil & Dasgupta 2012). Cortical irregularities can be visualised and could be indicative of pathologies including rheumatoid arthritic bony erosions (Bajaj 2007), osteoarthritic osteophytes (Patil & Dasgupta 2012), periostitis or stress fracture (Smith & Finnoff 2009a).

Bony erosion detection is a significant finding in rheumatoid arthritis and has been linked to an aggressive disease course and poor prognosis, (Norton et al 2013, Van der Heijde et al 1992, Van der Heijde et al 2005, Scott et al 2000 and Uhlig et al 2000). Erosions are a discontinuity of the bone surface or cortex greater than 2mm in diameter and should be visualised in two planes (Wakefield et al 2005). Erosion detection reliability with ultrasound has greater sensitivity than radiographic imaging, (Bajaj 2007, Koski et al 2010).

Stress fractures present diagnostic challenges, whilst early detection is important traditional radiographic imaging lacks sensitivity. Computer tomography imaging is more sensitive than plain X-Ray but is expensive and should be limited in use because of ionising radiation, (Papalada et al 2012). Early diagnosis enables appropriate management strategies are put in place including activity modification preventing worsening of the pathology (Bianchi 2014, Pegrum et al 2012). MSKUSI findings with stress fractures include periosteal thickening, calcified bone callus, cortical irregularities, subcutaneous oedema and hypervascularity with Colour Doppler, (Bianchi 2014). The role of MSKUSI in stress fracture diagnosis is relatively new but recent studies suggest a potential role, (Khy et al 2012, Banal et al 2009, Botchu et al 2012).

Musculoskeletal soft tissue structures are generally amenable to ultrasound imaging; tendons and ligaments both contain high levels of collagen in a structured organisation that produce distinctive images, (Hodgson et al 2012). These hyperechoic structures are bright and white on ultrasound, in transverse section their appearances are described as ‘broom end’ and in longitudinal section their fibrillar structure is clear. The hyperechoic collagen bundles are interspersed with hypoechoic ground substance producing distinctive fibrillar images (Smith & Finnoff 2009a). Principles underpinning ultrasound examination of tendons and associated pathologies have been explored extensively, (including Martinoli et al 2002, Smith & Finnoff 2009a, Smith & Maida 2013). The internal architecture of tendons can be assessed in more detail with ultrasound in comparison to MRI but operator skill alongside technical understanding is required to prevent misinterpretation of images. Anisotropy is an image artefact common when visualising tendons, it refers to the image of a normal structure appearing dark because the reflected beam is encountering the structure at a less than ideal angle. The ultrasound beam should be perpendicular to the imaged structure but tendon shape and structure will frequently reflect the beam obliquely to the transducer. An inexperienced clinician may misinterpret the dark area within the tendon as an area of pathology, whereas the experienced clinician would observe how the image can be modified with the transducer angle, (Smith & Finnoff 2009b, Micu et al 2011, Smith & Maida 2013). Tendon pathologies including tendinosis, partial tear, incomplete full-thickness tear or complete full-thickness tear can all be viewed with MSKUSI. A degenerative tendinopathy will present with thickening, hypoechoic areas and loss of smooth tendon borders, Doppler may reveal areas of neovascularisation and in chronic pathology, entheseal changes may be apparent (Smith & Maida 2013). Tears can be visualised as a discontinuity and fluid in tenosynovial tendons noted as an indication of tenosynovitis. The sensitivity of ultrasound exploring tendon pathology has been studied by several researchers, its high resolution alongside portability and the potential to examine these structures dynamically have justified the conclusion that it is regularly the imaging modality of choice, (Smith & Maida

2013). There is consensus in the literature that ultrasound should be the first choice of imaging when tendon pathology is suspected in the shoulder, (Smith et al 2011, de Jesus et al 2009, Middleton et al 2004). There is also a body of evidence that indicates that ultrasound imaging is reliable in the investigation of many tendon pathologies including elbow common extensor symptoms, (du Toit et al 2008, Clarke et al 2010), achilles pain (Malliaras et al 2012a, Elias et al 2011, Rosengarten et al 2014), greater trochanteric pain syndrome (Klauser et al 2013, Ramirez et al 2014) and peroneal tendon pathology (Grant et al 2005, Raikin 2009).

Ligaments share similar sonographic characteristics to tendons so can be evaluated well with ultrasound if they sit within the acoustic window of accessibility, (Smith & Finnoff 2009a), specific ligaments that can be reliably imaged include the anterior talofibular ligament (Hua et al 2012), thumb ulna collateral ligament (Melville et al 2014), dorsal lisfranc ligament, (Graves et al 2014), and the transverse carpal ligament (Shen & Li 2012). The highly portable nature of ultrasound lends this modality to the assessment of acute injuries in the emergency clinic when ligament ruptures are suspected and may require surgical intervention, (Tok et al 2012).

Entheses are frequently amenable to MSKUSI and entheseal changes may be significant to diagnosis, in particular when spondyloarthropathy is suspected. Changes include increased thickness, hypoechogenicity, enthesophytes, erosions, calcifications, associated bursitis and cortical irregularities. Whilst content validity and reliability for the evaluation of enthesitis has been established, there is a lack of a consensus for a standardised examination (Gandjbakhch et al 2011).

Muscle has mixed echogenicity on ultrasound imaging and can easily be identified with anatomical landmarks. In transverse section its appearance is described as resembling a 'starry night' and in longitudinal section it is 'feather like', (Smith & Finnoff 2009a). Imaging muscle has enabled clinicians and researchers to: assess and monitor muscle injury (Tok et al 2012), assess and train muscle activity (Day & Uhl 2013, Nuzzo & Mayer 2013) and calculate physiological parameters based on muscle architecture (Chino et al 2013, e Lima et al 2014).

Intra-articular structures can also be imaged and one structure that generates considerable interest is the synovial membrane. A special interest group convened by OMERACT, (Outcome Measures in Rheumatology – an International Organisation) completed a systemic review of publications in 2005. A large number of papers resulted but a noteworthy observation of the evidence reported synovitis as 'the most studied pathology', (Wakefield et al 2005). Synovitis in patients with inflammatory arthropathy e.g. rheumatoid arthritis can be assessed with ultrasound as the synovium becomes non-compressible and thickened hypoechoic intra-articular tissue. Synovitis generates increased power Doppler signals that are rated on a semi-quantitative scale, (0 – 3), though dedicated software also exists to review power Doppler more objectively (Teh et al 2003). The detection of synovitis is an indicator of disease activity and one of the key aims of rheumatoid treatment is to minimise active synovitis, (Patil & Dasgupta 2012). The sensitivity of the application to identify active synovitis has been shown to be greater than clinical examination, (Grassi 2003).

Many structures within the musculoskeletal system can be viewed with MSKUSI. It is evident that technological developments are improving image resolution and enabling imaging of structures that were previously inaccessible.

1.4: Professional Application of Musculoskeletal Ultrasound

MSKUSI is reported widely as a diagnostic tool and has becoming increasingly popular. Although it has traditionally been used predominantly by radiologists, several other professions including physiotherapists, sports physicians and rheumatologists, (Edwards 2010) have shown an interest. The popularity of MSKUSI has been attributed to several factors: it is highly portable, virtually risk free, non-invasive and relatively inexpensive when compared with other imaging modalities and can provide a dynamic assessment, (Patil & Dasgupta 2012).

The literature discussing the role of MSKUSI in rheumatology has increased significantly in the last decade and reflects the developing integration of the modality into rheumatologists' clinical practice. Kane et al (2004b, page 829) published a paper stating that 'rheumatologists remain divided' regarding the role of MSKUSI. The authors presented their view that many structures can be visualised well and crucially, the images have clinical relevance by playing a part in clinical decision making. The proven indications proposed include diagnosis of effusion and differentiation of cystic from solid masses. Some of the developing and potential indications proposed have become common clinical practice since this paper's publication, for instance, the improved efficacy of joint injections when ultrasound guided, (Park et al 2015) yet others have less distinct parameters to evaluate their clinical utility, including diagnosis of low grade synovitis. The four authors of this paper are highly regarded rheumatologists and have since published further papers evaluating ultrasound's role. One of the authors, Balint is a member of the OMERACT Ultrasound Task Force, a group that strives to provide evidence regarding the application of MSKUSI. Recent developments include the validation of the US Global Synovitis Score, (US-GLOSS) that evaluates synovial hypertrophy and power Doppler signal, combining them in a composite score. This group has also presented a system for detecting and grading tenosynovitis and tendon damage associated with rheumatoid arthritis, (Iagnocco et al 2014).

Rheumatologists have explored the impact of MSKUSI on early diagnosis of rheumatoid arthritis and patient monitoring, (Filippucci et al 2006, Grassi 2005, Patil & Dasgupta 2012). Ultrasound based diagnostic criteria have been studied and compared to other systems, for instance the DAS-28 is commonly used for rheumatoid arthritis, (Damjanov et al 2012). Many rheumatologists regard ultrasound as an essential component of the clinical assessment and disease monitoring process as well as a research tool, (Grassi & Filippucci 2014, Kang et al 2013, Kang et al 2014). It is evident that some applications would not interest other professions, for instance monitoring of rheumatoid arthritis disease progression and response to medication, but some applications may be relevant for other practitioners including physiotherapists, for instance assessment of joint effusions.

Sports physicians are another professional group that have seen the opportunity for MSKUSI and have recently incorporated it into practice. There are many case studies of athletes with sporting injuries where the imaging modality of choice has been ultrasound, (Faltus et al 2012, Nsitem 2013). Cohort studies have explored the typical ultrasound findings associated with pathologies including jumper’s knee or muscle injury (Hoksrud et al 2008, Guillodo et al 2011). Other cohort studies have explored typical ultrasound appearances associated with a specific sporting population, for instance badminton players were assessed for any relationship between pain and ultrasound findings, (Malliaras et al 2012b). Studies have compared ultrasound with MRI and whilst ultrasound is not always as sensitive in the case of muscle injury, (Balius et al 2014) its dynamic potential has been reported to add value and has been found to be superior in the investigation (Zaidman et al 2013). Machine portability has many advantages in the sporting environment and there are reports of pitch side scans and opportunities, (Fuller et al 2008, McCurdie 2012) as well as increasingly diverse environments including on mountains to evaluate snowboarders, (Nowak et al 2009). Many of the roles of MSKUSI reported by sports physicians may be applicable to physiotherapists, most notably assessment and monitoring of soft tissue injuries. Callaghan, (2012) described its value to physiotherapists in multiple environments: in the clinic, at pitch side and ‘on the road’, highlighting its transportability and the benefit from the immediate image availability.

One of the few studies that has explored the impact of ultrasound imaging on patient experience has been published by a sports physician, (Wheeler 2010). This pilot study with some methodological flaws, investigated patient satisfaction when ultrasound was incorporated into the sport physician's assessment. The patients completed a questionnaire after assessment, rating how useful they perceived the ultrasound imaging component including the impact it had on their understanding of their presentation and education regarding management. Whilst the sample size was limited, (n=35) and the style of the questions in the survey were somewhat leading, (for instance, question 1: '*Do you feel that you are better able to understand your problem after having the ultrasound scan in clinic today?'* (Page 70)), the results suggested that patients valued ultrasound imaging and that it made a contribution towards their understanding. Unfortunately, this pilot study was not followed by formal research.

Emergency physicians are also regularly linked in literature with MSKUSI. Authors have advocated its use in the emergency department by highlighting its sensitivity, as demonstrated by its comparability to plane X-Ray in the diagnosis of ankle fracture, (Canagasabey et al 2011). Other valued features include the speed of accessing results, for example diagnosing acute Achilles tendon rupture (Adhikari et al 2012), the relative comfort of the patient with this non-invasive tool and that no radiation risks need consideration for instance when evaluating paediatric bone injury including skull fracture (Gallagher & Levy 2014) or long bone injury (Barata et al 2012). In response to these roles and opportunities, professionals are now responding by publishing guidelines and guidance for ultrasound in emergency medicine, (Laursen et al 2014, Lewiss et al 2013).

Literature indicates that MSKUSI presents an opportunity to visualise many tissues that are assessed by the health care professionals discussed above. It is also evident that the patients assessed and managed by musculoskeletal physiotherapists regularly have symptoms and pathology in these tissues. The previously cited papers by physiotherapists, (Callaghan 2012, Malliaras et al 2012a, Malliaras et al 2012b) reflect an interest in the modality and whilst it is evident that professions beyond radiologists have integrated the modality into their practice, there is uncertainty regarding the use of ultrasound imaging in physiotherapy. Concern has been expressed about the increasing interest from new professions. Edwards (2010) has written a well-informed and justified article highlighting concerns regarding the 'burgeoning number' of clinicians who are scanning with very little or no formal training and are therefore 'posing a significant threat to the public'. A review of ultrasound education and regulation will follow to explore these issues and their relevance to the professional application of MSKUSI by physiotherapists.

1.5: Musculoskeletal Ultrasound Education and Regulation

In the United Kingdom, the practice of sonography has very few regulations and is not limited to specific professions for instance radiologists and sonographers. The Royal College of Radiologists states that radiologists must obtain and maintain core skills in all clinical areas. The core skills listed for MSKUSI are limited to 'basic MSK ultrasound e.g. common tendon injuries and joint effusions'. To obtain a Certificate of Completion of Training the trainee must demonstrate core skills and Level 1 competencies in two areas or Level 2 competencies in one area. Level 1 competency enables the clinician to practice with a special interest in the area and Level 2 competency indicates an expert in their field. Musculoskeletal imaging is listed as one of fifteen areas of clinical specialisation, a Level 1 radiologist would be able to perform ‘MSK ultrasound of joints, muscles, tendons and soft tissue masses’, (Royal College of Radiologists 2013). All radiologists should have exposure to MSKUSI in their training, but only a small proportion would have the skills required to assess the musculoskeletal system with proven competence, (at Level 1).

Sonographers’ training is complicated by the fact that neither the title ‘sonographer’ nor ‘ultrasonographer’ are protected. Most employed sonographers in Britain come from a healthcare background such as radiography or midwifery who then undertake post-registration training. Various options exist for post-registration courses, but most sonographers undertake a course that has been approved by the Consortium for the Accreditation of Sonographic Education (CASE), (Society of Radiographers 2014). CASE publishes a handbook listing all the institutions providing Post-graduate Certificates, Diplomas and MSc’s in medical ultrasound; currently sixteen institutions are listed and only six of offer a module in MSKUSI, in contrast all sixteen institutions listed offer modules in obstetric and gynaecological ultrasound, (Consortium for the Accreditation of Sonographic Education 2013). CASE also accredits short focused courses that reflect a specialty, there are currently three organisations accredited to deliver a focused MSKUSI course, (Consortium for the Accreditation of Sonographic Education 2014). Sonography in Britain is further complicated by a lack of a regulatory body, whilst sonographers from a radiography background register with the Health and Care Professions Council, (HCPC) to maintain their radiography title and midwives register with the Nursing and Midwifery Council, (NMC) there is no obligation for a sonographer to be affiliated with a specific regulatory body. The Society of Radiographers states that other professionals should be welcomed into sonography if they are ‘well qualified and competent’; there are a number of professionals who would not be eligible to register with the HCPC or NMC but have relevant expertise, in particular those from overseas or individuals who have a scientific first degree instead of a professional qualification, (Society of Radiographers 2014). The systems of training and regulating sonographers have resulted in most sonography based education excluding musculoskeletal content and the issues associated with the title ‘sonographer’ prevent any assumptions regarding musculoskeletal competence.

Beyond radiologists and sonographers, several interested professional groups have recognised that clinical competency is dependent on good quality education and have taken steps to ensure appropriate standards are met. The strategies of the varying professional groups reflect the different applications of the modality and indicate the challenges of developing education programmes to suit all professions’ requirements. Within a single profession, requirements still vary according to work practice and areas of specialism; for instance a physiotherapist who has specialised in the upper limb will have a different educational focus to a lower limb specialist, and a rheumatologist who specialises in rheumatoid arthritis will have different requirements to one who specialises in giant cell arteritis. Currently, there are few guidelines for professional groups to direct their education. British and American Sports and Exercise physicians, non-radiologist medics and surgeons benefit from guidelines supporting the integration of this modality into their practice (Faculty of Sport and Exercise Medicine 2012, Royal College of Radiologists 2012, Finnoff et al 2010). Rheumatologists’ training can be directed by guidelines first published in 2001 by the European League Against Rheumatism (EULAR) working group for Musculoskeletal Ultrasound, (Backhaus et al 2001). This document has been the basis for several publications guiding education for rheumatologists, (Brown et al 2005, Brown et al 2006, Naredo et al 2008, Naredo et al 2010, Iagnocco et al 2011).

Physiotherapists have very little guidance regarding appropriate training for integrating ultrasound into their assessment and management of patients. The professional body in the United Kingdom, the Chartered Society of Physiotherapy (CSP) does not currently offer any specific guidance in relation to ultrasound imaging. Discussions relating to professional guidelines between CSP and the Electro Physical Agents and Diagnostic Ultrasound Professional Network have not resulted in any publications to date. In the absence of ultrasound specific guidelines, there are publications and professional requirements that could influence physiotherapists' approach to the modality; documents include Code of Members' Professional Values and Behaviour, (Chartered Society of Physiotherapy 2011), Scope of Practice (Chartered Society of Physiotherapy 2014a) and Standards of Proficiency – Physiotherapists, (Health and Care Professions Council 2013). Development of guidance for physiotherapists may have been influenced by the lack of certainty regarding the role of MSKUSI for this professional group. It is evident that the profession's initial interest in the modality emerged from imaging muscle size and activity, (Stokes and Young 1986, Hides et al 1992, Hides et al 1998). This initial interest in ultrasound imaging coincided with the development of approaches to manage low back pain that aimed to improve muscle activity influencing lumbar stability, (Bergmark 1989, Penjabi et al 1989) and movement control, (Hides et al 1995, O'Sullivan et al 1997). It is evident that some physiotherapists' engagement with MSKUSI has been related to imaging of muscle activity and that this form of imaging has been referred to as 'rehabilitative ultrasound imaging', (Teyran 2006) but it is uncertain if this is currently a key role for ultrasound imaging for the profession, or if there are others.

The British Medical Ultrasound Society (BMUS) is a multidisciplinary body who promote the advancement of ultrasound related research, science and education. BMUS refers professionals interested in ultrasound educational matters to CASE, commenting that this is the only organisation that accredits training. Whilst BMUS states it is multidisciplinary, it is interesting to note that the membership application form requires a box ticked to reflect professional background and there is no box for physiotherapy. BMUS also acknowledges the multi-disciplinary attraction of ultrasound but offers no advice regarding education that may be profession specific and not eligible for CASE accreditation.

In light of the lack of standardisation, it is not surprising that confusion exists regarding requirements to perform MSKUSI. Edwards (2010) commented that 'ultrasound will continue to be used increasingly (as a diagnostic stethoscope) by an ever-broadening range of practitioners', whilst Mapes-Gonnella, (2013) reported greater concern in her revealingly titled paper 'The Impact of Education: Has the Failure to Standardize Musculoskeletal Sonography Undermined Its Value?'.

MSKUSI is an appealing modality for many professions and professionals involved in musculoskeletal assessment. The absence of guidance for physiotherapists who express an interest alongside a lack of sonographic regulation highlight an area for further formal exploration.

Chapter 2 Literature Review

2.1: The Application of Musculoskeletal Ultrasound by Physiotherapists

There is evidence from initial reading and professional communication that some musculoskeletal physiotherapists in the United Kingdom are using ultrasound imaging. There are also indications that physiotherapists have attempted to access support and education in this modality but this has sometimes been difficult to find. A formal literature review was required to explore this subject area and has been directed by constructing the following questions:

What is the evidence for interest and involvement from British physiotherapists in MSKUSI?

Why do British physiotherapists want to use MSKUSI?

What education and professional support has been available to support physiotherapists' learning of MSKUSI?

2.2: Search Strategy:

Two literature searches were performed using multiple databases including Medline, CINAHL (Cumulative Index to Nursing and Allied Health), SportDiscus and PsychArticles via The University of Essex's library database system. The first search explored the role of MSKUSI and physiotherapists' involvement in the modality and the second search explored education available for physiotherapists.

The first search was not limited to physiotherapists in the United Kingdom as international publications have relevance, it was however limited to publications in

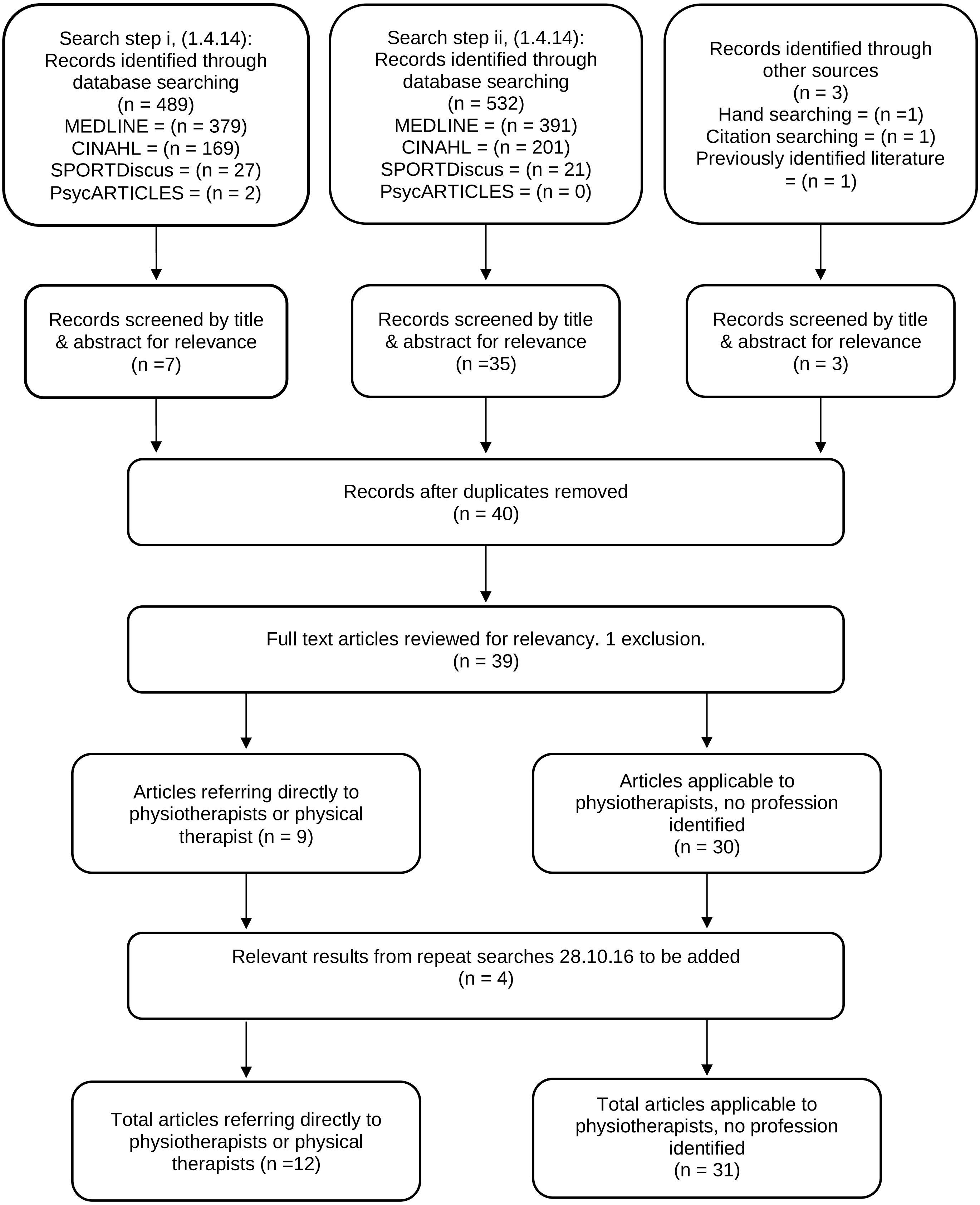
English but not by date as most of the relevant literature exploring this area has been published in the last fifteen years. Whilst a paper that is fifteen years old could be regarded as dated, the professional issues discussed in them, including suggestions for the future use of MSKUSI relate directly to the research questions. A search was conducted initially using the following words as search terms, 'physio* OR (physical therapist) AND musculoskeletal AND ultrasound OR sonograph* NOT therapeutic NOT (pelvic floor)'. The term 'therapeutic' was excluded to minimise the likelihood of finding papers exploring therapeutic ultrasound, an electrotherapy modality unlike ultrasound imaging. The exclusion of the term 'pelvic floor' limited the search to prevent unnecessary findings in relation to the use of ultrasound for the treatment of incontinence. This step i search produced 489 results, all of the results' titles were reviewed for relevancy and only seven results were directly relevant.

A factor that added complexity to the search was inconsistent terminology in the literature, in particular the terms 'rehabilitative' and 'diagnostic'. These terms and the implications of their inconsistent application have presented challenges in this review. Imaging of muscles to investigate their morphology with and without activity has been termed 'rehabilitative ultrasound' by several authors, (Kiesel et al 2008, O'Sullivan et al 2009, Whittaker et al 2007, Teyhen 2011). Whittaker's publication (2007) was included in one of two issues of Journal of Orthopaedic and Sports Physical Therapy devoted solely to imaging of muscle activity and termed 'rehabilitative ultrasound imaging'. Whittaker, (2007) presented a position statement, an outcome of an international symposium in 2006 that aimed to provide clarity to the role of ultrasound imaging for physical therapists. Whittaker and colleagues were keen to emphasise that rehabilitative ultrasound was a unique role for physiotherapists and contrasted with the diagnostic role of ultrasound that was undertaken by several specialities. The literature search revealed that whilst the authors linked to the international symposium used the term ‘rehabilitative ultrasound’ in a standard way, this application was not universal and will be discussed later in this review.

The outcome of this literature search produced a body of relevant evidence but it was apparent that contemporary papers discussing MSKUSI without identifying the professions or professionals involved had been excluded and may be relevant. The volume of literature that directly refers to physiotherapists or any other specific health care professional and MSKUSI is limited and previous reading had accessed studies evaluating ultrasound, its potential in musculoskeletal medicine and role in research without referring to specific professions, (Ozcakar et al 2012, Mapes-Gonnella 2013). The decision was taken in step ii to broaden the search to exclude professional identity with the search terms ‘musculoskeletal AND ultrasound OR sonograph* NOT therapeutic NOT (pelvic floor)’. The results of step i and ii were combined, duplicates were removed electronically and manually and the search was extended by citations and previously identified literature.

The searches were repeated on 28.10.16 to identify any relevant literature published since the initial search. The literature search process has been summarised in Figure 2.1.

Figure 2.1 Literature search flow diagram, Search Strategy 1 (Commenced 1.4.14)



The publications reflected three broad categories of literature, the first being exploring MSKUSI in relation to physiotherapists or physical therapists, next was literature that discussed an application of MSKUSI that may be relevant to a physiotherapist's practice but where the paper relates the modality to an alternative health care professional or no specific profession. The third category that emerged was one that uses ultrasound as a measurement tool and outcome measure in research studies. The authors undertaking the research represent many different professions and regularly address questions of relevance to physiotherapists. These three categories have been used to document the literature's evaluation and analysis.

2.3: Literature reviewing the role of Musculoskeletal Ultrasound for Physiotherapists.

The evidence base related to physiotherapists' use of MSKUSI is relatively small; only six studies included the professional name 'physiotherapist' in the paper's title. Several issues that have influenced the formation of this evidence including a lack of standardisation of professional titles internationally. The British term 'physiotherapist' is used in Canada, Australia and New Zealand but tends to be replaced by 'physical therapist' in the United States of America and by 'kinesiotherapist' in several countries including Argentina, Chile and France. The World Confederation for Physical Therapy (WCPT) represents therapists' professional bodies in over a hundred countries and whilst the title of the therapist may vary, the WCPT consistently refers to the professionals as 'physical therapists' in all policies and publications. The literature search has been extended to include material relating to physical therapists to access international opinion, but it has been noted when literature has reflected British practices including the term ‘physiotherapist’.

Another international influence has been demonstrated by an editorial written by Jackie Whittaker, a Canadian physiotherapist. Journals with an international audience aim to attract international authors, consequently the terminology typical for the country where the journal is published may vary from that of the author’s country. Canadian, Jackie Whittaker with an interest in MSKUSI has written the editorial for The Journal of Manual and Manipulative Therapy, published in the United States of America. Her editorial explores the application of ultrasound imaging and consistently refers to physical therapists, not the term physiotherapist which is used in her homeland, (Whittaker 2006).

The member organisations of the WCPT oversee professions concerned with musculoskeletal assessment, treatment and rehabilitation, there are however variations between the professionals’ clinical philosophies, autonomy and contexts of practice, (WCPT 2011). This professional international diversity will have impact on the evidence available and it has been observed that the predominance of relevant publications have been authored in Britain, Australia, Canada or the United States of America.

An international collaboration, (Stokes et al 1997) produced one of the first papers that explored MSKUSI and physiotherapy. This early review focused on the modality’s potential as technological advancements were underway that promised to improve the ease of operation and image quality of scanning systems. It is interesting to note that at this early stage, the authors had identified a role for the modality in both physiotherapists' assessment and management of patients. The proposed links to treatment and rehabilitation were to assess muscle wasting, monitor treatment effectiveness and as a feedback tool for muscle activity. The development from compound scanners to real-time imaging and the recent advancement in real-time scanners was predicted to offer opportunities to image muscle size. Real time scanners had offered a limited field of view for the assessment of muscle morphology but the improvements were anticipated to be of benefit to physiotherapists. The authors discussed the application of ultrasound for the musculoskeletal system and summarised the structures that can be viewed for diagnosis. The imaging potential for muscle is presented in considerable depth that has rarely been replicated. The process of estimating muscle area from linear measurements of muscle size is outlined and supported by strong evaluation of related literature, the complexities of producing valid, reliable and repeatable figures are evident with detailed justifications of statistical methods that should be employed. The authors also discussed technical challenges of calculating muscle strength from linear dimensions and provided clinical examples where they suggest this calculation contributed to understanding the patients' presentation. Links between theory and practice are not extensive but the theoretical and practical considerations required for accurate muscle measurement are reviewed in detail including the implications of complex muscle morphology. This paper attempted to outline foundations for physiotherapists' use of this new application whilst acknowledging that, as an emerging technology it would take time for it to become embedded in practice. The authors have made suggestions regarding the impact ultrasound imaging may have on clinical practice such as assisting diagnosis, muscle retraining programmes, biofeedback, guiding invasive technique and monitoring treatment effectiveness but these clinical uses are presented briefly and not supported by detailed clinical reasoning.

Subsequent authors have published papers with many similarities to that of Stokes et al (1997), one author, Deyle (2005) reviewed several musculoskeletal imaging modalities and developed many of the concepts discussed above but highlighted the need for imaging to be interpreted in context with the overall assessment. Deyle presented a strong argument for physical therapists to order musculoskeletal imaging and suggested that ultrasound appeared ‘well suited’ for their use. This paper developed the significance of clinical reasoning into the diagnostic imaging process and used the analogy of the probe as a deep palpation tool that provides images, thereby providing a good match of skills and knowledge required to those of the physical therapist. The complexity of evaluating tissue changes and their relevance to the patient’s presentation is highlighted as imaging findings are not always significant and the ability to identify normal variants and dismiss insignificant changes is important. Deyle’s acknowledgement of the role of clinical reasoning required to interpret the ultrasound images in a patient focused manner is a new topic in the literature, whilst many authors have documented the potential for operator error and the high skill level required, (Backhaus et al 2001, Brown et al 2006, Edwards 2010, Ferreira et al 2011) the significance of the operator’s musculoskeletal medicine knowledge and clinical decision making skills are not typical inclusions. This paper provides very little detail regarding the role of ultrasound in rehabilitation, it states that ‘valuable rehabilitation information …..could be provided’, (Deyle 2005, page 715), but the absence of detail here reflects the lack of published evidence establishing a role for ultrasound in rehabilitation.

The key concepts identified by Deyle, (2005) were developed by McKiernan and colleagues in a series of publications exploring MSKUSI, (McKiernan et al 2010, McKiernan et al 2011, McKiernan et al 2012). The first of these papers was a literature review that provides an excellent example of the lack of standard terminology in the field. The title of the paper includes the term ‘diagnostic ultrasound’, yet McKiernan focuses on the role of ultrasound as a biofeedback tool for rehabilitation. McKiernan, (2010, 2011, 2012) uses the term ‘diagnostic’ to include muscle activity imaging in all of her publications whereas some authors have used the umbrella term of ‘real time ultrasound imaging’ to include both diagnostic and biofeedback roles, (Jedrzejczak and Chipchase 2008) and others use the precise term ‘rehabilitative ultrasound’ for this application, (Whittaker et al 2007, Stokes et al 2007). Inconsistent terminology in the literature creates challenges to the reader and impacts evaluation of practice.

McKiernan (2010) provides an introduction to the modality’s potential for several professions including physiotherapists, anaesthetists and emergency care physicians but does not present significant new evidence in relation to physiotherapists’ engagement with the modality. The relative lack of research exploring the use of MSKUSI by physiotherapists has been highlighted, this was also identified by other authors in three studies, (Jedrzejczak and Chipchase 2008, McKiernan et al 2011, Potter et al 2012). Jedrzejczak and Chipchase’s observational study (2008) exploring the use of ultrasound imaging by physiotherapists in South Australia noted a growing body of anecdotal evidence and review papers suggesting ultrasound may have a role for musculoskeletal physiotherapists, but no research had investigated this topic to provide empirical evidence. The authors selected a panel of experts to create a three page questionnaire that was mailed to 1328 Australian physiotherapists and of these, fifty percent were returned. Of the respondents, 11.6% reported that they used ultrasound imaging and of these, 65% worked in the musculoskeletal field. Most of the respondents who stated that they did not use ultrasound imaging gave reasons of an inability to access a machine, lack of knowledge, a patient population where there was no relevance and the cost of the machine. The clinical uses recorded by the respondents have been reported with disappointing brevity. Whilst 88.3% of the physiotherapists who use ultrasound reported it had an 'assessment' role and 87% reported it was used for 'biofeedback', these terms have not been defined. The results suggest that assessment imaging was of muscle activity and not to identify abnormal or pathological tissue, but this has not been made clear by the authors. This has been complicated further by the statement in the discussion that 'nearly a quarter used it for diagnosis', this is not fully explained but is followed by a robust evaluation of the professional issues that underpin the use of diagnostic ultrasound. The authors highlight the controversy of physiotherapists diagnosing with ultrasound when this has traditionally been undertaken by sonographers and radiologists. They also raise the significant issue that the machine specification and resolution required for diagnosing soft tissue pathology is much higher than that required for visualising muscle activity. These higher specification systems are more expensive which may be a factor influencing the machines available to therapists. It is worth noting that the price of these more advanced systems has decreased in relative terms since this paper was published so may not have impact currently. Jedrzejczak and Chipchase (2008) also noted that a significant proportion of respondents had received very little training in the modality and most users had trained for two hours of less. Whilst these results relate specifically to the South Australian physiotherapy population and cannot be generalised, several issues have been identified that assist our understanding of physiotherapists' use of the modality and the questions that still need to be investigated. The limitations of the paper have been acknowledged by the authors and mainly relate to the survey; the concept of 'diagnosis' was not defined and the authors suggest that the majority of respondents who reported they diagnosed 'used the term simply to imply diagnosis of poor muscle control'. This study highlights the challenges associated with survey use and demonstrates that alternative methods of data collection should be considered to gain explanatory information.

