Examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint

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As the Candidate's supervisor, I have approved this dissertation for examination.

Dr Graeme Harpham

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DEDICATION

To my forever enduring parents who have always loved and supported me – this is for you two.

ACKNOWLEDGEMENTS

To my Lord, God, for giving me the gifts and abilities to do something as challenging as this. This verse pulled me through every year of this course –

'"For I know the plans I have for you," declares the Lord, "Plans to prosper you and not to harm you, plans to give you hope and a future."' Jeremiah 29:11

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"It always seems impossible until it's done"
– Nelson Mandela

ABSTRACT

Background: Hip pain is a common problem. Motion palpation is a manual technique applied by the hands in various degrees of joint motion that specifically evaluates range of motion in relation to specific anatomical landmarks, joint play and end feel. Motion palpation remains one of the most used diagnostic techniques and yet it remains unclear whether or not it is a reliable, sensitive and specific tool; especially in the hip joint.

Objectives: This study assessed intra- and inter-examiner reliability and clinical responsiveness of motion palpation when it is used as a diagnostic tool in patients with non-specific unilateral anterior hip pain and unilateral asymptomatic hip joints.

Methods: Ten participants, between the ages of 18 and 60, were included in this study (three ballet dancers, three golfers and four participants from the general population). The participants were assessed randomly by three blinded examiners. All of the participants then received one adjustment delivered by the researcher (half on the symptomatic side and half on the asymptomatic). The participants were then re-assessed. Data was recorded on a data collection sheet and analysed using SPSS version 23. Intra-examiner reliability and clinical responsiveness were analysed using McNemar's test and the Chi-Square Test of Independence. Inter-examiner reliability was analysed using Fleiss' Kappa.

Results: Intra-examiner reliability showed to be markedly better on the left-hand side for all three examiners. Kappa scores for inter-examiner reliability varied from none to perfect. The average pairwise agreement scores ranged from 33.3% to 100% at the first assessment, and from 46.6% to 100% in the second assessment. A mean and standard deviation were calculated for the pairwise agreements which represented the sensitivity and specificity respectively. Both showed improvement between the first and second assessments which is positive for inter-examiner reliability. Clinical responsiveness was shown to be absent for examiners A and B but was present for examiner C on the left.

Conclusion: This study found that, contrary to the expectations of many clinicians, motion palpation has limited to poor levels of intra-examiner reliability, inter-examiner reliability and clinical responsiveness. This is however limited by the small sample size and methodological limitations in this study. Therefore, the role of palpation as a diagnostic tool used in the diagnosis hip dysfunction may be limited.

Key terms: motion palpation, reliability, clinical responsiveness, hip pain

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CHAPTER 1 : INTRODUCTION

1.1 Introduction

Hip pain is a common problem that most commonly affects the elderly (Gleberzon, 2001) in the form of osteoarthritis, but may also affect slightly younger patients in the form of femoroactebular impingement syndrome (prevalence in the adult population 10-15%) (Laborie *et al.,* 2011). Children are more likely to suffer from slipped capital femoral epiphysis and its sequelae or Legg-Calve-Perthes (Zacher and Gursche, 2003). Collectively though it has been noted in the literature that acute transient synovitis is probably the most common cause of hip pain (Zacher and Gursche, 2003; Laborie *et al.,* 2011). These varying pathologies and their different mechanisms of injury implies, therefore, varied clinical implications for patients. For this reason it is often difficult to diagnose specific hip conditions due to the complexity of the clinical presentations that are associated with the hip the joint (O'Kane, 1999; Broome, 2003; Hyde and Gengenbach, 2007).

Palpation skills are recognised as an essential and integral skill by disciplines such as osteopathy (Beal, 1989), physical therapy / physiotherapy (Keating, Matyas and Bach, 2012), medical manipulators (Bergmann and Peterson, 2011) and chiropractic (Schafer and Faye, 1990; Gatterman, 1995; Bergmann and Peterson, 2011). For chiropractors, motion palpation is their principle manner of assessing the musculoskeletal system (Gatterman, 1995). Palpation is defined as the ability of the examiner to determine shape, size, tenderness, consistency, position and inherent mobility of the tissues to which she/he is applying variable manual pressure (Bergmann and Peterson, 2011). Palpation, therefore, involves both static and motion palpation (MP) procedures (Shafer and Faye, 1989; Gatterman, 1995).

The manual palpation of joints through applied pressure within the joints neutral position is known as "joint play" (Vizniak, 2005) as compared to stressing the joints at the end of their various ranges of motion (known as "end feel") (Isaacs and

Bookhout, 2002; Vizniak, 2005). Both of these assessments are utilised to ascertain areas of hypo- or hyper-mobility (Redwood and Cleveland, 2003) and motion quality and quantity (Vizniak, 2005).

With such a heavy reliance on palpation techniques in clinical practice as a decision-making tool for manual therapists (Gatterman, 1995; Maitland *et al.,* 2001; Isaacs and Bookhout, 2002; Byfield, 2005), it could be assumed that these palpation techniques are reliable (Stochkendahl *et al.,* 2006; Bergmann and Peterson, 2011), sensitive (Humphreys, Delahaye and Petersen, 2004) and specific (Humphreys, Delahaye and Petersen, 2004), allowing them to provide reproducible information by any examiners in a clinical setting. This is particularly pertinent when assessing a patient for manipulable lesions and using this information to decide on treatment and management plans for that patient and then also providing consistent results (i.e. the discovery of a manipulable joint fixation). Thus, this clinical procedure should be reproducible when the same examiner examines the same group of patients repeatedly (intra-examiner reliability) and again, when different examiners evaluate the same group of patients (inter-examiner reliability) (Haneline and Young, 2009). However, despite a few exceptions which showed good inter- and intra-examiner reliability (Wiles, 1980; Carmichael, 1987; Love and Brodeur, 1987; Leboeuf, 1989; Nansel *et al.,* 1989; Mior *et al.,* 1990; Huijbregts, 2002; Schneider *et al.,* 2008; Haneline *et al.,* 2008); the majority of studies show poor examiner reliability (Wiles, 1980; Gonella et al 1982; Viikari-Juntura, 1987; Breen, 1991; Paydar *et al.,* 1994; Mior *et al.,* 1995; Potter and Rothstein, 1985; Strender *et al.,* 1997; Meijne *et al.,* 1999; Schneider *et al.,* 2008). The majority of these published studies focused their attention on spinal and sacroiliac joint MP, which is confirmed by the systematic review conducted by van Trijffel *et al. (*2005), who showed that there has been almost no research conducted on inter-examiner reliability in the MP of the joints of the lower extremities.

There have, however, been unpublished studies conducted at DUT on motion palpation of the ankle joint (Belling, 2011); foot joints (Williams, 2010); the knee joint (Farrimond, 2010) and the patellofemoral joint (Vaghmaria, 2006). Therefore, this study was designed to evaluate the reliability, sensitivity and specificity of hip joint MP techniques. Should the findings of this study suggest that there is inter- and intra-examiner reliability in terms of hip MP and that MP is sensitive and specific for the hip; it would assist in providing a solid basis for the assessment of the hip pain patients and enable more appropriate care, resulting in improved clinical outcomes.

The design of this study was an intra- and inter-examiner reliability study. Three examiners motion palpated hip joints, the researcher then adjusted one of the hips (either the symptomatic or the asymptomatic side), into its restricted movement and the examiners re-motioned the joint. Randomisation occurred by flipping a coin to choose which side should be adjusted; the manipulable lesion was decided by majority agreement between the examiners. Ten participants were included in this study; three were dancers who as a category are known to have an increase in hip range of motion (Bennel *et al.,* 1999), three were golfers who are known as a category to have a hypomobile hip complex (Vad *et al.,* 2004) and the remaining four were people from the general population. The researcher selected participants of a certain demographic purposely, with the intention of finding equal numbers of hypermobile, hypomobile and unknown hips to increase the variability between participants. All participants included in this study were between the ages of 18-60 and had unilateral non-specific anterior hip pain. There is no statistical rule or sample size calculations for intra- and inter-examiner reliability studies thus sample size was based on the number of data sets that were obtained from the examinations (130 results) and the use of the Fleiss' Kappa statistical analysis to analyse the intra- and inter-examiner reliability, for which 120 results was determined as sufficiently high (Esterhuizen, 2015). Clinical responsiveness was analysed using the Chi-Square Test of Independence and the McNemar tests, with a p value of < 0.05 indicating a significant change between pre- and post-testing (Esterhuizen, 2015).

1.2 Research problem, aims and objectives for the study

Research Problem: Inter- and intra-examiner reliability of MP of the hip remains undefined.

The aim of this research was to determine the intra- and inter-examiner reliability and clinical responsiveness of MP of the hip joint to detect joint dysfunction in non-specific anterior hip pain and in symptomatic hip joints.

Objective 1: To determine the intra-examiner reliability of MP of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain.

Objective 2: To determine the inter-examiner reliability of MP of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain.

Objective 3: To determine the clinical responsiveness of the hip joint after manipulation of the present restrictions.

1.3 Rationale for the study

Many manual professions (Bergmann and Peterson, 2011), including the chiropractic profession, commonly use MP as a diagnostic tool to detect the need for manipulation (Walker and Buchbinder, 1997). A systematic review was conducted by van Trijffell et al (2010) (referring to studies by: Rothstein, Miller and Roettger 1983; Diamond *et al.,* 1989; Smith-Oricchio and Harris, 1990; Watkins *et al.,* 1991; Croft *et al.,* 1996; Fritz *et al.,* 1998; Hayes and Petersen, 2001; Van Gheluwe *et al.,* 2002; Aalto *et al.,* 2005; Erichson *et al.,* 2006; Cleffken *et al.,* 2007; Currier *et al.,* 2007; Cibere *et al.,* 2008; Sutlive *et al.,* 2008; Chevillotte *et al.,* 2009). A similar study by which focussed on MP of the spine was conducted by van Trijfell, *et al.* (2005). Further studies that could be found were unpublished dissertations (Vaghmaria, 2006; Farrimond, 2010; Williams, 2010; Belling, 2011). This suggests that that there has been little research conducted on the inter-examiner and intra-examiner reliability in the MP of the joints of the lower extremities, especially of the hip joint.

1.4 Benefits of the study

This research aimed to show whether or not the MP techniques used by chiropractors as an everyday diagnostic tool (to find joint fixation/s in the hip joint) are valid, reliable, sensitive and specific. The findings could result in chiropractors improving their clinical assessment and diagnosis of patients, thus providing a more accurate clinical diagnosis, with improved care and better clinical outcomes for the patient (Yeomans, 2000).

1.5 Limitations

Although studies have shown that the clinical experience of an examiner does not change the reliability of manual examinations (Stochkendahl *et al.,* 2006), the fact that two of the examiners used in this study were students was considered a limitation as they did not carry the years of experience of a qualified chiropractor. This was however addressed by using final year students who undertook one training session to standardize their motion palpation technique under the guidance of a qualified chiropractor with lecturing experience. These students had completed their required clinical requirements of their Master's Degree in Chiropractic – which gave them the relevant experience needed.

1.6 Conclusion

While MP is a commonly used tool that has been thoroughly tested in the joints of the spine, MP of the extremities, in this case the hip, does not seem to have been researched or published in peer reviewed literature. This is in contrast to the increasing use of manipulation of the lower extremity (Brantingham, *et al.,* 2010; Brantingham*, et al.,* 2012), which therefore requires that this assessment be evaluated for its use in the hip joint.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

The aim of this chapter is to discuss the anatomy of the hip, its biomechanics, non-specific anterior hip pain and its causation. This chapter also defines MP, discusses inter- and intra-examiner reliability studies and defines and discusses clinical responsiveness.

2.2 Anatomy of the hip

2.2.1 Introduction

The hip joint is a synovial joint that forms between the head of the femur and the acetabulum of the pelvis (Drake, Vogel and Mitchell, 2015). It is a multiaxial ball and socket joint which is designed to be weight bearing and stable and, at the same time, be flexible and mobile (Standring, 2008; Drake, Vogel and Mitchell, 2015). The hip joint forms a stable link between the lower extremities and the spine and pelvis and must accommodate for the great deal of mobility needed for walking and the performing of daily tasks (Bergmann and Peterson, 2011). The hip can move in flexion, extension, adduction, abduction, lateral (external) rotation, medial (internal) rotation and circumduction (Standring, 2008; Drake, Vogel and Mitchell, 2015).

2.2.2 Osseous anatomy and cartilage of the hip

The joint comprises two articular surfaces: the spherical head of the femur and the lunate surface of the acetabulum. The acetabulum fits almost entirely around the head of the femur and this surface is almost totally lined by hyaline cartilage, which greatly contributes to joint stability (Standring, 2008; Drake, Vogel and Mitchell, 2015). The acetabular labrum surrounds the rim of the acetabulum, serving to deepen and protect the acetabulum from the forceful impact of the femoral head during movement (Bergmann and Peterson, 2011). The centre of the acetabulum is filled with a layer of fatty tissue and covered by a synovial membrane which aids in shock absorption (Bergmann and Peterson, 2011). The head of the femur is also lined with articular cartilage except for a small area near the centre of the head, called the fovea capitis, through which the foveal artery supplies the femoral head and the foveal ligament which weakly assists in retaining the femoral head in the acetabulum (Bergmann and Peterson, 2011). This cartilage is thicker nearer the centre and thins towards the edge to aid in smooth movement and shock absorption (Bergmann and Peterson, 2011). The manner in which this joint is aligned causes it to have rheoplexic properties (Oates *et al.,* 2005). This means that as the joint undergoes shear forces, the viscosity of the synovial fluid increases to assist with the absorption of the applied stressors (Oates *et al.,* 2005). The normal pressures within the joint, between the head of the femur and the acetabulum, which measure about 18kg, are able support the whole limb with absolutely no assistance from the ligaments or the muscles that surround the joint (Bergmann and Peterson, 2011).

Figure 2.1 and Figure 2.2 demonstrate the bony anatomy of the head of the femur and serve as a reference point for the discussion on muscle attachments which follows (Drake, Vogl and Mitchell, 2015).

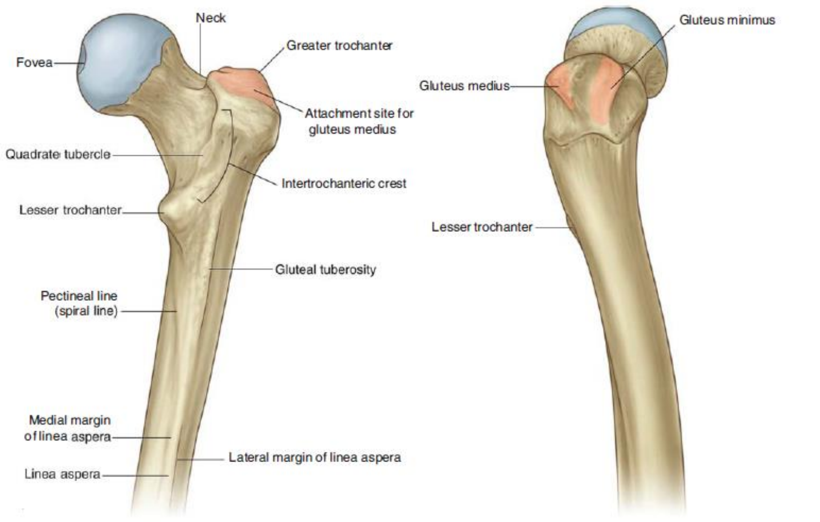


Figure 2.1: Bony anatomy of the head of the femur anteriorly (left) and laterally (right)
Source: Drake, Vogl and Mitchell (2015)

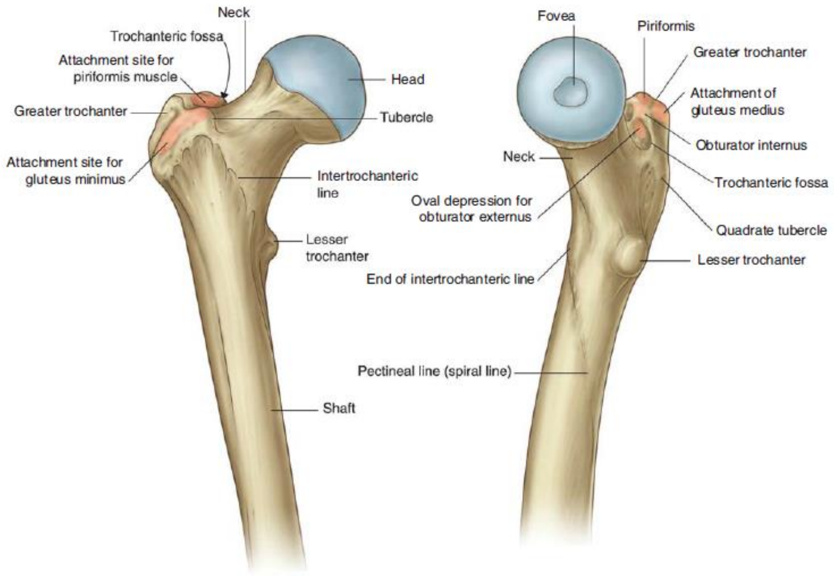
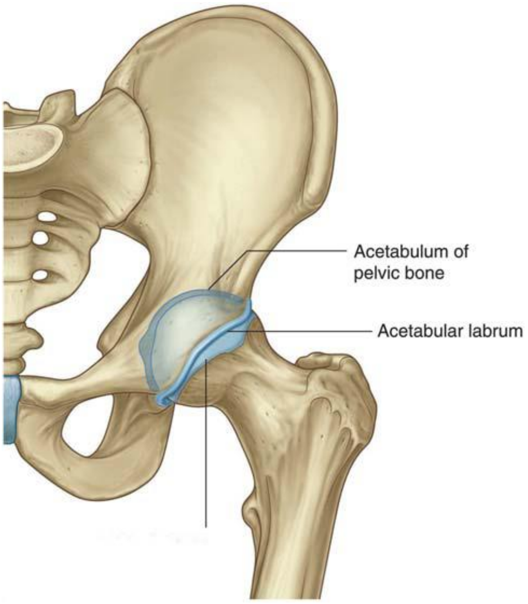


Figure 2.2: Bony anatomy of the head of the femur posteriorly (left) and medially (right)
Source: Drake, Vogl and Mitchell (2015)

Figure 2.3 demonstrates the bony anatomy of the pelvis as it relates to the femur to



become the hip joint (Drake, Vogl and Mitchell, 2015)

Figure 2.3. Bony anatomy of the articulation of the head of the femur as it inserts into the acetabulum of the pelvis
Source: Drake, Vogl and Mitchell (2015)

2.2.3 Muscles of the hip

The muscles that attach around the hip joint and contribute to movement of this joint are attached around all three axis allowing movement in all planes (Norkin and Levangie, 1992; Reider, 1999). The musculature primarily responsible for extension is composed of gluteus maximus, adductor magnus, biceps femoris, semitendinosus and semimembranosus muscles. The musculature primarily responsible for external rotation is composed of piriformis, gemellus superior and inferior, obturator internus and externus and gluteus maximus muscles perform external rotation (Moore and Dalley, 2006). The musculature primarily responsible for flexion is composed of iliacus, psoas, pectineus, sartorius, gracilis, quadratus femoris (vastus lateralis, vastus medialis obliquus and vastus intermedius), tensor fascia latae and rectus femoris muscles; with a smaller input from the adductor longus and brevis muscles (Moore and Dalley, 2006: Drake, Vogel and Mitchell, 2015). The synergists contributing to abduction are gluteus medius, gluteus minimus and the tensor fascia latae muscles (Moore and Dalley, 2006). The antagonists to this motion, causing adduction, are adductor longus, brevis and magnus, along with a smaller input from the pectineus, gracilis and obturator externus muscles (Moore and Dalley, 2006; Bergmann and Peterson, 2011; Drake, Vogel and Mitchell, 2015).

Table 2.1 describes the muscles that surround the hip joint and their origin, insertion, innervation and action.

Table 2.1: Muscles of the hip

Name of muscle	Origin	Insertion	Innervation	Action
Biceps femoris	Long Head – inferomedial part of the upper area of the ischial tuberosity; Short head – lateral lip of line aspera	Head of fibula	Sciatic nerve (L5, S1, S2)	Flexes leg at knee joint; extends and laterally rotates thigh at hip joint and externally rotates leg at knee joint
Gemellus inferior	Upper aspect of ischial tuberosity	Along length of inferior surface of the obturator internus tendon and into the medial side of greater trochanter of femur with obturator internus tendon	Nerve to quadratus femoris (L5, S1)	Externally rotates the extended femur at the hip joint; abducts flexed femur at hip joint
Gemellus superior	External surface of ischial spine	Along length of superior surface of obturator internus tendon and into the medial side of the greater trochanter of femur with obturator internus tendon	Nerve to Obturator internus (L5, S1)	Externally rotates the extended femur at the hip joint; abducts flexed femur at hip joint
Gluteus maximus	Fascia covering gluteus medius; external surface of ilium behind posterior gluteal line, fascia of erector spinae, dorsal surface of lower sacrum, lateral margin of coccyx, external surface of sacrotuberous ligament	Posterior aspect of iliotibial tract of fascia lata and gluteal tuberosity of proximal femur	Inferior gluteal nerve (L5, S1, S2)	Powerful extensor of flexed femur at hip joint; lateral stabilizer of hip joint and knee joint; externally rotates and abducts thigh

Table 2.1 Muscles of the hip continued

Name of muscle	Origin	Insertion	Innervation	Action
Gluteus medius	External surface of ilium between anterior and posterior gluteal lines	Elongate facet on the lateral surface of the greater trochanter	Superior gluteal nerve (L4, L5, S1)	Abducts femur at hip joint; holds pelvis secure over stance leg and prevents pelvic drop to the opposite swing side during walking; medially rotates thigh
Gluteus minimus	External surface of ilium between inferior and anterior gluteal lines	Linear facet on the anterolateral aspect of the greater trochanter	Superior gluteal nerve (L4, L5, S1)	Abducts femur at hip joint; holds pelvis secure over stance leg and prevents pelvic drop to the opposite swing side during walking; medially rotates thigh
Iliacus	Posterior abdominal wall (iliac fossa)	Lesser trochanter of femur	Femoral nerve (L2, L3)	Flexes the thigh at the hip joint
Obturator externus	External surface of the obturator membrane and the adjacent bone	Trochanteric fossa	Obturator nerve (posterior division (L3,L4))	Externally rotates the thigh at the hip joint
Obturator internus	Anterolateral wall of pelvis; deep surface of obturator membrane and surrounding bone	Medial side of greater trochanter of femur	Nerve to obturator internus (L5, S1)	Externally rotates the extended femur at the hip joint; abducts the flexed femur at the hip joint.
Piriformis	Anterior sacral surface between anterior sacral foramina	Medial side of superior border of greater trochanter of femur	Branches from S1 and S2	Rotates the hip joint externally. Abducts the flexed femur at the hip joint
Psoas Major	Posterior abdominal wall (Lumbar transverse processes, intervertebral discs, and adjacent bodies from T12 to L5 and tendinous arches between these points)	Lesser trochanter of femur	Anterior rami (L1, L2, L3)	Flexes the thigh at the hip joint
Quadratus femoris	Lateral aspect of the ischium just anterior to the ischial tuberosity	Quadrate tubercle on the intertrochanteric crest of the proximal femur	Nerve to quadratus femoris (L5, S1)	Externally rotates femur at hip joint
Rectus femoris	Straight head originates from the anterior inferior iliac spine; reflected head originates from the ilium just superior to the acetabulum	Quadriceps femoris tendon	Femoral nerve (L2, L3, L4)	Flexes the thigh at the hip joint and extends the leg at the knee joint
Sartorius	Anterior superior iliac spine	Medial surface of tibia just inferomedial to tibial tuberosity	Femoral nerve (l2, L3)	Flexes the thigh at the hip joint and flexes the leg at the knee joint

Table 2.1 Muscles of the hip continued

Name of muscle	Origin	Insertion	Innervation	Action
Semimem-branosus	Superolateral impression on the ischial tuberosity	Groove and adjacent bone on medial and posterior surface of medial tibial condyle	Sciatic nerve L5, S1, S2	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint
Semiten-dinosus	Inferomedial part of the upper area of the ischial tuberosity	Medial surface of proximal tibia	Sciatic nerve L5, S1, S2	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint
Tensor Fascia Latae	Lateral aspect of crest of ilium between anterior and superior iliac spine and tubercle of the crest	Iliotibial tract of fascia lata	Superior Gluteal nerve (L4, L5, S1)	Stabilizes the knee in extension

Source: adapted from Drake, Vogel and Mitchell (2015)

2.2.4 Innervation of the hip

The innervation of the hip is direct via the articular branches of the femoral, obturator and superior gluteal nerves, as well as the nerve to quadratus femoris muscle (Standring, 2008; Drake, Vogel and Mitchell, 2015). This excludes the innervation as outlined in Table 2.1, which supplements the innervation of the hip and provides innervation to the main movers of the hip as per Hilton's Law (Moore, Dalley and Agur, 2010).

2.2.5 Ligamentous structures supporting the hip

The ligaments that contribute to joint stability are the transverse acetabular ligament, the ligament of the head of the femur (also known as the teres ligament), the iliofemoral, pubofemoral and ischiofemoral ligaments (Standring, 2008; Moore, Dalley and Agur, 2010; Drake, Vogel and Mitchell, 2015) as well as the acetabular labrum and the articular capsule (Moore, Dalley and Agur, 2010). The iliofemoral, pubofemoral and ischiofemoral ligaments are oriented in a spiral manner around the hip joint to allow it to become taut when the joint is extended, which aids in stability and reduces the amount of energy used by the muscles to maintain a standing position (Standring, 2008; Drake, Vogel and Mitchell, 2015).

2.2.5.1 Articular capsule

This is a loose fibrous capsule that strongly attaches the femur to the pelvis (the acetabulum is a confluence of bone from the ischium, ilium and pubic bones). The principle anterior attachments on the femur are the intertrochanteric line and the root of the greater trochanter, where posteriorly the capsule attaches to just proximal to the intertrochanteric crest. Most of the fibres of the capsule spiral around the hip, but some form an orbicular zone, by passing circularly around the neck. This latter phenomenon provides capsule constriction and assists in holding the femoral head in the acetabulum (Moore, Dalley and Agur, 2010). As a result, the capsule provides limitation to hip motion, with a “springy” end feel, unless the capsule has become distended by intra-articular swelling which then provides a “boggy” end feel.

The spiralling fibres of the capsule cause thickenings in the capsule which are referred to as ligaments (e.g. the iliofemoral, ischiofemoral and pubofemoral ligaments) (Standring, 2008; Drake, Vogel and Mitchell, 2015).

2.2.5.2 Iliofemoral ligament

This ligament runs anteriorly to the hip joint in a triangular shape. The apex of the ligament is attached to the ilium between the margin of the acetabulum and the anterior inferior iliac spine. The base of the ligament is attached to the intertrochanteric line of the femur (Moore, Dalley and Agur, 2010). Some parts of the ligament attach above the intertrochanteric line and other parts attach below it; this gives the ligament its “Y” shape (Standring, 2008; Drake, Vogel and Mitchell, 2015).

When uninjured this ligament prevents extension and external rotation (Moore, Dalley and Agur, 2010); however, when ruptured, it does not prevent these motions and provides a platform for hypermobility. By contrast when contracted, it may further limit movement in these directions providing a basis for hypomobility when palpated.

2.2.5.3 Pubofemoral ligament

The pubofemoral ligament runs antero-inferior to the hip joint and is also triangularly shaped. The base of the ligament attaches to the iliopubic eminence and adjacent bone medially and to the obturator membrane. As it moves laterally, it blends with the fibrous membrane that encloses the hip joint and the deep surface of the iliofemoral ligament (Standring, 2008; Drake, Vogel and Mitchell, 2015).

This ligament prevents extension, abduction and external rotation (Moore, Dalley and Agur, 2010) and can therefore provide "springy" resistance to motion palpation in external rotation (end feel) and posterior to anterior movement (if assessed prone) (joint play). The "springy" resistance may become firmer particularly if the pubofemoral ligament has previously been injured.

2.2.5.4 Ischiofemoral ligament

The ischiofemoral ligament supports the posterior aspect of the fibrous membrane by attaching medially to the ischium, slightly posterior inferior to the acetabulum. Laterally, it attaches to the greater trochanter, on the underside of the iliofemoral ligament (Standring, 2008; Drake, Vogel and Mitchell, 2015).

This ligament prevents extension and internal rotation (Moore, Dalley and Agur, 2010) and controls flexion (Anderson, Strickland and Warren, 2001). In comparison to the pubofemoral ligament, the ischiofemoral ligament can potentially provide a "springy" resistance to internal rotation, posterior to anterior movement (if assessed prone) and may provide tissue approximation "sponginess" on flexion. These movements may also show firmer resistance if there has been injury to this ligament.

2.2.5.5 Acetabular labrum

This is a fibrocartilaginous structure that outlines the acetabular socket. It is usually a continuous triangular structure (but may be round, irregular or flattened) that attaches to the bony rim of the acetabulum (non-articular side) and on the articular side to the bone of the underlying acetabular socket. It is completed inferiorly at the acetabular notch by the transverse foraminal ligament which spans the notch (Groh and Herrera, 2009).

2.2.5.6 Transverse acetabular ligament

This ligament is a continuation of the labrum of the acetabulum and bridges across the acetabular notch, converting the notch to form a part of the labrum (Standring, 2008; Drake, Vogel and Mitchell, 2015), thereby reducing the likelihood of femoral instability (Moore, Dalley and Agur, 2010). Together the transverse acetabular ligament and the labrum resist superior to inferior glide of the femoral head (Groh and Herrera, 2009) and therefore a “springy” yet firm resistance is felt on long axis (superior to inferior) glide of the hip joint (with the patient supine). This end feel may feel “empty” or provide a lack of end feel if the transverse acetabular ligament has been torn or compromised.

2.2.5.7 Ligament of the head of the femur (teres ligament)

The ligament of the head of the femur is a delicate band of connective tissue that forms a flat band to attach to the fovea of the femoral head on one side and to the acetabular fossa, acetabular ligament and the margins of the acetabular notch on the other side. This ligament usually carries the foveal artery to the head of the femur (Moore, Dalley and Agur, 2010). Based on its attachments this ligament also prevents the movement of the head of the femur out of the acetabulum (Moore, Dalley and Agur, 2010), thereby providing a “springy” end feel for medial to lateral movements of the femoral head when the ligament is intact. However, when the ligament is not intact it may provide an “empty” end feel (Schafer and Faye, 1990; Chaitow and DeLany 2000; Bergmann and Peterson, 2011).

Figure 2.3 shows some of the ligaments of the hips and their attachments.

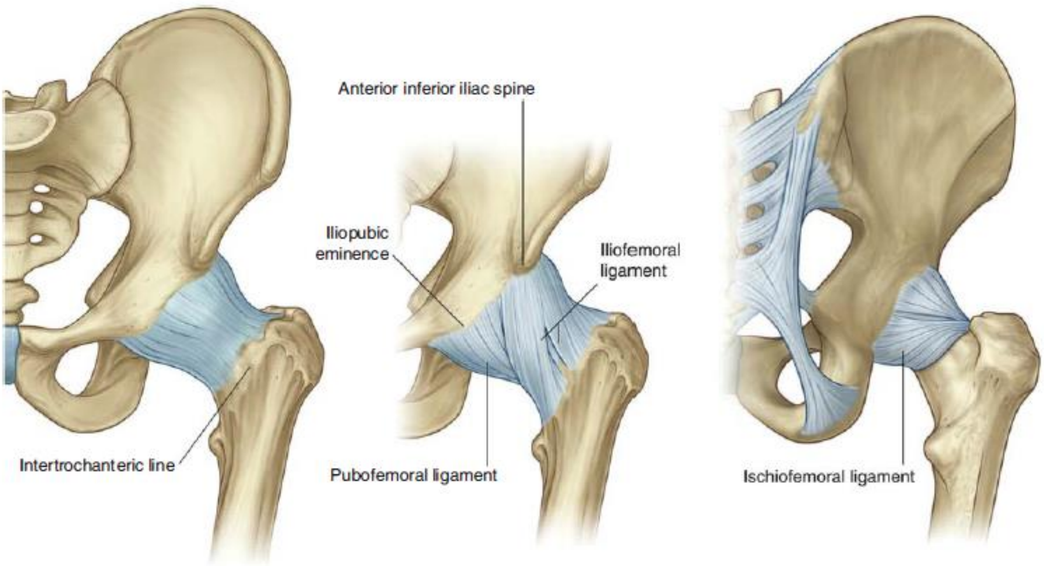


Figure 2.3: The ligaments of the hip
Source: Drake, Vogl and Mitchell (2015)

Collectively it can be seen that the muscles, ligaments, capsule and labrum may all contribute to movement changes within the hip joint, either as a result of normal anatomical variation or as a result of changes within their form or function due to disease or pathology (Reider, 1999; Vizniak, 2005; Magee 2014). These changes often lead to changes in the biomechanics of the hip and subsequently the biomechanical chain (Norkin and Levangie, 1992), which results in palpable changes within the hip and its associated structures.

2.3 Biomechanics of the hip

The hip joint is a multiaxial ball and socket joint that gets its stability as a result of its deep insertion of the femoral head into the acetabulum (Magee, 2014); the rheopexic properties of the synovial fluid (Oates *et al.,* 2005); the combination of the various ligament functions (Moore, Dalley and Agur, 2010); and, the complex movement interactions provided by the muscles that co-ordinate its movement (see Table 2.1) (Moore, Dalley and Agur, 2010; Drake, Vogel and Mitchell, 2015).

Normally, the neck of the femur is long and anteverted, which allows for sufficient range of movement and proper alignment of the joint (Magee, 2014). The acetabulum is lined with a labrum which aids in deepening and stabilizing the joint by increasing the articular surface area and volume thereby creating a seal within the articular compartment where the femoral head fits into the acetabulum (Anderson, Strickland and Warren, 2001; Magee, 2014). The seal creates negative pressure within the joint which aids in the resistance of distraction of the femoral head and in the nutrition of the hip's articular cartilage which allows for a smooth surface against which the femoral head may glide (Oates *et al.,* 2005; Magee, 2014).

The major ligaments of the hip and pelvis are known as the strongest in the body in order to bear the load of the forces that are transmitted between the spine and the lower extremity (Anderson, Strickland and Warren, 2001; Magee, 2014). The Y-shaped iliofemoral ligament prevents hyperextension of the hip and aids in maintaining the upright position at the hip and limits anterior translation while the pubofemoral ligament prevents excessive abduction and limits extension (Anderson, Strickland and Warren, 2001; Magee, 2014). The posteriorly placed ischiofemoral ligament tightens on flexion of the hip and winds tightly on extension, thus helping to stabilise the hip in extension (Anderson, Strickland and Warren, 2001; Magee, 2014). Together, these three ligaments limit medial rotation of the femur (Magee, 2014). The ligament of teres provides an attachment between the head of the femur and the acetabulum (Magee, 2014).

At low loads, the joint surface remains incongruous; however when under heavy loads, they become congruous (Magee, 2014). Loads of up to 5.8 times an individual's body weight can be placed on the hip joint when walking and six times the weight during jogging, and presumably even greater loads during vigorous athletic competition (Anderson, Strickland and Warren, 2001; Magee, 2014).