Physiotherapy ultrasound utilisation has been investigated by two recent studies with several similarities, (McKiernan et al 2011, Potter et al 2012). McKiernan's e-mail survey was distributed to 483 Australian physiotherapists known by university databases and Potter's survey was e-mailed to a convenience sample of British physiotherapists and further distributed by a snow-balling technique. Both authors acknowledge the limitations of their sampling method; the Australian paper was affected by accessing only two databases that were linked to the university and the British paper's method may have resulted in a trail of like-minded physiotherapists being approached via the snow-balling technique. McKiernan's survey was distributed to a range of physiotherapists without any prior knowledge of their interest in ultrasound, whereas Potter's survey was sent to a targeted group of individuals and special interest groups who were selected for their potential links with 'rehabilitative' ultrasound. Potter also accepts that the sample accessed was small, the nature of the questionnaire distribution meant it was impossible to calculate a percentage response rate and that credibility of the results may have been affected by the sampling process. Whilst both of these papers have methodological limitations, they contribute to the evidence regarding the role physiotherapists have for ultrasound imaging and highlight significant gaps in current knowledge and methodological challenges.

Inconsistent terminology is demonstrated in these papers, McKiernan (2011, page 121) interpreted 'diagnostic ultrasound' for physiotherapists to be 'mostly for biofeedback' whereas, Potter et al, (2012) used the terms 'diagnostic' and 'rehabilitation' in relation to imaging for distinctive purposes; diagnostic imaging refers to imaging to identify musculoskeletal injury and pathology and rehabilitative imaging refers to the assessment of muscle function and its training through biofeedback. Potter, (2012) reported the aim of the study was to focus 'on ultrasound imaging within physiotherapy practice, not diagnostic imaging', this correlates with the survey content that explored training and skills related to imaging muscles and their activity. This study does not however provide evidence that physiotherapists in Britain use ultrasound for the purposes Potter describes as 'rehabilitation' more than 'diagnostic' purposes and is not supported by evidence that a clear distinction exists between the two. It is uncertain if this investigation failed to access data from other British physiotherapists who were using musculoskeletal ultrasound imaging for purposes distinct from Potter's definition of rehabilitation.

The terminology and sampling methods used in these surveys vary but they share similar aims and some common results. Both studies explored the training received by physiotherapists who used ultrasound imaging, Potter, (2012) reported only 7% of respondents had received twenty or more hours of training, (formal or informal) and a majority of 87% had undertaken twelve or less hours of formal training. McKiernan (2011) offered less detail regarding training undertaken but 67% of the respondents had received training that 'had only lasted for several hours, not days or weeks'.

The respondents from Potter's survey rated their competence for a list of muscle morphology and activity imaging skills. Whilst the physiotherapists generally reported perceived competence with the skills, there was widespread reporting of training needs in particular related to gaining information on muscle activity.

McKiernan's survey respondents were a less targeted group in that there was no prior knowledge or perceptions about the subjects' interest in ultrasound imaging. The data have not been presented as clearly as Potter's study and it remains uncertain how many respondents regularly used ultrasound in the clinic. The training needs of the respondents were investigated; a large proportion but unstated percentage preferred training in a workshop instead of other indirect methods for instance a DVD and the content of the desired training included professional issues such as 'standards of practice for physiotherapist' as well as scanning practice. The practical procedures favoured for training included imaging muscle activity, for instance of the abdominals but it is interesting to note that a similar number of respondents requested training for imaging the shoulder. The authors have not clarified the purpose of shoulder imaging, but this is an anatomical area routinely scanned for diagnostic purposes whilst scanning for biofeedback is not well established, (Day & Uhl 2013, de Jesus et al 2009, Smith et al 2011). The practical challenges presented by these Australian physiotherapists typically related to accessing a suitable machine, McKiernan comments on these difficulties and that the practice of radiology departments passing on superseded machines may provide a solution. She is careful to highlight that these machines have a higher specification than many found in physiotherapy departments, so passing them on must be supported by appropriate training. The full potential for physiotherapists using these higher specification machines has not been evaluated. The limited resolution and imaging quality regarded as acceptable for imaging muscle activity in the physiotherapy clinic is not adequate for diagnostic imaging performed by professionals investigating for musculoskeletal pathology, for instance in radiology. If physiotherapists were able to access machines with excellent image quality, it could be argued that they should be able to access the full machine’s capability if it supports their patient management. McKiernan, (2011) has not reviewed the associated professional issues or opportunities that could be available to physiotherapists if high specification machines were utilised to support patient diagnosis in the clinic.

Potter (2012) reported similar practical challenges to the Australian physiotherapists, (McKiernan 2011) and that a significant percentage of the survey respondents did not use ultrasound imaging in the clinic, the main reason given by 71% of therapists for not imaging was lack of availability of a suitable scanning system. The complexities of matching machine availability, specification and therapist's aims were not evaluated in this paper but the authors observed physiotherapists were using ultrasound for biofeedback in muscle training despite the limited evidence base to support this application.

McKiernan (2011) and Potter (2012) provide evidence that some physiotherapists are regularly using MSKUSI but the scanning purposes vary; the studies have not fully investigated physiotherapists using the modality for diagnostic purposes and provide limited information regarding the role of scanning in rehabilitation. Whilst these two studies reflected an interest in the modality, the nature of the methodologies limited the depth of information that the subjects provided.

Literature accessed following the initial search identified two publications related to physiotherapist's diagnostic ultrasound skills. Thoomes-de-Graaf et al (2014) from the Netherlands and Marovino & Caffo (2015) from the United States both reported studies relating to diagnostic ultrasound of the shoulder performed by physiotherapists. Thomes-de-Graaf et al explored diagnostic agreement between physiotherapists and radiologists; agreement was high for full thickness tears but for other pathologies, agreement was lower. The authors observed agreement was higher for the physiotherapists who had received considerable training and lower for those who had received minimal training. Marovino & Caffo's brief report from a congress presentation summarised their study exploring the validity of physical therapists performing ultrasound when compared with MRI. A high diagnostic accuracy of 87% was reported, but the methodological detail was extremely limited. These two studies indicate researchers are now exploring physiotherapists' diagnostic accuracy with ultrasound and whilst they relate to one anatomical area only, were not based in the United Kingdom and provide no information regarding training programmes, they suggest physiotherapists' use of MSKUSI is evolving and that for some researchers and clinicians, the diagnostic application of ultrasound is an interest.

2.4: Literature that reviews the role of Musculoskeletal Ultrasound for unspecified health care professionals or those who are not physiotherapists.

A substantial and increasing body of literature evaluates the role of ultrasound in musculoskeletal medicine; whilst much of the literature does not specify the professional group involved, some studies propose ultrasound roles that may be relevant to physiotherapists and other papers appear to purposefully disregard physiotherapists. Literature related to rheumatologists and sport physicians has been discussed above, other professional groups whose interest in the modality is documented include orthopaedic surgeons, (Scholten-Peeters et al 2014, Ziegler 2010) and general or rehabilitation physicians (Ozcakar et al 2012, Primack 2010, Smith 2010). The evidence base presents a clear indication of the role of ultrasound in the diagnosis of musculoskeletal conditions for these professions and in some cases, no specific professional group is described, (Smith & Finnoff 2009b, Tok et al 2012) There is also an emerging evidence base that links the application of ultrasound to guiding interventions including intra-articular injections and nerve blocks, (Lento & Strakowski 2010, De Muynck et al 2012, Royall et al 2011, Smith & Finnoff 2009a).

Studies which deliberately exclude the relevance of ultrasound to physiotherapists were discovered in the literature search. Ozcakar et al, (2010) reported a survey distributed to delegates at the International Society of Physical and Rehabilitation Medicine in 2009. There are similarities with Jedrzejczak and Chipchase (2008) as the subjects were asked if they used MSKUSI and if they had received training. The survey by Ozcakar et al, (2010) varied from Jedrzejczak’s as it asked the subjects to identify anatomical regions and type of structure that should be imaged and compared these results with a small section of the cohort who received one day of training before the conference. Interestingly, whilst the conference was open to all professions interested in musculoskeletal medicine and rehabilitation and all delegates were asked to complete questionnaires, only the results of doctors were analysed and eighteen physiotherapists' questionnaires were discarded. The authors can defend their research question that focused purely on the interest of doctors in ultrasound, but it is hard to justify gathering potentially valuable data without continuing to analyse them. Whilst much of the evidence base discussing ultrasound reflects a multidisciplinary interest, it is revealing to find studies that are professionally exclusive.

2.5: Literature that reviews the role of Musculoskeletal Ultrasound as an Outcome Measure in Research Studies.

The final body of evidence found in the literature related to the use of ultrasound imaging as an instrument to view and measure structures in research. Ultrasound's role as an outcome measure in research varies greatly but can be broadly categorised into three categories: to review muscle dimensions at rest and during activity, to measure movement and to evaluate the effect of an intervention on pathology.

Several studies have used ultrasound to review muscle thickness during activity, the interest in this area initially focused on the clinical potential of viewing the abdominal and posterior trunk muscles and their contribution to the concept of 'core stability' (Hides et al 1998). Research has evolved to enable the development of valid measurement protocols, (Whittaker 2008, Cuellar et al 2017) and responses to technical complexities, (Worsley et al 2012, Worsley et al 2014). Physiotherapists who specialise in female continence have continued to explore the pelvic floor and abdominal muscles with ultrasound (Arab & Chehrehrazi 2011, Tahan et al 2014, Ehsani et al 2016a). Musculoskeletal physiotherapists are now informed that muscle changes regularly accompany pain presentations but have struggled to identify a clear role for imaging based rehabilitation (Ferreira et al 2011, Koppenhaver et al 2009, Mew 2009, Ehsani et al 2016b). Investigators have started to transfer the technical knowledge gained from abdominal and posterior trunk muscles imaging to other anatomical regions, this includes the scapulo-thoracic muscles where the effects of upper limb load on control are a consideration, (Day & Uhl 2013).

The dynamic potential for ultrasound has been the key feature for several researchers; nerve movement has been explored, (Dilley et al 2008, Ridehalgh et al 2012, Wang et al 2014) and one study has looked at joint mobility, (Wang et al 2005). All of these studies have acknowledged technical challenges, potential for error from a lack of training or standardised protocols and the lack of transferability of the measurement tool to clinical practice.

Pathological features viewed with ultrasound have also been accessed by researchers as an outcome measure to evaluate effectiveness of treatment programmes. Typically, authors have reviewed the tissue before and after treatment and have commented on changes to specific parameters, for instance tendon thickness, muscle cross-sectional area or Doppler response. The changes witnessed in tissues have been regarded as evidence of treatment regime effectiveness and have provided opportunities to explore the correlation of imaging findings with symptoms, (McCreesh et al 2013).

Ultrasound imaging has been incorporated into a significant volume of research in the last decade and many authors propose further studies with the modality. It is not always possible to establish the professional roles of the authors but it is worth noting, that a large number of the authors are physiotherapists, (Ridehalgh et al 2012, Endleman and Critchley 2008, Malliaris et al 2013).

2.6: Search Strategy 1: Summary

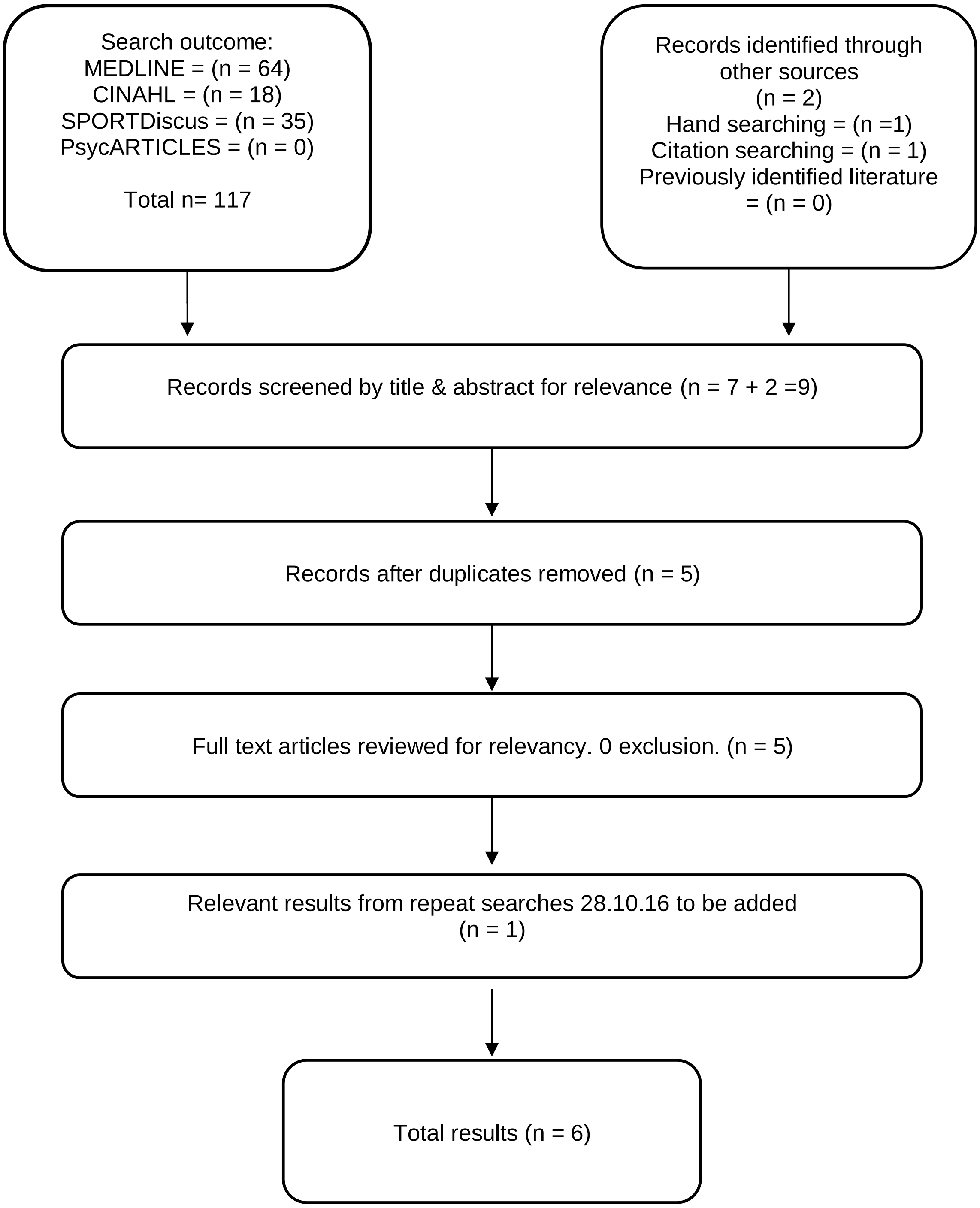
The literature identified from this search was explored in three categories: MSKUSI by physiotherapists or physical therapists, MSKUSI relevant to a physiotherapist's practice but where the paper relates the modality to an alternative health care professional or no specific profession and finally, where ultrasound is a data collection tool in research. This division of literature has been supported by a paper published subsequent to the initial search, (Roll et al 2016) that reported a scoping review of 'non-physician rehabilitation providers' use of MSKUSI. Roll et al, (2016) categorised the literature into three categories: use of MSKUSI in a rehabilitation context generally to support diagnostic clinical reasoning or biofeedback, use of MSKUSI in a research context and use of MSKUSI in a non-rehabilitation context that has relevance to non-rehabilitation providers for diagnostic clinical reasoning and monitoring. The literature search conducted above and published scoping review, (Roll et al 2016) share findings and have identified common themes, they both concluded that non-medically qualified professionals in the field of musculoskeletal management have shown an interest in MSKUSI to support their practice. The current evidence base lacks detail regarding these specific clinical applications or the links between traditional musculoskeletal management approaches but reflects a keen interest in this developing application.

2.7: Search Strategy Related to Musculoskeletal Ultrasound and Training:

One of the research questions identified was: What education and professional support has been available to support physiotherapists' learning of MSKUSI? The previous literature search conducted had identified literature related to this question and this was supported with a formal search. This search was performed using multiple databases including Medline, CINAHL (Cumulative Index to Nursing and Allied Health), SportDiscus and PsychArticles via The University of Essex's library database system. The search was limited to journals written in English and as before, there was no limit date as this is a contemporary topic.

A search was conducted using the following words as search terms, 'physio* OR (physical therapist) AND musculoskeletal AND ultrasound OR sonograph* AND education OR training'. This search produced 117 results, the results' titles were reviewed for relevancy and only 4 were directly relevant. The search was extended by citations and previously identified literature producing a total of 5 unique results. The searches were repeated on 28.10.16 to identify any relevant literature published since the initial search. The literature search process has been summarised in Figure 2.2.

Figure 2.2 – Search Strategy 2



2.8: Literature reviewing Education and Training in Musculoskeletal Ultrasound.

The initial literature review identified five papers that discuss musculoskeletal ultrasound education for physiotherapists, the small number, in itself reflects a limited evidence base and the short timescale of physiotherapy involvement.

McKiernan et al (2011) was the first study that specifically focused on the physiotherapy profession and their education requirements in MSKUSI. An eighteen item questionnaire gathered data exploring a range of topics with both open and closed questions. The responses were inevitably somewhat brief and did not reflect the complexity of issues explored including educational demands. The topics identified as training needs have been listed by the respondents using very short phrases such as ‘regional modules’ and ‘training standards’. These responses have been grouped together into five categories: ‘diagnostic ultrasound anatomy’, ‘diagnostic ultrasound machine controls’, ‘diagnostic ultrasound physics’, ‘diagnostic ultrasound ethics’ and ‘other’. These topics provide baseline information regarding the perceived knowledge requirements of physiotherapists but provide little detail and no information regarding skills or knowledge that would be unique requirements for physiotherapists. The paper explores some professional issues but inevitably, in an extremely superficial manner as it is not this article’s focus. It is suggested that ‘the professional body should be involved and develop guidelines and codes of practice in relation to physiotherapy’, (McKiernan et al 2011, page 124) and that support should be sought from experts in the field. This valuable paper identifies topics that are relevant to physiotherapists’ use of MSKUSI, these topics all warrant further investigation in particular the requirement to provide training that matches this professional group's clinical needs.

McKiernan identified one specific topic from the questionnaire that formed the basis for further research. The method of training preferred by physiotherapists was the focus of one question in the 2011 study, this revealed that the majority of respondents suggested workshops or DVDs were the methods that 'best suited' them. A subsequent publication, McKiernan (2012) compared the outcome of these two different education approaches for physiotherapists and concluded that neither produced superior results when the participants' skills and knowledge were assessed following the training. Both training methods were well received with virtually all participants reporting they enjoyed the training and that the delivery of content was good. This study offers an extremely limited insight into appropriate and efficient ultrasound education and does have several methodological limitations including the fact that the physiotherapists were able to choose the educational approach they preferred to engage with instead of random allocation. The training material covered technical and practical aspects of scanning but at an introductory level only and provided a limited insight into the modality. The workshop lasted one day and the DVD included the same lecture material and films of scanning techniques alongside the ultrasound images. The impact of inconsistent terminology 'rehabilitative' and 'diagnostic' imaging skills was apparent, (as in McKiernan 2011) as muscle activity imaging was classified as diagnostic. The practical content of the education focused on abdominal muscle, multifidus and pelvic floor activity which is not typically categorised as diagnostic and did not include any scanning protocols of joints or peri-articular structures that could support a typical musculoskeletal examination. This education content reflects a valid starting point for clinicians and may be defended by its unique relevance to physical rehabilitation practitioners including physiotherapists, but does not include several elements that have been prioritised in other professionals' formalised education programmes, (Royal College of Radiologists 2013, Brown et al 2006, Consortium for the Accreditation of Sonographic Education 2015). The participants completed knowledge based assessments before and after the education that revealed both groups had learnt from the educational products, but neither group demonstrated greater knowledge acquisition. Participants were also encouraged to express views on the education in an open comment section. The authors reported that a number of participants expressed 'the training made them very aware of how much they did not know', this may have been a response to the limited content of the education delivered but also the participants' realisation of the modality's complexity and potential application.

Two linked studies, Arroyo-Morales et al (2012) and Cantarero-Villanueva et al (2012) both explored ultrasound education for undergraduate physiotherapy students at a Spanish university. Both explored effects of an e-learning package on the development of palpation and sonographic skills, one paper focused on the knee, the other targeted lumbo-pelvic muscles. In each study, the students were divided into two groups who received standard on-campus education in palpation and ultrasound. Following this period of instruction, one group were guided to books to supplement their learning and the other group were given access to e-learning material. The students' knowledge and practical skills were assessed and in both studies, the students who had supplemented their education with e-learning had superior practical assessment marks. These studies suggest e-learning may have a role as a teaching method for ultrasound imaging and palpation skills but the authors have not provided a clear rationale for the inclusion of the modality in under-graduate education or commented on curriculum content for the learning to have a clinical application. The anticipated role of ultrasound imaging in clinical practice is not clear but the authors highlighted that clinicians place value on the modality, 'over the past decade, physiotherapists have increasingly incorporated musculoskeletal ultrasound examination into their clinical or research activities', (Arroyo-Morales 2012, page 474).

Potter et al (2012) was the final study from the initial literature search that explored education for physiotherapists. Forty-six questionnaire responses were received from physiotherapist users of MSKUSI, of these, 87% had undertaken 12 hours or less of formal training and 48% had received no formal training at all. The respondents who had not received formal training were less likely to have had any training in physics and safety; only 28% of the informally trained physiotherapists had covered this area. The physiotherapists were asked to rate their perceived level of competence for a list of specific skills and whilst for each skill a large proportion of respondents reported they felt competent, the proportion of respondents who reported they were not competent generally exceeded 20% for each skill. The questionnaire also explored the respondents' priorities for future training and approximately 70% reported training in 'operational aspects to achieve a clear quality image' and 'recognition of cross sectional anatomy' were moderate or high priority training needs. It is evident that therapists' training had generally not met their requirements, a large proportion of them expressed a desire for more and reported a lack of competence at several skills. This study has many limitations, both in the number of subjects involved and the sampling methods but it does provide evidence that physiotherapists are interested in ultrasound imaging and the training received had not fully met their needs. Potter et al (2012) is a revealing study of British physiotherapists that demonstrates the cohort of clinicians' awareness of their limitations and training potential, it does however provide support for the concerns of some individuals who report anxieties about physiotherapists using ultrasound imaging without appropriate training, (Edwards 2010).

The search completed on 28.10.16 identified one more publication related to education in MSKUSI for physiotherapists, (McKiernan et al 2015). This publication focused on the study that had been reported in the previous paper, (McKiernan 2012) where the outcome of two different training packages for physiotherapists were evaluated. The 2012 publication concluded that DVD and workshop training methods produced similar assessment outcomes, the 2015 publication provided greater detail of the training packages' content. It is evident that the training offered to the physiotherapists focused on assessment of muscle activity, abdominals, multifidus and pelvic floor and that no content provided training related to articular or peri-articular structures. This latest publication included the phrase 'diagnostic ultrasound' in its title and adds further evidence to the inconsistent use of this term. It provides more detail of the training package's restricted curriculum for the physiotherapists and reiterates the challenges faced by clinicians who are keen to engage with MSKUSI.

2.9: Summary of Emergent concepts from the Literature Review

Despite developments in musculoskeletal ultrasound systems that have improved the quality and ease of use of this technology, there is currently no evidence that indicates the extent that British physiotherapists have integrated it into their professional practice. This clear gap in the evidence warrants investigation.
The number of academic papers that incorporate MSKUSI as an outcome measure in research or discuss it as a modality for diagnosis or rehabilitation is increasing and the frequency of publications incorporating MSKUSI is also rising. Publications have not however explored the professional motivations for the individuals who accessed the modality; why were these physiotherapists interested in MSKUSI and what did they envisage it would add to their practice? Professions already exist that provide MSKUSI diagnostics, so the question should be asked as to why physiotherapists want to access it. Similarly, for clinicians who have incorporated ultrasound into their practice, there are no studies that have explored the impact it has made or the perceived contribution for clinicians or patients.

Existing literature uses terms related to MSKUSI inconsistently, the specific details of the division between diagnosis and rehabilitation are not always evident and have not been explored in relation to current clinical practice.

Whilst it is clear that educational requirements for physiotherapists in MSKUSI have not been standardised, it is also evident that a gap exists in the evidence regarding physiotherapists' educational experiences. Researchers have explored the training that physiotherapists have undertaken but there is little detail related to professional support or barriers encountered once they have expressed an interest in MSKUSI. It is evident that some professionals may have reservations regarding physiotherapists' interest in using ultrasound, but no studies have investigated these professional issues fully including the possibility that physiotherapists have been able to access training and support from colleagues including radiologists, rheumatologists and sonographers.

The need to set standards and monitor training for the use of MSKUSI appears regularly in the literature, but the details of the training required for the varying uses of the modality by physiotherapists have not been clarified. The training needs of a physiotherapist who intends to integrate ultrasound into their full assessment process will be very different to the requirements of a physiotherapist who only wants to view muscle activity. The view of physiotherapists of their training needs and the suitability of current training provision has yet to be fully investigated. Ultimately, for training to be developed and delivered that matches physiotherapists' requirements, it is imperative that clinicians provide information regarding the type of training desired.

Existing literature provides virtually no information regarding the influence of MSKUSI on patient assessment or management outcome. Some authors have hinted that diagnostic ultrasound is well suited to physiotherapists (Deyle 2005, Potter et al 2012), yet the impact the intervention has on clinician's clinical reasoning or patient management has not been explored. Physiotherapists' clinical reasoning has been evaluated by many authors, (Edwards et al 2004, Langridge et al 2015, Knox et al 2015) and has been reported as a process that runs throughout patients' management. It would be valuable to explore the relationship between reasoning and MSKUSI as clinicians observe diagnostic labels can be modified throughout the course of management, (Edwards et al 2004). It is not known if MSKUSI could add clarity to this process, enabling diagnostic confirmation at an earlier stage, or if the clinical reasoning outcome remains unaffected by this imaging modality. The orthodox medical model of tissue-based pathology dominates MSKUSI literature, (Chew et al 2008, Cozzarelli 2012, Patil and Dasgupta 2012) there are references to ‘incidental findings’, ‘normal variants’ or ‘age appropriate changes’ but the implied link between tissue-based pathology and symptoms is prevalent. This orthodox model of tissue-based pathology is reflected in traditional ultrasound training and therefore the practice of clinicians including radiologists and sonographers. Physiotherapy education routinely explores non-nociceptive pain, complex pain states and biopsychosocial impacts on presentations and physiotherapists may therefore be in a strong position to integrate these concepts into their MSKUSI. The integration of this aspect of professional education into diagnostic ultrasound interpretation has not yet been included in literature.

Some evidence exists that MSKUSI can have impact on patient satisfaction, (Wheeler 2010) and whilst this pilot study included small patient numbers and was linked to a sport physician’s assessment it raises the issue that the intervention will influence the patient experience. No studies have explored the impact of ultrasound on the patient experience in physiotherapy from the view of either the therapist or the patient. It could be insightful to seek the views of physiotherapists on the perceived influence on patient assessment or management. Do the therapists feel that the ultrasound has any impact on the patient’s understanding of their condition, their ability to perform exercise or their compliance with rehabilitation regimes? Whilst it would be valuable to seek the opinions of both patients and physiotherapists, the therapist’s viewpoint links most directly to their motivations for accessing the modality.

2.10: Research Question:

The following research question was constructed to frame further investigation:

Why are physiotherapists interested in musculoskeletal ultrasound imaging and what are the clinical roles of the modality for this professional group?

This was studied by an initial questionnaire that will aim to identify physiotherapists who have an interest in MSKUSI including some of their professional characteristics and indications of the modality's clinical application for physiotherapists. This will be followed by an interview based study that will enable the concepts identified by the literature review to be addressed. Questions to be explored include:

Why does MSKUSI interest physiotherapists?

What is the clinical role of MSKUSI for physiotherapists?

Do physiotherapists use terms to categorise the role of MSKUSI, for instance 'diagnostic' or 'rehabilitative'?

What professional issues have impacted on physiotherapists' intentions to integrate MSKUSI into the clinic?

What impact does MSKUSI have on patient management including clinical reasoning underpinning diagnosis and treatment?

What education is available in MSKUSI and does it meet the requirements of physiotherapists?

Chapter 3 Methodology

3.1: Theoretical Framework:

This research study included the application of two data collection tools and has been classified as a mixed-methods study. This approach to research has been described with varying terminology including mixed-methods (Creswell 2003, Tashakkori and Teddlie 2003), multi-methods, (Brannen 1992), combined design (Niglas 2004) or multi-strategy, (Bryman 2004).

Mixed-methods research has been described as the third paradigm, alongside qualitative and quantitative approaches, (Johnson et al 2007, Morgan 2007 and Florczak 2014) and as an approach, the intention is to combine multiple viewpoints and perspectives.The appealing pragmatic feature of this paradigm is described as the focus on addressing the research question; this should be the key motivation and paradigmatic dogma that creates obstacles should be avoided (Alexander et al 2011). The researcher should embrace research practices that enhance quality and rigor of the study, but accept that scientific knowledge should be accompanied by common sense, (Johnson et al 2007, Florczak 2014). Mixed-methods researchers consider integration of many types of knowledge may be required to answer a research question and switching between data collection methods and paradigms provides opportunities that are not available to paradigm purists, (Jick 1979, McEvoy and Richards 2006).

The historical development of mixed-methods research is reflected by a lack of consensus regarding the role of this approach, in particular the process for integrating the two paradigms in one study. A number of authors propose triangulation as a major component, (Campbell and Fiske 1959, Webb et al 1966, Smith 1975, Denzin 1978 and Jick 1979), this process seeks to converge data from two or more sources across qualitative and quantitative methods. Triangulation of two strands of data provides one justification for accessing more than one method, but is not an essential feature of mixed-methods research. Several authors have observed that papers documenting mixed-methods research have been published whereby no triangulation of data has occurred, (Bryman 2004, Niglas 2004). Sieber (1973) published an account of justifications for integrating fieldwork and surveys into a single study and the significance of data collection order. Sieber presented several examples to demonstrate the role of a survey prior to fieldwork, for instance to enable sampling of representative or unrepresentative cases.

The rationale for combining quantitative and qualitative paradigms in one study was explored further by Greene et al (1989). Five justifications for this combination were proposed; triangulation, complementarity, development, initiation and expansion. Triangulation has been defined above but its definition is not consistent in literature. Complementarity relates to the aim of seeking elaboration and clarification of the results of one method with the results of another, the development role uses the results of one method to inform the development of the other, the first method may be used to guide sampling or another aspect of implementing the second research method. Initiation relates to the aim of seeking contradiction between methods and expansion is the process of extending the breadth of the enquiry by accessing more than one method. Methods have been combined in this ultrasound based study for the main purposes of complementarity and development, the aim was also to integrate some components of data in the analysis stage thereby incorporating triangulation.

Greene’s development role shares similarities with the concept of sequential triangulation, whereby the results of one study are necessary for the second part of the study to be planned including the development of sampling strategies and interview topic guides. Sequential triangulation also acknowledges that the data may not necessarily be formally analysed together, but the results may complement each other and the integration of the two methods offers greater depth than a single paradigm, (Morse 1991).

Greene’s scheme for classifying justifications for mixed-methods research has been applauded by other authors, (Bryman 2004 and Niglas 2004). The value of Greene’s five category scheme’s simplicity has been highlighted but observations have been made that there are some limitations. Niglas, (2004) extended Greene’s scheme and identified eighteen rationales for mixed-methods research. Several of the eighteen rationales offered can be applied to this ultrasound based study; the relevant rationales include completeness, sampling and illustration. Completeness acknowledges contributions from both quantitative and qualitative approaches enable researchers to include data from varying perspectives, offering a more comprehensive response to a research question than possible with a single paradigm and has features in common with Greene’s complementarity role. Sampling shares features with Greene’s development role that one approach facilitates the sampling strategy employed for the second approach and illustration refers to the role of qualitative exploration of quantitative findings. Niglas' illustrative role and the complementarity role as presented by Greene both acknowledge that one approach may yield data that warrants clarification and exploration with another approach.

3.2: Research Design

This ultrasound based research was divided into two sections; a survey and in-depth interviews. The two components were distinct in that the data were collected at different times. The data analysis from the first component was used to inform the sampling for the in-depth interviews and to identify concepts for exploration and elaboration. This mixed-methods study design follows, to some extent the explanatory-sequential design outlined by Cresswell and Plano Clark, (2011) as it involves the collection and analysis of quantitative data, this is the priority data collection tool in their model. This phase is followed by the collection and analysis of qualitative data that should enable explanation of the findings found in the quantitative study.