The muscles of the hip joint are deemed to be at a mechanical disadvantage due to the short lever arm they have when creating movement about the joint (Anderson, Strickland and Warren, 2001). Despite this, they are able to produce forces across the joint that are several times an individual's body weight (Anderson, Strickland and

Warren, 2001). The hip's muscles are able to produce the following active movements (Vizniak, 2005; Magee, 2014):

- Flexion: 110º - 120º
- Extension: 10º - 15º
- Abduction: 30º - 50º
- Adduction: 30º
- Lateral rotation: 40º - 60º
- Medial rotation: 30º - 40º

Based on the hip's requirement to provide a stable joint with an ability to provide a significant range of motion (Hyde and Gengenbach, 2007; Standring, 2008; Drake, Vogel and Mitchell, 2015), it is reliant on ligaments and muscles for stability and motility (Groh and Herrera, 2009). As a result no one motion assessed through motion palpation is limited exclusively to the resistance provided by the joint in isolation, but rather by the collective resistance of the joint, its ligaments and its muscles. This complicates motion palpation as the resistance to stressing the joint may not only be related to joint pathology (like a labral tear), but also pathology of the surrounding muscles (muscle spasm) (Chaitow and DeLany, 2000), ligament injury (tear) (Groh and Herrera, 2009) or ligament changes (as would be found in pregnancy) (Dehghan *et al.,* 2014). It is therefore important to consider all pathologies that can affect the soft tissue structures in and around the hip as well as those that affect the joint directly.

2.4 Differential diagnoses of hip pain

As a result of the complexity of the various anatomical factors influencing the hip joint (see Sections 2.2 and 2.3) as well as its need to bear weight, hip pain is a common problem experienced by both adolescents and adults (Gleberzon, 2001; Broome, 2003; Zacher and Gursche, 2003; Hyde and Gengenbach, 2007; Laborie *et al.,* 2011). However, this also makes it difficult to diagnose (O'Kane, 1999; Broome, 2003; Hyde and Gengenbach, 2007). Despite hip pain occurring less frequently than dysfunction of the spine and other extremities, its diagnosis and treatment are important and is often overlooked according to Brantingham *et al.* (2010), Bergmann and Peterson (2011) and Brantingham *et al.* (2012).

Pain in the hip can either be described by its location (groin or anterior; thigh or medial, hamstring or posterior) or by the structures (soft tissue, bone, joint) from which the pain arises (Hyde and Gengenbach, 2007). For example, anterior hip pain was defined by O'Kane (1999) as symptoms that extend medially to the pubic symphysis, laterally to the anterior superior iliac spine, superior to the abdomen and inferiorly to the proximal 5-10cm of the anterior thigh. By contrast soft tissue injuries may include muscle tears, bursitis, snapping ligament syndrome; bone changes may include fractures, tumours or congenital problems; and, joint injury may include hip dysplasias, labral tears or degeneration (Clohissy *et al.,* 2009; O'Kane, 1999; Anderson, Strickland and Warren, 2001; Hyde and Gengenbach, 2007; Laborie *et al.,* 2011). As a result, when pathological or traumatised, a dysfunctional hip can create a number of functional limitations; some of which may be as basic as walking, climbing stairs, lifting or carrying a load, dressing oneself and driving a car (Bergmann and Peterson, 2011).

2.4.1 Bone injuries / pathologies

2.4.1.1 Stress fractures

Stress fractures occur due to chronic repetitive forces caused by exercise (e.g. running) and most commonly affect the pubic ramus, femoral neck and proximal femur leading to anterior hip pain and limited internal rotation (O'Kane, 1999; Anderson, Strickland and Warren, 2001). Stress fractures are known to be more common in women, especially female runners and are often a result of training errors (Anderson, Strickland and Warren, 2001). Factures of the hip are also common in the elderly with the National Osteoporosis Foundation in the USA estimating that the risk of fracture in patients 50 years or older was 55% (Sahni *et al.,* 2013). Treatment of stress fractures initially should consist of rest for 4-6 weeks with non-impact activity only beginning when the patient is pain free (Anderson, Strickland and Warren, 2001). Stress fractures that do not respond to rest should be treated with surgical fixation (Anderson, Strickland and Warren, 2001). Observation is important in order to prevent displacement as displaced fractures of the hip need to be treated as a surgical emergency and an operation to ensure vascular supply remains intact to prevent osteonecrosis is necessary (Anderson, Strickland and Warren, 2001).

2.4.1.2 Osteonecrosis of the hip

Osteonecrosis and avascular necrosis are also features in Legg-Calve-Perthes disease and secondary causes of avascular necrosis include corticosteroid or alcohol abuse; intravascular coagulation (e.g. fat embolism), chemotherapy, chronic liver disease, hepatocellular carcinoma, decompression sickness, Gaucher's disease, gout, hemoglobinopathy, idiopathic hyperlipidemia, idiopathic atraumatic osteonecrosis, metabolic bone disease, pregnancy, radiation, smoking, systemic lupus erythematosus, vasculitis (Haslett *et al.,* 1999; Norris, 2004; Hyde and Gengenbach, 2007).

For this condition, the pain is most commonly localized to the groin area (anteromedial), but it may also be associated with pain in the ipsilateral buttock, the knee and / or the greater trochanteric region. The symptoms are usually made worse on weight bearing and relieved by rest. A straight-leg raise test against resistance will provoke pain in symptomatic cases. Usually passive range of motion of the hip is limited and may be painful (especially on forced internal rotation). There is also a limitation of passive abduction and passive internal and external rotation of the extended leg can elicit pain that is consistent with an active capsular synovitis (Reider, 1999; Vizniak, 2005. Magee, 2014).

2.4.1.3 Slipped capital femoral epiphysis (SCFE)

This condition is a result of the anterosuperior translation of the femoral metaphysis whilst the femoral epiphysis remains in the acetabular fossa (Peck and Herrera-Soto, 2014). The typical patient is either an overweight adolescent boy, with one or more of groin, thigh and / or knee pain and presenting with a limp (Peck and Herrera-Soto, 2014) or an adolescent that is very athletically active and has undergone a rapid growth spurt (Norris, 2004). This usually presents with anterior hip pain on activity (e.g. running), but usually presents as anteromedial knee pain in younger patients (Hatfield and Baxter, 2012). Peck and Herrera-Soto (2014) and Norris (2004) note that in this condition the patient presents with decreased hip range of movement (flexion, abduction and medial rotation) and the patient usually prefers to hold the limb in external rotation.

2.4.1.4 Tumours of bone around the hip

The most common tumours of the hip include osteoid osteoma, leukemias, solid tumours (primary or metastatic) and / or pigmented villonodular synovitis (Haslett *et al.,* 1999). The pain is usually severe, worse at night and may be accompanied with such signs and symptoms as fever, night sweats and weight loss (Gleberzon, 2001). Although these conditions may provide for significant pain (Gleberzon, 2001), the pain is usually described as “bone pain” or “deep pain” (Haslett *et al.,* 1999) which rarely decreases the range of motion of the hip when assessed passively unless it has led to a pathological fracture (Gleberzon, 2001).

2.4.2 Joint injuries / pathologies

2.4.2.1 Femoro-acetabular impingement and labral tears of the hip

There are a multitude of causes of hip pain in adults, a common cause being femoro-acetabular impingement (FAI). This is known to commonly affect young active patients (Clohissy *et al.,* 2009). It is characterised by the insidious onset of moderate to severe groin and anterior hip pain that is worse for activity (Clohissy *et al.,* 2009). Also closely linked to FAI are acetabular labral tears, which are a source of chronic anterior hip pain that is also activity related and worse on extension (O’Kane, 1999). A study that looked at FAI in 51 patients found that 88% of the patients presented with pain in the affected hip on anterior impingement and that hip flexion was limited on average to 97º and internal rotation was limited to 9º (Clohissy *et al.,* 2009). FAI is caused by one of two deformities in the hip joint: a cam lesion where the head of the femur is not spherically shaped and a pincer deformity, which is caused by excessive acetabular cover (Beck *et al.,* 2004 and Clohissy *et al.,* 2009). These deformities can occur singly or in combination (Clohissy *et al.,* 2009). In this context (associated with labral tears or not) FAI may present with decreased passive range of motion on flexion (Beck *et al.,* 2004) with either internal or external rotation (Hyde and Gengenbach, 2007). These movements may also be associated with clicking or popping and pain during these movements with a firm end feel (Hyde and Genegbach, 2007). It was found that both cam and pincer deformities cause osteoarthritis of the hip and that labral damage rarely occurs without impingement (Beck *et al.,* 2004; Tanzer and Noiseux, 2004). Repetitive FAI has also been shown to result in arthritis of the hip joint, thus its early detection is vital in order to prevent or delay end-stage arthritis (Tanzer and Noiseux, 2004). However, it was found that many patients who do suffer from symptomatic FAI often experience delays in diagnosis due to factors such as insidious onset of symptoms, and other musculoskeletal problems of the pelvis that overlap with the symptoms of FAI (Clohissy *et al.,* 2009). A systematic review of non-operative treatment for FAI was carried out and concluded that although more thorough evaluation is needed in this field, physical therapy and activity modification does show benefit in patients suffering this condition (Wall *et al.,* 2013).

2.4.2.2 Arthritis of the hip (degenerative and arthritis secondary to systemic conditions)

Arthritis of the hip (Haslett *et al.,* 1999) is another common aetiology of hip pain, with osteoarthritis occurring more commonly in patients over 50 years of age while inflammatory arthritis can occur at any age (O'Kane, 1999; Anderson; Strickland and Warren, 2001; Laborie *et al.,* 2011). This condition generally presents initially as intermittent pain with increasing constancy (O'Kane, 1999) and may be described as groin pain, buttock pain, greater trochanter pain and / or anterior thigh pain extending to the knee (Gleberzon, 2001). As the pain becomes more severe and the condition progresses, pain becomes worse on internal rotation and extension of the hip with a progressive loss of range of motion (O'Kane, 1999). The pain is usually worse for significant activity (increased joint irritation and subsequent inflammation), better for moderate activity (assisting the fluid dynamics in the joint) and worse for prolonged inactivity (when fluid accumulates and distends the capsule) (Haslett *et al.,* 1999; Norris, 2004). The movement of the joint is usually limited by pain and / or muscle spasm initially (providing a firm end feel) and later replaced by hard end feel when the range of motion becomes limited by capsular fibrosis, "joint mice" and osteophyte formation (Haslett *et al.,* 1999). Treatment of arthritis of the hip by chiropractors is often high velocity, low amplitude manipulative therapy of the hip itself, mobilisation of the hip joint and stretches (Brantingham *et al.,* 2012). Allopathic treatment of mild osteoarthritis also includes range of motion exercises as well as non-steroidal anti-inflammatory medication, as well as arthroscopic debridement and loose body removal as the condition progresses (Anderson, Strickland and Warren, 2001).

2.4.2.3 Congenital conditions of the hip

These include congenital hip dysplasia, changes in the normal degrees of hip anteversion and retroversion and / or coxa profunda (protrusio acetabuli) amongst others (Reider, 1999; Beck *et al.,* 2004). As an example congenital hip dysplasia generally increases the amount of external rotation of the hip, preventing internal rotation, with a spongy or a hard end feel, dependent on the changes that have occurred in the femoro-acetabular joint and the relationship between the head and shaft of the femur (Reider, 1999), by contrast protrusio acetabuli tends to decrease motions in all directions (Beck *et al.,* 2004).

2.4.2.4 Infections of the hip

These may commonly include Lyme disease, osteomyelitis of femoral head or pelvis, transient synovitis, idiopathic chondrolysis of the hip and chronic recurrent multifocal osteomyelitis and septic arthritis (Haslett *et al.,* 1999). These conditions will present in much the same manner as osteoarthritis of the hip in terms of the changes in the range of motion. The difference in the presenting complaints will be related to the systemic signs and symptoms associated with these conditions that are not present in degenerative disease (e.g. fever) (Gleberzon 2001; Haslett *et al.,* 1999).

2.4.2.5 Osteitis pubis / traumatic aseptic osteitis pubis

Osteitis pubis causes bony erosion of the pubic symphysis and pain over the anterior hip and pubic area (O'Kane, 1999; Anderson, Strickland and Warren, 2001; Norris, 2004). This condition is found more commonly in males than females and there is a higher incidence in athletes (O'Kane, 1999). The patients generally present with decreased hip abduction (due to muscle spasm and shear at the pubic symphysis) (Norris, 2004). A systematic review that looked at 195 athletes who were diagnosed with osteitis pubis found that treatment measures included conservative measures such as manual therapy, local injection with corticosteroids and/or a local anaesthetic, antibiotic therapy, dextrose prolotherapy and, in severe cases, surgery (Choi, McCartney and Best, 2011). A more conservative approach to treatment may include rest, non-steroidal anti-inflammatory medications and moist heat to relieve pain and spasm (Anderson, Strickland and Warren, 2001).

2.4.3 Soft tissue injuries / pathologies

2.4.3.1 Strains and tendonitis

Strains and tendonitis of the muscles surrounding the hip are frequent sources of hip pain (O'Kane, 1999; Anderson, Strickland and Warren, 2001). The muscles most commonly affected are iliopsoas, hamstring muscles (semitendinosus, semimembranosus and biceps femoris), adductor longus, rectus femoris and rectus abdominus (O'Kane, 1999; Anderson, Strickland and Warren, 2001; Hyde and Gengenbach, 2007). Each of these muscles and their associated tendons effect range of motion in the manner outlined in the Table 2.2.

Table 2.2: Motion limitations associated with strains, tendinitis and bursitis

Name of muscle	Action	Limitations of motion when there is a muscle strain/ tendinitis	Associated bursa
Adductor longus	Adduction of the hip	Passive abduction of the hip	
Biceps femoris	Flexes leg at knee joint; extends and externally rotates thigh at hip joint and externally rotates leg at knee joint	Passive knee extension, hip flexion and internal rotation	Ischiogluteal bursa
Iliacus	Flexes the thigh at the hip joint	Passive hip extension	Iliopsoas bursa / iliopectineal bursa
Psoas Major	Flexes the thigh at the hip joint	Passive hip extension	Iliopsoas bursa / iliopectineal bursa
Rectus femoris	Flexes the thigh at the hip joint and extends the leg at the knee joint	Passive hip extension and knee flexion	
Semimem-branosus	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint	Passive hip flexion and knee extension with external rotation	Ischiogluteal bursa
Semiten-dinosus	Flexes leg at knee joint and extends thigh at hip joint; medially rotates thigh at hip joint and leg at knee joint	Passive hip flexion and knee extension with external rotation	Ischiogluteal bursa
		Passive hip adduction with passive flexion and extension (as this frictions the ITB over the greater trochanter)	Trochanteric bursa

Source: adapted from Norris (2004), Hyde and Gengenbach (2007), Drake, Vogel and Mitchell (2015)

Initially, strains and tendonitis should be treated by controlling haemorrhage and oedema by using compressive wraps, ice and rest (Anderson, Strickland and Warren, 2001). This can be followed by gentle range of movement exercises and non-steroidal anti-inflammatory drugs, followed by strengthening and gradual return to activity (Anderson, Strickland and Warren, 2001). Treatment of strains and tendonitis by chiropractors has been shown to be high velocity, low amplitude manipulative therapy of the hip itself, as well as grade IV mobilisation and oscillating mobilisations of the hip (Brantingham *et al.,* 2012).

In a similar manner to the tendinitis presentation, patients presenting with bursitis will present with pain and muscle spasm (of the muscle associated with the bursa e.g. iliopsoas bursa and iliopsoas muscle). Therefore, the limitations of motion when there is a muscle strain or tendinitis will also be the passive stretch position of the muscle (see Table 2.2).

2.4.4 Hernias

Inguinal and femoral hernias are recurrent causes of anterior hip pain, however, it has been found that so too are “non-palpable”, or as they are also known, “sports” hernias (O’Kane, 1999; Anderson, Strickland and Warren, 2001; Norris, 2004). Sports hernias are usually caused by a tear in one of the muscles of the groin as a result of a sudden twisting movement and or as a result of lifting heavy objects (Norris, 2004). These patients present with chronic, activity-related hip and/or groin pain (O’Kane, 1999). The pain is usually associated with the anterior hip, along the inguinal ligament and into the groin, which is worsened by closing the angle between the hip and the torso (i.e. hip flexion) and provides for a spongy end feel that is painful (Norris, 2004). It is recommended by the European Hernia Society that mild hernias are “treated” via watchful waiting and that more severe, symptomatic or strangulated hernias be treated surgically (Simons *et al.,* 2009).

2.4.5 Nerve entrapment

Although nerve entrapment represents a fairly small portion of causes of hip pain, it is nonetheless to consider in order to ascertain a definitive diagnosis and treatment plan (McCrory and Bell, 1999). Nerve entrapment presents with pain and/or numbness to the affected distribution of the nerve that is involved (O’Kane, 1999; Anderson, Strickland and Warren, 2001; Morris, 2006). Although pain in and around the femoro-acetabular joint may be caused by radicular pain arising from the spinal cord (central canal stenosis), the lumbar nerve roots (lateral canal stenosis, dynamic entrapment, Maigne’s syndrome), peripheral entrapment (piriformis syndrome and referred pain from various spinal structures (e.g. myofascial trigger points in muscles related to the low back and pelvis)) (McCrory and Bell, 1999; Chaitow and DeLany, 2000; Morris, 2006; Kim *et al.,* 2013). The peripheral nerves most commonly involved in true nerve entrapment affecting the hip are the obturator nerve (often caused by adductor muscle overdevelopment) (Anderson, Strickland and Warren, 2001) and the lateral femoral cutaneous nerve (branch of the femoral nerve) (often caused by entrapment under the inguinal ligament and / or tight clothing) (Cheatham, Kolber and Salamh, 2013).