This ultrasound based study has commonalities with Cresswell and Plano Clark's explanatory-sequential design sequence but whilst the initial part of the research involved a survey that was designed to fulfil a number of roles, it was not the priority data collection tool. The roles of the survey included accessing physiotherapists with an interest in MSKUSI, collecting background data about the physiotherapists including their work environment and educational history in

MSKUSI, enabling a purposive sampling strategy for the second part of the study and gaining consent from physiotherapists who would be willing to be contacted for interviews. Sieber,(1973) highlighted the role a survey can play guiding subject sampling prior to fieldwork and presented ideas relating to the elimination of ‘elite bias’. He proposed that subjects who are known to be related to a field are typically those initially approached for fieldwork and that they can represent a limited subject group, this elite group may be very articulate but may not reflect the full strata of possible interview subjects, those who are not so well known may be equally qualified informants. Within this study, it would have been tempting to make direct contact with the small number of physiotherapists who have become known and recognised for their work with MSKUSI. It was important however, for a range of physiotherapists with an interest in the modality to be approached, thereby accessing a wider subject group who may reflect features inconsistent with the elite group.

The roles of the survey outlined were achieved by the collection of data with two different question types. There were questions answered by selecting one response from a list of options, these produced nominal data that could be analysed using quantitative methods. The survey also included open questions, these were designed to provide leads and identify themes that could be further explored in the second stage of the study, the in-depth interviews, (Sieber 1973). These open questions provided data that could not be comparably analysed using quantitative methods and represented the inclusion of mixed-methods within a data collection instrument as well as the whole study.

The survey is aligned with Greene's development role for a study component in mixed-methods research (1989). This initial component enabled development of the second stage; the in-depth interviews aimed to explore topics relevant to the research question whilst responding to issues raised in the survey. This aim of seeking elaboration and clarification of the results of one method with the results of another is aligned to Greene's complementarity rationale for mixed-methods research, (Greene et al 1989).

3.3: Ethics

Research must be conducted ethically by ensuring the rights of others are protected. Prior to data collection, an application was submitted to the University of Essex's research approval system to ensure this study complied with ethical standards. This 'Application for Ethical Approval of Research Involving Human Participants' is enclosed in appendix 1. The response from the university's Faculty Ethics Committee has been enclosed in appendix 2. As the study did not involve patients in any way, the university approval process was the only one required.

The university research approval process is aligned with publications and guidelines related to ethical health related research, (World Health Organisation 2011, Egan-Lee et al 2011, Guerriero and Correa 2015, Gelling 1999). The World Health Organisation, (2011) lists criteria that should form the basis for ethical approval review, these include: a strong methodological design, an analysis of risks against benefits, appropriate subject selection, protection of research participants' confidentiality, informed consent and consideration of financial motivations. These criteria relate to terms routinely used when evaluating the ethical basis for a research study such as beneficence and non-maleficence. The analysis of risks against benefits can be considered as the potential beneficence (potential benefit to health care and patients) and non-maleficence, (the intention to do no harm to health care and patients), (Andersson et al 2010, Gelling 1999) alongside reviewing the intent of the research, Guerriero and Correa 2015). This study's risk of non-maleficence could be assessed as extremely high as no patients were involved, all of the participants consented their involvement and the data collection methods were not attempting to access information of a sensitive nature. The approval process's review of potential beneficence of this ultrasound based study may not have considered imminent patient benefits but may have evaluated the value of obtaining professional opinion and the advantages of developing the evidence base.

The study's participants must be assured protection by evidence of a process to gain consent and confidentiality. Research ethics committees and organisations involved in health care research such as The World Health Organisation emphasise that participants' rights must be respected. Health care practitioners in the United Kingdom should all be familiar with professional codes of conduct that ensure non-disclosure of patient information, (Chartered Society of Physiotherapy 2011, Health and Care Professions Council 2016) and as research participants should expect identical levels of respect and anonymity. The approval process for this this ultrasound based study included the assurance that participants consented freely and that data would remain confidential.

The study's participants and the impact of dissemination of this ultrasound based study are also protected by the ethical principle, veracity. Veracity encompasses honesty that should accompany research and can be evidenced in the information available for participants, the interview style designed to facilitate the participants' views and the truthful reporting of findings (Gelling 1999, Egan-Lee et al 2011).

3.4: Reflexivity

There is a requirement when conducting any form of research to review the role of the researcher in the process, some authors have commented that this analysis is too frequently absent and that publications focus on what was done in the study rather than how it came to be done, (Cheek et al 2015). The positivist approach dictates that data should be collected and analysed in a replicable manner, irrespective of the researcher. In qualitative research however, the role of the researcher must be considered as their personal experiences and knowledge will influence the entire research process, (Lambert et al 2010).

The significance of my profession warrants consideration as it could be argued that as a physiotherapist, I would choose to present the profession in an unjustifiably positive way. There is a viewpoint that a neutral stance is required to enable the researcher to obtain data that is not biased and to conduct a fair analysis.

Qualitative analysts however argue that the researcher’s position is integral to the research process and the presentation of any study should include a review of this position, (Rolfe 2006, Darawsheh 2014).

My position as a physiotherapist has influenced the research process in several ways. Firstly, it underpins the formation of the research question. As a physiotherapist with 25 years of musculoskeletal clinical experience and 17 years of contributing to higher education relating to musculoskeletal medicine, I have witnessed and been influenced by a plethora of professional environments, clinical challenges and educational frameworks. Having attended an introductory weekend course exploring MSKUSI for physiotherapists approximately 15 years ago, I had not been able to access equipment or develop my interest in the modality. Recruitment to the University of Essex in 2008 reintroduced me to ultrasound, a module relating to MSKUSI alongside several other modules dedicated to advanced musculoskeletal practice had been validated, but remained undeveloped and undelivered. My role was to deliver these postgraduate musculoskeletal modules and a module aimed as an introduction to MSKUSI was delivered by external tutors for the first time over 4 days of teaching in 2010. Many of the complexities associated with MSKUSI education were immediately apparent and several issues related to physiotherapists engaging with the modality emerged, these contributed to the formation of this study’s research question.

My profession and professional experience have also influenced access to subjects. Personal factors have had impact; several physiotherapists in key roles, (within CSP Professional Networks and / or have curriculum vitae reflective of noteworthy success) acknowledged the value of the research questions, which alongside my personal professional record lead them to offer support with questionnaire distribution.

The impact of my profession as a physiotherapist extends beyond accessibility of subjects to many elements of the process including prior knowledge to guide questioning in the interviews and familiarity with professional terms used by subjects. My personal knowledge of musculoskeletal pathology, management and professional skills typical of a physiotherapist enabled the in-depth interviews to progress without pauses for clarification or lack of understanding.

Researchers need to maintain reflexivity throughout the entire research process including data analysis. During this process, researchers should attend to the data whilst acknowledging their own influences, biases and assumptions, this has been neatly summarised by Probst, (2015) who commented, ‘Reflexive researchers are, in essence, gazing in two directions at the same time’. The analysis of the research data, in particular, the interview data were highly dependent on my ability to interpret the participants’ terminology. My own accessible understanding of this terminology which is core to musculoskeletal physiotherapists informed analysis alongside the requirement to be ‘gazing in two directions’, (Probst 2015) ensuring my personal viewpoints did not underpin the analysis.

Adopting a reflexive stance has revealed my personal position has been an enabling factor; it has enabled me to gain access to an appropriate cohort, provided me with knowledge of musculoskeletal medicine and theoretical issues associated with MSKUSI. This approach contributes to the rigour and credibility of the study by acknowledging the influence of myself as the researcher and presenting this impact with transparency, (Rolfe 2006, Darawsheh 2014).

3.5: Research Paradigm

The term ‘paradigm’ is used to reflect a stance on the nature of research and has been occasionally replaced by terms such as ‘worldview’ or ‘shared understanding of reality’, (Morgan 2007). This worldview or understanding, extends to an epistemological position that reflects issues associated with the philosophy of knowledge, for instance realism and constructivism. The two elements in this mixed-methods study are associated with differing paradigms; these contrasting paradigms will now be explored and the philosophical position that enables them to be integrated into one study will be presented.

Quantitative research typically follows the positivist paradigm, this is linked to the natural sciences and based on the viewpoint that reality is independent of the observer, (Stahl 2007). Quantitative methods use validated measurement tools to generate data, statistical methods are then employed to explore relationships between dependent and independent variables. The aim of positivist research is to eliminate bias with standardised and validated protocols so that outcomes can be described with statistically verified terms. Research findings can then be presented with a view to generalise findings from small cohorts to larger populations, (McEvoy and Richards 2006). Historically, positivist development can be traced to Descartes’ doctrine that there was a separation of mind, (soul substance) and matter, (physical substance), (Hirschheim 1985) and has provided the basis for many laboratory based studies, randomised controlled trials, structured questionnaires and systematic reviews. The survey used in the first stage of this study includes elements of a quantitative research tool (which, if used in isolation follows the positivist paradigm).

Challengers to positivism argue that detached observation of an independent reality is unlikely to be the most effective mechanism to improve our understanding of a phenomenon. Alternative approaches are therefore required to access rich data that reflects subjects' attitudes, beliefs and experiences as well as acknowledging the position of researchers involved, (Haralambos and Holborn 2008, Schwandt 2003 and Chen et al 2011). Qualitative research responds to the view that exploration of social construction cannot be achieved with the positivist paradigm. The interpretivist paradigm that has evolved incorporates a wide range of philosophical perspectives including the qualitative approaches ethnography, phenomenology and symbolic interactionism. These interpretivist approaches all facilitate the study of subjects' opinions, personal experiences and life stories whilst acknowledging the interaction between researcher and participant, (McElvoy and Richards 2006). The opportunities and aims of interpretivism identified by individuals in the latter part of the twentieth century were summarised by Schwandt, (2003). Four key features were listed: firstly Schwandt cite's 'empathetic identification' that was described by Wilhelm Dilthey whereby the researcher has the opportunity to 'get inside the head' of the subject in terms of beliefs and thoughts. Secondly, there is intersubjectivity as proposed by Schultz in 1962 that acknowledges meaningful interpretations humans make of their own and others' actions in their everyday lives. Thirdly, Winch (1958) highlighted the need for the researcher to consider the meanings of their subjects' cultural and institutional normality. The final feature Schwandt identified was outlined by Taylor (1995) who emphasised the interpreter’s role including their relationship with the subject and their prejudices, acknowledging this link is in contrast to the positivist position whereby the research is independent of the observer.

The survey was designed to collect nominal data via closed questions with answers selected from a list of options, this data was suitable for quantitative analysis. Qualitative data was also collected via the open questions in the survey and the in-depth interviews. The aim was to collect rich data that reflected individuals’ beliefs, opinions and reported experiences. This type of data is not obtainable with quantitative data collection instruments and cannot be analysed with quantitative analysis tools: statistical methods. Blending of methods requires careful rationalisation, integration of contrasting data types and justification of epistemological issues.

Critical realism is a philosophy often associated with mixed methods research. Its origins are linked to the writings of Bhaskar (1975), these have been the basis for many subsequent authors who have explored and developed the approach, (Archer et al 1998, McEvoy and Richards 2006, Maxwell and Mittapalli 2010, Venkatesh et al 2013 and Zachariadis et al 2013). Critical realism evolved from realism, a key feature of the realist position is the acknowledgement of a real world that exists independently of our preconceptions. Critical realism retains ontological realism whilst accepting epistemological constructivism, that our understanding of a phenomenon is constructed from our own viewpoint, (Maxwell and Mittapalli 2010). Critical realism accepts that whilst we have knowledge of the world, this is incomplete and grounded in a particular perspective. It has been suggested that it is the ideal philosophy for mixed methods research as it acknowledges the existence of different types of knowledge, physical, social and conceptual that have varying epistemological and ontological contexts, (Venkatesh et al 2013) and allows these contrasting knowledge forms to be integrated into one study.

Bhaskar, (1975) divided reality into three domains: real, actual and empirical. The real domain includes structures with enduring properties and recognises that objects have attributes. In relation to the research topic under investigation, the real domain includes the existence of physiotherapists who practise in the musculoskeletal speciality. Bhaskar's actual domain relates to events that are generated by the structures and their mechanisms, so within this research study may relate to the education that a physiotherapist has undertaken. Bhaskar's final domain is termed empirical and relates to phenomena, events that are observed and experienced and for the current study could be the knowledge acquired regarding the physiotherapists' experience of ultrasound education including their personal reactions.

Critical realism aims to use perceptions of events, (the empirical domain) to improve our understanding of events and processes, (the real and actual domains). It is not seeking to identify causality but is aiming to understand the processes and conditions linked to events, these conditions may be causative, generative or not linked at all. This stance has implications on validity and generalisability of findings as it is acknowledged that a complex set of circumstances tends to generate mechanisms and events including the intransitive, (independent reality e.g.

physical features) and transitive aspects (constructed reality e.g. emotional reactions) of human attributes and social activities (Zachariadis 2013). Bhaskar termed the logic employed to explain events as retroduction, this process enables researchers to move from acquiring knowledge of empirical events to formulating explanations and mechanisms for events that have occurred and postulating the outcome of situations with some variances, (Bhaskar 1975). Subsequent authors have included elements of Bhaskar's retroduction in their mixed methods analysis of causality and have highlighted the need to include the context of any phenomena studied. They have concluded that phenomena cannot always be analysed in terms of variables, there are situations whereby the processes by which an event or situation occurs require recognition, (McEvoy and Richards 2006,Maxwell and Mittapelli 2010).

The opportunities offered to researchers in the field of health and social sciences by a critical realist approach have been highlighted in recent years by several authors, (Cruikshank 2012, DeForge & Shaw 2012 and Walsh & Evans 2014). It is an appropriate theoretical framework for this MSKUSI based study as it accepts the value of varying methodologies when exploring a research question. The aim of seeking explanation and meaning from data that reflects the real world is multidimensional (McEvoy and Richards 2006) and relates to the nature of this study as the application of MSKUSI by physiotherapists will be influenced by intransitive alongside transitive elements including professional opportunities, personal traits and experiences.

Chapter 4 Survey Method, Results, Analysis and Purposive Sampling Strategy

4.1: Survey Method

Survey research typically involves the collection of data in a standardised form from a sample or section of a population with the aim of gathering information about a specific phenomenon (De Vaus 2013, Kelley et al 2003). The first section of the study involved the distribution of a questionnaire as a survey tool. The questionnaire explored professional attributes of physiotherapists who reported an interest in MSKUSI and the features that had influenced their interaction with the modality.

Surveys have several qualities that have resulted in their common use. Advantages include their ability to produce original data based on real-world observations within a short time frame at a low cost whilst accessing a large population. This has practical benefits for researchers who are therefore able to set a time limit on data collection which can assist them in planning. Disadvantages have to be considered however, these include the lack of depth in the data that is generally obtainable and inability to verify the respondents' honesty (Dyson and Brown 2006). There are also challenges securing an adequate response rate that will have implications on the finding's generalisability (Kelley et al 2003).

A questionnaire was chosen as a survey tool as it is an efficient method of gathering data from a large number of participants that may be geographically widespread, it has ethical advantages over other methods as participants have considerable freedom regarding their involvement and is a method that has the flexibility to be combined with other methods for instance, an in-depth interview to gather rich data, (Mathers et al 2007).

4.2: Questionnaire Development

A questionnaire was developed as no existing questionnaire met the required criteria or were directly relevant to the research questions. The only published study relating to the use of ultrasound by physiotherapists in the United Kingdom, (Potter et al 2012) did not provide a suitable data collection tool. Potter's study had many limitations, including the significant statement 'the study focused on USI within physiotherapy practice, not diagnostic imaging' (Potter et al, 2012, page 40) and was introduced with a focus on muscle activity imaging. The current study aimed to explore physiotherapists' interests, did not assume this was related to muscle imaging and ensured no bias was introduced as no assumption was made regarding physiotherapists' interests. Potter's study does not provide a justification for the focus on muscle imaging but it is interesting to note that in contrast to the current study, she does not state a focus on musculoskeletal physiotherapists and that the panel of experts consulted during the questionnaire's development included a noteworthy number of experts in women's health physiotherapy and a significantly lower number of musculoskeletal clinicians. Potter's publication did however provide some guidance regarding questionnaire development, distribution and anticipated responses.

The questionnaire was informed by publications dedicated to questionnaire development (De Vaus 2013, Couper 2000) and those related to exploring the use of ultrasound, (Brown et al 2005, Brown et al 2006, Potter et al 2012). Discussions with colleagues and research experts guided the content, structure and questionnaire design. Several draft questionnaires were considered before one was formally piloted on a clinician known to use MSKUSI, this feedback on all questionnaire elements resulted in subtle adjustments before the data collection tool was finalised.

The content of the questionnaire was constructed to maximise content validity by aligning content to the research questions and to ensure the research tool was brief and simple to use, thereby minimising barriers to completion. Issues explored in the questionnaire included demographic material relating to work environment, education accessed in MSKUSI, clinical roles of MSKUSI and factors that had influenced the participants experience with the modality. It is acknowledged that testing of the research tool was rudimentary and limited to one participant who accessed the questionnaire via SurveyMonkey and commented on its content, presentation and ease of use including clarity of the covering letter. Questionnaire development was undertaken with an awareness that researchers can impose their own values and frameworks on their participants, (Dyson and Brown 2006). Questions were phrased to minimise any leads or influence on the participants' answers. As an example, the question 'Have any factors influenced your ability to use musculoskeletal ultrasound imaging in clinical practice?' was phrased to maintain its neutral stance; the terms 'positive' and 'negative' were not included, neither were probable topic leads such as the terms 'professional', 'equipment' or 'supervision'.

The questionnaire was semi-structured and included a mix of open and closed questions. Closed questions were chosen to optimise reliability for issues with a limited number of options for replies, (De Vaus 2013), for instance ‘Have you undertaken any education in musculoskeletal ultrasound imaging?’. Participants were instructed to tick an appropriate box to respond, for this question the available responses were ‘Yes’ or ‘No’. Open questions were included to enable subjects to respond in any way they wished and ensured response opportunities were not restricted. The rationale for open questions has been neatly summarised by Seale and Filmer, (2004, page 130) as they ‘allow a respondent to answer in their own terms, enabling the researcher to discover unexpected things about the way people see a topic’. The role of open-ended questions in quantitative questionnaires has been evaluated and linked to the five rationales for conducting mixed-methods research as proposed by Greene, (1989). It has been proposed that open-ended questions can add value to a mixed-methods study because they can contribute to all five processes: complementarity, initiation, expansion, triangulation and development (Harland and Holey 2011). The open-ended questions in this ultrasound based study were intended to offer complementarity, by further illustrating results obtained in the survey’s closed questions and for development purposes by facilitating topics to be discussed in the interviews and guiding the purposeful sampling, (Greene 1989).

4.3: Questionnaire Distribution

The target population of the questionnaire was made up of physiotherapists in the United Kingdom who define themselves as a ‘musculoskeletal physiotherapist’. As it is impossible to gain access to the entire population, a sample was accessed. The key aims of the questionnaire were to enable development of the interview topic guide and identification of a smaller group who were informationally representative of the questionnaire respondents. The questionnaire data were not being used for inferential statistics, so probability sampling including the use of a power calculation was neither appropriate nor possible (Al Subaihi 2003, Baker et al 2013). Non-probabilistic sampling strategies were employed to optimise access to the desired cohort.

Convenience sampling was used: a colleague distributed the questionnaire by hand at the conference held in June 2014 for the Association of Chartered Physiotherapists in Orthopaedic Medicine and Injection Therapy, (ACPOMIT). The participant letter accompanying the questionnaire has been enclosed in Appendix 3 and the questionnaire in Appendix 4. All delegates at the conference were invited to complete the questionnaire and the responses were collected by hand.

The second questionnaire distribution method was via e-mail that was accompanied by a link on SurveyMonkey. The letter providing information to participants about the study has been enclosed in Appendix 5. The physiotherapists contacted were selected from sources that reflected an interest in ultrasound imaging or musculoskeletal medicine in general. The physiotherapists included all those who had attended a study day held by the Electro Physical Agents and Diagnostic Ultrasound (EPADU), a Professional Network of the CSP. The study day was held in November 2013, where all the attendees gave permission to be contacted regarding the research. The questionnaire link was also e-mailed to all the members of EPADU. The distribution list provided included 130 e-mail contacts, 14 of them were duplicates from the study day and were removed to prevent contacting the same therapist twice.

The final distribution method was an example of self-selection sampling and was via interactive CSP (iCSP), an online discussion forum for members of the CSP. Discussions can be posted in designated specialist areas and professional themes, survey information and my contact details were posted as ‘news’ on the area dedicated to the Musculoskeletal Professional Network. The regulations associated with iCSP prevented postage of a direct questionnaire link; interested professionals were provided with an email address for further details. The regulations of iCSP also limited publishing the research information on more than one professional network but a sharing system enabled readers of the following Professional Networks to view the material: Orthopaedic Medicine and Injection Therapy, Electrotherapy and Diagnostic Ultrasound and Sports and Exercise Medicine. Physiotherapists were encouraged to forward the SurveyMonkey link to colleagues who had an interest in MSKUSI to ‘snowball’ its distribution. Snowballing sampling can facilitate access to cohorts that are difficult to reach but can impact the representativeness of the participants due to clustering, (Baker et al 2013). The questionnaire was open on SurveyMonkey for five weeks, no further responses were possible after this time.

4.4: Survey Results

A total of 75 questionnaires were completed and returned. The number of questionnaires returned from each of the three distribution methods has been presented in Table 4.1.

Table 4.1: Number of questionnaires returned from each distribution method.

Questionnaire Distribution Method	**Number of Questionnaires Returned**
ACPOMIT conference	26
SurveyMonkey to EPADU	47
iCSP request for link to SurveyMonkey	2
Total number returned	**75**

Of the 75 respondents, 34 reported that they used ultrasound imaging in clinical practice and 41 reported that they did not. The individuals who were using MSKUSI in practice were asked to briefly state the role of the modality and those who were not using it, were asked to comment on anticipated roles in clinical practice.

The respondents who responded ‘yes’ to the initial question provided varying levels of detail regarding the role of MSKUSI in their practice. Considerable repetition was evident so the answers could be categorised and have been presented below in Table 4.2 alongside the number of participants who stated each role. Most participants stated more than one role for the modality.

Table 4.2: Summary of responses from participants who use MSKUS when asked to briefly state the role of the modality in their practice:

Role of musculoskeletal ultrasound	**Number reporting this role**
Diagnostic	24
Support clinical decision making	10
Feedback / patient education	5
Tendon imaging	6
Guide injections	8
Monitor recovery	9
Research	1
Career progression	1

The respondents who were not using the modality in practice provided a selection of answers when asked for potential roles in their clinical practice. There were many similarities with the answers from the scanning cohort, the responses have been categorised and presented in Table 4.3 below.

Table 4.3: Non-scanning respondents' potential roles for MSKUSI in practice:

Role of musculoskeletal ultrasound	**Number reporting this role**
Diagnostic	31
Support clinical decision making	8
Feedback / patient education	7
Tendon imaging	3
Guide injections	8
Monitor recovery	2
Research	2
Animal physiotherapy	1

The answers provided regarding roles for MSKUSI were unstructured as the question was open and whilst the respondents' intentions were generally clear, there was some ambiguity regarding the terms 'feedback' and 'education'. The responses that referred to either of these terms have been grouped together in both of the tables above as it was not always apparent if feedback referred to imaging of muscle tissue to promote activity or for education (for the patient or physiotherapist's benefit). Examples of responses that relate to feedback include:

- 'as a motivational tool for patients - making a picture improves patient compliance by a factor'
- 'For patient and physio feedback of muscle contraction'
- 'to show patients the tissue involved and let them see why they are experiencing problems'

These example responses reflect a lack of clarity in terminology; 'biofeedback' has been used to describe the process of visualising muscle activity to facilitate training as part of rehabilitation (Chipchase et al 2009), but it was unclear if ‘feedback’ was being used to describe this process or a broader educational role.

The questionnaire responses that identified the nature of the respondents’ clinical practice have been presented in Table 4.4.

Table 4.4: Nature of clinical practice for respondents.

Professional Environment	**Environment reported by all respondents (n=75)**	**Environment reported by scanning respondents (n=34)**
NHS	43	19
Private practice	31	15
Private hospital	4	2
Sports team or institute	8	3
Research	10	5

The questionnaires indicated that the respondents were employed in a diverse range of environments, the NHS was the most common and several reported that they worked in more than one clinic e.g. NHS and private practice. It was interesting to note that the proportion of respondents working in each clinical environment was very similar in the scanning group, (n=34) to the entire group, (n=75).

The replies from the question, ‘Have you undertaken any education in musculoskeletal ultrasound imaging?’ indicated that 52 respondents had received education, 21 had not and 2 did not reply. Four of the participants who reported they had not received any education in MSKUSI also ticked the box to indicate they used the modality clinically. One of the participants clarified their role was to order

US imaging when it was indicated, but the imaging was performed by a radiologist or sonographer, it is not known what was meant by the other three subjects' positive responses. Of the 52 participants who had received education in MSKUSI, 23 physiotherapists reported they did not use it in clinical practice.

To explore education access and utilisation further, ultrasound education of all the respondents was reviewed by analysis of the open question inviting participants to 'state the nature and duration of the education'. The education received was categorised as 'formal - assessed' or 'informal – not assessed'. Participants who had completed Post-graduate certificates or diplomas all fulfilled the requirements of 'formal – assessed' education and those that had reported self-learning, or a two day introductory course were categorised as having received 'informal – unassessed' education. There were a small number of instances when the answer was not clear and the researcher investigated to enable an informed response. For example one participant reported they had completed 'Oxford Level 1 diagnostic ultrasound course, 3 days with follow up with mentors', this course was investigated and the subject's education categorised as 'formal – assessed'. There were also challenges with this basic classification system as the distinction between formal – assessed and informal – unassessed is subjective. A reply that indicated a clinician had undertaken a university module in musculoskeletal ultrasound was categorised as formal – assessed, whilst a clinician who reported they had attended a weekend introductory course was categorised as informal – unassessed. Although some clinicians' responses indicated they had accessed a significant volume of education by completing several informal courses and accessing many hours of clinical supervision, their education was still classified as informal – unassessed. The information supplied about education was sometimes extremely brief and contributed more uncertainty to this subjective system. This categorisation was performed for all participants and then sub-divided to reflect the groups of physiotherapists who use the modality and those that do not use. The results of this classification process have been presented in Table 4.5.

Table 4.5: Education reported by all questionnaire participants, sub-groups of physiotherapists who use ultrasound imaging and those who do not use ultrasound Imaging

	All questionnaire participants	Physiotherapists who use MSKUSI (responded ‘yes’ to question 1)	Physiotherapists who do not use MSKUSI (responded ‘no’ to question 1)
Participants have completed formal – assessed education	24	17	7
Participants have completed informal– unassessed education	26	12	14
Participants who have received no education	23	4	19
No response to education question	2	1	1
Total	75	34	41

Of the 24 participants who reported they had received formal – assessed education, 7 reported they were not currently using the modality in clinical practice. These 7 had all completed formal, university based education but 5 of them indicated they had completed a single module only, not a post-graduate course with an award of Post-graduate Certificate or Diploma. One respondent however, reported they had completed an MSc in Musculoskeletal Ultrasound but was not scanning in practice.

34 participants reported they were scanning, 17 of these had completed formal-assessed education, 12 had accessed informal – unassessed education, 4 reported no education in the modality and 2 did not respond to the question relating to educational details.

The final questionnaire item related to factors that had influenced the participants' ability to use MSKUSI in clinical practice. The returned questionnaires indicated that 57 respondents reported factors that had influenced their MSKUSI practice, 14 respondents had no factors to report and 4 individuals did not respond to this question.

Of the 34 physiotherapists who responded 'yes' to question 1 (indicating they use MSKUSI in practice), a dominant proportion of them (n=28) reported there had been factors that had influenced their use of the modality.

Of the 41 physiotherapists who responded 'no' to question 1, (indicating they were not using MSKUSI), 29 of them reported factors that had influenced their use of the modality.

The responses of 57 physiotherapists who had reported influential factors were analysed. Several had provided detailed information and others had listed items extremely briefly, yet it was evident that many factors featured repeatedly. Repeated factors were labelled and the labels have been listed below:

1. Cost and availability of ultrasound machines
2. Availability of appropriate education / courses
3. Availability of supervision
4. Resistance from radiologists or other colleagues
5. Time pressures
6. Lack of evidence to support its use
7. Personal commitment needed
8. Positive professional support from colleagues
9. Business case enabling a cost saving
10. Practical ease of use, low risk whilst being easy to integrate into clinical reasoning.
11. Other

Factors 1 – 7 were negative factors that had been reported by the respondents as barriers to the utilisation of the modality.

Factors 8 – 10 were positive factors that had been reported by the respondents as enabling their utilisation of the modality.

Factor 11 were factors that could not be placed in any of the other categories and could not be classified as positive or negative e.g. a technical calibration issue.

The number of participants who referred to each factor was noted and presented in Table 4.6. Some listed several factors that had influenced their ability to use US, others referred to only one or two factors. The data has been presented for all 57 participants who reported an influential factor, this group has then been divided into two; respondents who reported they were using the modality, the second group relates to the answers from the participants who indicated they were not using MSKUSI.

Table 4.6. Factors identified that have influenced participants' ability to use MSKUSI. Participants who reported a factor and then divided into groups of those using the modality and those not.

Factor identified	Participants who reported a factor had influenced their use of MSKUSI Total (n=57)	Participants using MSKUSI, reporting factor had influenced their use of modality (n=28)	Participants not using MSKUSI reporting factor that had influenced their use of the modality (n=29)
1: Cost and availability of ultrasound machines	21	6	15
2: Availability of appropriate education / courses	7	6	1
3: Availability of supervision	10	4	6
4: Resistance from radiologists or other colleagues	6	3	3
5: Time pressures	5	3	2
6: Lack of evidence to support its use	2	1	1
7: Personal commitment needed	5	2	3
8: Positive professional support from colleagues	12	12	0
9: Business case enabling a cost saving	8	7	1
10: Practical ease of use	15	12	3
11: Other	2	2	0

It is evident that cost and availability of ultrasound equipment had been a factor for many participants, (n=21). These participants referred to this challenge directly on the questionnaire; this figure comprised 15 physiotherapists who were not using the modality and 6 who stated they did use MSKUSI in practice. The high number who raised the difficulty in accessing equipment suggested a widespread challenge; clinicians who had been able to obtain equipment cited it as an obstacle to scanning and clinicians who reported they did not scan identified it as block to their progress. Lack of appropriate education was reported by some (n=7), most (n=6) were clinicians who were scanning but reflected on difficulties accessing education that met their requirements. It was interesting to note there were 6 responses who referred to resistance from radiologists or other colleagues directly, the ‘other colleagues’ were sometimes referred to as peers suggesting these individuals had experienced opposition from other physiotherapists. These barriers, alongside other regularly occurring themes identified in the questionnaire were noted as topics to be explored during the in-depth interviews, this process is aligned to the development role for mixed-methods studies, (Greene 1989). A small group of factors raised by participants related to contributions that were reported in extremely positive terms. The supportive contributions included positive input from colleagues, financial issues including the potential to construct pathways that preserved budgets and the inherent features of MSKUSI that enable it to be integrated into physiotherapists’ practice. These inherent features were described by clinicians who were using the modality and a small number who were not, they commented on the fact that MSKUSI is a very safe modality and the information acquired could be blended with the patients’ clinical assessment. The development role of the questionnaire to the entire study can be demonstrated again as these positive factors were noted as topics to explore in the in-depth interviews.

The final section of the questionnaire provided identifying information if the physiotherapist consented to being approached for interview, 49 physiotherapists completed this section and consented to be considered for an interview subject.

4.5: Survey – Initial Analysis

Initial analysis of the questionnaires' responses contributed to two processes: firstly the responses were evaluated to inform the in-depth interviews and secondly they facilitated the sampling method for interview participants.

It had been hoped that further analysis of the questionnaire data could take place later in the study by reviewing the responses from the open-ended questions alongside data from the in-depth interviews but the brevity of the questionnaire responses indicated this may not be an effective process.

4.6: Purposive Sampling Strategy for In-depth Interviews

The questionnaires were evaluated to inform a purposive sampling process, the aim of this was to produce an information rich cohort of participants appropriate for the second stage of the research study, the in-depth interviews.

The purposive sampling strategy followed was guided by Patton's 16 strategy classification and description of sampling methods (Patton 2002). The dominant aim of the g strategy was to optimise representation of the groups of clinicians who had responded and the factors identified in the initial analysis. A stratified purposive sampling process was used to ensure the interviewed subjects were representative of the questionnaire respondents, this process does not aim to be statistically representative but informationally representative, (Sandelowski 2000). Stratified purposive sampling accesses subjects based on preselected parameters, these parameters should be of central importance to the question under investigation (Patton 2002). The parameters included ensuring representation of physiotherapists who reported they were using MSKUSI from varying work environments, from formal and informal educational backgrounds and who had reported a selection of factors that had influenced their scanning experiences in question 4 of the questionnaire.

The physiotherapists who had consented to interview were reviewed and potential participants selected. 49 physiotherapists had consented to being approached, of these 26 had answered ‘yes’ to question 1, indicating they were scanning. This group of 26 physiotherapists were reviewed in an attempt to produce a sample representative of the scanning participants. When participants were contacted, a small number had personal commitments that prevented organisation of an interview date. The stratified purposive sampling enabled a group of 11 physiotherapists to be selected for in-depth interview.

It was felt that the physiotherapist’s work environment was a significant factor and the interview group should reflect the diversity of work environments reported by the full group of scanning clinicians. The interview participants selected were initially considered in terms of their representativeness for each work environment.

Only one clinician who consented to interview worked in a private hospital, unfortunately time constraints alongside geographical convenience prevented scheduling an interview with this individual, all other work environments were represented in the interview group.

To consider if the interview participants represented the prevalence of individuals using MSKUSI in each practice environment, the proportions of the interview group in each area was calculated. This has been presented in Table 4.7, (the total percentage of subjects exceeds 100% as some practitioners worked in more than one environment).

Table 4.7: Percentage of participants, (total participants and participants subjects) who reported they used MSKUSI per work environment.

Nature of work environment	**% of total participants who responded 'yes' in Q1**	**% of participants interviewed**
NHS	56%	73%
Private practice	44%	36%
Private hospital	6%	0%
Sports team or institute	9%	9%
Research	15%	27%

The representation of participants working in research interviewed appears high, but 2 of these 3 individuals also worked in other environments e.g. a sports institution or the NHS.

To consider if the interview participants represented the variation of education received within the group of scanning participants the proportions in the interview group and the total group of scanning participants was reviewed. This has been presented in Table 4.8.

Table 4.8: Percentage of participants, (total participants and interviewed participants) who reported they used musculoskeletal ultrasound imaging per MSKUSI education background.

Nature of Education Accessed	**% of total participants who responded ‘yes’ in Q1 for education accessed**	**% of participants interviewed per form of education accessed**
Formal – assessed	53%	82%
Informal – not assessed	35%	18%
No education	12%	0%

The interviewed participants who accessed formal education did not represent the same proportion of the group as in the entire group of participants who reported they used ultrasound in practice. This parameter was considered in the purposive sampling strategy after the work environment and answers to question 4 on the questionnaire, (outlining the factors that had impacted the participants’ ability to use MSKUSI in practice). The sampling process was also affected by the limited number of scanning participants who had accessed informal education or no education and consented to interview. Only 9 participants were scanning, had not accessed formal education and consented to interview and when contacted, very few had availability for an interview. The final interview group included 2 scanning individuals who had not received formal education.

The participants' responses to question 4 had identified 11 key factors that had influenced their ability to use MSKUSI. The purposive sampling strategy attempted to ensure that each of these 11 factors (excluding factor 11: 'other') were represented in the interview group. Inclusion of these factors was prioritised in the sampling strategy, in particular ensuring that physiotherapists who had reported the positive influences, (factors 8-10) were accessed alongside colleagues who had reported many negative influences, (factors 1-7).

The outcome of this purposive sampling strategy has been summarised in Table 4.9. The number of scanning clinicians who identified a factor that had influenced their use of MSKUSI has been presented, the percentage who reported each influential factor in the scanning group has been calculated and presented alongside the proportion of participants in the interview group who reported each influential factor. It is evident that the interview group was representative of the entire scanning group who reported influences with some exceptions; there were no inclusions of clinicians who had commented on time pressures of work challenging their MSKUSI use or the clinicians who commented on high levels of personal commitment required. The number of clinicians who had included these factors in the scanning group were relatively small and it was felt acceptable these clinicians were not interviewed but the factors should be noted for inclusion in the in-depth interviews.

Table 4.9: Factors that influenced scanning clinicians' use of MSKUSI. Number of clinicians in scanning group reporting each factor presented, percentage of scanning group reporting each factor presented and percentage of participants selected for interview reporting each factor presented.

Factor identified by physiotherapist.	**Participants using MSKUSI, reporting factor had influenced their use of modality (n=28)**	**Percentage of participants reporting each factor from group who use MSKUSI and reported influences**	**Percentage of participants reporting each factor in interview group**
1: Cost and availability of ultrasound machines	6	21.4%	27.3%
2: Availability of appropriate education / courses	6	21.4%	18.2%
3: Availability of supervision	4	14.3%	18.2%
4: Resistance from radiologists or other colleagues	3	10.7%	18.2%
5: Time pressures	3	10.7%	0%
6: Lack of evidence to support its use	1	3.6%	9.1%
7: Personal commitment needed	2	7.1%	0%
8: Positive professional support from colleagues	12	42.9%	54.5%
9: Business case enabling a cost saving	7	25%	27.3%
10: Practical ease of use	12	42.9%	36.4%

Chapter 5 Interview Methodology

5.1: Interview Method

Interviews are widely used in qualitative research and provide opportunities to collect rich data from individuals or focus groups. They enable the researcher to engage with the study's participants directly and whilst participants can all be directed to answer questions regarding the same topic, it is possible for the interviewer to respond to individuals as they guide the discussion, (Carter and Henderson 2009). Interviews tend to be classified as structured, semi-structured or unstructured. Structured interviews follow a list of predetermined questions whereas unstructured interviews do not include predetermined questions. Unstructured interviews tend to investigate a topic facilitated by the interviewer who responds to the participant's comments and the semi-structured interview sits between these. The semi-structured interview aims to explore specific issues and questions in a similar way to structured interviews but acknowledges the richness and complexity of data available will be greatly enhanced when participants are allowed to communicate more freely than the structured interview dictates. In semi-structured interviews, topic guides direct the interviewer to ensure key topics are covered, (including those identified by the questionnaires) but the communication includes open questions and opportunities for the participant to direct the interaction. The interviewer responds to the participant's story, uses prompts and may allow the participant to communicate freely without intervention. The open nature of the semi-structured interview should enable the participant to introduce unexpected concepts or offer a new perspective on a theme whilst the interviewer ensures all the key issues are included (Gill et al 2008, Carter and Henderson

2009). Semi-structured interviewing was selected as the most appropriate method of completing the second stage of this study, the analysed questionnaires and study's research question informed the development of a topic guide that provided a framework for each interview.

5.2: Development of Topic Guide for In-depth Interviews

A topic guide was written and is enclosed in Appendix 7. The guide was generated to ensure each interview included key concepts that were relevant to the research question. This included an introductory paragraph that was designed to open every interview in a standard way, this provided an opportunity to thank the participants for their involvement with the study and remind them of the its key aims. The topic guide was constructed to provide prompts for main questions, follow up questions and probes, (Rubin and Rubin 2005).

Questions were constructed to reveal the participants' understanding and experiences of MSKUSI and were supported by follow up questions for clarity and facilitation of specific topics. Attempts were made in the interview planning stage to incorporate open-ended questions as main questions that enabled participants to direct their narrative without being steered by the researcher. These main questions were constructed with wording that was as neutral as possible and avoided evocative terminology so that the participants' answers were not influenced and they could bring their own terms to the discussion, (McNamara 2009). Participants were all asked the open-ended question, 'What role does ultrasound imaging have in your area of (clinical) work?',('clinical' was omitted for the participant who had indicated his role was in a research, not a clinical environment). This question reflected a key component of the research aims and some participants responded with detailed narratives relating to their use of MSKUSI. Most participants needed some direction and initial responses were explored with follow up questions, for instance 'at what stage in the assessment do you incorporate ultrasound imaging?' and 'what role does ultrasound imaging have following assessment?'. Follow up questions were designed to facilitate the participants to expand their responses, providing more depth and sometimes to confirm unanticipated answers. The interviewer attempted to respond to oversimplifications and missing details with follow up questions and intended to demonstrate active listening with clarifying questions. Clarification ensured the participants did not leave a concept's explanation incomplete or a key term unexplained. The aim of using follow up questions to support the main questions was to demonstrate a thorough and personal investigation of the subjects' experiences (Rubin and Rubin 2005).

Developing the topic guide included planning probes to help regulate the interview. Probes have been characterised for a variety of roles including continuation, elaboration, attention, clarification, steering, sequencing and evidencing, (Rubin and Rubin 2005). The application of probes will be discussed below in the description of the interview process.

The topic guide's content was informed by the questionnaire's analysis and the aims of the research study. The guide was designed to facilitate questioning with the intention that each participant would provide a full account of their MSKUSI experience. The interview content was planned to include the participants' interest in MSKUSI, their involvement with it including any relevant education and other factors that may have influenced their engagement. The interview was planned to include a detailed review of profession specific issues, anticipated topics included the impact of MSKUSI on rehabilitation and the links between physiotherapists' clinical reasoning and MSKUSI imaging.

5.3: Interview Process

The purposeful sampling strategy identified 11 subjects who were available for interview. The number was determined by the objective of ensuring the subjects were representative of the initial survey cohort and the need to generate a volume of data appropriate for doctoral research. Practical issues such as the research's timeframe and geographical issues affected the selection of subjects. The eleven subjects were contacted by e-mail and a mutually convenient time arranged for the interviews to take place, subjects were provided with information about the study and a copy of the consent form that would be signed on the interview day, (Appendix 7). At the beginning of the interview, the subject was provided with a hard copy of this document and an opportunity to ask any questions before they provided their written consent. The interviews took place at the subject's place of work, they all opened with the same introductory paragraph as outlined in the topic guide. The interviews explored the issues presented in the topic guide but did not follow a specified order, instead the interviewer attempted to be responsive to the subjects' discussion points, allowed them to dictate the sequence of the topics covered and used the topic guide to monitor progress.

The topic guide ensured the main questions were all covered with every subject and follow up questions were utilised as required to direct the subjects to specific areas. The application of probes during the interviews was extensive and included a variety of different techniques. Examples of probes included continuation probes that encouraged the subject to keep discussing the present topic and could simply be a repetition of their last phrase with a questioning intonation, for instance 'so finding a mentor was difficult?'. Elaboration probes were used to facilitate the subjects to flesh out their answers and provide more detail, a question could be used such as 'could you tell me more about that?'. Non-verbal probes were employed extensively to convey attention; leaning forward with interest or allowing a brief silence after a subject's response signalled that their answers were interesting and it was hoped they would continue. Probes were also used occasionally to keep the conversation focused if a subject veered onto a tangent that was not related to the research questions, (Rubin and Rubin 2005).

The interviews' duration varied between 50 minutes and one hour, they were digitally recorded and all completed during August 2014.

5.4: Transcription:

The interview audio-recordings were transcribed verbatim by the researcher with a denaturalised style of transcribing. Denaturalised transcribing aims to document the communication and reflect its meaning, without recording details that fail to contribute to the overall message such as pauses, stutters, non-verbal communication and small errors, (Oliver et al 2005). This transcription approach is well suited to this study as it focuses on the factual information conveyed by the interviewees rather than the mechanics of the conversation. Several authors agree that the transcription process should be adapted to respond to the research question's requirements and facilitate data analysis, (Davidson 2009, Oliver et al 2005, Hammersley 2010). Decisions have to be made to ensure the style of data transcription is fit for purpose; this requires selectivity. In this study, every sentence spoken by the interviewees was transcribed, but the background noises, pauses in speech, hand gestures made and non-word elements (e.g. laughter) were not.

To enhance the credibility of this study, it was essential to produce trustworthy data. The data were transcribed with an aim of producing an honest record of the interviews. This process was followed by a period of reflection to ensure that sensitive material had been recorded appropriately and the denaturalised transcription process had not eliminated vital information but had retained the interviews' content, (Hammersley 2010).

Chapter 6 Analysis of In-depth Interviews

6.1: Thematic Analysis

The transcribed interview data were analysed thematically; this is ‘a method for identifying, analysing and reporting patterns (themes) within data.” (Braun and Clarke 2006, p. 79). The process of thematic analysis is particularly well suited to exploratory studies that require inductive reasoning and has some differences in approach to confirmatory studies that are testing hypotheses. Inductive analysis should be data driven whereby the investigator’s analysis facilitates the identification of codes and themes from the data without being framed by preconceptions, (Braun and Clarke 2006). Guest et al (2012) summarised the key differences between exploratory and confirmatory approaches to qualitative data analysis. They proposed that exploratory research questions provide data that needs to be reviewed prior to determining codes or categories and that these codes should be derived from the data. In contrast, hypothesis driven confirmatory research questions generally use predetermined codes and categories that have been generated by the hypotheses, a summary of the key variations in approach have been presented below in Table 6.1.

Table 6.1: Differences between Qualitative Analysis Approaches Depending of Exploratory or Confirmatory Research Question, (Adapted from Guest G, MacQueen and Namey. (2012) Applied Thematic Analysis, page 7).

Exploratory Studies	**Confirmatory Studies**
Specific codes/analytic categories NOT predetermined	Specific codes/analytic categories predetermined
Codes derived from the data	Codes generated from hypotheses
Data usually generated	Typically uses existing data
Most often uses purposive sampling	Generally employs random sampling
Analysis generates hypotheses	Analysis

The research questions of the MSKUSI based study were well suited to inductive analysis as the key aims were exploring physiotherapists' experiences, views and personal opinions regarding professional practice and the investigator was not seeking to investigate a specific hypothesis or theory related to the subject matter.

The role of thematic analysis has been summarised by Braun and Clarke (2006) who highlighted the flexibility of this approach in different theoretical frameworks including essentialist, constuctionist and critical realist. This MSKUSI study has been framed by critical realism as it aims to explore physiotherapists' experiences and perceptions to enhance our understanding of reality – the reality of physiotherapists' interest in ultrasound (Bhaskar 1975). Braun and Clarke (2006) proposed six steps should be used to frame the process of thematic analysis, these steps are:

1. Familiarising yourself with your data
2. Generating initial codes

3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report.

The first step, ‘familiarising yourself with your data’ commenced at a very early stage in the research process, during the interviews and continued during transcription. Denaturalised transcription facilitated analysis as it responded to the study’s aims of exploring the data’s information content rather than the conversation style, (Oliver et al 2005). Transcription was followed by reading and rereading of the transcribed interviews and ensured data familiarity.

The following steps of generating initial codes, searching for themes, reviewing themes and defining and naming themes were completed in phases that were not always distinct from each other. The coding process associated with this thematic analysis was guided by the principles documented by Saldaňa (2012). He emphasised the interpretive nature of coding and acknowledged that individuals were unlikely to code data in an identical manner; ontological issues underpinning the methodology and the study’s research question should direct the coding approach.

Saldaňa divides coding into several stages in a similar way to Braun and Clarke, there are two cycles, a first and second cycle but Saldaňa acknowledges that this division may not be a straight-forward and linear process. Qualitative data tends to be relatively unstructured and can appear vast; the first cycle of coding reduces the data and starts to organise it by dividing it into small labelled segments appropriate for analysis. During the first cycle of coding, a code (word or short-phrase) was used to label a section of data to capture its essence, this process was undertaken using Maximum Qualitative Data Analysis (MAXQDA 11, Verbi Software).

Saldaňa proposed seven broad subcategories of processes that can form the basis of the first coding cycle, these subcategories are Grammatical, Elemental, Affective, Literary and Language, Exploratory, Procedural and Theming the Data. The subcategories of coding selected for the first cycle of coding were Grammatical, Elemental and Theming the Data.

Initial coding is one of the Elemental processes proposed by Saldaňa whereby the data is broken down into parts and a content or concept related label is applied. It is suited to the first cycle of coding, particularly for interview data as it enables data to be organised and reduced, enabling similarly labelled sections to be drawn together. Review of these coded sections should highlight similarities and differences and provide analytic leads for further exploration in the second cycle of coding. Initial coding identified a large number of labels, for example: informal MSKUSI education, formal MSKUSI education, dynamic scanning, equipment access, HCPC, one-stop clinics and patient education. This process ensured the researcher was extremely familiar with the data which had been structured in a format that facilitated further analysis.

Simultaneous coding was also applied, it is regarded as one of the Grammatical Methods and relates to the notion that more than one code may be attributed to a single qualitative datum, for instance more than one label if a section of data includes descriptive material and inferences can be made that will facilitate further analysis and links (Miles and Huberman 1994, Saldaňa 2012). An example of simultaneous coding has been demonstrated with an interview excerpt from one participant:

'…..by peoples' response to reporting because, what we do, what I do, in terms of reporting to myself - is report what is relevant on the scan. What the radiologists do, or radiographers do, is report everything they see that is aberrant…'
(Participant 5)

This section was coded with 'reporting' to reflect the factual content and with 'professional variance' as there is a suggestion that different professionals who use MSKUSI may have varying approaches.

Saldaňa also advocates that Theming the Data can be part of the first cycle of coding, where data portions are coded against a phrase or sentence that relate to the its meaning. Once reading the data has produced some familiarity, it is possible in a first cycle to identify themes and code against them but the First Cycle of Coding should not involve a strong emphasis on interpretation. The term 'theme' is rarely defined in literature discussing qualitative analysis but themes have been neatly summarised as 'concepts indicated by the data rather than concrete entities directly described by the participants' (Morse and Field 1995). This summary reflects the notion that they should be revealed by evaluation of the data, this can happen in a First Coding Cycle but thematic analysis should develop considerably after this stage. During the First Coding Cycle, a small number of themes were evident as their concepts had been core to many of the interviews. These initial themes included musculoskeletal ultrasound education, assessment tool and professional barriers.

Saldaňa (2012) proposed that the second cycle of coding should be a stage whereby the researcher’s analysis identifies concepts and themes beyond those of the first cycle. These should emerge from the data following a high level of data synthesis, integration and evaluation. Saldaňa identified several approaches to second cycle coding, including longitudinal coding for data collected over a long time period and theoretical coding that seeks to identify central themes related to the research question and is well suited for grounded theory. Pattern coding was selected for this stage of data analysis which aims to identify major themes from the data by grouping codes and summaries into sets of data. This process is closely aligned with the steps identified by Braun and Clarke (2006) of searching for themes, reviewing themes and defining and naming themes.

The second cycle of coding involved reviewing the data several times and resulted in codes becoming linked into sub-categories of categories and the categories to be classified under themes. This complex process required a reclassification of some of the codes applied in the first cycle of coding; some codes became categories and were broken down into sub-categories and new codes. For instance, ‘equipment access’ was a code assigned in the first cycle of coding, this was revised and ‘equipment’ became a subcategory linked to the codes, ‘Department accessing a machine, Machine’s technical ability and Machine’s availability limited’. Similarly, in the first coding cycle the code ‘radiologist – barrier’ was applied, in the second cycle of coding this became a subcategory and three new codes were developed; ‘radiologist – concern regarding standards’, ‘radiology access barrier’ and ‘radiologist –professional threat’.

Pattern coding involved assembling similar codes together and scrutiny of the concepts underpinning their commonality, this pattern formation enabled codes to be clustered in sub-categories that were then scrutinised again for new patterns to form. The exploratory nature of this study framed by critical realism lead the analysis and the development of categories and finally themes.

Example of formation of a theme:

Following the first cycle of coding it was noted that there were links between a subset of the codes:

- Manager –lack of personal support
- Manager – trust policy issue
- Radiologist – general barrier
- Radiologist – concern regarding standards
- Limited access to radiology
- Colleagues – general barrier
- Colleagues - Should physios be doing this?
- Colleagues – limited CPD support

These codes related to content whereby the participants were describing professional circumstances perceived as a barrier to their ability to access and use MSKUSI. The codes were grouped together in a subcategory, ‘professional barriers’. This subcategory had features in common with another subcategory, ‘logistical challenges’ that highlighted barriers the physiotherapists encountered so the two subcategories were grouped together in a category ‘barriers’. On reviewing the data further, two other categories related to factors that influenced the ability of the interviewee to engage in MSKUSI, these categories were ‘education’ and ‘enabling factors’. These three categories were linked to one overarching theme, ‘Factors that have impacted physiotherapists’ ability to use MSKUSI.

Pattern coding was facilitated by MAXQDA as retrieved coded segments of data were reviewed in light of other coded sections and subcategories. This enabled the three steps suggested by Braun and Clarke, (2006) to blend and replaced the use of their suggested tools of mind-maps or theme-piles.

Five themes were identified from the data, they were named with intended to reflect the essence of their content:

1. Professional skill set – physiotherapists’ suitability for MSKUSI
2. Factors that have impacted physiotherapists’ ability to use MSKUSI
3. Physiotherapists’ Motivation to Use Ultrasound - Improving Patient Focused Care
4. Quality Assurance Strategies
5. Application of Biopsychosocial Model

The coding process was performed by the researcher, following formation of themes the coded data was reviewed by a colleague to verify the process. The involvement of the researcher in thematic analysis has been explored by several authors and there is a consensus that the complex interpretation of data required to produce a rich and full analysis could never be fully replaced by software (Guest et al 2012, Braun and Clarke 2006 and Cheek et al 2015).The researcher plays an active role in identification of patterns and themes within the data, selecting those that are relevant to the research question and then presenting the outcome in an accessible manner for the reader.

Tables 6.2 – 6.6 reflecting the link between the initial codes and formation of subcategories, categories and themes have been included below.

6.2: Summary of Coding Strategy and Formation of Themes

Table 6.2: Theme 1 - Professional Skill set - Physiotherapists' Suitability for MSKUSI

Codes	Subcategories	Category
Enhancement to physio skills	Interest in the modality	Trigger to explore MSKUSI
Contribution to evidence based practice		
Trigger / critical moment		
Dynamic scanning	Dynamic Application	
Imaging functional demos		
Gains respect	Curriculum Vitae Enhancement	
Responding to competitive workplace environment		
Research opportunities		
Work in radiology		
Knowledge of pathology	Musculoskeletal Medicine	Professional Experience
Knowledge of pathway options		
Noteworthy professionals	Professional influences	
Responding to competitive workplace environment		

Table 6.3: Theme 2 – Factors that have impacted physiotherapists' ability to use MSKUSI

Codes	Subcategories	Category
Informal MSKUSI Education	Education in MSKUSI	Education
Formal MSKUSI Education		
Course responds to physio needs		
How to establish competence		
Mentor access	Mentoring	
Mentor's requirements by regulatory body		
Mentor's reasoning paradigm		
Manager –lack of personal support	Professional Barriers	Barriers
Manager – trust policy issue		
Radiologist – general barrier		
Radiologist – concern regarding standards		
Limited access to radiology		
Colleagues – general barrier		
Colleagues - Should physios be doing this?		
Colleagues – limited CPD support		
Equipment – availability limited	Logistical Challenges	
Equipment – technical ability limited		

Department accessing a machine		
Cost of education / supervision		
Time pressures		
Course responsive to physios	MSKUSI Education Available	Enabling Factors
Good course		
Impact of relationships MDT	External Support	
Manager – positive		
Mentor – positive		
Colleagues – positive		
Patients – positive		
Luck	Positive Personal Factors	
Resilience		
Acknowledge learning curve		

Table 6.4: Theme 3 – Physiotherapists' Motivation to Use Ultrasound - Improving Patient Focused Care

Codes	Subcategories	Category
Diagnostic role	Verifies clinical assessment	MSKUSI – assessment tool
Dynamic scanning		
Extension of clinical assessment		
Increased certainty of treatment option	Guides treatment decisions	
Prevents waste of time		
Impact on belief in physio	Follow up – impact on patient	MSKUSI for follow ups
Patient compliance with rehab		
Patient education		
Guides injection	Follow up – role for physio	
Ongoing clinical reasoning		
Informs management		
Monitor soft tissue healing		
Reporting	Communication to referrer	Patient Pathway Efficiency
Advice to colleagues for further Management		
Minimise patient attendances	Business case	
One stop clinics		
Cost less than radiology		

Table 6.5: Theme 4 – Quality Assurance Strategies

Codes	**Subcategories**	**Categories**
CSP	Professional regulation	Formal quality assurance mechanisms
HCPC		
Lack of sonographic regulation		
Sonography professional groups eg BMUS		
Audit	Work place systems	
Image verification process		
Working with senior colleague		
Motivated by improved patient outcomes	Professional integrity	Informal quality assurance mechanisms
Working with peers		
Self-monitoring / professional risk		
Personal qualities required	Response to challenges	
Resilience		

Table 6.6: Theme 5 – Application of Biopsychosocial Model

Codes	Subcategories	Categories
Subjective informs scan	Subjective assessment	Clinical reasoning
Yellow flags		
Verify clinical assessment	Clinical assessment	
Guided by clinical assessment		
Image quality	Imaging – different professionals	Professional Variance
Lack of context		
Physiotherapist communication	Communication – different professionals	
Radiologist's communication		
Absence of communication		
Tissue based pain	Communication in presence of abnormal tissue	Communication opportunity
Communicate pathology		
Non-tissue based pain	Communication in presence of normal findings	
Patient information when normal		
Chronic pain prevention		
Requirement for rehabilitation		
Role of Reassurance		

Chapter 7 Findings from Interviews

7.1: Format:

The interview findings have been presented thematically and integrated with current relevant literature. Key findings for each theme have been summarised in tables at the end of each theme's section. Quotations from individual participants have been used to support the discussion and each participant has been labelled with an identifier, PT1 – PT11. The quotations from each participant will be followed by their identifier throughout the discussion enabling contributions from single participants to be considered across themes.

Table 7.1: Demographics of Interview Participants from Questionnaire Responses

Participant Number	Nature of practice	Nature of MSKUSI education	Factors that have influenced ability to use MSKUSI
1	NHS Private practice	PGCert	Availability of appropriate education / courses Positive professional support from colleagues
2	NHS	Informal – work based peer taught	Positive professional support from colleagues Business case enabling a cost saving
3	NHS	PGCert	Cost and availability of ultrasound machines Positive professional support from colleagues
4	NHS	MSc	Availability of supervision Resistance from radiologists or other colleagues Business case enabling a cost saving
5	Private practice	PGCert	Cost and availability of ultrasound machines Positive professional support from colleagues Practical ease of use
6	NHS	Assessed special interest group course.	Availability of appropriate education / courses Resistance from radiologists or other colleagues
7	Research	Informal - peer taught.	Lack of evidence to support its use Practical ease of use
8	NHS Private practice	PGCert	Positive professional support from colleagues Practical ease of use
9	NHS	University – CASE accredited Focused Course	Positive professional support from colleagues

10	Private practice Sport institute	PGCert	Availability of supervision Practical ease of use
11	NHS	University – CASE accredited Focused Course	Cost and availability of ultrasound machines Business case enabling a cost saving

7.2.1: Interview Findings – Theme 1

Professional Skill set – Physiotherapists' Suitability for MSKUSI

7.2.2: Category: Trigger to Explore MSKUSI:

The interviews provided a large volume of data that explored participants' prior knowledge and professional skills relating to MSKUSI. Pre-registration training and post-registration influences were presented as foundations for their interest and involvement with ultrasound. Material was coded as 'enhancement to physio skills', 'contribution to evidence based practice' and 'trigger / critical moment'. These sets of code were collectively sub-categorised as 'interest in the modality' and formed one of three sub-categories within the category 'trigger to explore musculoskeletal ultrasound'.

7.2.3: Subcategory: Interest in the modality

The subcategory 'interest in the modality' related to factors that initiated the participants' exploration of ultrasound and included data that reflected the close association the participants made between their core professional practice and ultrasound. Data coded 'enhancement to physiotherapy skills' conveyed the belief that the imaging modality supplemented the physiotherapists' skill set, it is an additional tool to be used but does not replace other tools that the participant would use in patient assessment or management. One participant explained this succinctly:

'this is the icing on the cake, this is something that strengthens my position as a physiotherapist….. it is absolutely about combining the two, to put me in a better position than I was before I had ultrasound' (PT5)

The view point that MSKUSI is well suited to be utilised alongside core elements of musculoskeletal physiotherapy practice was reported widely. The activities that are core to physiotherapy and those that are supplementary are challenging to define. Historically physiotherapy practice in the United Kingdom has been related to four pillars of practice that were granted to the profession by Royal Charter in 1920. These four pillars are massage, exercise and movement, electrotherapy and kindred forms of treatment (CSP 2013). The practices that can be recognised as 'kindred forms of treatment' have evolved during the profession's history and have led to debate regarding practices defined as physiotherapy and how a practitioner defines their scope of practice. The Chartered Society of Physiotherapy's, (CSP) position regarding scope of practice acknowledges healthcare provision has changed and will continue to evolve in the United Kingdom. This professional body supports physiotherapists' response to these changes but emphasises individual physiotherapists are responsible for their practice based decisions, (Owen 2014). The CSP's Code of Professional Values and Behaviour includes four principles, the first of which relates specifically to personal responsibility. An inclusion in this section of the code is that physiotherapists must 'limit their professional activity to those areas in which they are competent and qualified to work safely', (Chartered Society of Physiotherapy 2011). It is evident that physiotherapists who have received appropriate education in MSKUSI can consider integrating it into their practice and may be working within their scope of practice, but a series of questions provided by the CSP have been designed to enable individuals to evaluate if their practice is ‘within scope’, (Chartered Society of Physiotherapy 2014b). These questions direct clinicians to consider if their work is within the context of physiotherapy practice, for instance work environment has significant impact when considering MSKUSI; a physiotherapist working in radiology will have different issues to consider to one scanning in a physiotherapy department.

The CSP have provided assistance in defining scope of practice and has also responded to confusion associated with the terms ‘extended scope of practice’ and ‘extended practitioner’, These terms are no longer used by the CSP, instead the term ‘advanced practice’ is advocated to define ‘a level of practice, rather than a specific role’, (Chartered Society of Physiotherapy 2016).

The interview participants used terminology consistent with the CSP’’s viewpoint that they were advancing their practice and in order to do this, had accessed training to gain competence in areas that would enhance patient care and improve practice. The participants repeatedly reflected their opinion that physiotherapists should engage with ultrasound imaging so that their services can be enhanced, this has been summarised by one participant:

‘use musculoskeletal ultrasound imaging to supplement what a physio department can offer….’ (PT8)

The potential for enhancement to physiotherapy skills described by participants was also reported in terms that reflected professional responsibility. Their interest was described by a small number of participants in terms of a professional obligation to engage in modalities that would improve patient care and satisfaction; *'Whereas, if you hold back on that, you don't give them what is out there ….they are getting a second rate service and that is important for trust, to be trying to push the boundaries as to what we can deliver for patient satisfaction'* (PT9)

This professional obligation and drive to deliver high quality services is well aligned to the core values of physiotherapy as presented in the CSP's Code of Members' Professional Values and Behaviour publication (Chartered Society of Physiotherapy 2011). This document's four key principles all include codes that indicate physiotherapists must aim to deliver the best service possible and provides several indications that members should be proactive with personal, professional and service developments. Examples of codes of behaviour that CSP members should follow include: 'Recognise that their individual scope of practice evolves and must be supported by appropriate CPD', 'Deliver services that are of value to an individual, supported by evidence of their effectiveness' and 'Contribute to the development of physiotherapy, including by enhancing its evidence base and implementing this in practice'.

The subcategory 'interest in the modality' included two other codes, these were 'contribution to evidence based practice' and 'trigger/ critical moment'. The material coded 'contribution to evidence based practice' demonstrated the participants' awareness that contemporary health care should be supported by robust evidence but that large gaps exist in current evidence. All of the participants reported MSKUSI has recently become a sought after modality and that one of the reasons for this is research that demonstrates high sensitivity and specificity for imaging musculoskeletal presentations, (Banal et al 2009, Clarke et al 2010, de Jesus et al 2009). The evidence that presents correlation with other imaging approaches alongside the low risk of direct harm (Edwards 2010, Elias and McKinnon 2011 and Patil and Dasgupta 2012) was reported as a significant factor that triggered interest. Several participants discussed the fact that there was often a poor correlation between imaging findings and patients' symptoms (Grassi 2003 and Primack 2010) and that imaging should be supported by clinical assessment. This discussion was extended by some participants who regarded existing evidence, alongside the lack of research that has explored physiotherapist's interventions as an opportunity to question their practice and for formal research questions to be studied. One participant outlined a concise viewpoint regarding the relationship between evidence based practice and ultrasound imaging;

'I think in the world of research validation, evidence based practice - then it is a tool when used well, with appropriate underpinning, then there might be something to validate our effectiveness, when it is relevant.' (PT5)

The third code that was categorised in the sub-category 'interest in the modality' was 'trigger / critical moment'. The participants reported a large number of diverse triggers that they linked to their initial interest in MSKUSI. These triggers contributed to the participants exploring options for accessing the modality, relevant education or professionals who could offer guidance. Several participants discussed being able to see musculoskeletal structures in real time and this produced links with their previous education and clinical practice;

‘When for the first time, you are looking at your anatomy live and you are looking on screen, you know those structures, you have heard of them, you studied up on them. But when you are looking at them physically, that fascinated me and that sort of started it.’ (PT1)

A small number of participants explained that their interest started with injection therapy and their desire to administer this with accuracy, the participants generally referred to steroid and local anaesthetic injections but other medication including articular viscosupplementation was considered;

‘The time I got very interested in musculoskeletal ultrasound was about 9-10 years ago now. I was working in an orthopaedic triage along with 2 colleagues and we wanted to try and prevent people going in for arthroscopy for mild to moderate OA. We hoped to inject the substance called Ostenil….. and because we had to be fairly accurate with needle placement …… (he) suggested that we use an ultrasound scanner .’ (PT4)

Several participants told stories of initial triggers related to imaging muscle activity, including the potential to incorporate biofeedback of muscle activity into management pathways of low back pain patients, or conduct research exploring this area. The enthusiasm and excitement of a participant whose interest in the modality started this way is evident in his interview;

‘And a seminal moment for me was listening to a talk by Maria Stokes, who was investigating, talking about different ways of measuring muscle function and innovative ways to measure muscle function and talking about muscle noise. She

seemed quite keen on it at that time and ultrasound and I'd also heard Paul Hodges talk, before anything had been published…… so I talked with our radiologist and talked her into showing me how ultrasound worked and whether or not you could see the abdominal muscles and it was a Damascene moment because you could see incredibly clearly, you could watch the muscles contract and relax. It was tremendously exciting ……' (PT7)

Another participant explained how his trigger was also related to muscle imaging. His key interests and clinical application altered significantly with exposure to the modality, changing focus to diagnostic confirmation alongside standard physiotherapy assessment;

'I have been qualified 25 years and I have been using diagnostic ultrasound for the last 10 years. My motivation behind that was initially quite bizarrely was around biofeedback, in the paradigm that we were in at the time around core stability, I was very interested in looking at biofeedback as part of my intervention and then rapidly got involved in the sort of diagnostic capability of ultrasound, so it shifted massively and the biofeedback became fairly quickly redundant. And then I started to look at the whole diagnostic capability and - my motivation behind that? Well, I was just interested in specific details, diagnostic details, diagnostic accuracy and the fact that it was real time and the fact that it was something that could be seemingly seamlessly connected to my physical examination, so that was really the motivation behind it.' (PT5)

Many participants proposed their trigger of interest developed from the ability to support clinical diagnoses. Participants acknowledged that clinical testing procedures all have limitations and that a verification method was appealing. One participant also hinted that the autonomy associated with ultrasound was positive as it decreased reliance on others;

'Then suddenly, you have a tool, before we had to rely on our clinical acumen and expertise of your consultant. Suddenly, you have a tool that can actually give you objectivity' (PT6)

The appeal of autonomy featured in several interviews, the background to the desire for increased autonomy was explained clearly by one participant;

'And you are immediately exposed to this one stop shop musculoskeletal screening opportunity. One of the frustrations is that you reach a better level of knowledge or expertise, you have a bit of mileage behind that, about the 5 year barrier, that becomes frustrating: you are not responsible as a clinician in physio, you are not responsible for investigations, not necessarily have the ability to refer for the things that you think are appropriate. But to do them yourself and then perhaps treat with the most appropriate thing….' (PT8)

The recurrent triggers identified by participants were related to viewing musculoskeletal anatomy in real time, verification of clinical assessment and increased autonomy. These individual factors were drawn together by one participant who had managerial responsibilities and regarded MSKUSI as a response to external time pressures alongside improving patient care;

‘Our objectives in a sense, from an organisational perspective were to influence the 18 week pathway - that was the most important thing. So accuracy of clinical diagnosis and treatment to improve timely intervention, patients' satisfaction and potentially reducing the 18 week target’ (PT6)

7.2.4: Subcategory: Dynamic Application

The material that was classified into sub-category ‘interest in the modality’ was sometimes also coded into the other two sub-categories within the theme, ‘trigger to explore musculoskeletal ultrasound’. The two other categories were ‘dynamic application’ and ‘curriculum vitae enhancement’ and many links between the coded sections were noted. The participants repeatedly referred to the appeal of dynamic imaging, it was emphasised by every participant as an attractive element and well aligned to the profession’s core skills;

‘I think it is ideal for physiotherapists because you are actually watching things move, which is what we do, it is all about movement, that is what we are about, joints and muscles moving and the fantastic thing about ultrasound is that, that was my immediate impression, ‘finally I can actually watch things moving in real time’.’ (PT7)

Another participant readily listed several anatomical areas and pathological features where dynamic imaging was preferable to a static imaging modality;

‘shoulders, we can look for dynamic impingement and certainly between 60 & 90 degrees, we can see things impinging. Medial collateral ligaments of the knee, ulna collateral ligaments of the thumb, inferior tib-fibular ligaments, TFL ligaments of the ankle, even synovitis, fluid in joints, we can see that moving, we can see

*impingements on tendons so, yes we can integrate it. If you can get a probe there and if you have got the right equipment and you keep the range so that you can still maintain contact, perfect' (*PT4)

The dynamic imaging element of MSKUSI was discussed with noteworthy enthusiasm by many who were keen to emphasise the natural and comfortable integration of a dynamic imaging modality with their existing dynamic assessment, this has been summarised by the following comment;
'it is something I have adapted naturally into it because I am a physio, because I like to look at the way things move and touch things, feel things, see things' (PT10)

Current literature includes references to the 'dynamic' nature of MSKUSI, (Martinoli et al 2002, Patil and Dasgupta 2012, Iagnocco et al 2014, Ozcakar et al 2012) but fewer publications explore this dynamic nature or even state a definition for the term 'dynamic'. 'Dynamic' has been applied to a scanning procedure when the patient's joint is moved actively or passively whilst being imaged as demonstrated in a study by Feuerstein and colleagues (2014). This research explored the diagnostic capability of static ultrasound imaging when compared to a dynamic evaluation of the plantar plate and concluded sensitivity, specificity, positive predictive value and negative predictive value were improved when scanning was dynamic. This comparative study was methodologically sound despite the relatively small cohort and suggests that performing joint movement during the scan can significantly influence the outcome. The term 'dynamic' has also been applied in studies that focus on muscle and tendon kinematics, typically reviewing muscle architecture changes during force production, (Sikdar et al 2015, Löfstedt et al

2012) whilst this research contributes to the evidence base it is not closely related to the scanning aims reported by the interview participants. A small number of studies have investigated the addition of ultrasound imaging to standard musculoskeletal clinical testing procedures, (Fodor et al 2009, Leong et at 2012, Vincent et al 2013). It is evident from the interviews that several participants were routinely combining clinical testing with MSKUSI and have adapted scanning protocols to respond to patient specific requirements. This responsive approach to ultrasound and its integration with clinical examination is rarely discussed in current literature.