Other nerves that may be affected causing anterior hip pain include the iliohypogastric nerve, the ilioinguinal nerve (Kuniya *et al.,* 2014), the genitofemoral nerve and the femoral nerve (McCrory and Bell, 1999; Cheatham *et al.,* 2013).

The range of motion in these patients is limited dependent on the nerve involved, for example the entrapment of the lateral femoral cutaneous nerve usually results in limited extension and external rotation whereas the entrapment of the cluneal nerves (in Maigne's syndrome) may result in a decrease in hip extension (causing low back pain) and hip flexion (causing increased hip pain) (Kuniya *et al.,* 2014)

Treatment of these conditions may involve spontaneous resolution, analgesics and other neuropathic medications, injection of local anaesthetic or corticosteroids and in severe cases surgical exploration to find any local compressive lesions (McCrory and Bell, 1999).

2.4.6 Athletic injuries

Athletic injuries can occur in the hip. Although they are less frequent than athletic injuries at the more distal lower extremities, they often require extensive rehabilitation time. Epidemiologic studies have shown that injuries to the hip region make up approximately 5% to 9% of high school athletic injuries (Anderson, Strickland and Warren, 2001). In soccer, groin injury / hip pointers account for as much as 5 to 13% of all injuries (Choi, McCartney and Best, 2011). These injuries may be associated with contusions of the superficial soft tissue and / or the underlying bone as well as avulsion fractures of the structures around the hip (Hyde and Gengenbach, 2007). These types of injuries tend to restrict motion dependent on the muscle attachment to the site of the injury, for example a contusion of the anterior superior iliac spine will limit the degree of hip extension and internal rotation due to pain.

Chronic hip pain has been shown to make up 10% of all sport-based injury visits to sports medicine practices worldwide; however, due to a lack of scientific evidence for the various pathological causes of hip pain, clinicians are often frustrated by this condition (McCrory and Bell, 1999). Therefore, an accurate diagnosis and a well put-together treatment plan are vital (Anderson, Strickland and Warren, 2001).

2.4.7 Other conditions of the abdomen that may cause hip pain

These include common conditions such as appendicitis or abdominal/pelvic abscess (psoas abscess), but may also extend to conditions such as ovarian cysts, uterine, bladder, prostate or rectal dysfunction (Travell and Simmons, 1983; Chaitow and DeLany, 2000). The restrictions of motion in the hip will be directly related to the muscles affected by the condition (for example, appendicitis or psoas abscess are intimately related to the psoas muscle) (Moore, Dalley and Agur, 2010). Thus an attempt to extend, internally rotate and / or abduct the hip will be met with resistance due to muscle spasm of the psoas muscle (Haslett *et al.,* 1999).

2.5 Manual palpation

2.5.1 Definition of manual palpation

Motion Palpation: "The manual palpation of bony structures and soft tissues through applied pressure, applied in various directions of joint motion to ascertain areas of joint hypo- or hyper-mobility" (Schafer and Faye, 1990; Redwood and Cleveland, 2003; Bergman and Peterson, 2011; Triano *et al.,* 2013).

The purpose of manual palpation is to determine the clinical outcomes related to the PARTS evaluation of the patient (Hyde and Gengenbach, 2007; Brantingham *et al.,* 2010; Bergmann and Peterson, 2011):

- Pain – location, quality, character and intensity.
- Asymmetry qualities of structure and function.
- Range of motion:
    - Neutral – joint play, which is defined as the "discrete, short-range movements of joints independent of the action of voluntary muscles,

determined by springing each vertebra / joint in the neutral position." (Bergmann and Peterson, 2011);

  - Active range of motion;
  - Passive range of motion; and
  - End feel, which is defined as the "discrete, short-range movements of joints independent of the action of voluntary muscles, determined by springing each vertebra / joint at the limit of its passive range of motion." (Bergmann and Peterson, 2011).
- Tone, texture and temperature of the skin and underlying soft tissues.
- Special tests, which include orthopaedic evaluations, muscle tests and specific tests applied by manual therapists.

2.5.2 Characteristics of motion palpation

Within the manual palpation sequence, motion palpation (MP) is a technique that specifically evaluates range of motion in relation to specific anatomical landmarks, joint play and end feel. In the case of range of motion, this is specifically applied to the sacroiliac joints (Hyde and Gengenbach, 2007). Therefore, in this this study only joint play and end feel were used to detect changes in joint movement in a variety of different patients. Figure 2.4 indicates at what point in the range of motion joint play and end feel are assessed.

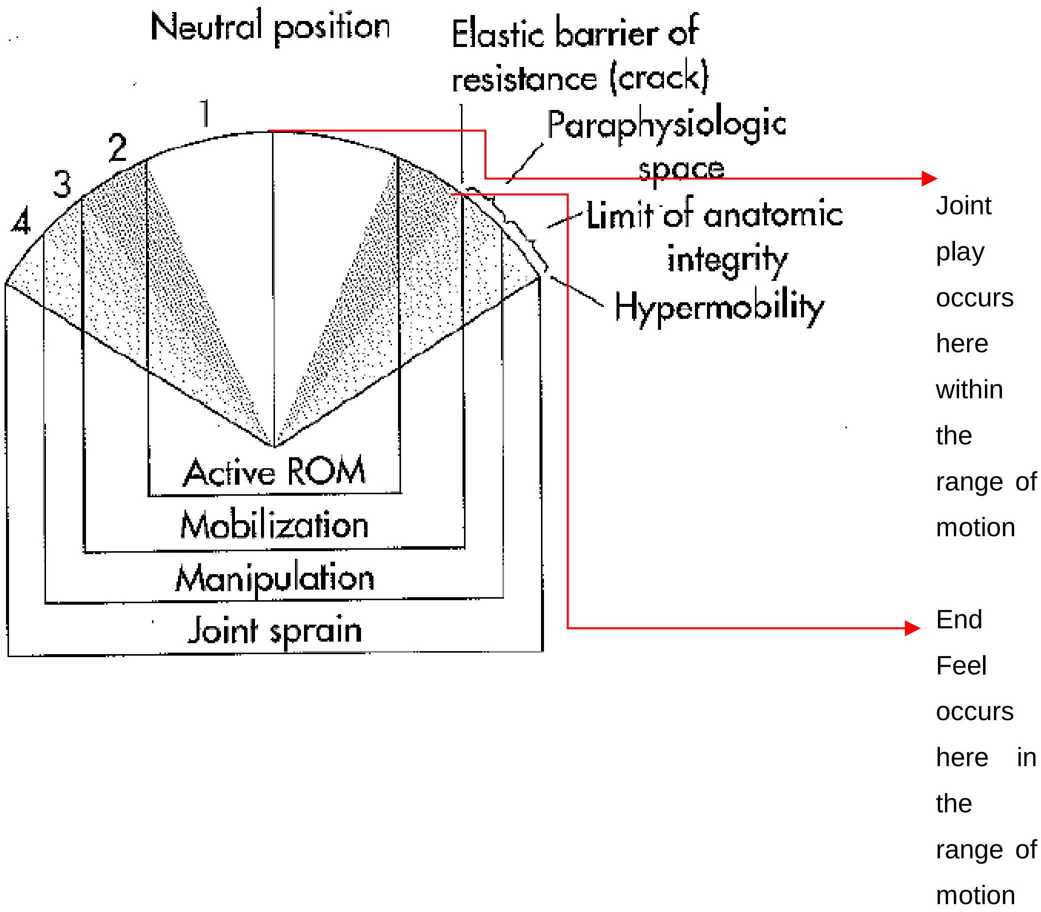


Figure 2.4: Degrees of joint motion
Source: Gatterman (1995)

Thus, it can be seen that MP is used to identify the site and characteristics of altered joint motion both in the neutral and end range of motion positions of the joint (Schafer and Faye, 1990; Redwood and Cleveland, 2003; Bergmann and Peterson, 2011). Assessing joint play and end feel are described by Bergmann and Peterson (2011) as being performed by having the patient sitting or lying in a relaxed position while the examiner steadies the joint being assessed and carries out a particular set of involuntary movements, and then may further feel for accessory joint movement, noticing the small "give" or "play" within a joint, whilst feeling for any resistance to the "end feel" (Schafer and Faye, 1990; Bergmann and Peterson, 2011).

Whilst performing these procedures the examiner feels for the quality and quantity of motion as well as one or more of the characteristics outlined in Table 2.3.

Table 2.3: Characteristics of motion palpation

Characteristic	Description
Bogginess	Here the tissue texture is abnormality characterized by a palpable sense of sponginess in the tissue, which is interpreted as resulting from congestion associated with an increase in fluid accumulation in the area being palpated.
Bony end feel	Here there is blocking to normal motion, at the start of range of motion, during the range of motion or at the end of range of motion (Leach, 2004). Also see hard end feel.
Distortion	Here there is a mechanical departure from the “ideal” or normal symmetry in the body motion when the motion is compared to a similar joint (e.g. opposing limbs) or a different level with similar joints (spine).
Elastic end feel	Tissue stretch as found with external rotation of the shoulder (Norris, 2004).
Elasticity	Here reference is made to the property of a structure to return to its normal length or form after removal of the deforming load. This may be interpreted as a “springy end feel” where for example there is muscle approximation, or the examiner is testing ligamentous plasticity or viscoelastic properties of the soft tissues.
Empty end feel	This is when the patient stops the motion due to apprehension in anticipation of pain or instability (Norris, 2004). Also refer to lack of end feel or instability.
End feel	This describes what the examiner manually feels at (end of active range of motion) or just beyond the voluntary range of motion (end of passive range of motion).
Gliding	Where the joint surfaces move past one another freely.
Hard end feel	Bone on bone approximation (for example elbow extension or bony degeneration) (Norris, 2004).
Instability	Where the quality of the movement is unstable, infirm, not fixed or fluid. Usually it is referred to as a “lack of end feel”. An example is when a ligament has been torn and the joint no longer has stability.
Joint play	This assessment done during motion palpation provides information on the passive flexibility of the motion segment.
Lack of end feel	Refer to instability.
Spastic end feel	This is associated with muscle spasm that is involuntary – usually as a result of a painful / irritated joint (Norris, 2004).
Springy end feel	This is associated with mechanical joint displacement where there is a loose body in the joint or a meniscal tear (Norris, 2004). Also refer to elasticity.
Ropiness or ropy end feel	This is when a tissue texture is characterized by a cord-like or string-like feeling when palpating over it.
Soft end feel	Soft tissue approximation as found in elbow flexion (Norris, 2004).
Stiffness:	This is a subjective measure of resistance that is provided against external load applied by the examiner (as the tissue is deformed). This may occur in patients with degenerative changes where movement has become limited but not blocked.
Stringiness	This is a palpable tissue texture similar to ropiness but of a finer texture.

Source: (Adapted from Schafer and Faye (1990). Chaitow and DeLany (2000), Bergmann and Peterson (2011)

This information is then reported in terms of limited / restricted, excessive / unstable, aberrant or normal motion (Triano *et al.,* 2013). For the hip joint specifically, joint play consists of the following motion palpation parameters: supine long axis distraction, supine anterior to posterior glide, supine posterior to anterior glide (the latter may also be able to be applied in the prone position) and supine medial to lateral distraction (Hyde and Gengenbach, 2007). By contrast the end feel is assessed by means of supine superior to inferior glide with the hip at 90º degrees, supine external rotation of the hip (with the hip at 90º), supine internal rotation of the hip (with the hip at 90º) as well as hip adduction and abduction in the supine position (Hyde and Gengenbach, 2007).

2.5.3 Clinical usefulness of motion palpation as a tool

As a result of the characteristics of MP, Walker and Buchbinder (1997) described MP as a tool, commonly used by chiropractors and other manual therapists, to detect the need for particular forms of intervention (e.g. manipulation), particularly as manipulation has been found to be effective and appropriate for a range of musculoskeletal pain syndromes (Bergmann and Peterson, 2001; Brantingham *et al.,* 2010; Dagenais and Haldeman, 2012; Brantingham *et al.,* 2012).

Notwithstanding that MP has been utilised to determine the location for manipulative procedures for many decades (Basmajian and Nyberg, 1993) and that patients have had beneficial outcomes to manipulation based on the MP assessment (Bergmann and Peterson, 2001; Brantingham *et al.,* 2009; Dagenais and Haldeman,2012; Brantingham *et al.,* 2012); it is still important for these evaluation tools to be appraised in terms of their reliability, validity and responsiveness to improve the practitioners ability to accurately contextualise the outcome of the MP findings in the patient's specific situation (Liebenson and Lewit, 2003; Leach, 2004; Hyde and Gengenbach, 2007). In order to accomplish this, motion palpation, like any other diagnostic tool, is required to be assessed repeatedly in order for the practitioner to be able to know and understand its function, its ability to be accurate as well as its limitations (Leach, 2004; Hyde and Gengenbach, 2007). As a result, the practitioner is accurately and ethically be able to assess and treat patients according to the highest clinical standards possible (Leach, 2004; Hyde and Gengenbach, 2007; Dagenais and Haldeman, 2012). This is achieved by applying criteria that have been developed for the assessment of various clinical / diagnostic tools (Yeomans, 2000), in order to be able to provide the required assessment of the diagnostic tool.

The evaluation criteria for any diagnostic procedure (including motion palpation) are outlined in Table 2.4.

Table 2.4: Evaluation criteria for diagnostic procedures

Criteria		Definition
Accuracy	This is defined as the degree to which measured outcomes reflect the true value of the variable / outcome being tested and includes the concepts of sensitivity, specificity and predictive value.	
	Sensitivity	This is the ability of the procedure to "rule out" a particular condition, in order to identify patients with a particular condition (true positives); or the ability of a diagnostic procedure to detect a disease / condition in a patient.
	Specificity	This is the ability of the procedure to "rule in" a particular condition, in order to identify patients without a particular condition (true negatives) or the ability of the diagnostic procedure to avoid giving positive results falsely.
	Predictive value	Positive predictive value asserts that the diagnostic tool has the likelihood of a positive result being a true positive outcome and a negative predictive value asserts that the diagnostic tool has the likelihood of a positive result being a true negative outcome.
Clinical Utility	Indicates that the diagnostic procedure has associated health care benefits that are provided because of the use of the procedure.	
Reliability	This is often referred to as the ability of a diagnostic procedure to consistently provide the same outcome in terms of repeatability and precision. There are two types of reliability: intra-rater and inter-rater reliability:	
	Intra-rater	This is the ability of the same examiner to repeatedly apply the same tool and consistently reach the same results each time the rater measures a particular subject.
	Inter-rater	The ability of more than one person to be able to reach the same outcome post measurement.
Responsiveness	This is the ability of the diagnostic procedure to respond to changes in the condition and show progression or regression of the patient's condition over time or pre-post an intervention.	
Test Utility	This means that the diagnostic procedure presents practical usefulness.	
Validity	This is determined by the accuracy with which the diagnostic procedure evaluates what it is intended to or the degree to which a particular measure serves its purpose. Validity consists of face validity, construct validity, criterion validity, predictive validity, concurrent validity (convergent validity or divergent validity), discriminative validity and social validity.	
	Concurrent validity	This means that a tool has the ability to be compared with another tool that has a similar outcome that it measures (convergent validity) or that the tool has the ability to be compared with another tool that is dissimilar (divergent validity).
	Construct validity	This form of validity attempts to measure the accuracy of the procedure in measuring a particular construct when a known gold standard is not available and the tool can only be measured against a theoretical model / construct.
	Criterion / content validity	This form of validity requires that the diagnostic procedure is tested against a gold standard. This is however not possible with manual therapy diagnostic procedures as there are no gold standard assessments against which motion palpation can be tested.
	Discriminative validity	This means that the diagnostic tool should not correlate with another unrelated diagnostic tool.
	External validity	This refers to our ability to generalise the outcomes of the study.
	Face validity	This form of validity is based on logic and "biologic reasonableness" that on the "face" of it, the tool (motion palpation) seems plausibly able to assess the construct (joint).
	Internal validity	This is when it can be demonstrated that that the intervention was the true cause for the changes observed by the tool used to measure it.
	Predictive validity	This is the ability of a particular tool to be able to predict something that associated with what it measures
	Social validity	This looks at whether the tool measures something that should be measured in patients and that this measurement actually produces a benefit for the patient.

Source: Najm *et al.* (2003), Leach (2004), Morris (2006), Bergmann and Peterson (2011), Dagenais and Haldeman (2012)

Based on the criteria above, studies have been completed to determine various aspects of reliability and validity in terms of motion palpation. An outline of the studies is presented in Table 2.5.