Participants extended their discussion about dynamic imaging to patient specific imaging of functional problems. Several revealed that the appeal of MSKUSI was increased by the ability to explore tissue when it was challenged functionally and this was guided by patient information;

‘The patient with that impingement pain who says ‘this is when I get it’, then you can put the scan on at that point and I think that is great.’ (PT5)

A small number of participants provided specific functional examples. Their detailed explanations suggested MSKUSI during functional activities was incorporated into clinical practice and the potential to achieve this had been a significant factor in their motivation to engage with the modality;

‘I will be just looking at their function, so looking at forward flexion, looking at them picking up a handbag that is out in front of them, and you can see what is happening under ultrasound. Or, another example is if someone has got anterior

ankle impingement then you may get them to squat or lunge whilst you are doing the ultrasound to see if that gives you any more information.' (PT10)

The links between the dynamic potential of MSKUSI and patient specific functional problems have not been explored in the literature to date. A small number of studies that generally discuss muscle hernias have suggested provocative activities should be undertaken before imaging, (Bates 2001, Kotha et al 2014, Artul and Habib 2014). Literature discussing the potential to adapt imaging protocols to investigate patients in positions that replicate their functional problems is lacking, this is clearly an area of evidence that has yet to be studied or reported extensively.

7.2.5: Subcategory: Curriculum Vitae Enhancement

The final subcategory within the category 'trigger to explore musculoskeletal ultrasound' was 'curriculum vitae enhancement' where the participants presented a number of justifications for their motivation to explore MSKUSI, these justifications related to long-term career opportunities and were identified from sections coded 'gains respect', 'responding to competitive workplace environment', 'research opportunities' and 'work in radiology'. The participants observed that using MSKUSI was regarded positively by colleagues and peers, but was also a modality linked to self-validation by responding to a challenge that has clinical value;

'I think there is also an issue with stagnating really, 'what is next?' or 'what can I do next?' and that was the next challenge.' (PT9)

Participants identified links between MSKUSI and enhancing their personal curriculum vitae, there was a strong consensus that the modality improved employability. There were however contrasting viewpoints regarding the participants' ambitions to perform MSKUSI in radiology departments as well as, or instead of within a physiotherapy based service. A small number of participants described their role in radiology; the following participant described how the opportunity developed from a relationship with a radiologist who had been his mentor for a formal course;

'We do a full day's list together, so it started out as being me observing him and doing little bits and him teaching me, now I tend to, apart from the injections (which is another issue) but I tend to do the list and tell him the reports and he dictates the reports' (PT3)

Another participant who had considerable ultrasound experience reported he had been strongly encouraged to assist in the radiology department because radiology waiting lists were growing and the trust was at risk of financial penalties. This participant reported that his manager had not offered support when he had been seeking mentorship or education in MSKUSI. His description of the situation whereby the manager asked him to contribute to the radiology workload was accompanied by a level of cynicism; his curriculum vitae enhancement had been noted and valued, but not on the terms he had initially intended:

'Yes, I think financial, i.e they will then get fined. I can scan musculoskeletal, there has been an absolute four-fold increase to musculoskeletal referrals and therefore I may have fulfilled a very functional and very critical role within the radiology department.' (PT4)

The participants' viewpoints contrasted significantly regarding their desire to work in radiology. Some participants reported they had naturally taken on responsibility for musculoskeletal lists once they had established a rapport with the radiologists, one participant had been strongly encouraged to help a struggling radiology department due to the pressures of waiting lists whilst other participants clarified they were not interested in using their skills outside the physiotherapy department. The following participant expressed this sentiment assertively;
'It is an interesting one and you hear of therapists that have got so into scanning, that they have extended their scope of practice out of their existing practice into a completely different practice. That is not my aspiration at all, I could not think of anything worse than scanning people, long lists of people,' (PT5)

It is evident that several participants were motivated by the potential to enhance their curriculum vitae and improve their employability. The participants' opinion regarding the clinical value of ultrasound was a factor identified regularly, whereas none of them identified an ambition to work in radiology as a significant trigger despite the fact that a subsection of the participants were undertaking regular radiology lists.

7.2.6: Category: Professional Experience

The first theme in this study included a second category that related to the participants' professional experience, how this has contributed to their skill set and provided a foundation for their involvement with MSKUSI. The category 'professional experience' was formed from two subcategories, 'musculoskeletal medicine' and 'professional influences'.

7.2.7: Subcategory: Musculoskeletal Medicine

The first subcategory, 'musculoskeletal medicine' was formed from material that reflected how the participants regarded knowledge of pathology and treatment options as a valuable asset. The asset of musculoskeletal pathology knowledge was highly regarded by the participants, they emphasised that years of professional experience in the field of musculoskeletal medicine had enabled them to link theory to practice and provided a platform for MSKUSI. One participant provided a simple summary of his opinion:

'As a physio, we are in a great position to understand those conditions in terms of, from a physio point of view: how they behave and all that sort of thing' (PT1)

The participants also highlighted that their professional experience prepared them for this imaging modality as they were familiar with pathway processes, treatment options and typical outcomes for patients with musculoskeletal presentations:

'*arrogantly maybe, we are in a unique position to take this on because I think that we have that broader perspective.*' (PT5)

A small number of the participants developed the discussion and explained that their knowledge of musculoskeletal presentations impacted on their scanning. Participants described that their awareness of the course of a presentation, (in particular the degenerative pathologies such as osteoarthritis 1st carpo-metacarpal joint), alongside the time related restrictions imposed by service providers to treatment pathways had influenced their relationship with ultrasound. They accessed the modality to support manoeuvring patients through pathways as efficiently as possible without making mistakes that could waste time. The following participant explained,

'my experience is that I have a purpose, because I want to reassure myself that I am on the right pathway for this patient - treating them and I know my time limit for getting them better' (PT11)

This aim for efficient patient management correlates well with several publications from professional bodies related to sonography. The Society and College of Radiographers and British Medical Ultrasound Society's joint publication, 'Guidelines for Professional Ultrasound Practice, (2015, page 24) confirms that the scanning clinician should ensure that 'the role of the ultrasound examination is understood in the clinical context for the patient'. Similarly, the following statement published in the handbook of the Consortium for the Accreditation of Sonographic Education, (2015, page 5) further clarifies that scanning clinicians should have the skills to support timely diagnosis and management to patients: 'Workforce modelling and the development of innovative training routes to meet the demand for sonography services should demonstrate increased efficiency of provision and effectiveness in delivery of diagnosis and treatment to patients'. It is evident that the participants' knowledge of musculoskeletal pathology and management pathways is valued by the participants and aligns well to the requirements of ultrasound imaging as stated by key professional organisations.

7.2.8: Subcategory: Professional Influences

The category 'professional experiences' explored factors that included a second subcategory, 'professional influences'. This subcategory was formed from data that linked specific professional factors to the subjects' suitability to ultrasound imaging. The selected data was coded 'noteworthy professionals' and 'responding to competitive workplace environment', the latter section of code had already been considered in the subcategory 'CV enhancement' but also had a role in this subcategory.

Participants stated that a small number of physiotherapists played a key role in providing a context for the profession's use of MSKUSI. The names of this select group of practitioners were given by most participants. These practitioners were observed to have successfully accessed ultrasound education, utilised the modality in the clinical environment and had achieved a level of expertise that was widely respected. This accomplished group were regarded as role models, virtually all of the participants identified at least one of these clinicians by name. Emphasis was placed on the influence of these physiotherapists who have achieved a high skill level and tried to increase accessibility of MSKUSI through their involvement with professional networks. A participant's comment regarding one of these influential physiotherapists is typical of the entire group; it reflects respect for the acquired skill, notes the physiotherapist's professional identify and provides hints of the professional challenges associated:

'*But, yes, he is probably one of the bigger influences, because he is just a physio and he makes it look so easy.'* (PT4)

The professional influence of this select group of physiotherapists was profound, it was evident that a very small number of clinicians had provided an example that others wanted to pursue. Other professional influences reported included contemporary healthcare instability and perceived insecurity within the competitive workplace environment. Several participants indicated that physiotherapists were strategically seeking education to respond to this perceived instability. Some participants had experienced dramatic changes to employment circumstances when service-tendering processes had resulted in new employment. They wanted to optimise their employability value by responding to service needs prioritised by commissioners, in particular ultrasound guided injections. The following participant expressed his concern about the fast track education routes that clinicians are accessing to perform guided injections, it provides an example of how physiotherapists appear to be responding to commissioners' agendas:

'and the market everybody is talking about is guided injections, I mean there isn't any great evidence but everybody is, the commissioners think that guided injections - that is where the market is at the moment. So people are going on 1 or 2 day courses on an interventional course, or an introductory course and they think themselves, they can do the guided injections Nobody can stop themselves' (PT1)

The participants observed that physiotherapists' skill set prepared them to engage with MSKUSI and respond to current NHS workforce demands, including guided injections. Whilst their preparedness to react to service provider and commissioner requirements was evident and formed the coded material 'responding to competitive workplace environment', the other elements in the category 'Professional Experience' dominated, in particular the value of musculoskeletal medicine knowledge.

The first theme 'Professional Skill set – Physiotherapists' Suitability for Musculoskeletal Ultrasound' evolved from interview data that presented diverse and numerous links between physiotherapists' skills, knowledge and professional experiences that were reported to align well to the requirements of MSKUSI.

Table 7.2: Key Findings from Theme 1

Professional skill set – physiotherapists' suitability for MSKUSI

Participants reported a close association between their core physiotherapy skills and knowledge and those of MSKUSI
Training in MSKUSI enabled participants to advance their physiotherapy practice
Evidenced based practice should be a key influence in physiotherapists' engagement with MSKUSI
The dynamic application of MSKUSI aligns well with physiotherapists' interest in functional movement analysis.
Participants viewed knowledge of musculoskeletal medicine and management options as an essential basis for effective use of MSKUSI
A small number of physiotherapists who have successfully integrated MSKUSI into their practice have provided direction and motivation for others.

7.3: Interview Findings - Theme 2

Factors that have impacted physiotherapists' ability to use MSKUSI

7.3.1: Category: Education

The second theme identified, explored factors that impacted on participants' ability to use MSKUSI. Three categories were drawn together in this theme; 'education', 'barriers' and 'enabling factors'. The 'education' category has been formed by two sub-categories, 'education in musculoskeletal ultrasound' and 'mentoring'. The first of these related to material that had been coded to reflect the various forms of education available and their associated issues, the second of these derived from data that explored the specific topic of mentoring.

7.3.2: Subcategory: Education in MSKUSI

The subcategory of 'education in MSKUSI' included material that had been coded with four labels: 'informal musculoskeletal ultrasound education', 'formal musculoskeletal ultrasound education', 'course responds to physio needs' and 'how to establish competence'. These four codes collectively identified a large volume of data that explored issues participants perceived as relevant to MSKUSI education.

Most of the participants had accessed informal ultrasound education to investigate if it was a modality that interested them. The participants were split into groups; one who had accessed informal education and another group who had then sought formal education, (assessed and generally university based). All participants who had accessed informal education, valued it and acknowledged it had played a part in their relationship with the modality. The participants who had not pursued formal education provided several considered reasons for this. Some had access to experienced colleagues who had supported their learning and enabled them to develop their practice in the work place. A number of comments reflected the belief that this style of learning provided the closest match to the individual participant's requirements and prevented them engaging with irrelevant material. The value of the clinical environment as a source of learning has been recognised for many years, (Raelin 1997, Jasper 2010, Phillips 2012). Within the over-arching paradigm of work-based learning, authors acknowledge a variety of approaches are available to match different environments, (Baxter et al 2009, Cameron et al 2012) and whilst it may not be appropriate for every clinical environment, it is an approach to learning commonly linked to service development, (Phillips 2012, Williams 2010). The term 'work-based' learning was used by participants to refer to supervised and structured learning in the work place, this learning was not affiliated to an academic institution and was not assessed formally. The participants reflected on the specific requirements of MSKUSI including the need for employers to judge their employee's ability and regarded work-based learning to have tremendous value. These participants emphasised the need for rigorous training in the field of musculoskeletal medicine whilst contrasting it with the education requirements for alternative ultrasound specialisms used by physiotherapists, one participant whose education had been entirely informal summarised this;

'When we write the protocols and the training framework and training guidelines (for physiotherapists using musculoskeletal ultrasound)*, people who use it for rehab - women's health, students, research students, neuro physiotherapists using*

ultrasound to target a particular structure, they don't need that rigorous training.' (PT2)

Several participants commented on the potential complexities of compulsory formal education, highlighting that responsible clinicians should work within an area that they have received appropriate training and should be able to identify their personal limitations. The following participant assertively expressed the opinion that clinicians should work within their abilities, seek assistance when required and act accordingly if ultrasound imaging revealed something that required another professional's involvement. This participant placed value on clinical reasoning, common sense and professionalism and held the opinion that a clinician should be able to direct the patient to the next stage of management but does not have to be fully informed of all the components in that next stage;

'It is a little bit like to use an analogy, like the so called orange flags used for back pain - coming across people who are profoundly depressed and possibly suicidal. We are not taught how to administer the depression questionnaires for example, but we have a rough idea as to what to do with people when we find someone who is profoundly depressed or suicidal. And similarly, with using ultrasound if we found something that we really weren't so sure about or not happy with, I think we would have a rough idea about what to do with people -we do not need certification in order to use it.' (PT 7)

'Formal musculoskeletal education' was the second code in material assigned to the subcategory, 'education in musculoskeletal ultrasound'. The interview data revealed two issues related to formal MSKUSI education, these were the participants’ desire to obtain an accredited qualification and their response to the compulsory course content, in particular the physics and instrumentation section.

Several participants’ interviews suggested they did not access formal education for the academic course content or even for the supervised elements, the key motivation was the formal qualification:

‘And by then, I was confident on most of the joints but I wanted some formal qualification ‘ (PT 5)

Some expressed a degree of cynicism regarding the higher education institution’s involvement with the process as expressed by the participant below:

‘I mean as the formal education is apart from giving you a piece of paper,' here you are, you are qualified' and it all depends on the supervisors and the work place where you learn it. And the university does not give you much’ (PT 1)

A small but noteworthy number of participants commented on the value of the physics and instrumentation component of formal qualification. This is a compulsory element of CASE accredited courses, (Consortium for the Accreditation of Sonographic Education 2015, page 36). Participants reported that this theoretical knowledge facilitated their image optimisation skills and that they could not rely on colleagues in the work place to do this;

‘ the stuff that I got, the physics and how to optimise an image, so they are greater in depth, detail I got from the course is still probably the most useful thing that I have learnt in terms of scanning. If you have got that and you have some good support, skill will come but the, the real basic physics of what you are looking at,

how the image is generated what you can do to get a better image, I think that gives you a lot more than just scanning, scanning, scanning - which if you do an introduction course and then that's it, having formalised knowledge is important.' (PT 3)

Two other code labels were included in the subcategory 'Education in Musculoskeletal Ultrasound', these were 'course responds to physio needs' and 'how to establish competence', several links were found between these two labels. The participants reflected on their education in light of the course's framework and influence from radiologists and sonographers. The participants considered if the course they had accessed had responded to the needs of physiotherapists and how, as a practitioner on a learning curve, they could establish competence when they were using the modality in subtly different ways to other professionals.

A number of the participants commented that the philosophy of the course they had accessed was firmly embedded within the traditional practice of radiologists and sonographers. The participants were accepting of this, as historically ultrasound practice was initially only based in radiology departments and it has been in recent years that the modality has been used in other specialities, (Edwards 2010). One participant highlighted there could be a mismatch between educator providers and physiotherapy students of ultrasound:
'if you take just a radiologist that has different training and does not understand what you are doing, then they are going to shape up a course which will not really suit the physios that want to come into it.' (PT9)

Another participant developed this potential mismatch of clinical educator and physiotherapist when he described the role of different professions contributing to ultrasound related education:

'The reason I say that is, because our assessment is totally different to the orthopaedic surgeon or rheumatologist, and radiologists don't assess at all. So I am thinking that if I assess something and it is telling me something different, I will probably use the ultrasound in a different way because I'm looking for something different to them.' (PT11)

Many participants noted the aims and clinical practice of educators from a radiology or sonography background may not exactly match their own, but were keen to emphasise the value of sharing knowledge, inter-professional communication, learning from individuals who are regarded as experts in their field and to explore opportunities as they emerged. There was however a lack of consensus when participants discussed how competency can be established within this field that is relatively novel to the physiotherapy profession.

The term 'competency' was an emotive one and was linked to a large volume of interview data. The educational institutions who deliver CASE accredited courses must include competency based assessment, without this, some students were offered alternative pathways that did not include any verification of practical ability. The following participant explained the routes that were available when mentor access became challenging:

'If I did not have a mentor, there was no reason why I could not continue with the Post-Grad Cert, but all you would then have is a Post-Grad Cert in the theory of

ultrasound. But you need a mentor to give you competency and you need to pass the competency exams, so that you competently use and diagnose based on ultrasound findings. Competency was given to me by someone more competent than myself.' (PT 4)

This participant described that after finding a mentor, completion of the Post-graduate Certificate accredited by CASE was possible and that the clinical mentor was the key player in defining competency and assessing the student was able to demonstrate it. Another participant reflected on the Post-graduate Certificate he had completed and viewed the entire assessment pathway as an assessment of competence. It is evident that he did not regard the assessment as an adequate review of his competency levels and indicated an under assessment of musculoskeletal medicine knowledge alongside practical skills:
'Our assessment of competency ranged from essay writing, to Powerpoint presentations and in my opinion, the competency was judged in the field by your mentor. I think there is an argument, a very strong argument for saying you have to meet a protocol driven practical competency. It screamed to me that is what you should do. You actually have to go, 'can this person scan this region? And can they do everything and can they answer questions around pathology and whatever?. I think that is absolutely fundamental. I think that was a glaring weakness', (PT 5)

This participant expanded the discussion exploring competency with clarification of his viewpoint; a practical assessment without evidence of supporting knowledge of musculoskeletal medicine was not a robust competency assessment. He repeatedly referred to the practical ability of other professionals on the course he attended and did not feel their interpretation of the ultrasound image was fully assessed as they did not have to articulate musculoskeletal clinical reasoning or the role of MSKUSI in the patient's pathway. His comments were summarised in the following question accompanied by a brief response:

Question 'Just reiterating that, the sonographers and radiographers had great probe control and ability to optimise the image and the physios had great musculoskeletal clinical knowledge, but it is the mixing of those 2 that then needs to be evaluated to establish the competency '

Participant: 'Absolutely 100%'. (PT 5)

The opinion that cognitive knowledge, practical skill and context provided by clinical environment all need consideration is aligned with contemporary literature and some older publications exploring competency, (Miller 1990, Leggett 2015). Several participants concluded however, that assessment processes employed by course providers had provided a limited profile of competence. The missing factor was the link between musculoskeletal knowledge and the practical process. Rigorous self-audit was advocated as the most effective method by some, but lacks standardised criteria. One participant was keen to emphasise the limitations in current competency based assessment and explained alternative processes that he valued;

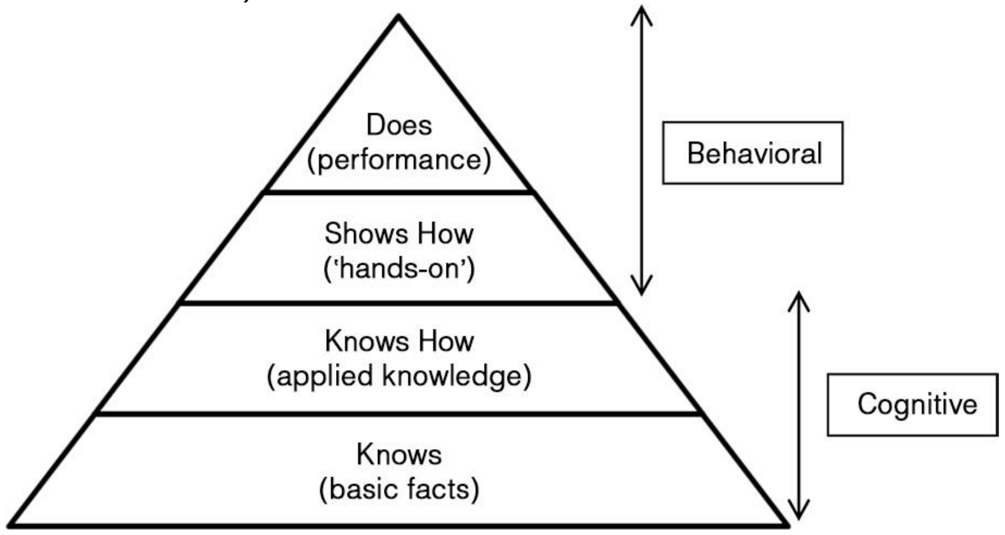
'In an exam, it is difficult to examine, it is difficult to assess. There are a number of routes to competency that you could possibly use: what other people have used which include confirming your scans against known imaging results like MRI, CT or a previous ultrasound scan. so you can look at the reports, do a report yourself and

compare the two. Look at the correlations, surgical correlation is very good, a lot of people that had no formal mentorship have started looking at scan results and getting surgical correlation and they have done very well, so there are different routes.' (PT 4)

Literature exploring competency acquisition and evaluation in health care has grown in the last decade as regulation, litigation and professional frameworks underpinning advancing practice have all increased, (Harrison 2015, Wing Fu 2015, Bidwei and Casserly 2011, Kissin et al 2013).

A popular framework for the assessment of professional competence was proposed by Miller,(1990). This framework was presented as a pyramid with four divisions, (Figure 3), the bottom level represents knowledge required by a professional to perform a task. In the field of MSKUSI, the knowledge required includes musculoskeletal anatomy and medicine alongside technical operation of ultrasound systems. Above Miller's base layer of knowledge, the next layer in the 'competence pyramid' is the professional's knowledge of 'how to' perform the skill. The musculoskeletal ultrasound practitioner needs the ability to conduct scans following protocols or focused scans as indicated. This knowledge of how to perform the skill is not a purely a technical task, it includes the ability to interpret the investigation's output and understand its role in a management pathway. Miller emphasised that knowledge had to be accompanied by judgement for a professional to demonstrate competence. Several of the interviewed clinicians outlined the assessment processes included in the courses they had undertaken had considered the bottom layer of the pyramid in considerable detail and elements of the second layer. The extent of assessment for ‘knowing how’ to perform a task was not consistent as some institutions’ practical examinations incorporated discussion regarding clinical relevancy of ultrasound findings and future management, other examinations did not explore these areas.

Figure 7.1: Pyramid of Skills Required for Competent Clinical Practice, (Adapted from: Miller 1990)



Miller suggested that assessment procedures that only explored the bottom two tiers of his pyramid did not fully assess clinician’s performance. Professional performance depends on health care professional’s ability to demonstrate skills in the two upper tiers of the pyramid, these have been classified as ‘shows how’ and ‘does’. Assessment in the clinical environment involving patients provide more opportunities to replicate the components of these upper two tiers, incorporating the realities of clinical reasoning and unpredictable challenges found in the work place, (Harrison 2015). The value of work-based competency assessment has been explored in recent literature, many complexities and factors that can influence the assessment outcome have been identified including the relationship between the student and the assessor alongside the transparency of the assessment procedure depending on guidance from the academic institution, (Palermo et al 2015). Strategies can be incorporated into the assessment procedure to maximise its transparency, these may include ensuring two assessors are present and appropriate moderation is undertaken but the precise mechanisms involved lack agreement amongst students or educators (Harrison 2015).

One participant who worked independently in private practice and had completed a CASE accredited Postgraduate Diploma acknowledged the complexity of assessing competence, in common with the other participants he was unable to articulate a robust method for establishing it:
‘I can't answer it. No, that is complex. I think you have a different way of looking at it; how can you prove to someone that in a court of law that potentially you are competent? And that has to be formal training, that has to be - it is not an attendance thing, it is a 'I have been examined thing, I can prove my supervision and this is what I have done in the last past year to try to try to keep up my skills. I strongly believe that there needs to be a basic level of competency for a physio working unsupervised with an ultrasound machine, but it is not a PG Cert - but it is assessed.’ (PT 10).

Professional variation in competency requirements has been acknowledged and some profession specific MSKUSI competency frameworks have been proposed, (Kissin et al 2013, Bidwei and Casserly 2011). There are no physiotherapy specific musculoskeletal competency frameworks and the participants presented mixed views on their potential value. One participant regarded a competency framework as a possible threat as it could constrain practice and limit innovation:

'*guidelines will be thrust upon us and that may actually limit physios' practice, not enhance physios' practice*.' (PT4)

This participant's viewpoint was developed that a lack of standardisation amongst professions existed and that physiotherapists' desire to protect themselves with regulation was a reflection on our lack of professional confidence:
'Interestingly, radiologists don't seem to have to sit competency exams to use ultrasound and I think that it is possibly to do with our professional paranoia, how we are viewed by other professions and how we view our own profession.' (PT4)

The subject matter competency including its application in MSKUSI education is vast, complex and warrants research in its own right. Competency based assessment reportedly decreases gaps between education providers and clinical environments by providing an assessment process that clarifies an individual is capable of working effectively, (Legget 2015, Shin et al 2015). It is apparent however, that many interview participants did not feel the assessment process they had undertaken in formal education had effectively evaluated competency. This study has highlighted some of the questions that need addressing, including the practical standard that is deemed to be competent and if the definition of competency for this modality should be task or profession based.

7.3.3: Subcategory: Mentoring

The second sub-category within the category 'education' related to 'mentoring' and was made up of data coded with three labels; 'mentor access', 'mentor's requirements by regulatory body' and 'mentor's reasoning paradigm'. Virtually all of the participants commented on the challenge of accessing a suitable mentor, the difficulties associated with mentoring were influenced by several factors including the limited number of clinicians prepared to take on the role. Several participants reported radiology colleagues would not support their learning:

'I approached the radiology department and was flatly refused.' (PT 4)

Many reasons were given for this including radiologists stating time pressures meant they were already unable to meet training requirements of junior radiologists, participants also reported resistance from radiologists who refused to offer supervision to other professions. One participant recalled a conversation with a radiology colleague:

'*And then afterwards he said 'well, it is going to be a little bit difficult because I am also teaching my registrars, so you will have to take your time. You will have to take your place, they are my priority'*.' (PT 6)

The difficulties associated with accessing mentorship were exacerbated for some who reported that some university courses required the mentor to have completed a CASE accredited course. The current CASE handbook states that clinical mentors 'must hold a recognised qualification in the area of practice being studied by the student', (Consortium for the Accreditation of Sonographic Education 2015, page 54). This document suggests that university courses can approach clinicians with a relevant qualification even if that qualification has not been accredited by CASE but is unclear if the entire qualification has to relate to the clinical speciality, for example MSKUSI, or if single modules are adequate. The CASE requirement does however suggest mentors who have received their training informally can never be considered as mentors irrespective of their reputation or extent of their experience and implies that rheumatologists, sports physicians, sonographers and physiotherapists who have developed their skills by work-based learning would not be considered appropriately qualified to mentor. It is evident that quality assurance procedures need to be in place ensuring mentors are capable of providing a high quality learning experience for students, but there are indications that some highly skilled individuals would be excluded by regulations, thereby contributing to the national shortage of available mentors.

The final difficulty described by participants was accessing a mentor whose clinical reasoning paradigm was aligned with their own. Many reported that the dynamic potential of ultrasound imaging made a significant contribution to its appeal; it was then a frustration when these participants discovered that supervisors did not always fully utilise or embrace the dynamic opportunities available. The following participant who teaches on a number of different courses made this observation regarding the style of scanning he witnessed from other professionals:

'*a radiologist or a sonographer, who, obviously they do not all work like this but from my experience of teaching lots of these on my courses, they seem to have more of a flat, less dynamic, protocol type of scan'* (PT 10)

Another participant had undertaken informal education and expressed reluctance to enrol on a formal course. His colleague had recently undertaken a CASE accredited course and reported frustration at the mismatch between the clinical supervisor's approach to scanning and his own:

'*he found a few difficulties with the training course that he undertook, just purely because if they are not looking at the things he is looking at in the same way..'* (PT 9)

The requirement to modify education or mentoring for specific professional groups has not yet been thoroughly explored in literature. As previously discussed, some professional groups have established competency frameworks, (Kissin et al 2013, Bidwei & Casserly 2011) and a small number have documented educational requirements, (Brown et al 2005, Faculty of Sport and Exercise Medicine 2012). Physiotherapists in the United Kingdom have not produced any literature discussing their education or mentoring requirements. The participants in this research reported they had attended courses that welcomed a wide range of professional groups and the students' expectation of the mentor and the product of ultrasound imaging were diverse. The desire to access a mentor who would enable physiotherapists to fully integrate MSKUSI into their clinical assessment using established clinical reasoning processes was reported by most of the participants and summarised neatly by one:

'We can use our assessment skills and use your moving the joints, dynamic ability of scanning. Yes, if you ended up having a supervisor who is a radiologist, you would not get that, definitely you would not get that. And that is where I would probably, having a physio-sonographer as your supervisor gives you that side of learning, I think that is what everybody who is a physio who goes into doing the ultrasound scanning should realise, that they are in a great position they should never leave their physio skills for ultrasound that, if they do it, that will be a real shame.' (PT 1)

The category ‘education’ presented a set of contrasts between the participants who had accessed informal learning in the work-place where they had access to mentorship and those who accessed formal learning but struggled to find a mentor. The first group of participants avoided the constraints they perceived were associated with formal learning and an accredited course whilst they benefitted from having mentorship available in their own workplace. In contrast, the participants who were keen to complete a validated course were sometimes constrained by the mentorship requirements. This second group of ‘formally educated’ participants regularly struggled to find mentorship and were sometimes disappointed by the mismatch between their mentor’s reasoning paradigm and their own.

7.3.4: Category: Barriers

The second category in this theme exploring factors that impacted physiotherapists’ ability to use MSKUSI was ‘barriers’, this drew together a large list of coded material that was organised into two subcategories ‘logistical challenges’ and ‘professional barriers’ .

7.3.5: Subcategory: Logistical Challenges

Logistical challenges included a diverse range of issues, the single factor that was reported more than any other was access to appropriate equipment. Previous studies have reported similar findings, whereby clinicians who have received education have been unable to scan because of challenges accessing equipment, (Jedrzejczak and Chipchase 2008, McKiernan et al 2011, Potter et al 2012).

Participants who had overcome their ultrasound machine availability problems outlined the process that had enabled them to source a system, this was typically reported in terms of '*financial good luck'* (PT11). A proportion of the participants explained that their departments did not have adequate funding to purchase a machine but support was available from other sources including hospitals' Friends Associations and '*a one off innovation fund'*, (PT 3):

'again we did not get funding for it, my manager said that we are not going to get funding for this and so we went to the Friends of the Hospital and they bought one of the machines for us' (PT 6)

The process of gaining access to equipment was sometimes time-consuming and difficult. One participant's response is revealing as she described her delight and surprise when her department was given its own system:

'*that is our machine. Somebody signed that off and we don't know if they thought they were signing it for somebody else because it is an expensive, cracking machine…*' (PT 2)

A small number of participants were restricted by their dated equipment that produced poor quality images, whilst replacement was not financially viable:

'I am still soldiering on with an ancient device' (PT 7)

Logistical challenges discussed extended beyond accessing equipment and the equipment's technical ability, several participants were keen to highlight that limited financial support for education and study leave also impacted their ability to engage with the modality. Participants generally had to self-fund their courses, some of them had additional mentoring fees and very few had adequate study leave to complete all educational requirements. One participant with extensive ultrasound experience discussed the impact of a limited supply of mentors and the financial commitment many students were undertaking:

'*many people who want to do this, they will have to do it on their own, people are spending a lot of money just to do it, they spend more money to get the supervision than they are spending on the course, it is hard now, but that is how it is'* (PT 1)

One extremely positive participant who did have study leave, access to a highly qualified mentor and course funding was eager to express how fortunate he viewed his position:

'When you are in the NHS at the moment and while you are being invested in with training, you have absolutely nothing to complain about really. Whether that be your pay, or conditions or whatever, I think if someone is paying for you to add to your CV then you are one of the fortunate ones and you should be trying to work as hard as you can.' (PT 8)

7.3.6: Subcategory: Professional Barriers

The category 'barriers' included the subcategory 'professional barriers'. A number of codes in this subcategory related to a diverse range of professional issues that impacted on the participants' ability to access ultrasound education or use it in clinical practice.

Participants' managers and colleagues were both identified as contributors to some individuals' challenges. The following participant observed how her support disappeared when one manager left and was replaced by someone with a contrasting management style:

'*So what happened is, that when you have a champion who is championing, and then that champion goes away, then it will be very different. It was quite interesting because my first line manager was a nurse by background, she worked in a private organisation. So she knew the value of the cutting edge, but the line manager who came was a very archaic physiotherapist who sort of asked 'where do you think you are going? Come back here', kind of approach and lets control it*' (PT 6)

An infrequent but noteworthy inclusion in the data was the opinion of some physiotherapy colleagues, who expressed opposition to the participants who were trying to access ultrasound related education:

'Initially there was a lot of criticism from a lot of our own physios, 'are you good enough at doing it, can you really master the art of it?' (PT9)

There is a robust evidence base confirming smooth implementation of new services in physiotherapy, (in particular those involving skills regarded as 'extended scope') is dependent on involvement and support from a number of stakeholders including managers, colleagues and professionals responsible for financial and policy decision making, (Morris et al 2014, McPherson et al 2006, Kersten et al 2007). Publications that review service developments incorporating professional role diversification have reported many challenges, these include opposition from professions traditionally associated with a role, variation in local and national requirements and an inadequate evidence base of clinical outcomes and quality assurance processes prior to service change, (Hart and Dixon 2008, Royal Australian and New Zealand College of Radiologists 2015, Innes et al 2015). Several of the interview participants were aiming to incorporate MSKUSI into a physiotherapy service with the intention of adding value; using it to verify their clinical assessment, improve patient education and monitor patient progress. Some managers expressed resistance to this, reasons provided included concern regarding risk, a lack of evidence supporting the added value and uncertainty relating to stepping into other professions' territory. This model of service development lead by provider's motivations contrasts with traditional healthcare delivery models when service development responds to an identified need, for example the requirement to provide a new intervention, an unacceptable weighting list or a workforce shortage, (Aiken et al 2008, Hart and Dixon 2008, Reid et al 2016) . There are some contrasting examples of service expansion where professions and professionals have based new service provision on the professionals' personal expectations and motivations. Birch and colleagues, (2013) provided the example of the British paediatric orthodontist industry as one of supplier induced demand. Neither Government nor national health policy had identified the health requirement of paediatric orthodontics as a priority. Despite this, a rapid expansion in orthodontic provision has occurred in the last decade, dentists' regard of their orthodontic professional expertise has facilitated a dramatic increase in service provision. Physiotherapists aiming to use MSKUSI have a high regard for the modality, this high regard could provide the foundations for supplier induced service development despite barriers from management. Physiotherapists may need to consider this alongside the traditional elements of service development including accreditation of training, marketing, proactively addressing barriers and service quality evaluation (Morris et al 2014).

A number of participants described a general reluctance and lack of support from their managers, a small number of participants reported specific management concerns regarding safety, as indicated by the following participant:
'*The trust's manager would not allow the physios to use it and it was in a cupboard and her reason for people not using it, was the fact that she didn't think that it was safe to use because they might make false diagnoses'* (PT4)

It is evident that individuals' professional obligation to declare compliance with the requirements of their regulatory body the Health and Care Profession Council and Chartered Society of Physiotherapy Code of Values (Chartered Society of Physiotherapy 2011) does not satisfy some managers of the clinician's ability. Despite formal training involving competency based assessment, some participants still experienced opposition from managers who reported concerns regarding safety and other clinical governance issues.

The profession of radiology and its impact on MSKUSI and related education was raised by many participants. Material was coded as 'radiologist – general barrier', 'radiologist – concern regarding standards' and 'limited access to radiology'. Collectively, these codes reflect a significant volume of data that links barriers reported by the participants to engaging with ultrasound. It is important to highlight that some participants reported support from their radiology colleagues, this material will be discussed in the next category 'enabling factors'.

The presence of concerns from radiologists regarding patient safety, quality assurance and standards when physiotherapists use MSKUSI were a barrier for an extremely small number of participants. In contrast, a significant proportion of participants provided extensive reports regarding other barriers from radiologists that affected their engagement.

One participant provided a justification for the reluctance of radiologists to provide access or mentoring for musculoskeletal ultrasound, he reported the radiology team had to prioritise the training requirements of radiology registrars and regarded interest from physiotherapists as a training responsibility for the physiotherapy department:

'the feedback from our radiology is just, 'what is in it for us?' We have no interest in supporting your training at all with physio, it is nothing to do with us ' (PT 8)

Widespread reports of 'political' issues dominated the discussions regarding limited access to radiology and radiologists. Publications exploring advancing practice for non-radiologists into territory traditionally held by radiologists is limited, there are examples of support and a dominant agenda of improving service efficiency, (Reid et al 2016, Field and Snaith 2013, Society and College of Radiographers 2008) and other indications of opposition alongside strong professional opinion, (The Royal Australian and New Zealand College of Radiologists 2015).

One participant reported that despite his good relationship with a radiologist, the radiology manager blocked access to radiology. The participant explained:

'I think there is a crossing of professional boundaries for one thing and 2nd, losing control of ultrasound; it is a radiologist's job, sonographer's job, it is not a physio's job. So I think it was protectivism - also about losing control because the ultrasound genie was out of the bottle at that point.' (PT 4)

A small number of participants reported frustration when other professionals appeared to hinder patient-focused care, these participants allowed themselves to discuss the emotional impact of this behaviour. One participant was part of a small team of physiotherapists who offered an established and successful ultrasound guided injection service. She reported her frustration that consultants did not consistently refer to this service, instead their patients had to wait long periods for simple injections that could take place in an outpatient clinic:

'the consultants will still, knowing we offer all of this and can extend the list, will still book them for theatre, for guided injection in theatre, which they wait 2-3 months for. And they have to gown up, they have to have TED stockings on and take nail varnish off, so I had a lady out there, a guided AC joint and I went 'why did you not come back to us? We could have done that in an half an hour session?'. So we have got 15 years of figures nearly, no infections because this is what the consultants bang on about, no anaphylaxis or any of it. 70% satisfaction from patients whenever we have questionnaired them and stuff you know, so she said, 'I was here for hours and it took about 2 minutes' and they still do that, and my colleague has even approached them from an income generation point of view of getting the waiting list down but, 'no' they want their little theatre bit, it is like a brick

wall, very difficult. Sorry to digress, but it is politics. I think they have got 400 at the moment, waiting.' (PT 2)

7.3.7: Category: Enabling Factors

The final category in this theme drew together the enabling factors that had impacted participants' experiences with MSKUSI.

7.3.8: Subcategory: MSKUSI Education Available

This subcategory related to data coded 'course responsive to physios' or 'good course'. A very small number of participants referred to aspects of the courses they had pursued and regarded acceptance onto the course as it being responsive to physiotherapy needs. Several participants who completed their ultrasound training several years ago reported they were the 'only physio on the course', whilst the participants who have accessed recent education suggested professional diversity had increased significantly. Participants rarely commented on the quality of the course, generally they reported satisfaction for being accepted and their ability to meet the course requirements e.g access to a mentor but an occasional statement indicated some had considered the value of formal course's structure. One participant summarised their reason for choosing a course with modules and accreditation instead of a series of unlinked educational events; *'formalised knowledge is important*.' (PT3).

7.3.9: Subcategory: External Support

The second sub-category relating to enabling factors draws together the external support that impacted the participants' ability to access education. Virtually all of the participants made reference to mentors and many described this relationship as highly influential and positive. The following candidate accessed a mentor before, during and after his formal course and clarified mentored learning offered an experience that was not available in the classroom:

'I think that if I was left just with that course, then I think that it would have been fairly deficient in terms of giving me the practical competency. I think the mentoring was absolutely critical to that process. The course gave me the academic underpinning, it gave me awareness, but did not give me the practical competency that came from the mentoring. And I know from speaking to other people who did not have that opportunity, then that was really fundamental and that went, as I said before, that predated that course and I continued after that course up until fairly recently, till I started my PhD and then I stopped.' (PT5)

All of the participants who had experienced mentored practice indicated professional respect for their mentors. The participants who were able to access a mentor in their own workplace were particularly positive and observed the convenient availability of this expertise:

'*But because (mentor's name) is so high up and does so much teaching, it just been a doddle really, because he is on tap'* (PT2)

Those who received mentoring in their own work place also highlighted their training was often the product of a service development plan which facilitated opportunities in their clinical department. The following participant reported that the radiologist who had acted as his mentor delegated musculoskeletal scanning lists to his student once he was satisfied with competency and was now able to commit to other responsibilities:

'*he is quite happy for me to run his lists and he wants me to do injections, so he does not have to do them, which frees him up. He is the lead radiologist for the trust, so he is often called away which means he often overruns, but actually, if I can do more, then he can do less'* (PT3)

Participants reflected on other external support and highlighted that managers and colleagues had been influential in their MSKUSI experience and had made positive contributions. The other group acknowledged by participants was their patients, many commented that whilst learning, they would scan as many patients as possible. They informed patients that they were practising and that the information from the scan may be limited, patients typically consented to this as they appeared to want to help and many believed the scan may be useful to them:

'*they wanted to be a help: if somebody wants to learn something, that somebody has to learn at some point. Everybody has to learn and you don't mind, even if they think they get some information out of it. Probably that's another thing from a patient's point of view, but again I never had somebody say 'you are not qualified, I don't want you to scan me'.'* (PT 1)

Patients were described as receptive to the scanning process, there were many reports of enthusiastic patients who wanted to hear about their images. One participant summarised the patients' receptiveness to scanning with the following comment:

'So, yes - the patients love it, that is the thing. Patients love information' (PT 5)

The sub-category, 'external support' provided a stark contrast to that found in 'barriers', the second category in this theme. It was evident that mentors, managers and colleagues sometimes provided essential guidance and facilitation, enabling participants to make progress with MSKUSI. The data from the sub-category 'barriers' reflected many challenges but these barriers were generally managed with positive input from professional colleagues and patients.

7.3.10: Subcategory: 'Positive Personal Factors'

It is possible that the final sub-category in this theme provides the link that has enabled participants to access external support and move on from barriers, this final sub-category relates to 'positive personal factors'. Data included had been coded 'luck', 'resilience' and 'acknowledge learning curve'.

A majority of the participants used either the term 'luck' or 'fortunate' when they relayed their personal journey. Alongside the reports of good fortune were anecdotes that reflected the participants' personal qualities that had supported their journeys, the qualities that were noted included resilience and perseverance. There were many inclusions that reflected the participants' drive to practice as evidenced by the following participant:

'I really scanned every patient. Somehow I fitted that into my time slot, that time that takes about 5 to 10 minutes, I fitted in it.' (PT 1)

Several participants commented on the personal drive required to overcome logistical challenges alongside the need to practice around work commitments. The following participant discussed this and referred to her mentor's experience when he started to learn MSKUSI;

'*difficult, really difficult. Because I know X used to nick the scanners, he used to take patients down or staff to practice at lunchtime'* (PT2)

The demonstration of personal qualities was extended as participants emphasised learning MSKUSI was a long term commitment; data coded 'acknowledge the learning-curve' related to the duration of the study needed to develop required skills including personal and financial investments. One participant who is a private practitioner described how he funded his education, mentorship and the ultrasound system's cost:

'*Yes, it was all self-funded. So I self-funded the original one which was, cost about £7000 initially so that was a big outlay initially. So I thought long and hard about what I wanted, I had watched another therapist and his use of ultrasound'* (PT 5)

Participants generally discussed their achievements with pride, some observed other colleagues had not persisted with the learning experience those who had started the journey but not continued:

'There was a big dropout rate, people realised that is was quite a mammoth task and you need to spend a lot of time and put a bit of effort into it, to get good at it.' (PT 9)

There are currently no published studies exploring the personal traits that enhance the likelihood of individuals successfully gaining competency in MSKUSI. There are a small number of studies related to other healthcare professionals that suggest resilience, high self-efficacy and other non-cognitive factors may contribute to healthcare students' successful progression in education, (Jackson et al 2007, Adam et al 2012, Taylor and Reyes 2012, Pitt et al 2014).

The second theme in this study drew together a large quantity of data that explored factors reported by the participants that had influenced their use of MSKUSI. The complex interaction between access to education and mentors, logistical challenges, managers, colleagues and personal qualities has had impact on all of the participants, most of them have been able to successfully complete their chosen education and utilise the modality but some have faced obstacles that have limited their progress.

Table 7.3: Key Findings from Theme 2

Factors that have impacted physiotherapists' ability to use MSKUSI

Participants reported skill acquisition required for MSKUSI in clinical practice required extensive training.
Several participants engaged in validated university-based education because the award provided formal recognition of ability and would be valued by employers.
Access to an appropriate mentor is an essential component of MSKUSI education but mentor availability is extremely limited.
Mentorship offered by radiologists and other medical professionals supports education but may not include some MSKUSI applications of interest to physiotherapists, these include optimising dynamic imaging in response to functional aggravating activities and correlation of imaging with clinical examination.
Participants placed great value on the input from their mentors and were all appreciative of support when it was available.
Participants observed the term 'competency' was not applied in a standard way in MSKUSI education and competency assessment rarely included clinical reasoning or an understanding of patient management options.
Barriers to MSKUSI utilisation by physiotherapists includes limited mentor access, lack of machine availability, lack of managerial support and opposition from other professional groups.
Some participants were able to report high levels of support from education providers, mentors and colleagues from medical specialisms.
Several participants who had successfully integrated MSKUSI into their practice had responded to challenges and demonstrated high levels of resilience.

7.4: Interview Findings - Theme 3

Physiotherapists' Motivation to Use Ultrasound - Improving Patient Focused Care

The third theme drew together material whereby participants related MSKUSI to improving patient-focused healthcare. Three categories were identified, the first explored the role of MSKUSI as an assessment tool, the second considered its role when reviewing patients and the third related to the impact on pathway efficiency.

7.4.1: Category: MSKUSI as an assessment Tool

7.4.2: Subcategory: Verifies Clinical Assessment

The impact of MSKUSI as a mechanism to verify clinical assessment was discussed by all participants. They proposed it is an extension of the physical examination, a dynamic imaging modality that can be integrated into the examination and ultimately a tool to assist with forming a diagnosis.

Participants emphasised that scanning would always be informed by clinical assessment. Most reported that clinical assessment preceded scanning and for a small number, the scanning was integrated into components of the clinical examination as explained below;

'…always I will do my subjective assessment; take their history, do a clinical examination and then I very much see my clinical examination and my ultrasound as a continuation of each other. And I will do a lot of clinical examination under ultrasound' (PT1).

The majority of participants reported a process whereby they completed the subjective assessment and the physical examination before scanning. Clinical reasoning informed decision making regarding the value of MSKUSI. One participant succinctly commented, '*after I have done the objective assessment, or probably while I am doing the objective assessment, I would decide whether to do it or not'* (PT 3).

The participants' interviews evidenced a process to assess the value of MSKUSI, this took place before patients were scanned. This process can be compared with the assessment completed by a clinician, (general practitioner or specialist) who then refers a patient to radiology for ultrasound imaging. Referring clinicians are guided by contemporary literature to ensure 'Imaging requests should include a specific clinical question(s) to answer, and contain sufficient information from the clinical history, physical examination and relevant laboratory investigations to support the suspected diagnosis', (Society and College of Radiographers and British Medical Ultrasound Society 2015, page 26). The interview participants indicated that their scanning process was always informed by clinical history and physical examination as advised in this document. The participants also highlighted that scanning was part of a process they regarded as cohesive. They contrasted this to the pathway typically experienced by patients in radiology that was termed '*fragmented*', (PT 11) when patients are scanned by clinicians who have not completed a clinical assessment and may not be responsible for treatment decision making. Issues relating to patient pathways will be explored later in this theme under the category 'patient pathway efficiency' but there are some common issues with this initial category, 'MSKUSI – assessment tool' as clinicians were keen to emphasise the modality's integration into practice.

Integration of MSKUSI into a physiotherapist's clinical assessment has been summarised by one participant who emphasised ultrasound findings must not be considered in isolation and are not valued more than the clinical examination:

'*Yes, does it make sense? When I scan, does it actually confirm what I am expecting to find? I won't treat on a scan'* (PT2).

Interview data revealed that verification of clinical assessment is also supported by the dynamic potential of MSKUSI. The participant's perceived value of MSKUSI's dynamic nature was discussed in Theme 1 as it was a factor that had attracted several participants to the modality. It was evident that for many participants, this initial attraction to dynamic scanning had developed into a core element of their practice. One participant summarised his aim of visualising tissues' response to movement and the patient's symptoms with dynamic evaluation:

'I tend to do a dynamic scan around most joints, so you can see things how things are moving, the quality of the tissues and things like that, how the cuff moves in relation to the coracoid process at the front or how the talus moves around in the ankle and the information you get, what happens to the tissues and then the patient and their pain during that assessment.'   (PT 3)

MSKUSI's diagnostic capability and its potential to verify findings from the clinical examination was reported by all participants except the one who only used the modality in research. MSKUSI's contribution to the diagnostic process was widely viewed positively, participants concurred that a diagnosis was the foundation for instigating appropriate patient management. One participant was aware of a publication that explored some of the professional issues associated with MSKUSI including the question of whether physiotherapists can use the modality to contribute to diagnosis formation. This paper cited two physiotherapists who were reported to state they were using MSKUSI to 'support clinical assessment' rather than 'to diagnose', (Edwards 2010) and the paper's author commented that this appeared to 'a strange denial'. It appears the cited physiotherapists' comments have not been presented fully, the original source of this statement confirms the physiotherapists 'stress ultrasound imaging is not a diagnostic tool' and that it should be used to support 'clinical assessment', (Oxlade 2007). The sentiment expressed in Oxlade's publication is aligned to the opinions expressed by the interview participants who reported that as physiotherapists, their ability to diagnose was assisted by MSKUSI, but not based purely on imaging findings. One participant stated:

'We do don't we. Why shouldn't physios use ultrasound to make diagnoses when we, patients want diagnoses, we want to give them a diagnosis. We, perhaps, less so with back pain, my particular area - I would hope to be able to offer a diagnosis. If someone came to me with a sprained ankle, to be able to identify the particular structures involved. If another means of confirming, making me more confident in that diagnosis was available to me, why shouldn't I use it?' (PT 7)

Another participant shared the outcome of his patients' imaging experience and emphasised his aim was to provide patients with a diagnosis alongside other information:

'They get a diagnostic scan, they get explained all the structures. They get explained the severity of the condition there and being a physio is another good thing - in musculoskeletal physio, is they get me explaining the management of their condition' (PT 1)

A substantial proportion of interview data related to the subcategory 'verifies clinical assessment', it represented a key topic for the participants who were frequently assertive as they expressed strong opinions and professional experiences relating to MSKUSI. A participant who has been scanning for over a decade was emphatic it was the key reason to use MSKUSI:

'It is the way I see ultrasound, is a way of validating my clinical assessment and I see it absolutely in that way and it is about for me correlating what I am finding with my clinical examination with the available radiological findings' (PT5)

7.4.3: Subcategory: Guides Treatment Decisions

This subcategory explored the impact of MSKUSI on treatment and management decisions. Participants presented the logical link between their increased diagnostic assuredness and their ability to direct patients to correct management pathways in a timely manner. The following participant was representative of others as she discussed this link but was in a very small group of participants who referred to national targets,

'*Our objective, in a sense, from an organisational perspective was to influence the 18 week pathway that was the most important thing. So accuracy of clinical diagnosis and treatment to improve timely intervention, patients' satisfaction and potentially reducing the18 week target'* (PT 6)

7.4.4: Category: MSKUSI for Follow Up

The impact of MSKUSI for patient treatment was explored further in the category ‘MSKUSI for follow up’, this was divided into two subcategories, the first focused on patient related factors, the second on physiotherapist related factors.

7.4.5: Subcategory: Follow up – impact on patient

Participants suggested the scanning experience increased patients’ belief and trust in the physiotherapists’ message, in particular when the scan verified the findings and explanation accompanying the clinical examination:

‘*I think that it definitely helps with understanding and education is an important part of trying to dictate compliance, I think there might be that. I think it gives confidence, therapeutic alliance, believing someone, being credible’*. (PT 5)

This participant highlighted the possible link between credibility and compliance, suggesting patients who believe in their physiotherapist’s opinion and are provided with education may be more compliant with recommended management than patients of physiotherapists who do not scan. These links were expressed in subtly different ways by many participants, the following participant reported his patients appeared satisfied with a verified diagnosis and this enabled self-management:

‘ …*they like imaging, it is what happens in sports stuff isn't it, they have their scans and that tells us what is wrong and that is what cures it, so for a physio to,’* (PT 3)

Question: *‘telling them what is wrong is what cures it?’*

‘*I think so. The magic of naming isn't it? Patients do say, 'I just want to know what is wrong. I don't want surgery, if my muscle is torn then I will get on with it' and that does happen. But because it is uncertain, until they see it they are not sure what is* *going on and they probably don't have complete faith but, once you can show the patient, that 'yes, they do have a tear in it, it measures this much, or it is only this big', ….giving the patients something they can understand and something they can see, a simple example they can understand helps to reinforce that message of self-management most of the time*.' (PT 3)

All participants suggested impact on patient's management process was favourable for the reasons stated above, some provided specific examples that reflected their view about MSKUSI's power. The following participant who has been using MSKUSI in a physiotherapy lead shoulder service for several years provided examples including occasions when she used MSKUSI to manage challenging patients' expectations:

'Just to get them on board really, I think that is really helpful and equally, the other way to say to some; I had a right stroppy lad the other week, a 25 year old: 'I pay my taxes, I want this, that and the other'. I was like, 'OK, shh a minute type thing', but, I can see that if he carries on like that, I will scan him just to go, 'look, there isn't fluid, this is not torn, this is here, your bones look pristine', cause I am certain, clinically from his exam, there will be no clinical reason to scan him, but to get him on board, I think it might become a useful thing.' (PT 2)

MSKUSI's influence on patient experience has not been explored to date in publications and reflects an element of practice that participants viewed as significant.

7.4.6: Subcategory: Follow up – role for physio

Participants presented data that discussed MSKUSI from the clinician's perspective when reviewing patients. Some participants only assessed new patients and were not involved in their follow up, but of those who were involved in patient management, they all highlighted the impact of MSKUSI on their ongoing clinical reasoning. Participants reported MSKUSI assisted evaluation of practice:

'is this, what I am doing, going to be effective? Or do I need to change; is it a complete waste of time?' (PT 8)

This participant provided many examples of his clinical reasoning process, how he repeatedly challenged his thinking and incorporated scanning information into his patient evaluation. He succinctly articulated how the imaging process informed patient management and contribute to decision making processes:

'*Should we inject this now or, is it sensible to wait and watch or, work on the exercises and those kind of things*' (PT 8)

MSKUSI's contribution to informing patient management was extended by one participant who works in elite sport. In common with other participants, he used the scanning findings alongside clinical information to guide decision making but also used imaging data to communicate with sports coaches and justify the athlete's return to training.

'*I see lots of sprinters and I will look at muscle tears and I will make treatment decisions on what I can see on ultrasound combined with my clinical findings*.' (PT 10)

Question: '*Because you are evaluating the change in pathology?*'

‘*Yes, so a good example is a Grade 2 tear in hamstring or quadriceps or a calf, and obviously you rehab according to their pain, their function, but also, in those examples I will also follow the tear each week and a good example is quads tears, you can clearly see a hole in the muscle and then I would hold that person back and will send the scan to the coach and say 'there is still a hole there, it measures 2 centimetres by 1 centimetre'*.’ (PT 10)

Literature linking MSKUSI to clinical decision making is extremely limited but a small number of publications have acknowledged this link. Whittaker, (2006) suggested MSKUSI had a role in treatment evaluation in an editorial exploring ultrasound and stated that ‘it is imperative that physical therapists be allowed access to the tools that will optimize the effectiveness of their interventions’. Couturier et al, (2016) discussed the impact of ultrasound on the decision making of rheumatologists for patients with knee pain, Ozcakar et al (2016) outlined the influence of imaging on the decision to inject and Dale et al (2014) evaluated the ultrasound’s impact on treatment decisions for patients with early rheumatoid arthritis. A growing body of literature exists that relates non-musculoskeletal ultrasound imaging to clinical decision making (Novak et al 2015, Norlen et al 2014, Bulsiewicz et al 2014) but there is an absence of literature discussing MSKUSI and its role in treatment decisions and evaluation.

The final code in the sub-category ‘follow up – role for physiotherapist’ was ‘guide injection’. Several participants had reported the ability to perform guided injections had been part of the attraction to MSKUSI, but only a small number had received training and integrated it into their practice. The participants who were regularly

performing guided injections placed value in the accuracy gained and the assuredness that they could minimise risk by avoiding specific structures:
'*but it will be guided, you don't inject into the tear, but can you be competent knowing that when you go in blind? So it allows that accuracy in that situation'* (PT 2).

All participants were asked to explain how MSKUSI contributed to patient management and probing ensured this area was explored in detail. It was evident that the participants did not generally use ultrasound for muscle imaging as part of an assessment strategy or to inform biofeedback as a rehabilitation strategy, (Whittaker 2007). The exception was one participant, who used MSKUSI in university based research to explore muscle activity. Several participants provided their rationale for not imaging muscle activity and an example is below,

'.... not looking at isolated muscles at all. I probably have not done that now for about 6 or 7 years, so it was pretty soon after I bought it for that intentional purpose but decided not to use it for that purpose. It just never, when all the literature came out about core stability and isolated muscle activation, when the motor control learning had not really caught up and we had not really got a context in which to put that, then it was very much the thing at that time, and as we got more understanding I have moved massively away from that…' (PT10).

7.4.7: Category: Patient Pathway Efficiency

This category explored organisational factors viewed as contributors to patient management. Communication channels linked to MSKUSI and their perceived impact on pathways were discussed. Key communication routes reported were written reports and verbal communication, in both cases the participants clarified that contextualising the ultrasound findings within the patient's overall presentation was a crucial element.

7.4.8: Subcategory: Communication to referrer

One participant, a private practitioner, discussed his documentation strategy stating the MSKUSI reporting process was incorporated into his standard patient documentation and was a means of facilitating personal clinical reasoning as well as fulfilling legal and professional requirements:

'what I do, in terms of reporting to myself - is report what is relevant on the scan. What the radiologists do, or radiographers do, is report everything they see that is aberrant, so, therefore they are not contextualising it.' (PT 5)

The contribution of the MSKUSI reporting process to the participants' clinical reasoning was demonstrated by another who confirmed it as a system for communicating with other professionals:

'*but I strongly suggest that the reports that I write, show that I have integrated it in the way I use ultrasound has helped me facilitate the clinical decisions. So the communication side of it is very, very important*.' (PT 10)

Several participants discussed systems they used to communicate with other clinicians including referrers or those involved in the patient's pathway. The verbal and written communication systems were described simply, but the impact of these systems was a topic that several participants discussed in depth because of their link with modifying patients' pathways. The interviews provided material that explored the pathway from a resource management perspective as well as an opportunity to influence the patient experience. One participant provided a brief explanation of the reporting system used in his physiotherapy department and the communication with relevant clinicians:

'we started to do a pathway where patients can be referred after a physio assessment into an ultrasound clinic. We would do the scan, advise the referring physio of the outcome and they would carry on their management or refer on based on that, and that is how we carried on.' (PT 3)

7.4.9: Subcategory: Business Case

One participant explained that her physiotherapy service for shoulder patients included a communication pathway and professional trust that enabled her to access priority appointments with the shoulder surgeon. These patients were assessed, scanned, injected if required and offered rehabilitation within the physiotherapy department and then directed towards the surgeon for a surgical opinion if required:

'*we have links with, here the surgeons a lot, because we set up a shoulder service with the proviso that if we have done everything we can, we can get them to see a surgeon within 2 weeks because essentially, we have done the scan, we have done the injection, we have done the this, which is stuff they normally do. So when* *they arrive from us at their door, it is for a surgical opinion and nothing else, so it is useful. It is like, not quite a one stop shop, but it is that sort of thing.*' (PT 2)

Participants repeatedly commented that this ability to minimise the number of appointments and departments patients needed to attend was a positive outcome from MSKUSI. A small number referred to the financial pressures of NHS providers meeting targets or to the relatively lower fees associated with physiotherapists performing MSKUSI when compared with a radiologist. One participant reported these financial factors had enabled her access support for MSKUSI education:

' *the time was right, because the tariff for sending patients for ultrasound to the acute unit was phenomenally, astronomical. And they were saying 'well we could do this in the community, yes, we can do this in the community'* (PT 6)

The following participant observed that the financial circumstances were often appealing to budget holders, but as clinicians in the NHS, there was no personal financial reward or direct advantage to the physiotherapy department:

'*Whereas unfortunately, we don't get paid any extra for any of it, which is very frustrating, because we are working at such a high level, skill level and we get absolutely nothing as a department*' (PT2)

Literature exploring the role of incorporating ultrasound into clinics alongside other assessments, (sometimes termed 'one stop shops) is increasing in other ultrasound specialisms beyond musculoskeletal, (Sporea 2016, Buxbaum and Eloubeidi 2013, Groszmann & Benacerraf 2016). Publications relating to MSKUSI evaluation conducted alongside other assessments and interventions cannot be found easily with standard literature searching tools. Literature does however link injection therapy performed by physiotherapists to a cost effective service and cohesive patient experience, (Smith et al 2014, Marks et al 2014) but published studies have not yet extended to MSKUSI.

This third theme that relates participants' experiences of MSKUSI to optimising patient focused care has revealed several topics that are relatively unexplored in the current evidence base. Whilst participants enthusiastically discussed the impact of MSKUSI on patient assessment, management and a cost-effective, cohesive patient pathway there is an absence of research in these areas. There are several research opportunities and emergent questions including the patients' viewpoint on this imaging modality.

Table 7.4: Key Findings from Theme 3

Physiotherapists' Motivation to Use Ultrasound - Improving Patient Focused Care

Participants reported MSKUSI has a role verifying clinical examination findings and contributes to the physiotherapist establishing a diagnosis.
Several participants regarded the MSKUSI process as an extension of their clinical examination.
Increased diagnostic assuredness enabled the participants to direct the patient to the correct management pathway in a timely manner.
Participants reported patients' belief and trust in the physiotherapists' message was enhanced with MSKUSI and may positively influence patients' compliance with management
Patient management could be influenced by MSKUSI: physiotherapists performed guided injections, monitored soft-tissue healing and incorporated imaging information into their clinical reasoning processes.
The only participant who regularly used MSKUSI to image muscle activity worked in a research role.
Communication systems used by participants, including written communication to referrers were key to ensuring optimal efficiency of patients' management pathways.
Several participants highlighted the resource management opportunities associated with MSKUSI. One key outcome from including MSKUSI in physiotherapy practice was a reported decrease in the number of patient attendances required.

7.5: Interview Findings - Theme 4

Quality Assurance Strategies

The fourth theme drew together data exploring formal and informal quality assurance mechanisms relating to MSKUSI.

7.5.1: Category: Formal quality assurance mechanisms

7.5.2: Subcategory: Professional Regulation

Formal quality assurance mechanisms were divided into two subcategories; 'professional regulation' and 'work place systems'. The subcategory 'professional regulation' drew on data that had been coded, 'CSP', 'HCPC', 'lack of sonographic regulation' and 'sonography professional groups'.
All participants were members of the professional body the CSP, despite this, very few of them referred to the CSP when they were discussing support strategies and groups to optimise quality assurance. The participants who referred to their professional body generally emphasised a lack of information, support or apparent willingness to engage with the modality from the CSP:
'Totally useless our professional body. I don't mind saying that either……it does not seem to be something that they have massively embraced. And the fact that they put it as a special interest group with electrotherapy, to me sums it up that they have no idea what the role or the potential is,' (PT 10)

'I think it is probably not fully understood by the powers that be at Bedford Row' (PT3)

Despite the perceived lack of direct support or guidance from the CSP, the participants readily referred to CSP rules relating to professional values and behaviour that were regarded as central to their practice. One participant's interview included a section indicating he was not anticipating support or guidance from the CSP to improve but he continued to discuss personal mechanisms for ensuring appropriate standards and referred to the CSP 'constitution':

Q: *'What overarching things are in place already that should mean that physiotherapists should behave professionally?'*

PT 4*: 'It is in our CSP constitution somewhere. One of the professional values – not sure I have ever read it!'*

Q: *'But without reading it……?'*

PT 4: *'That you are going to be trained in something before you use it. It is just common sense, I would not drive a car if I did not pass my driving test or being taught to drive.'*

Q: *'Do you think that is the attitude of most physiotherapists?'*

PT 4: '*Pretty much so. But in the eyes of other professions; if you want to be taken seriously, then you have got to have some form of internal CSP checks that we are actually, actively doing something to provide some degree of quality control.'*

Numerous similar inclusions indicated participants want to comply with their professional body's standards but specific MSKUSI related guidance had not been forthcoming.