Table 2.5: Previous studies on inter- and intra-examiner reliability

Reference	Region	Inter or Intra-examiner reliability	Country	Private clinic/ University	No. of Partici-pants	Symptomatic / asymptomatic	Exam-iner numb-er	Examiner occupation	Examiner experience	Degree of Reliability	Findings
Arab *et al.* (2009)	Sacro-iliac	Inter and Intra	Iran	University	25	Symptomatic	2	Physical therapist	1 year	Moderate to substantial	K = 0.36 - 0.84
Binkley, Stratford and Gill (1995)	Lumbar	Inter	Canada	Private Clinic	18	Symptomatic	6	Physical therapist	> 6 years	Slight	K = 0.09 ICC = 0.25(CI, 0-0.39
Brismee *et al. (*2006)	Thoracic	Inter	United States of America	University	43	Asymptomatic	3	Physical therapist	≥ 12 years	Fair to substantial	K = 0.27 - 0.65 % = 63 - 83
Carmichael (1987)	Sacro-iliac	Inter	United States of America	University	53	Asymptomatic	10	Chiropractor	Students	Slight	K = -0.07 - 0.33 % = 60 - 90
Christensen *et al.* (2002)	Thoracic	Inter and Intra	Denmark	University	56 29	Both	2	Chiropractor	"experienced"	Inter: Fair Intra: Moderate to substantial	K = 0.22 - 0.24
Comeaux *et al.* (2001)	Cervical and Thoracic	Inter	United States of America	University	54	Asymptomatic	3	Osteopath	> 10 years	Slight to moderate	K = 0.12 - 0.56
Cooperstein, Haneline and Young (2010)	Thoracic	Inter	United States of America	University	52	Asymptomatic	2	Chiropractor	> 20 years	Good	ICC = 0.3110 - 0.8266
Cooperstein, Young and Haneline (2013)	Cervical	Inter	United States of America	University	29	Asymptomatic	3	Chiropractor	2: >20 years 1: 3 years	Good	ICC = 0.61
Degenhardt *et al.* (2005)	Lumbar	Inter	United States of America	University	119	Asymptomatic	3	Osteopath	< 10 years	Slight	K= 0.20 % = 66
Downey, Taylor and Niere (2003)	Lumbar	Inter	Australia	University	20	Symptomatic	6	Physical therapist	7-15 years	Fair to moderate	K= 0.23 - 0.54
Fjellner *et al.* (1999)	Cervical and Thoracic	Inter	Sweden	University	47	Symptomatic	2	Physical therapist	6 & 8 years	Slight	Kw= 0.01 - 0.18 % = 60 - 87
Flynn *et al.* (2002)	Sacro-iliac	Inter	United States of America	University	71	Symptomatic	8	Physical therapist	"experienced"		K = -0.08 -0.59
Fryer, McPherson and O'Keefe (2005)	Pelvis	Inter and Intra	Australia	University	10	Asymptomatic	10	Osteopath	Students	Poor	Kw = -0.01 - 0.31
Gonella, Paris and Kutner (1982)	Lumbar	Inter	United States of America	University	5	Asymptomatic	5	Physical therapist	≥ 3 years	Inter: Unacceptabl e	Visual inspection of raw data

Table 2.5 Previous Studies on Inter- &/ Intra-examiner reliability continued

Reference	Region	Inter or Intra-examiner reliability	Country	Private clinic/ University	No. of Partici-pants	Symptomatic/ asymptomatic	Exam-iner numb-er	Examiner occupation	Examiner experience	Degree of Reliability	Findings
Hanten, Olson and Ludwig (2002)	Cervical	Inter and Intra	United States of America	University	40	Symptomatic	2	Physical therapist	"experienced"	Inter: None to almost perfect Intra: Fair to almost perfect	K = -0.71 - 0.86 % = 70 - 95
Hicks *et al.* (2003)	Lumbar	Inter	United States of America	Private Clinic	63	Symptomatic	3	Physical therapist	4 - 8 years	None to slight	Kw = -0.02 - 0.26 % = 52 -69
Horneij *et al.* *(*2002)	Thoracic	Inter and Intra	Sweden	Private Clinic	84	Symptomatic	3	Physical therapist	18-25 years	Inter: Acceptable Intra: Acceptable	K= 0.40
Humphreys *et al.* (2004)	Cervical	Inter	Canada	University	3	Symptomatic	20	Chiropractor	4th years students	Moderate to substantial	K= 0.46 - 0.76
Hungerford *et al.* (2007)	Pelvis	Inter	Australia	Private Clinic	33	Symptomatic	3	Physical therapist	Average 14.7 years	Good	K = 0.67 - 0.77 % = 89.9 - 91.9
Johansson (2006)	Lumbar	Inter	Sweden	University	20	Symptomatic	3	Physical therapist	Students	Poor	Kw = <0.20 - 0.40
Keating *et al.* (1990)	Lumbar	Inter	United States of America	University	46	Both	3	Chiropractor	2.5 years	None to fair	K = -0.15 - 0.31
Love and Brodeur (1987)	Thoracic and Lumbar	Inter and Intra	United States of America	University	32	Asymptomatic	8	Chiropractor	Students	Inter: Inconclusive Intra: Inconclusive	r = 0.01 - 0.49 r = 0.02 - 0.65
Maher and Adams (1994)	Lumbar	Inter	Australia	Private Clinic	90	Symptomatic	6	Physical therapist	≥ 5 years	Poor to fair	ICC = -0.4 - 0.73 % = 13 - 43
Maher, Latimer and Adams (1998)	Lumbar	Inter	Australia	University	40	Asymptomatic	5	Physical therapist	≥ 5 years	Fair to good	ICC = 0.50 - 0.77 SEM = 0.72 - 1.58
Marcotte *et al.* (2002)	Cervical	Inter	Canada	University	3	Asymptomatic	25	Chiropractor	1:"experienced" 24: Students	Moderate to substantial	K = 0.6 - 0.8
Marcotte *et al.* *(*2005)	Cervical	Inter	Canada	University	3	Asymptomatic	24	Chiropractor	1 "experienced" 24 Students	Moderate to substantial	K = 0.7 - 0.75
McPartland and Goodridge (1997)	Cervical	Inter	United States of America	University	18	Both	2	Osteopath	≥ 10 years	Fair	K = 0.34 % = 66,7

Table 2.5 Previous Studies on Inter- and Intra-examiner reliability continued

Reference	Region	Inter or Intra-examiner reliability	Country	Private clinic/ University	No. of Partici-pants	Symptomatic / asymptomatic	Exam-iner numb-er	Examiner occupation	Examiner experience	Degree of Reliability	Findings
Meijne *et al.* (1999)	Sacro-iliac	Inter	The Netherlands	University	38	Both	2	Physical therapist	Students	Poor to substantial	K = -0.30 - 0.75 % = 48 - 100
Mior *et al.* (1985)	Cervical	Inter and Intra	Canada	University	59	Asymptomatic	2	Chiropractor	Students	Inter: None - to slight Inter: None - to slight	K = 0.15 % = 61
Nansel *et al.* (1989)	Cervical	Inter	United States of America	University	270	Asymptomatic	4	Chiropractor	3 "experienced" & 1 student	Almost none	K = 0.01 % = 45.6 - 54.3
Olson *et al.* (1998)	Cervical	Inter and Intra	United States of America	University	10	Asymptomatic	6	Physical therapist	≥ 4.5 years	None to slight	K = -0.04 - 0.12
Paydar, Thiel and Gemmel (1994)	Sacro-iliac	Inter and Intra	United Kingdom	Private Clinic	32	Asymptomatic	2	Chiropractor	Students	Inter: Fair Intra: Fair	K = 0.09 % = 34.4
Phillips and Twomey (1996)	Lumbar	Inter	United Kingdom	University	72	Both	2	Physical therapist	Not Indicated	None to fair	Kw = -0.15 - 0.32 % = 55 - 99
Piva *et al.* (2006)	Cervical	Inter	United States of America	University	30	Symptomatic	2	Physical therapist	2 years & 10 years	Fair	K = 0.25 - 0.91
Potter and Rothstein (1985)	Sacro-iliac	Inter	United States of America	University	17	Symptomatic	8	Physical therapist	2 - 18 years	Poor	% = 23 - 90
Potter, McCarthy and Oldham (2006)	Lumbar	Intra	United Kingdom	University	12	Asymptomatic	8	Physical therapist	> 2 years	Poor	ICC = 0.96
Robinson *et al.* (2007)	Sacro-iliac	Inter	Norway	University	61	Both	2	Physical therapist	Average 5.8 years	Poor	K = -0.06 % = 48
Schneider *et al.* (2008)	Lumbar	Inter	United States of America	Private Clinic	39	Symptomatic	2	Chiropractor	10 and 25 years	Poor to fair	K = -0.20 - 0.17
Smedmark, Wallin and Arvidsson (2000)	Cervical	Inter	Sweden	Private Clinic	61	Symptomatic	2	Physical therapist	> 25 years	Fair to moderate	K = 0.28 - 0.43 % = 70-87
Strender, Lundin and Nell (1997)	Cervical	Inter	Sweden	University	50	Both	2	Physical therapist	≥ 21 years	Poor	K = 0.06 - 0.15 % = 26 - 44
Strender *et al.* (1997)	Lumbar	Inter	Sweden	University	71	Symptomatic	4	2 Medical Doctors & 2 Physical therapists	"experienced"	Poor	K = -0.08 - 0.75 % = 48 - 88
Tong *et al.* (2006)	Sacro-iliac	Inter	United States of America	University	24	Symptomatic	4	Osteopath	Not Indicated	Slight to moderate	Stork test: K = 0.27 - 0.50 Flexion Tests: K = 0.06 - 0.30

Table 2.5 Previous Studies on Inter- and Intra-examiner reliability continued

Reference	Region	Inter or Intra-examiner reliability	Country	Private clinic/ University	No. of Partici-pants	Symptomatic / asymptomatic	Exam-iner numb-er	Examiner occupation	Examiner experience	Degree of Reliability	Findings
Van Suijlekom *et al.* (2000)	Cervical	Inter	The Netherlands	University	24	Symptomatic	2	Medical Doctor	Not Indicated	Low to medium	K = 0.27 - 0.46
Vincent-Smith and Gibbons (1999)	Sacro-iliac	Inter	Australia	University	9	Asymptomatic	9	Osteopath	≥ 4 years	Poor	K = 0.013 - 0.09 % = 34 - 50
Walker *et al.* (2015)	Thoracic	Inter	Australia	University	25	Asymptomatic	2	Chiropractor	"experienced"	Poor	K = -0.27 - 0.36
Wiles (1980)	Sacro-iliac	Inter	Canada	University	46	Asymptomatic	8	Chiropractor	Average 2.75 years	Slight to moderate	r = 0.13 - 0.43 % = 47 - 64
Zitto, Jull and Story (2006)	Cervical	Intra	Australia	University	77	Both	1	Physical therapist	"experienced"	Substantial to almost perfect	K = 0.78 - 1.0

K = Kappa; Kw = Weighted Kappa; % = percent agreement; r = Pearson's correlation; ICC = Intraclass correlation coefficient

The following section attempts to summarise the known information on motion palpation and inter- and intra-examiner reliability.

2.5.4 Inter and intra-examiner reliability

In previously published literature reviews on spinal motion palpation, it was reported that there had been poor reproducibility of spinal palpation in the past, with severe criticism being made of studies for many reasons (Stochkendahl *et al.,* 2006; Haneline *et al.,* 2009). Some of these criticisms included the use of asymptomatic patients, inexperienced examiners, weak description of the results of the studies, and even the use of Cohen's Kappa, which is the most commonly used statistical tool in reproducibility studies (Stochkendahl *et al.,* 2006 Haneline *et al.,* 2009; Triano *et al.,* 2013). In the Stochkendahl *et al. (*2006) systematic review, it was found that in all 48 studies that met the inclusion criteria, inter-examiner reliability was reported and in 19 of the 48 studies, intra-examiner reliability was also reported, with intra-examiner reliability being consistently higher (Stochkendahl *et al.,* 2006). By contrast, the studies of Jull *et al.* (1988) and Leboeuf *et al.* (1989) showed good reliability. Thus there is evidence supporting clinically acceptable reproducibility for intra- and inter-examiner spinal motion palpation (Stochkendahl *et al.,* 2006). Nevertheless, the reliability of motion palpation is generally poor to fair (van Trijffel *et al.,* 2005; Stochkendahl *et al.,* 2006).

In terms of the outcomes of the studies represented in Table 2.5 and the above discussion, it can be seen that, in general, motion palpation has poor sensitivity, fair specificity and a poor positive predictive value in the context of spinal motion palpation, with fewer studies representing positive outcomes than negative ones. This generalisation however does have some limitations in that the studies represented in Table 2.5 are variable in terms of the palpatory test(s) used, the terminology and its definitions, the research designs, the methods as well as the statistical analyses employed (Najm *et al.,* 2003).

Further to this, systematic reviews conducted on motion palpation suggested that whilst there have been many inter-examiner reliability studies published on motion palpation of spinal joints, there has been little research done on the inter-examiner reliability in the MP of the joints of the lower extremities (van Trijffel *et al.,* 2005; Haneline *et al.,* 2009; Triano *et al.,* 2013). This can also be seen in Table 2.5 which reports on known motion palpation studies. There have, however, been unpublished studies conducted at the Durban University of Technology on motion palpation of the ankle (Belling, 2011) foot joints (Williams, 2010), the tibio-femoral joint (Farrimond, 2010) and the patellofemoral joint (Vaghmaria, 2006).

Farrimond (2010) conducted a study on inter-examiner reliability of the tibio-femoral joint in patellofemoral pain syndrome and asymptomatic knees and hypothesised that there would be inter-examiner reliability of motion palpation of tibio-femoral joints with patellofemoral pain syndrome. This study found that the Kappa scores of the symptomatic knee ranged from 0.2081 to 0.1802 (Farrimond, 2010). A kappa score below 0.2 indicates poor agreement, thus most of these scores show poor reliability of motion palpation in symptomatic patients with patella-femoral pain syndrome (Farrimond, 2010). Farrimond (2010) also hypothesised that there would be inter-examiner reliability of motion palpation of the asymptomatic knees. The Kappa scores for motion palpation of the asymptomatic knee ranged from -0.2836 to 0.0339, which again shows fair to poor agreement for motion palpation of the asymptomatic knees (Farrimond, 2010). The Kappa results when comparing motion palpation of an asymptomatic vs a symptomatic knee joint were below -0.0714, which indicated little difference in terms of agreement on the presence of particular motion palpation findings between the asymptomatic and symptomatic joints (Farrimond, 2010).

Williams' (2010) study on inter-examiner reliability of motion palpation to detect joint dysfunction in the mid- and hind-foot joints found that kappa values ranged from poor to almost perfect on the symptomatic foot, with a mean Kappa of 0.267, which indicated fair agreement. On the asymptomatic foot, Kappa values ranged between 0.250 and 0.318, with a mean value of -0.248 indicating poor inter-examiner reliability of MP (Williams, 2010). In comparison, the inter-examiner reliability of motion palpation between symptomatic and asymptomatic feet proved to be better in symptomatic feet (Williams, 2010).

Vaghmaria (2006) studied motion palpation of the patella and found it to be reliable, with a mean Kappa value of 0.231 in participants with patellofemoral pain syndrome, which was deemed as “fair”. It is interesting to note that Vaghmaria (2006), Manley

(2010) and Williams (2010) agreed that intra- and inter-examiner findings were more reliable in the symptomatic participants compared to the asymptomatic participants. Thus, despite contradictory evidence shown by Liebenson (1999), it is important for motion palpation of the hip joint to be investigated to determine whether or not current motion palpatory techniques are valid, reliable and reproducible.

A study testing the inter-examiner reliability of orthopaedic tests for the hip joint was carried out by Martin and Sekiya (2008), who tested the FABER test, the log roll test, the flexion-internal rotation-adduction impingement test and the test for greater trochanter tenderness in patients with musculoskeletal hip pain. They determined that the inter-examiner reliability for these tests showed moderate to substantial agreement with kappa values ranging from 0.58 to 0.67 (Martin and Sekiya, 2008). It was stated that there is little information available that allows for the interpretation of clinical examination of patients who present with musculoskeletal hip pain (Martin and Sekiya, 2008).

Another inter- and intra-examiner reliability study tested goniometric readings obtained by physiotherapists and visual estimates provided by an orthopaedic surgeon (Holm *et al.,* 2000). This study found that there was no statistical difference between the first and second readings – i.e. intra-examiner testing was reliable (Holm *et al.,* 2000). They also found that the agreement was high between the visual estimates and the goniometric readings (Holm *et al.,* 2000). The outcomes of the studies by Holm *et al. (*2000), Vaghmaria (2006), Martin and Sekiya (2008), Williams (2010), Manley (2010), Farrimond (2010) and Belling (2011) seem to agree with the suggestions by Chesworth *et al.* (1998), where these authors suggested that there is a greater likelihood for agreement in motion palpation of extremity joints as compared to spinal joints (Table 2.5).

2.5.5 Factors affecting the assessment of reliability

2.5.5.1 Factors decreasing reliability

Publications by Wolff and Lonquich (2000) and Liebenson and Lewit (2003) suggested that one reason for the variance in reliability of motion palpation is the fact that both active and passive ranges of motion are constantly changing. This is indirectly supported by Bergmann and Peterson (2011), who indicate that mobilisation is a "passive rhythmic graded movement of controlled depth and rate to a particular joint". If motion palpation as an activity can be defined as having similar characteristics, it is possible that it too will allow for a change in movement changes in the joint between different examiners assessing the same joint and between assessments of the same joint by the same examiner. This would decrease the reliability within a study (Huijbregts, 2002).

Another variable to consider is that smaller joints have lower motion variance and therefore a greater likelihood for decreased reliability as compared to joints with larger ranges of motion, which have greater variance and therefore a greater likelihood for increased reliability, as discernment of the point of restriction is easier. For example, this assertion would be true when comparing reliability of spinal motion palpation to shoulder motion palpation (Chesworth *et al.,* 1998).

It has been suggested that the variance in patient presentation for any condition increases the likelihood that any one diagnostic tool (e.g. motion palpation) is not going to produce a highly valid result; therefore decreasing the reliability of the diagnostic tool (e.g. motion palpation) (Huijbregts, 2002).

The patient physique is another factor that can influence the motion palpation and affect its reliability. With decreased ability to palpate the bony landmarks in a patient, the greater the difficulty in being able to assess normal ranges of motion let alone motion palpation parameters (Huijbregts, 2002); thereby decreasing reliability.

Utilising patient pain as a marker or response during motion palpation may decrease reliability, as relying too heavily on pain or tenderness has been shown to result in false positive findings (Jull, Treleaven and Versace, 1993; Jull, Treleaven and Versace, 1994).

There may also be a disjuncture between the examiner palpating the correct level (i.e. correctly identifying it) and then reporting the correct level (Huijbregts, 2002). This may increase intra-examiner reliability, but decrease the inter-examiner reliability (Leboeuf *et al.,* 1989; Huijbregts, 2002).