The HCPC is physiotherapists' regulatory body, controlling each participant's registration and ability to work, despite this, very few comments were made about the HCPC. All references to the HCPC reflected uncertainty regarding the acceptance of MSKUSI education as compulsory continuous professional development.

It was evident that physiotherapy related professional bodies had limited impact on the participants' experience with sonographic education or MSKUSI in clinical practice. A small number reported they were a member of the British Medical Ultrasound Society and regarded their advice as a substitute to the CSP. A general lack of sonographic regulation was identified by many and a significant volume of data was coded with this label. Some had concerns that the lack of regulation caused vulnerability, the response to this was generally to complete a university based course to provide evidence of formally assessed and accredited education: *'I'm very attracted to using it to integrate it but I have nothing to regulate the way I am doing it. There is no quality measure and so I went along with the thought that maybe this will give me the ultimate qualification and I don't know what it will give me in real terms but, at least it will give me a belt and braces sense of security around the use of it. So that is what I did'* (PT 5)

Other participants reported concern that the lack of professionally specific guidance regarding education or accepted standards of practice exposed physiotherapists to having criteria forced on them by others. As participants had expressed applications of the modality that appeared distinctive to physiotherapists, there was concern that guidelines or protocols imposed may not be responsive to these practices:

‘it is an unregulated profession, there will come a time when it is regulated, but at the moment it is unregulated. What will happen is, if we do not take the bull by the horns, if we do not seize this opportunity to actually produce our own guidelines, guidelines will be thrust upon us and that may actually limit physios’ practice, not enhance physios’ practice.’ (PT 4)

Published literature acknowledges there are issues associated with the lack of MSKUSI regulation and generally responds with advice for high quality, consistent education, (Mapes-Gonnella 2013, Consortium for the Accreditation of Sonographic Education 2015 and Harrison 2015). There are very few inclusions that reflect MSKUSI education requirements may vary for different professions and that highly specific recognition and certification may be required, for instance as a rheumatologist ultrasonographer, (Iagnocco et al 2013). There is an absence of literature that relates MSKUSI application to the professional needs of physiotherapists or their clinical reasoning paradigms despite McKiernan’s observation in 2011 that training should be based on ‘an understanding of the physiotherapists’ requirements’.

7.5.3: Subcategory: Work place Systems

Many participants were keen to clarify that despite a lack of sonographic regulation, they had incorporated quality assurance systems into their practice. These included internal audit, formal image and report verification and peer review. Individual participants sometimes commented that quality assurance processes were not as robust as they would like and reported challenges encountered, most notably the documented difficulty of interpreting a dynamic investigation from static images, (Society and College of Radiographers and British Medical Ultrasound Society 2015).

7.5.4: Category: Informal quality assurance mechanisms

7.5.5: Subcategories: Professional Integrity and Response to Challenges

This category was formed by contributions from all participants to most of the sections coded: ‘motivated by improved patient outcomes’, ‘working with peers’ and ‘self-monitoring / professional risk’. These sections formed the subcategory ‘professional integrity’ and ‘personal qualities required’ with ‘resilience’ formed the subcategory ‘response to challenges’. Data included an unexpected volume of material that reflected participants’ personal characteristics, traits and motivations. The inductive analysis process had enabled codes and themes to be identified from the data without being framed by preconceptions, (Braun & Clarke 2006). Unanticipated features that appeared to be related to the participants’ successful implementation of MSKUSI were identified.

There was significant overlap between codes in these categories as participants’ comments revealed many factors. Participant 9 made the following powerful comment towards the end of his interview:

‘I try to do my best for patients and keep it professional, it comes from within.’ (PT 9)

This brief statement that relates to patient outcome, professional motivations and the clinician's personal qualities reveals the complexity underpinning participants' preparedness to engage with MSKUSI and its associated challenges.

The subcategory 'professional integrity' included material from participants who evaluated their practice by reflecting on patients' outcomes and valued the contribution of MSKUSI. Several described work-based protocols that contributed to quality, peer scanning was an example:

'the major safety factor was, bear in mind we are not completely irresponsible, is that we still scan in pairs.' (PT 3)

Informal quality assurance strategies were reflected by participants' evaluation of their professional risk and their self-monitoring strategies. Incorrect interpretation was highlighted as the greatest risk with MSKUSI scanning and numerous personal or department strategies had been implemented to manage this. One participant reflected on her personal learning curve, acknowledged the time it took before she regarded herself as competent and reviewed the risk of misinterpretation in terms of the scan's purpose:

'Incorrect interpretation I suppose is the biggest risk…. if they are working within just the physio department and the patients within there, and they are assessing to assist their clinical reasoning or direction, I think, that is fine as long as the decision making does not have an impact on whether it's an invasive procedure. So if you are learning, it took me a long time before I would say 'this has got this and it requires an injection', or 'this has got a tear, I think this needs a surgical opinion' and to call that wrong - it's big.' (PT 2)

One participant was succinct when asked about his concerns:

‘*The things that worry me are cancer and informing surgical decision making. Missing something, yes, 100%.*’ (PT 8)

In response to this risk, participants’ replies included terms and concepts that related to core professional values: ‘appropriate training’, ‘continuous professional development’, ‘considering the best interest of the patient’,’ evaluation of practice’ and ‘self-monitoring’. All of these concepts align well with the CSP’s Code of Member’s Professional Values and Behaviour, (2011) that should underpin all participants’ practice.

The impact of image misinterpretation was reported primarily as a concern for patients, but the potential effect on the physiotherapy professional and profession were also noted. It was evident that the participants were aware that the profession’s reputation could be influenced:

‘it could come back and haunt you and your profession because you are misusing it.’ (PT 11)

It was interesting to note that a risk identified by several participants related to over use of MSKUSI and subsequent under-utilisation and de-skilling of core physical assessment skills:

‘I will tell you what can go wrong; people get more dependent on ultrasound, they lose out their actual physical examination and the skills of it’ (PT 1)

Informal quality assurance mechanisms included the participants' personal responses to challenges presented. Personal qualities including luck and resilience were discussed in Theme 2, but it is important to link these qualities to quality assurance. One summarised how personal drive and motivation underpin the learning curve required to gain competence and ultimately deliver a high quality service:

'I choose this because I wanted to learn because when I started in 2010-2011, I really scanned every patient. Somehow I fitted that into my time slot, that time that takes about 5 to 10 minutes'

Some participants who had been scanning for several years were able to make noteworthy contributions that indicated their personal qualities enabled them to deal with territory and situations unfamiliar to physiotherapists:

'*In the early phases we were a bit cavalier, we had to be because, to be visionary you have to start doing something, but having said that - the caveat was always on… so it would be, 'I am learning to do this Do you mind if I scan you?'. I would always scan them in my lunchtime so I would not be using work's time. I would use my own time to scan them and patients, if you explain and that you try and help them, try and get an answer for them, try and get the best treatment possible*…' (PT 4)

The personal qualities represented appear to align with literature exploring healthcare practitioners who work in demanding environments. A recent qualitative study in Northern Scotland concluded that healthcare practitioners who were able to overcome challenges demonstrated traits including optimism, adaptability,

initiative, tolerance, keeping within professional boundaries, assertiveness and a sense of self-worth, (Matheson et al 2016). Matheson and colleagues proposed these traits worked synergistically with work place factors and opportunities, thereby determining the healthcare professionals' resilience and desire to continue with their professional role. Whilst the MSKUSI interview participants have not been subject to rigorous psychological analysis, it is evident they share many characteristics with the successful professionals outlined in Matheson's study. No literature has explored personal characteristics of clinicians using MSKUSI and links to other health care groups should be considered with caution. It is impossible to generalise from literature exploring other professionals that may be reliant on different factors, for instance benevolence for nurses, (Koch et al 2014), conscientiousness for medical students, (Abbiati et al 2016) and understanding holism for occupational therapists, (Aguilar et al 2013). The MSKUSI participants do however indicate that professional self-monitoring has been integral to their progression with alongside resilience and their sense of self-worth. This requirement for perceived self-efficacy and worth has been summarised:
'It has been around personal growth, it's been about professional feeling of worth and doing something worthwhile for a patient.' (PT 5)

The data that contributed to Theme 4 were unanticipated but appear to reveal certain professional traits underpin the application of MSKUSI in these participants and that multiple quality assurance strategies have been considered. There are limitations in the data collected as the interviews were not designed to explore these individual characteristics but whilst the participants relayed the policies and protocols that underpinned their practice, it became evident that personal, informal and formal elements were involved.

Table 7.5: Key Findings from Theme 4, Quality Assurance Strategies

Participants want to comply with their professional body's standards but specific MSKUSI related guidance from the Chartered Society of Physiotherapy has not yet been published.
Some participants were concerned that poorly considered guidance from the Chartered Society of Physiotherapy or increased sonographic regulation could limit innovative physiotherapy practice.
Most participants engaged with formal quality assurance processes to validate their MSKUSI practice.
All participants engaged with informal quality assurance processes to minimise professional risk.

7.6: Interview Findings - Theme 5

Application of Biopsychosocial Model

7.6.1: Category: Clinical Reasoning

7.6.2: Subcategory: Subjective Assessment

Participants reported that scanning was a component of a wider examination and not an event to occur in isolation. Several, who had unlimited access to an ultrasound system were able to choose precisely when to scan patients and the role of MSKUSI in the assessment. Other participants had limited machine access, so organised scanning lists as an add-on to their normal assessment. Some reported part of their working week was in radiology where the scan was the focal examination process, these clinicians still supported the scan by information gained by questioning or brief clinical examination procedures. These assessment procedures informed the scanning process by providing context; the subjective assessment, (full or modified) was identified as the key means of obtaining context and also highlighted psychosocial features that may have relevancy. The coded data related to the subjective assessment were initially identified with the code 'subjective informs scan', virtually all of the subjects' interview data included a section that was coded with this label and an example is below:

'I would think of it while you are taking the subjective based on what they say and you think, maybe the mechanism of injury or something in the history makes you think, maybe a scan will be useful' (PT3)

Several participants identified specific components of the subjective assessment that influenced the scanning procedure or their overall clinical decision making. The two components that were referred to on several occasions were the activities patients reported as pain provocative or problematic, (clinicians generally called these aggravating and easing factors) and the identification of yellow flags. Participants commented that detailed information gained about provocative activities during the subjective facilitated targeted scanning procedures:

‘and we have actually got them in the position with the probe and shown them, 'look that pinches' and they go 'ow, that's my pain'.’ (PT2)

The code ‘yellow flags’ was categorised into the subcategory of ‘subjective assessment’. The term ‘yellow flag’ has evolved from the biopsychosocial model that was proposed in 1977 by psychiatrist, George Engel. Engel believed that patients’ experiences could only be fully understood when clinicians took account of biological, psychological and social factors. A failure to consider psychological and social factors would result in patient dehumanisation and an over-reliance on biological phenomena. The biopsychosocial model has been widely accepted and incorporated into many medical specialities including musculoskeletal medicine, (Foster et al 2003, Borrell- Carrió et al 2004, Blyth et al 2007, Laisne et al 2012). Physiotherapy related literature has included extensive analysis of this model including its clinical relevance for the last two decades and literature suggests that students would have been exposed to this model during pre-registration training in this time period, (Jones et al 2002, Bishop & Foster 2005, Stevenson et al 2006, Sanders et al 2013, Bientzle et al 2014). There have been variations in the literature’s focus, earlier literature tended to focus purely on low back pain but later publications have related the model to broader musculoskeletal management issues. It is evident that this model of clinical assessment and management is firmly embedded within the musculoskeletal physiotherapy profession and has formed the basis for many management pathways, (Beneciuk & George 2015, Alrwaily et al 2016, Scholten-Peeters et al 2002 and Meeus et al 2012, Moseley 2003).

The term ‘yellow flags’ relates to psychological, social and environmental factors that could increase the likelihood of disability and originally were used with reference to low back pain, (Kendall et al 1997). Psychological factors include unhelpful beliefs about pain and injury that result in behaviours such as extended rest or movement avoidance. Social and environmental factors include difficulties with claims or compensation, perceptions of a lack of support from the work place and overly protective family members, (Gray and Howe 2013). The flag classification system has extended in recent years and has become more complex; some authors refer to an assortment of flag colours that relate to psychological, work and environmental factors. Blue flags have been proposed to describe work-related issues, black flags relate to practical obstacles such as insurance systems and orange flags symbolise psychiatric conditions including clinical depression, (Nicholas et al 2011). This complicated colour coding is not consistent in the literature so, for the purpose of this study, the term ‘yellow flags’ and its application by participants relates to all psychological, social and environmental considerations.

The participants all referred to information from the subjective assessment including its links with MSKUSI and patient management, several provided detail regarding the specific impact of yellow flags. Yellow flags were discussed in three distinct ways and supported by clinical examples, for instance their potential to sustain a painful presentation and cause pain amplification, (Linton & Shaw 2011, Dankaerts et al 2006) was raised by one participant:

'If you have examined somebody and asked the right questions and think that they are somebody who is perhaps, higher risk or in medium risk bracket for developing disability secondary to their pain problem: the injury was at work and they have already been off and not been back and things are disproportionate, and none of it makes any great deal of sense in terms of these wide receptive fields and there are neurological sensations, nothing really appears mechanical with it.' (PT8)

This clinician has applied their understanding of neurophysiological changes associated with sustained pain presentations which can result in unpredictable pain behaviours. Neurophysiologic adaptations associated with chronic pain have been reported throughout the central and peripheral nervous systems, the plethora of changes include over-activation of the hypothalamic-pituitary-adrenal axis, (Oberg 2011), reorganisation of the primary somatosensory and motor cortices which correlate with the chronicity and severity of pain (Moseley & Flor 2012) and a reduction in the efficacy of descending pain inhibiting systems in the central nervous system (Pelletier et al 2015). Several participants' comments drew on their knowledge of these phenomena and they observed, that for some patients with psychosocial markers alongside persistent pain, imaging findings were unlikely to fully explain symptoms.

The second link between yellow flags and scanning found was a strong sense of professional responsibility; the clinicians did not want the imaging process to increase the likelihood of patients developing preventable chronic presentations. There were several examples when clinicians emphasised they were careful not to promote any yellow flag related beliefs or behaviour by poorly considered communication. One clinician summarised his awareness that MSKUSI could be linked to providing unhelpful information to patients that would adversely affect their prognosis:

'I have got that responsible position of using ultrasound in a way that does not then make the patient scared, catastrophising concern about findings that are not relevant.' (PT5)

The third view point regarding the application of yellow flag identification and MSKUSI also reflected professional responsibility. The participants demonstrated an awareness of professional errors, in particular the risk of over-reliance of psychological contributions to a patient's presentation, (Jull 2009). These clinicians observed that patients who appeared to demonstrate excessive pain behaviours or other yellow flags warranted thorough investigations as their symptoms could be predominantly nociceptive in origin. One participant presented a patient who was improving slowly following an injury and the physiotherapist suspected yellow flag related behaviours of catastrophisation and fear avoidance. The scan revealed a dramatic soft tissue injury and this information had impact on subsequent clinical decision making, including modifying the therapist's view of the patient's psychological profile:

‘*She did not look like she was going to get off crutches, after 4 weeks she was still on crutches, my friend said ‘can you scan this patient, I think she is a malingerer?’. Scanned the patient, found a twelve centimetre calf tear, aponeuritic tear medial calf, typical tennis leg*.’ (PT4)

This viewpoint that yellow flag identification is valued but consequent investigations and clinical reasoning must include a thorough evaluation of tissue-based pathology has been neatly summarised by the following subject:

‘I see an awful lot of what you might refer to as yellow flags, things that you immediately flag up in the sonography room and I have to almost separate my mind, ok, we are not looking at that, we are looking to see if there is some form of pathological change in these tissues’ (PT8)

Participants demonstrated their understanding of the biopsychosocial model was embedded in their clinical reasoning and applied knowledge of psychological, social and emotional factors that may contribute to patient’s presentations. They also ensured possible biological contributions to pain were investigated and were able to place the orthodox medical model of pain in a contemporary multi-factorial framework, (Dankaerts et al 2006, Beneciuk & George 2015, Alrwaily et al 2016).

The subcategory ‘subjective assessment’ was one component of the category ‘clinical reasoning’. The components of this category indicated that participants used clinical reasoning processes to assist decision making regarding the role for

MSKUSI. Participants also reported a natural and unchallenging process of integrating information from pre-scan assessments with the scan that utilised standard clinical reasoning processes.

7.6.3: Subcategory: Clinical Assessment

The material coded into subcategory ‘clinical assessment’ provided evidence of advanced clinical reasoning processes as the participants described systems to link MSKUSI with the clinical assessment. Clinical reasoning skills were described as enabling and were utilised in two subtly different ways in relation to the clinical assessment’s outcome. Firstly, reasoning supported the process of verifying findings from the clinical examination and secondly, as a facilitator of the scanning process; the participants reported they wanted to respond to clinical findings instead of following a standard scanning protocol.

Many participants discussed the process of clinical assessment verification and generally supported their argument by acknowledging clinical testing procedures’ lack of sensitivity and specificity, (Farber et al 2006, Nunes et al 2013, Hegedus et al 2015). They also observed that MSKUSI has its own limitations, (Alavekios et al 2013, Ellegaard et al 2015 and Hinsley et al 2014) but aimed to use the strengths of each assessment approach to maximise diagnostic ability. The prevalent conclusion was that ultrasound verified clinical examination findings, it followed them, it did not precede them and clinical reasoning processes drew on the strengths of both strategies to reach a diagnosis. One clinician ended her discussion on this subject emphatically stating, ‘*I won’t treat on a scan’.* (PT2)

The second clinical reasoning application was the participants' adaption of scanning protocols in response to the clinical assessment. Several therapists evidenced the confident clinical reasoning that enabled this responsive scanning and has been conveyed by one participant who reported a comfortable process of moving between scanning and physical testing:

'In terms of using the ultrasound to find the painful bit, we often palpate things and we ask people where it hurts and then you can do that under ultrasound and you can push your finger through and you can see whether that corresponds to a part of the structure or something that…… I may actually get the ultrasound machine out straight away because while I am actually conducting the whole clinical assessment and you end up sometimes jumping between the two.' (PT10)

Participants repeatedly emphasised scanning was adapted to respond to assessment findings, this link and MSKUSI integration was exemplified by participants who worked in private practice. Private practitioners reported that patients' fees were not affected by the inclusion of a scan and placed more value on the ability to move between MSKUSI and clinical testing in an uncontrived manner than the financial opportunity of charging patients for a separate service or 'add on' assessment. For some clinicians the scan and clinical assessment could not be detached from each other:

'So, in a way, my practice is now completely integrated. I examine clinically, because that gives you your differentials, ultrasound is only an imagery of those tissues, that is then how that clinical knowledge is used to back up your decision making processes.' (PT5)

Commonalities were found in the data from the category ‘clinical reasoning’ and material categorised ‘communication opportunity’ or ‘professional variance’. The application of the biopsychosocial model was the overarching theme that linked data.

7.6.4: Category: Communication Opportunity

A significant volume of interview data was coded with identifiers that were subsequently sub-categorised with ‘communication in presence of abnormal tissue’ or ‘communication in presence of normal tissue’. These two subcategories were linked in one category, ‘communication opportunity’. Communication to patients was a topic that many participants discussed extensively and emphasised as playing a key role.

7.6.5: Subcategory: Communication in the Presence of Abnormal Tissue

Participants were unanimous that communication in the presence of abnormal tissue should be factual to ensure imaging findings are explained. They also repeatedly highlighted this explanation of tissue-based findings must be placed in context and that pain presentations may not be fully explained by the scan’s findings. The contextualising of scan findings has been summarised by the following interview subject:

'*As a physio, because I have an understanding of orthopaedic medicine and I have an understanding of this pathology and the management of it because I work in a triage service, so I share those with the patients'* (PT1)

Communication in the presence of abnormal tissue was reported as an opportunity that should be respected; the clinicians placed great value on explaining tissue-based findings, placing them within the patient's individual context and ensuring that irrelevant scan findings were not discussed inappropriately. The high level of clinical reasoning employed to guide this communication was rarely identified by the participants themselves. The evaluation of the communication task revealed they were aware of its multiple elements but this did not extend to the clinical reasoning associated with drawing these elements together. It appears tacit knowledge acquired from years of experience enabled the participants to process multiple sources of data. One contribution revealed some understanding of this complex process but the intended focus was to highlight the need for considered communication when scanning abnormal tissues:

' we know that it is very difficult to pick all the influences and pain is multifactorial by its nature. So you have to try and think of all the things that might influence it and then draw that together, but it is a difficult task, but I am really aware that you shouldn't be seen as a physio who is using sonography, be re-enforcing those things I have already seen that in situations where: 'all of this must be really sore or this must be awful'. Because, we know that there is not really a direct correlation between pathology and symptoms, so we should not be saying "this is what you are feeling' because there is a risk of that.' (PT8)

The formation of tacit knowledge in professionals' work was defined by Polanyi as 'that which we know but cannot tell', (1967). Several authors have explored tacit knowledge in relation to learning and health care professionals and generally use the term to describe knowledge that is rarely fully articulated, there is however a lack of consensus regarding whether tacit knowledge can be communicated or only represented, (Eraut 2000, Reinders 2010). Researching the presence of tacit knowledge and the non-formal learning that is associated with it presents many challenges and the literature exploring this domain is expanding (Eraut 2005, Carrier et al 2010, Langridge et al 2016). Authors propose tacit knowledge underpins the clinical decision making that punctuates professionals' practice during tasks and it could be debated to be a more accurate term than the commonly employed phrases 'clinical intuition' or 'gut feeling'. This intuitive clinical decision making, whereby the practitioner displays responses to pattern recognition and adapts rapidly to acquired information without necessarily being able to articulate the process is regarded as a feature of an expert (Eraut 2005 and Langridge et al 2015). Several of the interviewed subjects presented features of the expert clinician as complex decision making processes underpinned their communication with patients, they were able to articulate why they placed great emphasis on the communication process but rarely attempted to evaluate the decision making that informed the communication.

Advanced clinical reasoning processes were also found to underpin communication between the participant and patient when imaging findings were entirely normal. Interview data coded with the labels, 'non-tissue based pain', 'patient information when normal', 'chronic pain prevention', 'requirement for rehabilitation' and 'role of reassurance' provided a large volume of material that related to the communication opportunity available in the absence of imaged pathology. The reasoning process in the absence of abnormal pathology was presented neatly:

'*as a result, you use your clinical reasoning and reason, 'why is the pain still there?'* (PT3)

7.6.6: Subcategory: Communication in Presence of Normal Findings

Many of the participants were keen to emphasise that imaging that revealed normal tissue was still a communication opportunity and could represent a therapeutic event:

'because if you can reassure somebody 'that things look OK really we can't see anything necessary too wrong'. It is a really powerful message to somebody who is in that kind of situation' (PT8)

The evidence base exploring the role of information and communication in management of pain is extensive and includes issues raised by the participants: causes of chronic pain, prevention and management of pain and the role of reassurance. Communication providing education has been related to improved patient self-management for unexplained pain syndromes; a number of studies have concluded that cognitive reassurance (information and explanation) are associated with improved outcomes when compared with affective reassurance, (empathy and rapport), (Traeger et al 2015, Pincus et al 2013, Phillips et al 2012). A majority of the participants conveyed the value they placed on the opportunity to inform and educate in the scanning room. The volume of data coded as 'non-tissue based pain', 'patient information when normal', 'chronic pain prevention', 'requirement for rehabilitation' and 'role of reassurance' indicated the perceived impact of this patient-therapist interaction. Participants readily related this communication to elements of the biopsychosocial model and their aim of providing knowledge, understanding and skills to patients to enable self-empowerment and minimise disability, (Lotze & Moseley 2015).

One participant's comments reflects the widely reported opinion that a normal scan is not a waste of time and can be a therapeutic intervention:
'to reassure somebody that actually it is, at a tendon level, a tissue based level, that things are OK and their limbs are not going to fall off, even if it might feel like it is. Even if that gives them a kind of, it modulates those kind of thoughts, those processes in terms of how their catastrophising or their avoiding movement because of pain, then that is quite powerful thing to say, 'what you need is to get moving, and you need to start exercising and you need to get back to doing normal things. And linking that to that perhaps that has come from somebody that who they perceive has a bit more expertise than just saying ; 'Oh, I can't really explain why you have symptoms and can't really explain why it appears so bad to you and is having such a big impact on your quality of life at the moment'. (PT8)

A robust systematic review questioned the impact of communication content on patient outcomes, concluding that neuroscience education has a positive impact for pain, disability, anxiety, and stress in chronic musculoskeletal pain patients, (Louw et al 2011). There are strong indications that clinicians who offer education to patients in the form of the scientific principles underpinning their pain presentations are providing a more effective service than those who purely focus on pain management. Pain management programmes include strategies to assist patients to optimise function in the presence of pain, such as encouraging movement despite pain as pain does not correlate with tissue damage. It has been argued that pain management programmes have limitations and should be supported by neuroscience and pain education, this extends patients' knowledge of the physiological processes causing their pain state, (Lotze & Moseley 2015, van Oosterwijck et al 2011). Data from the participants presented their strong desire to educate patients when imaging findings were normal, whilst a small number expressed an enthusiasm to explain neural sensitivity and other mechanisms of pain amplification, it was evident that communication about principles of neuroscience was not a component of all participant's interactions with their patients.

Participants demonstrated an understanding of several communication challenges relating to MSKUSI, these included the lack of correlation between scan findings and pain and the observation that following successful treatment, symptoms including pain may have subsided but imaging findings may not have changed. Participants observed the value of the communication opportunity outweighed its challenges and had all developed strategies to deal with the challenges. One clinician responded to the limited correlation between scan findings and the patient's presentation very concisely. He acknowledged there was a risk of rescanning a patient whose symptoms had resolved but a previous scan revealed imaging findings, but would tell his patients:

'now you are 100% better, this stuff is still there so - ignore it , don't worry about it.' (PT11)

7.6.7: Category: Professional Variance

7.6.8: Subcategory: Communication – different professionals

The communication opportunity and practice presented by the participants appears to contrast with common practice of sonographers or radiologists in radiology. The evidence base exploring communication between the scanning clinician and musculoskeletal patient is extremely limited. A literature review and informal communication with sonographers has revealed that formal guidelines exist for pre-scan communication with patients and gaining consent, but the guidance regarding communication of scan findings is restricted and is reflected by this excerpt from a professional publication, sonographers should 'explain and discuss the findings with the patient within local guidelines', (Society and College of Radiographers and British Medical Ultrasound Society, 2015). Discussions with musculoskeletal sonographers and radiologists confirm that the post-scan communication typically focuses on informing patients about the process by which the referring clinician will receive the scan report and does not necessarily include any details of the scan findings themselves:

'Whereas typical sonographers or radiologists from the department, they say, 'this is what we found, we will let your consultant or GP know, they will know what to do' (PT9)

Variation in communication practice between scanning physiotherapists and other professionals was raised by several participants and provided a volume of data that was coded and sub-categorised as, ‘communication – different professionals’. Unusually, the participants were keen to emphasise contrasting practice instead of similarities in practice. Historically, as clinicians have taken on advanced practitioner roles, publications have presented the correlation in practice between the expert, (typically the medical doctor) and the alternative practitioner, for instance the nurse, physiotherapist or sonographer, (McClellan et al 2010, Ashmore et al 2014, Oakley & Shacklady 2015). The aim of research has typically been to investigate whether advanced practitioners provide equivalent care to medical practitioners but some researchers have progressed to exploring practitioner variance. One study did not assess correlations between professionals, instead it explored sensitivity and specificity of the practitioners’ diagnostic capabilities when compared with gold-standard procedures and reported higher clinical accuracy outcomes from the non-medical practitioner, (Ronan & Ramsay 2015).

7.6.9: Subcategory: Imaging Different Professionals

Professional variance was reported for many aspects of the scanning process beyond the communication element. A small number of participants commented that the image quality achieved by other scanning professionals, (radiologists or sonographers) was not optimal as they tended to use the same pre-sets as for general sonography, such as abdominal investigations. A large proportion of the participants regarded the scanning process they undertook to vary significantly from other professionals who did not contextualise the imaging with other information. This lack of context was related to a perceived limitation in musculoskeletal medicine knowledge, treatment pathways and alternative assessments including subjective data and physical testing procedures. One clinician reported that she was supporting a sonographer with his MSKUSI training: *'he's learning the musculoskeletal pathology and yes, the musculoskeletal clinical reasoning. But his handling and his pictures are beautiful'* (PT2)

A participant with considerable scanning experience used an anecdote to support his argument:
'*this patient had an ultrasound scan before by the radiology department which had inconclusive findings and then he asked for another scan……… I asked her do whatever you need to do, in order to bring on that lump and she had to hop around, jump around for a good 2 to 3 minutes and I scanned the part where she thinks the pain is beforehand and after her jumping around and hopping around, I scanned her again. And there it was…… and my radiologist who had been qualified MSK experienced for 10 years said 'I wouldn't have done that in a million years'.* (PT1)

Contextualising the imaging findings was also discussed in relation to the reporting process undertaken. Reporting was discussed in Theme 3 as a means of professional communication but is also provides an example of professional variance.

Literature relating to report writing provides guidance for all sub-specialities, for instance breast imaging or abdominal imaging and detail can be minimal. One publication summarises the process into five sections: clinical history, areas examined, description of findings, interpretation of findings and conclusion, (Edwards et al 2014). These brief but limited guidelines support the participants' view that a list of imaging findings is not sufficient, these findings should be interpreted in light of clinical context. Professional guidelines for ultrasound report writing and content are available from The Society and College of Radiographers and British Medical Ultrasound Society (2015). The publication, 'Guidelines for Professional Ultrasound Practice provides an outline of the reporting practice and stipulate the 'report must be considered in the light of the wider clinical picture….In this context, it is essential that the report author has extensive medical knowledge to reach a diagnosis or a series of ranked differential diagnoses on which clinical decisions can be made', (page 36-37). The widely held participants' opinion, that an understanding of musculoskeletal medicine and an ability to frame imaging within management frameworks is aligned with these professional guidelines. An interview subject expressed his view that other professionals do not always offer this link between clinical presentation and imaging outcome:

'….. reporting because, what we do, what I do, in terms of reporting to myself - is report what is relevant on the scan. What the radiologists do, or radiographers do, is report everything they see that is aberrant, so, therefore they are not contextualising it.' (PT5)

Participants did not express any disappointment with indications of professional variance, in contrast, there was a sense of professional pride. They were keen to report their scans were guided by subjective information, deviated from protocols when indicated, responded to patients' aggravating and easing factors and included communication alongside dynamic scanning to optimise the education opportunity.

Theme 5 is the product of a large volume of interview data that related MSKUSI to the biopsychosocial model whereby participants drew on their pre-existing musculoskeletal knowledge and management frameworks. The links between MSKUSI and clinical reasoning were presented by the participants as enabling and opportunities to develop practice.

Table 7.6: Key Findings from Theme 5, Application of Biopsychosocial Model

Participants incorporated MSKUSI findings into the biopsychosocial of musculoskeletal assessment and management.
Participants' knowledge and understanding of yellow flags underpinned communication with patients.
Communication strategies were implemented to minimise unhelpful beliefs and behaviour associated with sustained pain presentations.
Participants reported a belief that communication to patients from MSKUSI represents an opportunity to educate patients about their presentations. Separating out the communication from the scanning experience reflects a missed opportunity for patients to understand their condition.
Participants expressed a sense of responsibility to ensure patients were assessed thoroughly for tissue based pain causes even when excessive pain or other yellow flags were evident.
Advanced clinical reasoning skills underpin the integration of MSKUSI findings with clinical examination findings and enabled adaptation of scanning processes in response to individual patients' presentations.
Participants reported significant variation in practice between professional groups and an awareness that some practitioners do not fully utilise the unique communication opportunity associated with MSKUSI.

7.7: Integration of Mixed Methods:

Two methods have been combined in this ultrasound based study for the main purposes of development and complementarity (Greene et al 1989). The development role used the results of the first quantitative method to inform the second qualitative stage of the study. The questionnaire's analysis informed purposive sampling and the development of the interview topic guide.

The purposive sampling strategy effectively selected a group of participants who were informationally representative of the entire cohort, this group was able to provide data of central importance to the research question. Specific parameters were identified to frame the sampling strategy, for instance the participants' work environment, factors that had influenced engaging with MSKUSI and education in the modality. During the interviews and their subsequent analysis, it became apparent that the sampling strategy had achieved its aims and that the participants' accounts included a significant number of recurrent inclusions. The selected participants also recounted events and circumstances that were personally unique and sometimes in contrast to those of other participants.

The value of the questionnaire guiding the interview's topic guide development was evaluated during the interview process. It was evident that the topic guide's construction and content reflected the key issues related to the research question. The participants readily responded to the interview questions with relevant information and whilst the participants were provided with opportunities to extend the discussion and raise new topics, this rarely occurred.

The details provided by the in-depth interviews and questionnaire responses were very different. The participants had responded to the open questions on the questionnaire with brief answers, these were often in note form and not supported by explanations. The in-depth interviews provided opportunities for the participants to elaborate on the questionnaire data and to clarify information, thereby fulfilling the intended complementarity role, (Greene et al 1989).

The integration of mixed methods in this study have enabled a more complete understanding of the research topic than a study using only one data source. Analysis of the data for validity convergence was not undertaken, this relates to the process of evaluating the findings from different methods that investigate the same phenomena, the data are compared for agreement or disagreement, (Fielding 2012). During the planning phase of this study, it was anticipated that the responses from the open questions in the questionnaire could be analysed alongside the interview data and that this would validate results. The lack of detail in the questionnaire responses limited their analysis and it was evident that their role should be confined to identifying parameters for purposeful sampling and topic guide development. Literature exploring the process and value of validity convergence is dominated by disagreement and discussion relating to inconsistent terminology and philosophies, (Fielding 2012, Denzin 2012, Howe 2012). It is evident that for this study, the research questions could be addressed by accessing qualitative and quantitative approaches but between-methods triangulation was not applicable - each method had its own distinctive role, (Howe 2012).

Chapter 8 Discussion

8.1: Summary of Methodology

The methodology selected for this study shared similarities with Cresswell's explanatory-sequential design sequence, (2011). The quantitative data collection process was used to select a group of participants for the larger qualitative study and to inform the in-depth interviews. This process has been described by Cresswell, (2011) as a participant-selection variant of the explanatory-sequential design process but this term has not been applied widely in the literature. The epistemological approach was based in critical realism, (Bhaskar 1975) which acknowledges the existence of different knowledge types (Venkatesh et al 2013) and allows these contrasting knowledge forms to be drawn together. Critical realism has facilitated the use of the participants' experiences, (the empirical domain) to improve our understanding of events and processes such as the availability of MSKUSI education and the reality of using it in a clinical environment, (the real and actual domains).

8.2: Evaluation of Methodology

Evaluation of research for quality and acknowledgement of any limitations is integral to the research process, (Shenton 2004, Cresswell and Plano Clark 2011, Cope 2014).

All research has weaknesses that have to be considered and there are elements in this study with some methodological limitations.

The questionnaire's development process could have been extended to optimise the rigour of this data collection tool. It had been discussed with several colleagues and piloted on one, but this was an extremely restricted pilot that failed to adequately test the questionnaire. It became evident that the term 'clinical use' in the questionnaire had resulted in some confusion, researchers in particular were uncertain if they met inclusion criteria and it is possible that some physiotherapists did not complete the questionnaire for this reason.

The questionnaire distribution was unrestricted and snowballing was encouraged, it became evident that some clinicians were passing on the questionnaire link to overseas colleagues with an interest in MSKUSI. Some international physiotherapists contacted me and volunteered to participate, (their offers were declined) but it is not known if any of the anonymous questionnaires came from beyond the United Kingdom. The distribution methods were selected to optimise responses which were substantially higher than the number reported by Potter et al, (2012). The lack of a need for inferential statistics supports the non-probability sampling methods but, it is acknowledged that the sampling methods had limitations and the resultant sample may not have been representative of the entire population, (Baker et al 2013).

The purposive sampling strategy to select the interview participants was designed to be informationally representative for specific parameters but it is accepted that these parameters affect the transferability of the study, in particular to physiotherapists who use MSKUSI but have not accessed formal education. The purposive sampling strategy reviewed the 34 physiotherapists who reported they were scanning, of these 34 clinicians, 26% reported they had not accessed formal education. A slightly lower figure of 18% of the interview cohort had not accessed formal education. In contrast, 50% of the scanning clinicians had accessed formal education and a higher figure of 81% of the interview participants had accessed formal education. Whilst the limited representation of informally or ‘uneducated’ participants in the interview cohort could be regarded as a weakness, it was the result of limited availability to these individuals and prioritising other factors in the purposeful sampling process e.g. work environment and factors reported to impact use of MSKUSI. It would however be valuable to complete a further study with a focus on clinicians who are using MSKUSI in practice but have not accessed formal education.

This study included a dominant qualitative section that resulted in a large amount of data and contributed significantly to the results. Many criteria have been proposed to evaluate qualitative research, (Shenton 2004, Cohen and Crabtree 2008, Santiago-Delefosse et al 2016) and commonly applied are those proposed by Guba and Lincoln (1994) which include credibility, dependability, confirmability and transferability.

Credibility refers to the truth of the data including its representation and interpretation and several strategies were employed to optimise this; during the interviews I frequently sought clarification of participants’ intended meaning, sometimes this was achieved by paraphrasing and asking for confirmation and at other times the participant was asked to expand. The data’s transcription and coding were independently verified and the interview participants were informed their transcribed interviews could be sent to them for further verification. Dependability relates to consistent and repeatable approaches, for instance with logical connections between data collected and themes described, (Schou et al 2012). Confirmability relates to the researcher demonstrating the findings are a true representation of the data, in this study this has been reflected by adding many detailed interview quotations to depict codes, categories and themes. Transferability relates to the extent research's findings can be applied to subjects beyond the group involved, this is enhanced with information about the participants, to enable an assessment to be made regarding the transference of findings (Cope 2014). In this study, the individual participants all reported their unique and individual narratives, but the combination of reporting widespread findings and the available background information of the participants should enable a judgement on transferability to be made.

Overall, this study benefits from several methodological strengths including the multiple questionnaire distribution methods that enabled a large number of physiotherapists to be approached. Additional strengths include the purposive sampling strategy that accessed participants who were representative of the entire sample for selected criteria, the thematic analysis process that carefully followed Saldaňa's coding strategies and the impact of my professional experience.

8.3: Impact of Researcher's Personal Professional Experience:

As a musculoskeletal physiotherapist, I was able to access subjects for this study but more significantly, my clinical knowledge and expertise informed the data collection process. Whilst I approached the interviews with relevant knowledge, this was not accompanied by clinical scanning experience. This lack of personal experience enabled me to probe with genuine curiosity as to the professional integration of the modality into clinical practice. Considerable personal effort was made to explore the participants' experiences without adding personal opinions, the interview transcriptions provide evidence that the participants recounted their narratives freely and generally with very little prompting. It was my intention to enable the participants to discuss links between MSKUSI and their practice in musculoskeletal medicine whilst remaining receptive to any viewpoint or opinion (Darawsheh 2014).

Despite my lack of personal experience using MSKUSI in a clinical environment, the participants were aware that I have extensive experience in the musculoskeletal clinical field and have a link with MSKUSI education. My background of clinical work in the musculoskeletal specialism enabled discussion of in-depth case examples in a way that would not have been possible with an interviewer with limited musculoskeletal medicine knowledge. This allowed information rich data to be gathered that was supported by many specific illustrations relating to musculoskeletal pathologies and treatment pathways. The participants may also have been aware of my connection with university based modules related to MSKUSI education. This was not explicitly stated on the information accompanying the questionnaires but it appeared that most of the interview participants knew of this link. The interviews' aims were to explore the participants' own experiences with MSKUSI not those of the interviewer, so whilst my personal link to education provided a basis of information regarding anticipated topics it was ensured that the interviews focused on the participants' experiences and opinions not those of the interviewer. It is acknowledged that my experience with MSKUSI education influenced my personal opinions but the interviews appear to have been viewed by the participants as an opportunity to tell their own stories, voice their opinions and inform an educator about MSKUSI in a situation that would not jeopardise their personal progression through an academic award or influence their relationship with a mentor.

My personal experience as a musculoskeletal physiotherapist has also influenced the analysis of interview data and has enhanced its credibility. I needed to acknowledge the language and concepts used by the participants to frame their discussions and use these as a foundation for categories and themes. Terminology was often technical and professional specific, for instance, 'functional demo', 'orange flags' and 'fear-avoidance' and a non-physiotherapist may have struggled to understand them or form connections with other data.

8.4: Summary of research questions and future research

The aim of this research was to review physiotherapists' use and interest in MSKUSI, this was subdivided into questions to frame the study:

Why does MSKUSI interest physiotherapists?

What is the clinical role of MSKUSI for physiotherapists?

Do physiotherapists use terms to categorise the role of MSKUSI, for instance 'diagnostic' or 'rehabilitative'?

What professional issues have impacted on physiotherapists' intentions to integrate MSKUSI into the clinic?

What impact does MSKUSI have on patient management including clinical reasoning underpinning diagnosis and treatment?

What education is available in MSKUSI and does it meet the requirements of physiotherapists?

In response to these questions, participants reported several reasons why they have an interest in MSKUSI and want to use it in clinical practice. These motivations and intentions have been presented in Theme 1, Professional Skill set - Physiotherapists' Suitability for MSKUSI and Theme 3, Physiotherapists' Motivation to Use Ultrasound - Improving Patient Focused Care. The reasons for using MSKUSI were numerous and whilst many participants highlighted the potential to validate their clinical assessment, other motivations included the desire to improve patient pathway efficiency and personal employability. Participants regularly discussed the role of MSKUSI for assessment of patients but the application of the modality for ongoing patient management was less consistent, some participants regularly used the modality to evaluate patients' progress or to educate patients, others did not. The impact of MSKUSI on patients' pathways warrants further investigation, in particular the impact MSKUSI may have on number of patient attendances and patient's understanding of their presentation.

The issue regarding MSKUSI terminology, whether 'diagnostic' or 'rehabilitative' ultrasound are distinct modalities was formally discussed in the interviews but was not a topic that many participants readily explored in great depth. Interestingly, none of the participants used the term 'rehabilitative' ultrasound and many did refer to the ‘diagnostic’ role, but as emphasised above, several participants described a role for MSKUSI in their patients’ post-assessment management. The participants who were clinicians also highlighted the ability to contribute to patient management at a very early stage in a patient’s pathway, including the communication and education at assessment clinics. The impact of the communication including education were presented as elements that contribute to the rehabilitation process. The practice-based clinical reasoning described by many participants indicated a lack of distinction between assessment and treatment. Several authors propose that intervention begins as soon as a health interaction commences and that outcomes are influenced by the relationship between the patient and clinician, (Testa & Rossettini 2016, Pinto et al 2012, O’Keeffe et al 2016) and there is a wealth of literature to support the role of education as a therapeutic intervention, (Puentedura & Flynn 2016, Traeger et al 2015, Mongini et al 2010, Hurley et al 2016).

The division of MSKUSI into rehabilitative and diagnostic imaging was not confirmed in this research. Whilst every participant was asked to outline the role of MSKUSI for rehabilitation, only one reported regular use to evaluate muscle activity and that was as an outcome measure in formal research. Reviewing the surveys, two other respondents may have been able to provide more detail on the clinical application of MSKUSI for muscle activity evaluation and rehabilitation. The purposive sampling strategy did not result in the selection of either of these respondents and it is evident that exploring the clinical use of MSKUSI for evaluation of muscle activity would require further data collection.

This research has produced a large volume of data exploring professional issues that have impacted on physiotherapists' intentions to integrate MSKUSI into their practice. Theme 2 presented a complex interaction of factors that have assisted and hindered the participants' progress with their MSKUSI ambitions. Some practical challenges were encountered including problems accessing an ultrasound system or funding for education, but these logistical issues related to a small fraction of the data when compared to material discussing professional obstacles including hostility from colleagues and lack of available mentorship. Some participants were able to reflect on enabling factors from supportive colleagues and many participants' narratives conveyed extraordinary resilience and commitment.

It is evident that some physiotherapists have attempted to engage with MSKUSI but this engagement has been negatively affected by barriers. The Chartered Society of Physiotherapy needs to be responsive to its members' professional interests, motivations and experiences. Further support from the CSP is needed to provide physiotherapists with a clearer framework as they advance their practice with MSKUSI. The CSP is ideally placed to defend its members from professional hostility and foster collaborative relationships with other professions. It also needs to provide guidance to members who are hoping to use MSKUSI in novel and innovative ways and ensure they are working within their scope of practice.

The exploration of data relating to the research question, 'What impact does MSKUSI have on patient management including clinical reasoning underpinning diagnosis and treatment?' was analysed and presented in Themes 3 and 5. Theme

3 related to clinical roles of the modality and Theme 5 related to the biopsychosocial model that underpins elements of the participants' practice. Participants had emphasised application of their clinical reasoning skills, this resulted in the integration of musculoskeletal medicine knowledge, including an understanding of pain physiology with tissue-based findings from MSKUSI and represents an aspect of MSKUSI not represented in the literature. Whilst publications regularly discuss imaging findings associated with common scenarios, (Adhikari et al 2012, Alavekios et al 2013, Khy et al 2012, Melville et al 2014) the evidence base has not fully explored the role of the imaging process when tissue changes are not evident and the impact this investigation may have on patient management and outcomes. There are a number of issues relating to the patient experience of MSKUSI that warrant further investigation, these include the influence of communication style and content during imaging, the effect MSKUSI may have on treatment compliance, the response of patients to dynamic imaging of their pain provocative movements and the patient's view regarding the placement of MSUSI in their overall management pathway.

The final question that was explored by this research related to availability and suitability of MSKUSI education for physiotherapists. Theme 2 presented the factors that influenced educational experiences and highlighted that as sonography is not regulated, clinicians have accessed unstandardised education. The lack of consistent practice and standards in education concerned some participants who feel that the profession and its professional body should review current regulation in relation to MSKUSI. Complex issues are associated and it could be argued that current regulation from the Health and Care Professions Council and the Chartered

Society of Physiotherapy is sufficient and further professional guidance might limit innovation. A viewpoint also exists that without further guidance regarding professional standards and a competency framework for physiotherapists, some clinicians may not be using MSKUSI appropriately.

9.1: Chapter 9 Conclusion

As an education provider, it is my responsibility to respond to research findings by ensuring they inform the development of good educational practice. It is evident that education offered must match the requirements and standards of accrediting organisations, (CASE) but also needs to be responsive to the professions who want to access it. Recent developments reflect some promising collaborations: CASE has now invited the CSP to become one of its member organisations and there are now two CSP representatives who report to CASE. It is hoped that these enhanced links will enable CASE to further understand the professional issues specific to physiotherapists. Similarly, the CSP must use this opportunity to optimise strategies to protect both the public and their professional members.

In my position as an education provider, my responsibility is to balance the complex and sometimes competing demands of CASE, the HCPC, the CSP, university regulations alongside the needs and expectations of potential students. This is extraordinarily challenging demand. This doctoral research, accompanied by my experience of MSKUSI in education and years of clinical practice as a musculoskeletal practitioner have placed me in an informed position with a strong level of knowledge and understanding to support this specific educational requirement.

Several of the key findings in this research have not been widely reported or discussed in literature at all. These key findings include:

- Participants reported a close association between their core physiotherapy skills and knowledge and those of MSKUSI

- Mentorship accessibility is limited. When offered by radiologists and other medical professionals, it supports education but may not include some MSKUSI applications of interest to physiotherapists.
- MSKUSI in physiotherapy practice was associated with a decrease in the number of attendances required in patient pathways.
- Patients' belief and trust in the physiotherapists' message was enhanced with MSKUSI and may positively influence patients' compliance with management
- Participants use advanced clinical reasoning to incorporate MSKUSI findings into the biopsychosocial of musculoskeletal assessment and management.
- Guidance from the Chartered Society of Physiotherapy is needed to support MSKUSI but poorly considered guidance or increased sonographic regulation could limit innovative physiotherapy practice.

This study has explored physiotherapists' interest and clinical use of MSKUSI, it has revealed that is a modality associated with many positive reports of clinical applications alongside uncertainties regarding its professional role. It is also a modality that has been accessed by the physiotherapy profession for a relatively short period of time and many professional and regulatory issues need to be explored further to enable physiotherapists to optimally integrate MSKUSI into their practice.

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Appendices:

Appendix 1: University Ethics Documentation: Application for Ethical Approval of Research Involving Human Participants

Application for Ethical Approval of Research Involving Human Participants

This application form should be completed for any research involving human participants conducted in or by the University. ‘Human participants’ are defined as including living human beings, human beings who have recently died (cadavers, human remains and body parts), embryos and foetuses, human tissue and bodily fluids, and human data and records (such as, but not restricted to medical, genetic, financial, personnel, criminal or administrative records and test results including scholastic achievements). Research should not commence until written approval has been received (from Departmental Research Director, Faculty Ethics Committee (FEC) or the University’s Ethics Committee). This should be borne in mind when setting a start date for the project.

Applications should be made on this form, and submitted electronically, to your Departmental Research Director. A signed copy of the form should also be submitted. Applications will be assessed by the Research Director in the first instance, and may then passed to the FEC, and then to the University’s Ethics Committee. A copy of your research proposal and any necessary supporting documentation (e.g. consent form, recruiting materials, etc) should also be attached to this form.

A full copy of the signed application will be retained by the department/school for 6 years following completion of the project. The signed application form cover sheet (two pages) will be sent to the Research Governance and Planning Manager in the REO as Secretary of the University’s Ethics Committee.

1. Title of project: Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?

2. The title of your project will be published in the minutes of the University Ethics Committee. If you object, then a reference number will be used in place of the title. Do you object to the title of your project being published? Yes ☐ / No X☐

3. This Project is: ☐ Staff Research Project ☐X Student Project

4. Principal Investigator(s) (students should also include the name of their supervisor):

Name:	Department:
Sue Mapes, (Known professionally as Sue Innes)	School of Health and Human Sciences

5. **Proposed start date**: May 2013
6. **Probable duration**: Approximately 2 years, (component of Professional Doctorate)

7. Will this project be externally funded? Yes ☐ / No ☐X

If Yes,

8. What is the source of the funding?

9. If external approval for this research has been given, then only this cover sheet needs to be submitted

External ethics approval obtained (attach evidence of approval) Yes ☐/ No ☐X

Declaration of Principal Investigator:

The information contained in this application, including any accompanying information, is, to the best of my knowledge, complete and correct. I/we have read the University's *Guidelines for Ethical Approval of Research Involving Human Participants* and accept responsibility for the conduct of the procedures set out in this application in accordance with the guidelines, the University's *Statement on Safeguarding Good Scientific Practice* and any other conditions laid down by the University's Ethics Committee. I/we have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my/our obligations and the rights of the participants.

Signature(s): ....………………………………..

Name(s) in block capitals: S. INNES

Date: 28.3.14…….

Supervisor's recommendation (Student Projects only):

I have read and approved both the research proposal and this application.

Supervisor's signature: ..………………………………………………………………………….……….

Outcome:

The Departmental Director of Research (DoR) has reviewed this project and considers the methodological/technical aspects of the proposal to be appropriate to the tasks proposed. The DoR considers that the investigator(s) has/have the necessary qualifications, experience and facilities to conduct the research set out in this application, and to deal with any emergencies and contingencies that may arise.

This application falls under Annex B and is approved on behalf of the FEC ☐

This application is referred to the FEC because it does not fall under Annex B ☐

This application is referred to the FEC because it requires independent scrutiny ☐

Signature(s): ....……………………..……………….

Name(s) in block capitals: ....……..…………………….

Department: …………………………………………………………………………..………
……….……

Date: ……………………………………………………………………………………………
…………..

The application has been approved by the FEC

☐

The application has not been approved by the FEC

☐

The application is referred to the University Ethics Committee

☐

Signature(s): ....………………………
…………..

Name(s) in block
capitals: …..……………………

Faculty: ……………………….………………………………………...……………………………
…………

Date: …………………………..………………………………………………………………
……………

Details of the Project

1. **Brief outline of project** (This should include the purpose or objectives of the research, brief justification, and a summary of methods. It should be approx. 150 words in everyday language that is free from jargon).

Musculoskeletal ultrasound imaging has traditionally been performed by radiologists but in recent times, several other health care professions have expressed an interest in the modality. Some physiotherapists have sought education in this application and there is an emerging body of evidence that physiotherapists see a role for ultrasound imaging in their clinical practice. (Potter 2012, McKiernan 2011). Whilst the literature exists that identifies a lack of training availability for physiotherapists, (McKiernan 2012 and Teyhan 2011) there has been little exploration regarding the motivation for physiotherapists to incorporate this application into their practice. Some authors have expressed concern that this unregulated field could expose patients to risk if untrained practitioners start to use the modality without appropriate support, (Edwards 2010). In light of the concerns, there are clear questions that need addressing as to the reasons physiotherapists seek education in this imaging modality and the implications it can have on their patient management.

Participant Details

2. Will the research involve human participants? (indicate as appropriate)

Yes ☐X No ☐

3. Who are they and how will they be recruited? (If any recruiting materials are to be used, e.g. advertisement or letter of invitation, please provide copies).

This study has two components, the first part of the study includes a survey that has been enclosed alongside a letter of information explaining the purpose of the study. This survey will be distributed in several ways and participants will be invited to pass on the survey to ‘snow-ball’ its distribution. It will be distributed in hard copy at the ACPOMIT conference, (Association of Chartered Physiotherapists in Orthopaedic Medicine and Injection Therapy) and via e-mail using Survey Monkey to members of several special interest groups of the Chartered Society of Physiotherapy including ACPOMIT and the Electrophysical Agents and Diagnostic Ultrasound special interest group.

The second part of this research involves an interview based study. The surveys will be used to obtain a purposeful sample of ten physiotherapists who have consented to participate in semi-structured interviews exploring issues associated with the professional use of musculoskeletal ultrasound imaging. A topic guide has been enclosed.

Will participants be paid or reimbursed? No – they will not incur any expenses.

4. Could participants be considered:

(a) to be vulnerable (e.g. children, mentally-ill)? Yes ☐/ No ☐X

(b) to feel obliged to take part in the research? Yes ☐/ No ☐X

If the answer to either of these is yes, please explain how the participants could be considered vulnerable and why vulnerable participants are necessary for the research.

Informed Consent

5. Will the participant's consent be obtained for involvement in the research orally or in writing? (If in writing, please attach an example of written consent for approval):

Yes X ☐ No ☐

How will consent be obtained and recorded? If consent is not possible, explain why. The letter of invitation to participate in the survey is enclosed and includes information for the subjects regarding consent to analyse the survey material but only for the purposes of this study. The survey invites the subject to include contact details if they are willing to be interviewed. Written consent will be obtained by the subjects at the interview stage. The consent form to be used at interview is enclosed.

Please attach a participant information sheet where appropriate.

Confidentiality / Anonymity

6. If the research generates personal data, describe the arrangements for maintaining anonymity and confidentiality or the reasons for not doing so.

Each survey response will be ascribed an identifying code and survey data will then be analysed anonymously. Subjects will be purposefully selected following survey analysis and their contact details used to invite them to interview. The interviews will be transcribed verbatim but without identifying information; confidentiality of the participants will be maintained. The identities of the survey participants who are selected for interview will not be recorded or published at any time.

Data Access, Storage and Security

7. Describe the arrangements for storing and maintaining the security of any personal data collected as part of the project. Please provide details of those who will have access to the data.

The surveys will be stored securely; the hard copies in the researcher's office and digital replies will be password protected. The interview data will be transcribed and will be stored on the researcher's password protected computer. The only individuals who will access to the data are the researcher and her supervisors.

It is a requirement of the Data Protection Act 1998 to ensure individuals are aware of how information about them will be managed. Please tick the box to confirm that participants will be informed of the data access, storage and security arrangements described above. If relevant, it is appropriate for this to be done via the participant information sheet ☐X

Further guidance about the collection of personal data for research purposes and compliance with the Data Protection Act can be accessed at the following weblink. Please tick the box to confirm that you have read this guidance (http://www.essex.ac.uk/records_management/policies/data_protection_and_research.aspx)
☐X

Risk and Risk Management

8. Are there any potential risks (e.g. physical, psychological, social, legal or economic) to participants or subjects associated with the proposed research?

Yes ☐ No X ☐

If Yes,

Please provide full details and explain what risk management procedures will be put in place to minimise the risks:

9. Are there any potential risks to researchers as a consequence of undertaking this proposal that are greater than those encountered in normal day-to-day life?

Yes ☐ No X ☐

If Yes,

Please provide full details and explain what risk management procedures will be put in place to minimise the risks:

10. Will the research involve individuals below the age of 18 or individuals of 18 years and over with a limited capacity to give informed consent?

Yes ☐ No X ☐

If Yes, a criminal records disclosure (CRB check) within the last three years is required.

Please provide details of the "clear disclosure":

Date of disclosure:
Type of disclosure:
Organisation that requested disclosure:

11. Are there any other ethical issues that have not been addressed which you would wish to bring to the attention of the Faculty and/or University Ethics Committees

No

Appendix 2: Ethics approval

University of Essex

School of Health and Human Sciences
T 01206 872854
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Wivenhoe Park
Colchester CO4 3SQ
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02 May 2014

Mrs S Innes
c/o HHS, University of Essex

Dear Sue,

Re: Ethical Approval Application (Ref 13006)

Further to your application for ethical approval, please find enclosed a copy of your application which has now been approved by Dr Wayne Wilson on behalf of the Faculty Ethics Committee.

Yours sincerely,

Mel Wiltshire
Ethics Administrator
School of Health and Human Sciences

cc. Sarah Manning-Press, REO
Jo Jackson, Supervisor

University of Essex

Application for Ethical Approval of Research Involving Human Participants

This application form should be completed for any research involving human participants conducted in or by the University. 'Human participants' are defined as including living human beings, human beings who have recently died (cadavers, human remains and body parts), embryos and foetuses, human tissue and bodily fluids, and human data and records (such as, but not restricted to medical, genetic, financial, personnel, criminal or administrative records and test results including scholastic achievements). Research should not commence until written approval has been received (from Departmental Research Director, Faculty Ethics Committee (FEC) or the University's Ethics Committee). This should be borne in mind when setting a start date for the project.

Applications should be made on this form, and submitted electronically, to your Departmental Research Director. A signed copy of the form should also be submitted. Applications will be assessed by the Research Director in the first instance, and may then passed to the FEC, and then to the University's Ethics Committee. A copy of your research proposal and any necessary supporting documentation (e.g. consent form, recruiting materials, etc) should also be attached to this form.

A full copy of the signed application will be retained by the department/school for 6 years following completion of the project. The signed application form cover sheet (two pages) will be sent to the Research Governance and Planning Manager in the REO as Secretary of the University's Ethics Committee.

1. Title of project: Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?

2. The title of your project will be published in the minutes of the University Ethics Committee. If you object, then a reference number will be used in place of the title.
   Do you object to the title of your project being published? Yes ☐ / No X☐

3. This Project is: ☐ Staff Research Project ☐X Student Project

4. Principal Investigator(s) (students should also include the name of their supervisor):

Name:	Department:
Sue Mapes, (Known professionally as Sue Innes)	School of Health and Human Sciences

5. **Proposed start date:** May 2013

6. **Probable duration**: Approximately 2 years, (component of Professional Doctorate)

7. Will this project be externally funded? Yes ☐ / No ☐X
   If Yes,

8. What is the source of the funding?

9. If external approval for this research has been given, then only this cover sheet needs to be submitted

External ethics approval obtained (attach evidence of approval) Yes ☐/ No ☐X

Declaration of Principal Investigator:

The information contained in this application, including any accompanying information, is, to the best of my knowledge, complete and correct. I/we have read the University's *Guidelines for Ethical Approval of Research Involving Human Participants* and accept responsibility for the conduct of the procedures set out in this application in accordance with the guidelines, the University's *Statement on Safeguarding Good Scientific Practice* and any other conditions laid down by the University's Ethics Committee. I/we have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my/our obligations and the rights of the participants.

Signature(s): ....

Name(s) in block capitals: S. INNES

Date: 28.3.14.......

Supervisor's recommendation (Student Projects only):

I have read and approved both the research proposal and this application.

Supervisor's signature: ...J Maclean..

Outcome:

The Departmental Director of Research (DoR) has reviewed this project and considers the methodological/technical aspects of the proposal to be appropriate to the tasks proposed. The DoR considers that the investigator(s) has/have the necessary qualifications, experience and facilities to conduct the research set out in this application, and to deal with any emergencies and contingencies that may arise.

This application falls under Annex B and is approved on behalf of the FEC ☑

This application is referred to the FEC because it does not fall under Annex B ☐

This application is referred to the FEC because it requires independent scrutiny ☐

Signature(s): ....

Name(s) in block capitals: .....WAYNE WILES.....................................

Department: .....SHAS...

Date: .....1|5|2014...

The application has been approved by the FEC ☐

The application has not been approved by the FEC ☐

The application is referred to the University Ethics Committee ☐

Signature(s): ....

Name(s) in block capitals: ....

Faculty: ....

Date: ....

Appendix 3 – Participant letter distributed at ACPOMIT Conference

Dear Colleague,

‘Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?’

This question forms the basis for my Professional Doctorate research at The University of Essex, it aims to explore physiotherapists’ motivations for using musculoskeletal ultrasound imaging and the impact it may have on patient care.

The study has two components; the first is a brief questionnaire that is designed to provide some base line information from physiotherapists who use the modality and from those who have an interest in ultrasound imaging but have not started using it. If you fit into one of these categories, I would be extremely grateful if you could complete the questionnaire – this should take approximately 5 minutes.

The second part of the study involves interviewing a small number of physiotherapists regarding their interest in musculoskeletal ultrasound imaging. There is an invitation to provide your contact details on the survey if you would be happy to be approached for a face to face interview. Please leave the survey anonymous if you do not want to be contacted.

The questionnaires can be returned in hard copy via the ACPOMIT conference – you will be informed where you can hand it in.

The survey results will be analysed anonymously and all of the information will be stored securely ensuring confidentiality of the respondents. By completing and returning the survey you will be consenting to analysis of your responses.

Thank you for your assistance, I am very happy to answer any queries you may have regarding this study. I also look forward to feeding back the outcome of this work in publications and at conferences.

Regards,

Sue Innes

e-mail: inness@essex.ac.uk

Appendix 4 - Questionnaire

Questionnaire - Musculoskeletal Ultrasound Imaging Use by Physiotherapists

Please tick responses or provide brief answers in the areas indicated.

1. Do you use musculoskeletal ultrasound imaging in clinical practice?

Yes		No	

If yes:
Briefly state the role of musculoskeletal ultrasound imaging in your clinical practice:

……

……………………………………………………………………………………

If no:
What role(s) do you anticipate that musculoskeletal ultrasound imaging could have in your clinical practice?

……

……………………………………………………………………………………

2. Nature of your clinical practice:

NHS	
Private practice	
Private hospital	
Sports team or institute	
Research	

3. Have you undertaken any education in musculoskeletal ultrasound imaging?

Yes		No	

If yes, state the nature and duration of the education;

……

……………………………………………………………………………………

4. Have any factors influenced your ability to use musculoskeletal ultrasound imaging in clinical practice?

Yes		No	

If yes, please state these factors:

……

……………………………………………………………………………………

This survey will be followed by an interview based study involving a small number of subjects. If you are happy to be contacted to participate in an interview that will explore the issues affecting physiotherapists' use of musculoskeletal ultrasound, please provide your details below, thank you:

Name	Tel number:
e-mail address:	

Appendix 5 – Participant information letter to accompany questionnaire distributed via Survey Monkey

Dear Colleague,

‘Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?’

This question forms the basis for my Professional Doctorate research at The University of Essex, it aims to explore physiotherapists’ motivations for using musculoskeletal ultrasound imaging and the impact it may have on patient care.

The study has two components; the first is a brief questionnaire that is designed to provide some base line information from physiotherapists who use the modality and from those who have an interest in ultrasound imaging but have not started using it. If you fit into one of these categories, I would be extremely grateful if you could complete the questionnaire – this should take approximately 5 minutes.

The second part of the study involves interviewing a small number of physiotherapists regarding their interest in musculoskeletal ultrasound imaging. There is an invitation to provide your contact details on the survey if you would be happy to be approached for a face to face interview. Please leave the survey anonymous if you do not want to be contacted.

The survey results will be analysed anonymously and all of the information will be stored securely ensuring confidentiality of the respondents. By completing and returning the survey you will be consenting to analysis of your responses.

Thank you for your assistance, I am very happy to answer any queries you may have regarding this study. I also look forward to feeding back the outcome of this work in publications and at conferences.

Please forward this to any physiotherapist you know with an interest in musculoskeletal ultrasound.

Regards,

Sue Innes e-mail: inness@essex.ac.uk

Appendix 6: Interview Guide to Facilitate In-depth Interview

Interview Guide to Facilitate In-depth Interview

‘Thank you for agreeing to take part in this interview, as you are aware I am exploring physiotherapists’ interest in musculoskeletal ultrasound. The survey you have already completed provided some information regarding your interest in this modality and I hope to explore this in much more detail in this interview.’

Can you tell me why does musculoskeletal ultrasound interest you?

Can you tell me about your experience with the modality to date?

- Duration of use
- access to equipment
- courses attended
- major influences

Have you received any training in musculoskeletal ultrasound?

- Formal
- Supervision, access to support
- Evaluation of training
    - response to individual’s needs
    - competence evaluation

What role does ultrasound imaging have in your area of (clinical) work?

Clinicians:
Assessment: at what stage in the assessment do you incorporate ultrasound imaging?

What role does ultrasound imaging have following assessment?

What impact has it had on your patient management?

- Resource issues
- patient visits

Physiotherapists clinical reasoning underpins their patient management. I would like to explore how the information obtained from ultrasound imaging fits in with your clinical reasoning process.

- Diagnostic
- Education of patient
- Rehabilitation
- Compliance

Are there any ways that you incorporate musculoskeletal imaging that you think would be unique to physiotherapists?

Have you received any support or opposition from professional colleagues?

- Support – impact on practice
- Opposition – impact on practice
- Response to support and opposition – formation of governance procedures.

Are there any other professional or educational issues that may influence the future role of physiotherapists and musculoskeletal ultrasound?

- Professional opportunities
- Business opportunities
- NHS – patient focused care
- Resource management in the NHS,
- Quality assurance
- Clinical reasoning models

Appendix 7: Information and Consent Forms for Interview Participants

Dear Physiotherapist,

Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?

You previously completed a survey that investigated physiotherapists' views on musculoskeletal ultrasound imaging – thank you for completing this and for giving permission for me to contact you. A small number of physiotherapists have been approached for the second part of my study, this involves a face to face interview that will discuss the reasons why you are interested ultrasound imaging, it will take approximately 45 minutes and will be audio recorded.

The recording will then be transcribed and used for analysis, a copy of this transcription can be made available for you if you would like this.

The interview recording and any documentation linked to it will be securely stored and will not be made available to anyone who is not directly linked with the research. Your anonymity will be ensured throughout the research process and no identifying information will be published.

It is hoped this study will be followed by publications that will provide information on professional motivations for physiotherapists using this modality and will assist providers of ultrasound training programmes to match physiotherapists' needs.

Thank you for your participation and interest in this study. A consent form has been enclosed, please read this and let me know if you have any questions.

Yours Faithfully,

Sue Innes
Professional Doctorate student – The University of Essex
e-mail: inness@essex.ac.uk

Consent Form for Participants Invited for Interview:

Professional Doctorate Research – Why do physiotherapists express an interest in accessing musculoskeletal ultrasound imaging?

The University of Essex

I (Print name) ……………………………………………………………………….
confirm that I have fully understood the information provided about the research and give consent to participate in the interview based study. I confirm that I have been given the opportunity to ask questions and that these have been answered to my satisfaction. I understand that taking part is voluntary and that I can withdraw from the project at any point without having to give reason for doing so.
I understand all personal details will be kept confidential and any collected and stored data will be done so anonymously. I understand that it is the intention of the researcher to publish results of data collected and that confidentiality will be upheld in doing so.

Participants
Signature:……………………………………………………………………….

Date:…………………………………………………………………………………………
…

Researcher's Name: Sue Innes

Researcher's
signature:……………………………………………………………………