Having patients assume different positions (seated, supine, prone or standing) when being assessed will provide for differences in the loading of joints, thereby result in differences in the resultant motion palpation findings (Byfield, 2010; Cooperstein and Young, 2014).

It has been argued by some authors that the experience of the chiropractor is important as the practitioner is likely to have developed his / her palpation skills or “palpatory literacy” (Chaitow, 1991; Chaitow and DeLany 2000; Nyberg and Smith, 2013). This assumes that the more experienced the practitioner the greater their ability to improve the reliability of the diagnostic tool (motion palpation). This assertion has however been contested by the results obtained in the studies by Mior *et al.* (1990) and Hansen, Simonsen and LeBoeuf-Yde *(*2006) which suggested that the younger, more inexperienced chiropractor attained better results and improved the motion palpation reliability scores. “Idiosyncratic behaviour” of experienced practitioners may affect reliability (Huijbregts 2002). Nyberg and Smith (2013) have suggested that increasing age may negatively affect fingertip conformation, usage or mobility, the practitioner’s attention to the task and / or the frequency with which the practitioner palpates patients, thereby potentially negating the positive effects of experience. This may explain the contradictory findings when looking at examiner experience / age.

The use of the incorrect statistical analysis once the data sets from the motion palpation have been gathered. This reduces the reliability measures according to Huijbregts (2002) and Cooperstein and Young (2016).

2.5.5.2 Factors increasing reliability

Reliability is further influenced by whether the examiners in the study, worked together (Strender *et al.,* 1997) or trained together (Gerwin *et al*., 1997; Chesworth *et al.,* 1998; Sciotti, 2001) or were familiar with each other's manner of assessment (Gerwin *et al*., 1997; Sciotti, 2001; Huijbregts, 2002). The greater the degree of familiarity, the greater the likelihood for the reliability to increase; the converse would be true of examiners that did not know each other.

Some authors suggest that no individual test should be discarded on the basis of the lack of validity or reliability but that it should be incorporated into a battery of tests (Erhard and Delitto, 1994; Liebenson and Lewit 2003; Hyde and Gengenbach, 2007; Bergmann and Peterson, 2011) so that the heterogenicity of the patient population does not allow for false conclusions to be drawn in terms of their presenting condition (Liebenson and Lewit, 2003). This concurs with the authors that suggest the use of the PARTS system in the clinical assessment of the patient (Hyde and Gengenbach, 2007; Brantingham *et al.,* 2010; Bergmann and Peterson, 2011). When placed in this context, the reliability and contribution of the diagnostic tool increases (Hansen, Simonsen and LeBoeuf-Yde*,* 2006).

The setting of operational definitions for spinal stiffness and its measurement / recording (e.g. presence, absence, magnitude) by MP examiners would increase the reliability of MP as a diagnostic tool (Maher, Latimer and Adams, 1998; Huijbregts, 2002).

The use of the incorrect statistical analyses once the data sets from the motion palpation have been obtained. This reduces the reliability and therefore validity measures according to Huijbregts (2002) and Cooperstein and Young (2016).

General factors that may affect reliability could include the type of rating or reporting scale utilised in the research studies (Huijbregts, 2002).

2.5.5.3 Factors affecting the assessment of validity

The lack of a defined gold standard against which motion palpation can be measured makes it difficult to improve the reliability and therefore also **criterion / content validity** (Najm *et al.,* 2003; Cooperstein and Young, 2016).

The main factor affecting **construct validity** is the degree of difference between the construct as labelled (i.e. how motion palpation should be done) and how it is implemented in the practice setting / research setting by the examiners (Huijbregts, 2002)

Factors affecting **external validity** include the degree of similarity between the patients, examiners, motion palpation technique, the rating scale and the setting in which the study occurred as compared to the practitioners and patients in the field (Huijbregts, 2002). The most difficult of these to match between the research and practice settings are the levels of experience and skill of the practitioners as this varies greatly (Huijbregts, 2002).

Review of the available literature has not revealed any studies on joint play of the hip, but there are two noted studies that documented end feel of the hip (Currier *et al.,* 2007; Sutlive *et al.,* 2008), however the findings in these studies spoke more to clinical responsiveness than reliability (inter- and intra-examiner reliability).

2.5.6 Clinical responsiveness and clinical prediction rules

Table 2.6: Previous studies on clinical responsiveness

Reference	Region	Examiner number	Examiner occupation	Examiner experience	Result
Lakhani *et al.* (2009)	Cervical Spine	1	Chiropractor	16 years	Responsive
Chesworth *et al.* (1998)	Shoulder	2	Physical Therapist	Not Indicated	Acceptable reliability
Patla and Paris (1993)	Elbow	2	Physical Therapist	Not Indicated	Moderate to Substantial
Staes *et al.* (2009)	Wrist	2	Physical Therapist	Not Indicated	Poor to Fair
Currier *et al.* (2007)	Hip	2	Physical Therapist	Not Indicated	Poor to Fair
Sutlive *et al (*2008)	Hip	2	Physical Therapist	Students	Poor to moderate
Hayes and Petersen (2001)	Knee	2	Physical Therapist	Not Indicated	Poor to Fair

Belling (2011) investigated clinical responsiveness of motion palpation as a post-diagnostic tool in patients with chronic ankle instability syndrome. This study included forty patients who were split into two groups; one that received treatment and one that did not (Belling, 2011). Both groups were motion palpated, the one group received an adjustment, and then both groups were re-motion palpated (Belling, 2011). This study found that motion palpation showed a high level of responsiveness and sensitivity when being used as a post-treatment assessment tool with values of ($p < 0.001$) for end-feel improvement (0.90) for sensitivity and (0.95) for specificity (Belling, 2011).

Review of the available literature has not revealed any studies on MP of the hip. In previous published literature, it was reported that there was poor reproducibility of spinal palpation; however on review of a later study, it was found that there is strong evidence supporting clinically acceptable reproducibility for intra- and inter-examiner spinal MP palpation (Stochkendahl *et al.,* 2006). A study testing MP of the cervical spine showed that end-feel assessment of the joints was a reliable tool in the finding of restrictions before treatment; the sensitivity of this being excellent and the specificity being adequate (Lakhani *et al.,* 2009). Cooperstein *et al.* (2010) investigated MP of the thoracic spine and found that examiners can agree on their fixation findings. Van Trijffell *et al.* (2005) encouraged the use of symptomatic participants in reliability studies of MP although it is possible for asymptomatic participants to present with fixations as well (Breen, 1991; Cooperstein *et al.,* 2010). Thus, in this study, both of the patient's hips will be motion palpated, regardless of whether or not only one is symptomatic.

This study will help in adding to available knowledge in the chiropractic profession on the validity of MP as an assessment tool in detecting joint fixations and restrictions in the hip, as well as more depth to the limited literature available on non-specific anterior hip pain. Further research comparing technique and inter-examiner reliability will aid in validation of the more reliable methods of MP and aid in the rejection of others (Alley, 1983). A better understanding of the problems occurring in the joint can result in a better assessment of the patient and aid in determining the correct treatment for patients suffering from joint dysfunction.

2.6 Conclusion

Based on the above literature review it is clear that despite conflicting evidence, motion palpation does have the ability to be a sensitive and specific tool. Therefore, this study set out to determine the intra- and inter-examiner reliability and clinical responsiveness of MP of the hip joint to detect joint dysfunction in non-specific anterior hip pain and in symptomatic hip joints.

CHAPTER 3 : METHODOLOGY

3.1 Introduction

This chapter will discuss the methodology used to perform this study. This study received approval by the Research and Higher Degrees Committee of the Faculty of Health Sciences at the Durban University of Technology (DUT) and the Institutional Research and Ethics Committee (IREC) at the DUT prior to any data collection taking place (see Appendix A1 for the IREC approval; Appendix A2 for Faculty of Health Sciences Clinic and Appendix A3 for the Vice Chancellor letter).

3.2 Design

This was an intra- and inter-examiner reliability study (Patijn, 2004), based on a quantitative paradigm.

3.3 Population

One group of participants over the age of 18 years of age but under the age of 60 years of age.

The ages 18-60 were chosen to eliminate the need for parental consent as well as logistics (the patient being able to attend the Chiropractic Day Clinic (CDC) under the age of 18 and to ensure a larger variety of participants. The wider the patient variety, the more accurate the reliability and validity outcomes in this study (Patijn, 2004).

3.4 Recruitment and sampling

Purposive sampling was used in order to ensure that there were both participants who are hyper- and hypomobile included in the study. The researcher approached various dance schools and golf clubs and members of the general public of the greater eThekwini area (patients whose home phone number starts with 031) in order to recruit these patients. On approaching these places, the researcher handed out leaflets (Appendix B) to recruit research participants. None of the study participants were chiropractic students enrolled in the DUT CDC.

The researcher selected participants of a certain demographic purposely, with the intention of finding equal numbers of hypermobile, hypomobile and unknown variable hips (Huijbregts, 2002). Thus the researcher approached three ballet dancers of varying ages, sexes and body types to fill the quota of hypermobile hips, three golfers of varying ages and body types to fill the quota of hypomobile hips and the general population in order to find people to fill the variable group. The researcher chose these demographics as studies have shown that ballet dancers have a hypermobile hip complex (Bennel *et al.,* 1999) and that golfers have a hypomobile hip complex (Vad *et al.,* 2004). The participants were selected by filling the criteria of a short interview (see Table 3.1) as well as meeting the inclusion and exclusion criteria (see Section 3.4.1). The researcher adhered strictly to the interview and inclusion/exclusion criteria in order to avoid any bias and only selected participants who were willing volunteers.

The examiners were not told that purposive sampling was being utilized as this may have skewed the results they obtained from the participants as they may have guessed which patients were hypo- or hypermobile before even having assessed them (Patijn, 2004). The researcher chose to use 10 participants in the study, each with one symptomatic and one asymptomatic hip. Both of the participants' hips were examined twice each by the three examiners, thus the researcher obtained 130 data sets, which gave a sufficiently high Kappa coefficient for the statistics to be valid and reliable (Esterhuizen, 2015).

Table 3.1 shows questions which were asked either in person or via telephonic interview prior to booking the first consultation at the DUT CDC for the volunteer.

Table 3.1: Personal interview

Question	Inclusion Criteria	Exclusion Criteria
Are you willing to answer questions posed to you and for your responses to be recorded?	Yes / Yes	No / No
What is your age?	Between the ages of 18-60	<18 or >60
Do you suffer from one-sided hip pain or discomfort?	Yes	No
Where is the hip pain located / where do you feel the pain?	Anteriorly leg / thigh or groin	Posterior hip pain
Do you have a pre-diagnosed hip pathology?	No	Yes
Have you ever had surgery to either of your hips?	No	Yes

Participants were reminded at the interview that if they were going to participate that they needed to bring their formal identification with them for the purpose of the clinic reception staff being able to confirm the age of participant.

The participant’s suitability was determined by the personal interview followed by a full consultation (with examination) to determine eligibility.

3.4.1 Inclusion Criteria

- Between the ages of 18 and 60 years, provided there was no pre-diagnosed hip pathology (Gleberzon. 2001).
- Participants with non-specific anterior hip pain on one side only. Anterior hip pain was defined by O’Kane (1999) as symptoms that extend medially to the pubic symphysis, laterally to the anterior superior iliac spine, superior to the abdomen and inferiorly to the proximal 5-10cm of the anterior thigh.
- Patients need to be proficient in English in order to understand specific research related instructions in order not to affect the outcome of this study (Baynham, 1995; Scollen and Wong Scollen, 1995; Mouton and Babbie, 2006).

3.4.2 Exclusion Criteria

- Participants younger or older than the inclusion age.

- Participants presenting with hip pain in any location other than the anterior hip. This was to have some form of consistency in terms of the likelihood that all patients had pain of femoro-acetabular origin (Clohissy *et al.,* 2009).
- Participants with a pre-diagnosed pathology of the hip (e.g. osteoarthritis) as diagnosed by any health care practitioner. This was done to increase the degree of difficulty in locating motion palpation restrictions as these restrictions were not obvious (i.e. age related changes only and no pathology e.g. AVN, stress fractures, systemic arthritides). The latter were excluded as they constituted contraindications to manipulation (Bergmann and Peterson, 2011).
- Participants with low back pain (e.g. lumbar nerve entrapment syndrome) or knee pathology (e.g. patellofemoral pain syndrome). This was done to exclude the effects of altered movement parameters (Morris, 2006) not directly related to normal hip range of motion and motion palpation.
- Participants who had previous surgeries to their hips, pelvis, lower back or knees. This was done to exclude the effects of altered movement parameters (Morris, 2006) not directly related to normal hip range of motion and motion palpation.
- Non-signature of the informed consent form by the patients.

3.4.3 Criteria for withdrawal of a participant from the study

- Having had a major traumatic event between visit one and two, which would have increased the likelihood of the participant meeting any of the exclusion criteria outlined in Section 3.4.2.

3.5 Research procedure

3.5.1 Participant procedure

Participants who passed the personal interview were seen by the researcher at the DUT CDC. At the first appointment the researcher explained to the patient what the research procedure was and gave the patient a Letter of Information and Informed

Consent (Appendix C) to read and sign. The patient was required to sign this letter in order for them to be included in the study. This letter also served to explain to the patient that they were not allowed to move at all during the assessment by the examiners, nor would they be able to show any form of pain (i.e. through wincing), nor speak about anything related to their hips.

The researcher then carried out a full history, a physical exam and a regional assessment of the hip (Appendices D-G) and a second appointment was made for the motion palpation procedures to be carried out by the examiners.

At the second appointment, the clinic was “block booked” at a time when it would normally be empty; this happened early in the mornings between 7:00am-8:30am. There were three sessions; at the first and second sessions, three participants were seen (at each session respectively) by the three examiners who were taking part in the study (see Section 3.5.2. regarding examiner procedure).

On the day of the assessments by the examiners:

- The patients were all allocated their own examination room.
- It was ensured that the patients were wearing the correct clothing.
- Before the examiners started the assessments, the participants were reminded by the researcher not to speak of anything relating to their hips and to try to remain expressionless whilst being assessed by the examiners (Patijn, 2004).
- The researcher also reminded the participants that they had to remain on the bed throughout the whole procedure in order not to change the biomechanics of their hips between assessments (Patijn, 2004; Byfield, 2010; Cooperstein and Young, 2014).
- The researcher then assigned the examiners to their randomised order of patient assessment and issued each examiner with a recording sheet (Patijn, 2004).
- The examiners assessed the participants, in a randomised order that was previously organised by the researcher (see Section 4.2.1.6. for Tables 4.4 – 4.6 regarding the order in which the participants were assessed).

- Once the patients were assessed by all examiners, the researcher adjusted the participants on either the symptomatic or the non-symptomatic side. The choice of side was determined by a coin toss (head representing right and tails representing left) done by the researcher to ensure randomization with regards to side adjusted.
- The direction of the adjustment was determined by the majority agreement between the examiners in terms of the restriction found on the side selected by the coin toss.
- The participants were then assessed by the examiners a second time in an order different from the manner in which they assessed the participants the first time.
- The participants and examiners were then thanked by the researcher and allowed to leave.
- This implied that the participants had no more responsibility to the study. The examiners followed the procedure three times to enable all participants to be seen.

The participants were reminded that if at any stage they did not wish to continue to be in the study, they were welcome to drop out and their information would not be used in the study.

3.5.2 Examiner procedure

There were three examiners, who remained the same throughout the data collection process, selected by the researcher.

The criteria were as follows: Two examiners were masters' students, enrolled in the DUT Chiropractic program, and another was a clinician and full time staff member at the DUT Chiropractic program who had been qualified for three years (who had graduated from DUT). The fact that all examiners had come through the same qualification and training increased the likelihood that they would have similar techniques (Gerwin *et al.,* 1997; Strender *et al.,* 1997; Chesworth *et al.,* 1998; Sciotti, 2001; Huijbregts, 2002). However, they were still varied in experience and age which served to allow for enough variance between them to decrease the likelihood of agreement, therefore making more significant any points of agreement that they had with regards to their findings on motion palpation of the patients. The age of the oldest examiner was also such that it would not have been affected by age related changes that have been documented to affect motion palpation skill (Mior *et al.,* 1990; Chaitow, 1991; Chaitow and DeLany, 2000; Huijbregts, 2002; Hansen, Simonsen and LeBoeuf-Yde, 2006; Nyberg and Smith, 2013).

One training session (Patijn, 2004) was held with the researcher and the examiners as well as the researcher's supervisor, who is also a chiropractor with 11 years of experience. The training material was outlined in Schafer and Faye (1990) and Bergmann and Peterson (2011). At this training session the researcher demonstrated the way in which the examiners were to assess the participants and the examiners took turns practicing it on one another. The researcher asked the examiners to ensure that they had each practiced the defined procedure on at least two different people at the training session in order for them to feel more confident in the method and to standardise this method. The researcher asked the examiners at this training session and twice subsequently if they felt it was necessary to have another training session. It was however agreed by both the examiners and the researcher that they felt confident in the one standardised training.

The examiners and the participants were blinded (Patijn, 2004) as to which demographic the participants fell under; only the researcher knew which demographic the participant filled. The participants were assessed in a randomised order by the examiners in the following parameters of hip motion (Bergmann and Peterson, 2011):

- Quadrant scouring (1)
- Long axis distraction – general (2)
- Long axis distraction – specific (3)
- Internal rotation – at 90 degrees (4)
- Internal rotation – straight (5)
- External rotation – at 90 degrees (6)
- External rotation – straight (7)

- 90 degrees compression (8)
- Superior to inferior movement (9)
- Anterior to posterior movement of the greater trochanter (10)
- Posterior to anterior movement of the greater trochanter (11)
- Medial to lateral movement (12)
- Lateral to medial movement (13)

It should be noted that posterior to anterior movement of the greater trochanter was modified to be done in the supine position so that the patient remained supine throughout both examinations.

Once the examiners completed the assessment, they recorded their findings on the Examiner Findings Sheet (Appendix H) after which the researcher collected the paperwork. The researcher randomized the choice of which side (symptomatic or asymptomatic) the participants received an adjustment by tossing a coin until one of the groups (symptomatic or asymptomatic) was full, after which, the rest fell into the other group. Table 3.2 indicates the outcome of the coin tossing procedure.

Table 3.2: Adjustment per symptomatic and asymptomatic hip

Hip	Symptomatic	Asymptomatic	Total
Adjusted	5	5	10
Not adjusted	5	5	10
Total	10	10	20

The researcher then used the most common findings between the examiners (majority agreement) and adjusted the one restriction that was found to be most consistently agreed upon by the examiners. In the event that there was no examiner agreement on a particular restriction on that side, a coin was tossed in order to choose in which motion the participant was adjusted.

The examiners then re-assessed the participants, before the participant was allowed to move from the bed (within 10 minutes of receiving his/her adjustment). In this time the examiners recorded their findings and the researcher again collected these findings and recorded them on a “master sheet” (Appendix I).

The researcher then thanked the participants for their participation in the study. Each participant received a voucher (Appendix J) for one free treatment of any one musculoskeletal complaint at the DUT CDC to be redeemed with the researcher or, should the researcher be unavailable, any other student at the DUT CDC. The voucher specified that only the participant him-/herself may redeem that voucher and that it will be valid for a period of three years, as per the Consumer Act of South Africa (Section 63.2.*b*) (Republic of South Africa, 2009). The vouchers were numbered and a list of voucher numbers was given to the reception staff of the DUT CDC in order to ensure it was only redeemed once.

The study results were recorded, collected and captured by the researcher. Inter-examiner reliability was analysed using the Fleiss' Kappa statistical analysis and average pairwise agreement to assess inter-examiner reliability (Esterhuizen, 2015). Intra-examiner reliability and clinical responsiveness were analysed using the paired Chi-Square Tests of Independence and McNemar's tests (Esterhuizen, 2015). These results were analysed using SPSS version 23 (Esterhuizen, 2015).

Inter-examiner reliability was determined by comparing the similarity or difference of the findings of the different examiners upon both the first and second assessments. Intra-examiner reliability was determined by comparing the examiners findings when they motion palpated the participants on the non-adjusted side at both the first and second assessments. This was determined by testing whether or not the examiners' findings remained consistent or not on the side of the patient that had not been adjusted. Clinical responsiveness was determined by the examiners finding a lack of restriction where they previously had found one to be present between the first and second examinations.

A flow diagram of the procedure is available for a schematic overview of the procedure in Appendix K.

3.6 Variables

3.6.1 Independent variables

- Motion palpation techniques.

3.6.2 Dependant variables

- Examiner experience.
- Underlying hip pathology.
- The mobilisation effect that occurs due to the motion palpation by multiple examiners consecutively.

3.6.3 Confounding variable

- Personalised application of a standardised motion palpation technique.

3.7 Data analysis

The statistician used the Fleiss' Kappa statistical analysis method to analyse the inter-examiner reliability statistics and Chi-Square Test of Independence and McNemar's test to determine intra-examiner reliability clinical responsiveness using SPSS version 23 (Esterhuizen, 2015).

3.8 Ethical considerations

3.8.1 Justice

Purposive sampling was used in this study with the intent of selecting specific patients that enabled the researcher to reach the aims and objectives of the study. These participants were selected given attributes/criteria that supported the aims and objectives of the study and the participants had the right to refuse participation at any stage.

3.8.2 Autonomy

The participants of this study were given a Letter of Information and Informed Consent (Appendix C) and had the opportunity to ask the researcher questions regarding the study before they elected to partake/not to partake.

A letter of participation (Appendix L) was signed by the examiners stating that they had committed to being involved in the research until data collection was completed; that they agreed to the training session; and that they would keep all information regarding both the research and the participants confidential.

No patient was included in the study by force; all participants / examiners were volunteers only.

3.8.3 Beneficence

All of the participants in this study were symptomatic thus the researcher considered excluding a participant if they were in too much pain whilst being motion palpated (the purpose of the first consultation at which the patient was screened prior to inclusion into the study). The researcher also allowed any participant who had an increase in pain/symptoms between the first and second appointments to receive care and either be excluded from the study or have their participation postponed until after a three week "wash-out" period in order for their symptoms to abate (allowing them to meet the inclusion criteria again).

Patients in pain were deemed to have excessive when pain as assessed using the NRS pain scale was greater than seven (on an 11 point scale) (Hjermstad *et al.,* 2011).

All participants received a voucher for participating in the study for one free treatment of any one musculoskeletal condition at the DUT CDC (Appendix J).

All data was coded and password protected on the researcher's laptop.

3.8.4 Non-maleficence and confidentiality

The participants were assessed by the researcher prior to the study in order to ensure that they were eligible to participate based on their condition and that they did not need immediate further care. If the participant required immediate further care they required a three week “wash-out” period until they were eligible to partake in the study.

All paperwork that was generated during the research process in the DUT CDC had to comply with standard clinical practice guideline as required by the clinic and the Allied Health professions Council of South Africa (Act 63 of 1982 (as amended)).

CHAPTER 4 : RESULTS

4.1 Introduction

This chapter discusses the results of this study in the form of statistical data. It begins by outlining the statistical significance for each objective. Further discussion of the results is presented in Chapter Five.

4.1.1 Abbreviations

Please see table below that describes any abbreviations used in this chapter.

Table 4.1: Abbreviations

Asympt	Asymptomatic
Exact Sig.	Exact Significance
Pt	Participant
Sympt	Symptomatic
SD	Standard deviation
SE	Standard error

4.2 Results

4.2.1 Demographics

Ten participants were included out of 11 who were chosen for this study. The excluded participant came to the first appointment and the researcher performed the case history (Appendix D), physical assessment (Appendix E) and hip regional assessment (Appendix F) but he was excluded as he was over the age of 60. The remaining ten participants all met the inclusion criteria and thus there was no need to exclude any of them.

The hips were all age and gender matched as each participant had one symptomatic and one asymptomatic hip.

4.2.1.1 Number of participants

Ten participants with one symptomatic and one asymptomatic hip participated in this study (n = 20 hips).

4.2.1.2 Age

The mean age of the participants was 37.8 years old (standard deviation 5.7 years) with an age range from 26 to 53 years of age.

Table 4.2: Age of participants

N	Valid	10
	Missing	0
Mean		37.8
SD		9.4
Minimum		26
Maximum		53

4.2.1.3 Gender

In this study, 70% (n = 7) of the participants were female and 30% (n = 3) were male.

4.2.1.4 Symptomatic side

The split between the right (n = 10) and left (n = 10) side being symptomatic was 50:50. Thus, half the participants had anterior hip pain on the right and the other half had anterior hip pain on the left. This happened per chance and was not part of the purposive sampling.

4.2.1.5 Group distribution

As explained in Chapter Three, the participants were purposively selected to make up three groups. This was done to ensure that there would be a fair distribution of hypomobile (golfer), hypermobile (dancer) and "normal" hips to be examined by the examiners (Huijbregts, 2002). Table 4.3 shows into which group each participant fell.

Table 4.3: Participants groups

Participant	Dancer	Golfer	Normal
1			X
2			X
3	X		
4		XX	
5		XX	
6			XX
7	XXX		
8	XXX		
9		XXX	
10			XXX

Participant groups: X = session one; XX = session two; XXX = session three

4.2.1.6 Order of examination

Each participant was examined by the examiners in different orders. The tables below (Table 4.4, session one; Table 4.5, session two; Table 4.6, session three) shows the order in which the examiners examined each of the participants. This occurred at three different sessions (Table 4.3, noted as X, XX and XXX) during which the Durban University of Technology Chiropractic Day Clinic (DUT CDC) was block-booked. At the first (Table 4.3 noted as an X) and second (Table 4.3 noted as an XX) sessions there were three participants each and at the third (Table 4.3 noted as an XXX) session there were four participants. The researcher organised the examinations before each session to ensure the easiest flow between participants and a randomised order of examiners. The randomisation of examiner order ensured that the findings of the examiners would not be influenced by the order in which the participants were palpated as motion palpation can be a form of mobilisation and can result in the findings of the examiners being altered (Huijbregts, 2002; Cooperstein *et al.,* 2009).

Table 4.4: Participants of session one

Examination	Pt 1		Pt 2		Pt 3	
	Left Sympt	Right Asympt	Left Sympt	Right Asympt	Left Sympt	Right Asympt
1	A		B		C	
2	B		C		A	
3	C		A		B	
Adjustment	✓	x	✓	x	✓	x
4	C		B		A	
5	B		A		C	
6	A		C		B	

✓ = indicates that the hip was adjusted; x = indicates that the hip was not adjusted

Table 4.5: Participants of session two

Examination	Pt 4		Pt 5		Pt 6	
	Left Sympt	Right Asympt	Left Asympt	Right Sympt	Left Asympt	Right Sympt
1	C		A		B	
2	A		B		C	
3	B		C		A	
Adjustment	✓	x	x	✓	✓	x
4	A		C		B	
5	C		B		A	
6	B		A		C	

✓ = indicates that the hip was adjusted; x = indicates that the hip was not adjusted

Table 4.6: Participants of session three

Examination	Pt 7		Pt 8		Pt 9		Pt 10	
	Left Asympt	Right Sympt	Left Asympt	Right Sympt	Left Asympt	Right Sympt	Left Sypmt	Right Asympt
1	A		B		C		-	
2	-		A		B		C	
3	C		-		A		B	
4	B		C		-		A	
Adjustment	✓	x	✓	x	✓	x	x	✓
5	C		B		A		-	
6	-		C		B		A	
7	A		-		C		B	
8	B		A		-		C	

✓ = indicates that the hip was adjusted; x = indicates that the hip was not adjusted

Objectives

4.2.1.7 Objective 1: To determine the intra-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain.

For Objective 1, the Chi-Square Test of Independence and McNemar's test were used to calculate the paired proportion (Esterhuizen, 2015). This test was used to detect a change between what was found by the examiners in A1 (pre-adjustment assessment) and A2 (post-adjustment assessment).

The tables (Tables 4.7 - 4.12) presented below use paired 2 x 2 tables to present the Chi-Square Test of Independence and McNemar's test for all motion palpation parameters tested. It was not possible to perform these analyses for each of the thirteen motion palpation parameters that the examiners assessed as the sample sizes per test were too small.

Tables 4.7 - 4.12 look at the side on which the participant was not adjusted and whether or not the findings of the examiners remained the same – which they should have as the participant received no intervention on that side. The Chi-Square Test of Independence looks to determine whether there is any change from the 100% agreement that the examiners should have reached and whether or not there is an association between whether restrictions were found or not found from pre to post assessments. The McNemar test then determines whether there is consistency in the pre to post assessment reporting or not and if the difference is significant.

Therefore, a *p*-value smaller than 0.05 is considered statistically significant and the smaller that it is, the more significant it is. In this case, the less significant the *p*-value, the more reliable the result will be for intra-examiner reliability.

Please note that all the tables below for Objective 1 refer only to the hip that was NOT adjusted and are referred to as the "non-intervention side".

4.2.1.7.1 Examiner A

The results reported arise from comparison of the pre- and post- adjustment findings where the measured side was different to the side adjusted (i.e. the unadjusted side). The Chi-Square Test of Independence comparison showed that there was a difference between the total restrictions found pre-reading versus the post-reading (right 31%; left 20% error) and restrictions not found (right 11%; left 29% error). This should not have occurred as the participants were not adjusted and the examiner should have attained 100% reproducibility. Thus, a McNemar's test was run and it found no significant difference between pre- and post-ratings (McNemar's p = 0.180 for the right hand side and 0.375 for the left hand side).

Table 4.7: Cross tabulation of intra-examiner reliability for Examiner A

Cross tabulation of intra-examiner reliability					
Non-intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	81 (89%)	10 (11%)	91
		Restriction found	4 (31%)	9 (69%)	13
	Total		85	19	104
			Left		
Left	**Pre adjustment**	Restriction not found	17 (81%)	4 (29%)	21
		Restriction found	1 (20%)	4 (80%)	5
	Total		18	8	26

Table 4.8: Chi-Square Test of Independence for Examiner A

Chi-Square Test of Independence			
Non-intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test		0.180[a]
	N of Valid Cases	104	
Left	McNemar Test		0.375[a]
	N of Valid Cases	26	
a. Binomial distribution used.			

4.2.1.7.2 Examiner B

The results reported arise from comparison of the pre- and post-adjustment findings where the measured side was different to the side adjusted (i.e. the unadjusted side). The Chi-Square Test of Independence comparison showed that there was a difference between the total restrictions found pre-reading versus the post-reading (right 99%; left; 100% error) and restrictions not found (right 2%; left 9% error). This should not have occurred as the participants were not adjusted and the Examiner should have attained 100% reproducibility. Thus, a McNemar's test was run and it showed a significant difference between pre- and post-ratings on the right (McNemar's $p = 0.039$) but not on the left ($p = 0.687$).

Table 4.9: Cross tabulation of intra-examiner reliability for Examiner B

Cross tabulation of intra-examiner reliability					
Non-intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	91 (98%)	2 (2%)	93
		Restriction found	10 (99%)	1 (1%)	11
	Total		101	3	104
			Left		
Left	**Pre adjustment**	Restriction not found	20 (91%)	2 (9%)	22
		Restriction found	4 (100%)	0 (0%)	4
	Total		24	2	26

Table 4.10: Chi-Square Test of Independence for Examiner B

Chi-Square Test of Independence			
Non-intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test		0.039[a]
	N of Valid Cases	104	
Left	McNemar Test		0.687[a]
	N of Valid Cases	26	
a. Binomial distribution used.			

4.2.1.7.3 Examiner C

The results reported arise from comparison of the pre- and post-adjustment findings where the measured side was different to the side adjusted (i.e. the unadjusted side). The Chi-Square Test of Independence comparison showed that there was a difference between the total restrictions found pre-reading versus post-reading (right 67%; left 25% error) and restrictions not found (right 1%; left 0% error). This should not have occurred as the participants were not adjusted and the Examiner should have attained 100% reproducibility. Thus, a McNemar's test was run and it showed no significant difference between pre- and post-ratings (McNemar's $p = 0.125$ on the right and 1.000 on the left). This indicates that when Examiner C examined the left hip, the post findings almost mirrored pre-findings indicating an almost 100% accuracy and therefore reliability.

Table 4.11: Cross tabulation of intra-examiner reliability for Examiner C

Cross tabulation of intra-examiner reliability					
Non-intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	94 (99%)	1 (1%)	95
		Restriction found	6 (67%)	3 (33%)	9
	Total		100	4	104
			Left		
Left	**Pre adjustment**	Restriction not found	22 (100%)	0 (0%)	22
		Restriction found	1 (25%)	3 (75%)	4
	Total		23	3	26

Table 4.12: Chi-Square Test of Independence for Examiner C

Chi-Square Test of Independence			
Non-intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test	104	
	N of Valid Cases		0.125[b]
Left	McNemar Test	26	
	N of Valid Cases		1.000[b]
b. Binomial distribution used.			

4.2.1.8 Objective 2: To determine the inter-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain

4.2.1.8.1 The Fleiss' Kappa outcomes

In order to address this objective, inter-rater agreement between the three examiners was calculated for each motion palpation direction evaluated for each hip (left and right side) using Fleiss' Kappa (Statstodo, 2016).

Since Fleiss' Kappa is known to be very influenced by prevalence of the condition, the average pairwise agreement was also calculated and interpreted along with the Fleiss' Kappa statistic (Section 4.2.2.2.2.). The Fleiss' Kappa values where interpreted using Table 4.13.

Table 4.13: Scale for interpretation of Fleiss' Kappa

κ	**Interpretation**
< 0	Poor agreement
0.01 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 1.00	Almost perfect agreement

Source: Landis and Koch (1977); Patijn (2004); Triano *et al.* (2013)

Table 4.14 represents the Fleiss Kappa calculation based on the study data. The outcomes obtained from this first assessment of the patients by the examiners indicates that the examiners had ***poor to slight agreement*** for all motion palpation parameters with the exception of internal rotation right and internal rotation left (both at 90º); internal rotation left (straight), external rotation right (at 90º degrees); which reflected ***no agreement / the worst agreement***. In addition, there was ***almost perfect agreement*** for lateral to medial bilaterally, medial to lateral bilaterally, posterior to anterior bilaterally, anterior to posterior bilaterally as well as external rotation with the leg straight on the right. These values have been highlighted in Table 4.14.

Table 4.14: Kappa scores for Examiners A, B and C of the first assessment

Direction	Abbreviated	Kappa Score	Std Err	95% CI min	95% CI max
Quadrant scouring right side pre-adjustment	QSR1	-0.1180	0.1826	-0.4759	0.2398
Quadrant scouring left side pre-adjustment	QSL1	0.0683	0.1826	-0.2895	0.2467
Long axis distraction generalised right side pre-adjustment	LADGR1	-0.1111	0.1826	-0.4690	0.2467
Long axis distraction generalised left side pre-adjustment	LADGL1	-0.0714	0.1826	-0.4293	0.2864
Long axis distraction specific right side pre-adjustment	LADSR1	-0.1180	0.1826	-0.4759	0.2398
Long axis distraction specific left side pre-adjustment	LADSL1	-0.1538	0.1826	-0.5117	0.2040
90° Compression right side pre-adjustment	COMPR1	-0.0345	0.1826	-0.3923	0.3234
90° Compression left side pre-adjustment	COMPL1	-0.0345	0.1826	-0.3923	0.3234
Internal rotation at 90° right side pre-adjustment	IR90R1	**-0.3393**	0.1826	-0.6971	0.0186
Internal rotation at 90° left side pre-adjustment	IR90L1	**-0.2217**	0.1826	-0.5796	0.1361
Internal rotation with straight leg right side pre-adjustment	IRSR1	-0.1538	0.1826	-0.5117	0.2040
Internal rotation with straight leg left side pre-adjustment	IRSL1	**-0.2500**	0.1826	-0.6078	0.1078
External rotation at 90° right side pre-adjustment	ER90R1	**-0.3043**	0.1826	-0.6622	0.0535
External rotation at 90° left side pre-adjustment	ER90L1	0.1477	0.1826	-0.2101	0.5056
External rotation with straight leg right side pre-adjustment	ERSR1	**1.0000**	0	1.0000	1.0000
External rotation with straight leg left side pre-adjustment	ERSL1	-0.0714	0.1826	-0.4293	0.2864
Superior to inferior right side pre-adjustment	SIR1	-0.0714	0.1826	-0.4293	0.2864
Superior to inferior left side pre-adjustment	SIL1	-0.1538	0.1826	-0.5117	0.2040
Anterior to posterior right side pre-adjustment	APR1	**1.0000**	0	1.0000	1.0000
Anterior to posterior left side pre-adjustment	APL1	**1.0000**	0	1.0000	1.0000
Posterior to anterior right side pre-adjustment	PAR1	**1.0000**	0	1.0000	1.0000
Posterior to anterior left side pre-adjustment	PAL1	**1.0000**	0	1.0000	1.0000
Medial to lateral right side pre-adjustment	MLR1	**1.0000**	0	1.0000	1.0000
Medial to lateral left side pre-adjustment	MLL1	**1.0000**	0	1.0000	1.0000
Lateral to medial right side pre-adjustment	LMR1	**1.0000**	0	1.0000	1.0000
Lateral to medial left side pre-adjustment	LML1	**1.0000**	0	1.0000	1.0000

4.2.1.8.2 The average pairwise agreement calculations

The average pairwise agreement was calculated for each patient as either 33.3% if one of the ratings was different (e.g. a = 1 b = 0 c = 0: a versus b = 0% agreement; a versus c = 0% agreement; b versus c = 100% agreement with the average = 33.3%), or 100% if all ratings were the same. This was then averaged for all 10 patients and compared between the first and second assessments using paired t-test for each motion palpation parameter separately and overall.

The following three tables (Table 4.15 - 4.17), present the average pairwise scores for both the first motion palpation of the participants as well as the second motion palpation assessment of the participants. These tables present pairwise agreement scores that have remained unchanged from the first to the second assessment (Table 4.15), scores that have improved from the first to the second assessment (Table 4.16) and scores that have decreased from the first to the second assessment (Table 4.17)

Table 4.15 shows that quadrant scouring (left), anterior to posterior motion (right), posterior to anterior motion (right/left), medial to lateral (left) and lateral to medial (right) scores remain unchanged for these motion palpation parameters from first motion palpation examination to the second motion palpation examination session. This means that the examiners agreed between each other irrespective of the context of the patient – i.e. no assessment/previous exposure to the patient; treatment (an adjustment); lack of treatment of the patient; whether or not the patient presented with increased, decreased or normal mobility of the hip and whether or not the hip was symptomatic or asymptomatic. This implies that for these motion palpation parameters that they are highly specific, sensitive and that they can be utilised to monitor care (responsiveness). However, the latter will be investigated more specifically in Section 5.2.2. of Chapter 5.

Table 4.15: Average pairwise agreement at the first and second assessments

Unchanged Scores			First assessment	Second assessment
Measure	QSL	Mean	66.7%	66.7%
		SD	35.2%	35.2%
	APR	Mean	100.0%	100.0%
		SD	0.0%	0.0%
	PAR	Mean	100.0%	100.0%
		SD	0.0%	0.0%
	PAL	Mean	100.0%	100.0%
		SD	0.0%	0.0%
	MLL	Mean	100.0%	100.0%
		SD	0.0%	0.0%
	LMR	Mean	100.0%	100.0%
		SD	0.0%	0.0%

Table 4.16 shows that quadrant scouring (right), long axis distraction (general) (left/right), long axis distraction (specific) (left/right), compression (left/right), internal rotation at 90º (left/right), internal rotation straight (left), external rotation at 90º (left/right), external rotation straight (left), superior to inferior (left/right) and lateral to medial (left) scores improved for these motion palpation parameters from the first assessment to the second assessment. The difference in improved agreement was only statistically significant for external rotation on the right (p = 0.037) and long axis distraction (straight) on the right (p = 0.015). This means that the examiners improved agreement between each other irrespective of the context of the patient – i.e. no assessment/previous exposure to the patient; treatment (an adjustment); lack of treatment of the patient; whether or not the patient presented with increased, decreased or normal mobility of the hip and whether or not the hip was symptomatic or asymptomatic. This implies that these motion palpation parameters are highly specific and sensitive (with the exception of the left/right internal rotation at 90º) and that these motion parameters can be relied upon for monitoring care (responsiveness). However, the latter will be investigated more specifically in Section 5.2.2.

Table 4.16: Average pairwise agreement at the first and second assessments

Improved scores			First assessment	Second assessment
Measure	QSR	Mean	60.0%	73.3%
		SD	34.4%	34.4%
	LADGR	Mean	80.0%	100.0%
		SD	32.2%	0.0%
	LADGL	Mean	86.7%	93.3%
		SD	28.1%	21.1%
	LADSR	**Mean**	**60.0%**	**93.3%**
		SD	**34.4%**	**21.1%**
	LADSL	Mean	73.3%	86.7%
		SD	34.4%	28.1%
	COMPR	Mean	93.3%	100.0%
		SD	21.1%	0.0%
	COMPL	Mean	93.3%	100.0%
		SD	21.1%	0.0%
	IR90R	*Mean*	*33.3%*	*53.3%*
		SD	*0.0%*	*32.2%*
	IR90L	*Mean*	*40.0%*	*46.6%*
		SD	*21.1%*	*28.1%*
	IRSL	Mean	60.0%	73.3%
		SD	34.4%	34.4%
	ER90R	**Mean**	**53.3%**	**80.0%**
		SD	**32.2%**	**32.2%**
	ER90L	Mean	66.7%	80.0%
		SD	35.2%	32.2%
	ERSL	Mean	86.7%	100.0%
		SD	28.1%	0.0%
	SIR	Mean	86.7%	93.3%
		SD	28.1%	21.1%
	SIL	Mean	73.3%	80.0%
		SD	34.4%	32.2%
	LML	Mean	93.3%	100.0%
		SD	21.1%	0.0%

Table 4.17 shows that internal and external rotation (straight on the right), anterior to posterior (left) and medial to lateral (right) scores decreased for these motion palpation parameters from first motion palpation examination to the second motion palpation examination session. This means that the examiners became worse in their agreement between each other. This implies that these motion palpation parameters are highly non-specific, insensitive and that they should not be relied upon as parameters for monitoring care (responsiveness). However, the latter will be investigated more specifically in Section 5.2.2.

Table 4.17: Average pairwise agreement at the first and second assessments

Decreased Scores			First assessment	Second assessment
Measure	IRSR	Mean	73.3%	46.6%
		SD	34.4%	28.1%
	ERSR	Mean	100.0%	86.7%
		SD	0.0%	28.1%
	APL	Mean	100.0%	93.3%
		SD	0.0%	21.1%
	MLR	Mean	100.0%	93.3%
		SD	0.0%	21.1%

Collectively for the pairwise agreement assessment shows that in the first assessment, the agreements ranged from 33.3% to 100%, and from 46.6% to 100% in the second assessment. Most measurements showed an increase in agreement from the first to the second assessment with the overall change being significant (p = 0.002) (Table 4.18).

Table 4.18: Average pairwise agreement pre- and post-assessment

	Average pairwise agreement pre	Average pairwise agreement post
Mean	80.0%	86.1%
SD	30.6%	27.1%
Count	260	260

In conclusion for this objective, when comparing the Fleiss' Kappa score and the pairwise agreement assessment (PWA) changes, the following becomes apparent (Table 4.19):

- The ***bold and italics font*** motion parameters have high sensitivity and specificity and almost perfect reliability.
- The unbold, unitalicised font motion parameters have moderate sensitivity and specificity and no reliability.
- The **bold font** motion parameters have limited sensitivity and specificity and but almost perfect reliability.
- The remainder of the motion parameters have no sensitivity, specificity and reliability.

Table 4.19: Comparison of Fleiss' Kappa score and the pairwise agreement assessment (PWA)

Right			PWA1	PWA2
IR90R1	-0.3393	No agreement	33.3%	53.3%
ER90R1	-0.3043	No agreement	53.3%	80%
ERSR1	**1.0000**	**Almost perfect agreement**	**100%**	**86.7%**
APR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***
PAR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***
MLR1	**1.0000**	**Almost perfect agreement**	**100%**	**93.3%**
LMR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***
Left			**PWA1**	**PWA2**
IR90L1	-0.2217	No agreement	40%	46.6%
IRSL1	-0.2500	No agreement	60%	73.3%
APL1	**1.0000**	**Almost perfect agreement**	**100%**	**93.3%**
PAL1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***
MLL1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***
LML1	1.0000	Almost perfect agreement	93.3%	100%

4.2.1.9 Objective 3: To determine the clinical responsiveness of the hip joint after manipulation of the present restrictions

Clinical responsiveness was assessed by comparing ratings from the first and second assessments on the side that was adjusted.

The ratings were compared using cross tabulation tables for the Chi-Square Test of Independence, followed by the McNemar tests for all motion palpation directions measured in a combined score. This was done as it was not possible to perform the analyses per motion palpation direction as each motion palpation direction would have provided too small a sample size.

For the McNemar's test, a *p*-value smaller than 0.05 is considered statistically significant and the smaller that is, the more significant it is. In this case, the more significant the *p*-value, the more reliable the result was for clinical responsiveness.

Table 4.20 - Table 4.25 show the difference between the pre-adjustment assessment and the post-adjustment assessment on the side of intervention. Thus the examiners should have found a change in at least one direction as the participant received an

adjustment on this side. Please note that all the tables below for Objective 3 refer only to the hip that was adjusted which is referred to as the "intervention side".

4.2.1.9.1 Examiner A

For Examiner A, there was no greater tendency to find no restrictions post- than pre-adjustment on either side.

The Chi-Squared Test of Independence comparison showed that for the restrictions found pre-adjustment (right = 2 and left = 12), there was a change to three restrictions being found post-adjustment (an increase) on the right and to six restrictions post-adjustment (a decrease) on the left. With the participants having been adjusted more so on the left (Tables 4.4. - 4.6), there is a trend towards Examiner A having been able to detect this trend. This may have been because the researcher only adjusted one direction and therefore it is not reasonable to assume that the examiner would have found changes in all the pre-adjustment restrictions (i.e. make the assumption that the examiner should have found no restrictions post adjustment or attain a 100% clear on all motion parameters assessed).

Therefore, it is not unexpected that the McNemar's test showed *p*-values of p = 1.000 right and 0.238 left respectively. This implies that each motion parameter would need to be assessed individually for clinical responsiveness as the collective total assessment masks this outcome. Thus in terms of the motion palpation tests collectively there was no evidence of clinical responsiveness for this examiner and the study cannot comment on the clinical responsiveness of each of the individual motion palpation parameters.

Table 4.20: Cross tabulation of clinical responsiveness for Examiner A

Cross tabulation of clinical responsiveness					
Intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	16(84%)	3(16%)	19
		Restriction found	2(29%)	5(71%)	7
	Total		18	8	26
			Left		
Left	**Pre adjustment**	Restriction not found	77(92%)	6(8%)	83
		Restriction found	12(57%)	9(63%)	21
	Total		12	15	104

Table 4.21: Chi-Square Test of Independence for Examiner A

Chi-Squared Test of Independence			
Intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test		1.000[a]
	N of Valid Cases	26	
Left	McNemar Test		0.238[a]
	N of Valid Cases	104	

a. Binomial distribution used.

4.2.1.9.2 Examiner B

For Examiner B, there was no greater tendency to find no restrictions post- than pre-adjustment on either side.

The Chi-Squared Test of Independence comparison showed that for the restrictions found pre-adjustment (right = 4 and left = 4), there was a change to one restriction being found post-adjustment (a decrease) on the right and to one restrictions post-adjustment (a decrease) on the left. With the participants having been adjusted more so on the left (Tables 4.4. - 4.6), there is a trend towards Examiner B not having been able to detect this trend. This may have been because the researcher only adjusted one direction and therefore it is not reasonable to assume that the examiner would have found changes in all the pre-adjustment restrictions (i.e. make the assumption that the examiner should have found no restrictions post adjustment or attain a 100% clear on all motion parameters assessed).

Therefore, it is not unexpected that the McNemar's test showed *p*-values of p = 0.125 right and 0.375 left respectively. This implies that each motion parameter would need to be assessed individually for clinical responsiveness as the collective total assessment masks this outcome. Thus in terms of the motion palpation tests collectively there was no evidence of clinical responsiveness for this examiner and the study cannot comment on the clinical responsiveness of each of the individual motion palpation parameters.

Table 4.22: Cross tabulation of clinical responsiveness for Examiner B

Cross tabulation of clinical responsiveness					
Intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	21 (100%)	0(0%)	21
		Restriction found	4(80%)	1(20%)	5
	Total		25	1	26
			Left		
Left	**Pre adjustment**	Restriction not found	98(99%)	1(1%)	99
		Restriction found	4(80%)	1(20%)	5
	Total		102	2	104

Table 4.23: Chi-Square Test of Independence for Examiner B

Chi-Squared Test of Independence			
Intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test		0.125[a]
	N of Valid Cases	26	
Left	McNemar Test		0.375[a]
	N of Valid Cases	104	
a. Binomial distribution used.			

4.2.1.9.3 Examiner C

For Examiner C, there was a significantly greater tendency to find no restrictions post than pre adjustment.

On the right hand side, because of the lack of change in the Chi-Square Test of Independence, the McNemar test could not be computed. This was because Examiner C found no restrictions at either time point / assessment. However, this is positively significant as this examiner continued to find no restrictions at the second assessment thus their results are reliable.

On the left hand side the examiner first reported seven restrictions prior to the adjustment being administered and reported no restrictions after the adjustment was administered (a decrease over time). This is further re-enforced by the McNemar's test which found a significant outcome where $p = 0.016$. This indicates that this examiner was able to detect all changes made by the adjustments on the left. It may also, however, have happened that the restrictions found by this examiner were the restrictions adjusted for each of the patients (it required two examiners to agree and from the results it is possible that Examiner A and Examiner C tended to agree as both detected changes to a greater extent on the left), hence this examiners ability to detect these changes.

Therefore it would seem that Examiner C had the best results in terms of clinical responsiveness out of the three examiners utilised in this study.

Table 4.24: Cross tabulation of clinical responsiveness for Examiner C

Cross tabulation of clinical responsiveness					
Intervention side			**Post adjustment**		**Total**
			Restriction not found	Restriction found	
			Right		
Right	**Pre adjustment**	Restriction not found	26 (100%)		26
	Total		26		26
			Left		
Left	**Pre adjustment**	Restriction not found	95(100%)	0(0%)	95
		Restriction found	7(78%)	2(22%)	9
	Total		102	2	104

Table 4.25: Chi-Square Test of Independence for Examiner C

Chi-Squared Test of Independence			
Intervention side		Value	Exact Sig. (2-sided)
Right	McNemar Test	.	
	N of Valid Cases	26	
Left	McNemar Test	104	
	N of Valid Cases		.016[b]

a. Computed only for a PxP table, where P must be greater than 1.
b. Binomial distribution used.

4.3 Conclusion

As can be seen from the above results, intra-examiner reliability appears to be markedly better on the left-hand side for all three examiners. Kappa scores for inter-examiner reliability varied from poor to perfect, which was complimented by average pairwise agreement scores ranging from 33.3% to 100% at the first assessment, and from 46.6% to 100% at the second assessment. A mean and standard deviation were calculated for the pairwise agreements which represented the sensitivity and specificity respectively. These both showed improvement between the first and second assessments which is positive for inter-examiner reliability. Clinical responsiveness was shown to be absent for examiners A and B but was present for examiner C on the left.

CHAPTER 5 : DISCUSSION

5.1 Introduction

The objectives of this study were three fold:

- Objective 1: to determine the intra-examiner reliability of MP of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain.
- Objective 2: to determine the inter-examiner reliability of MP of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain.
- Objective 3: to determine the clinical responsiveness of the hip joint after manipulation of the present restrictions.

This chapter will discuss the demographics and patient recruitment followed by the results laid-out in the previous chapter, in the sequence order of the objectives.

A sample of ten participants was used, each of whom presented with one symptomatic and one asymptomatic hip (n = 20). These participants were split into three groups; dancers, golfers and “normal” people to ensure that there would be a fair distribution of hypomobile (n = 6 hips), hypermobile (n = 6 hips) and “normal” hips (n = 8 hips). This concurs with the work of Huijbregts (2002), who suggests that variability between patients is good in similar studies.

The participants were all between the ages of 18 and 60 years with a mean age of 37.8 years and there was a 7:3 split between females and males respectively (n = 7 females and n = 3 males). The inclusion of participants with a wide age range, differing mobility profiles and of different genders (McHorney *et al.,* 1994; Huijbregts, 2002) served to ensure the examiners were at no stage “prompted” into knowing what they might feel before they assessed the participant (Patjin, 2004). All participants received the same assessment of both hips by each of the examiners independently in order to determine the intra and inter-examiner reliability of motion palpation of the hip joint to identify hip joint dysfunction.

5.2 Discussion

5.2.1 Objective 1: To determine the intra-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain

Intra-examiner reliability was measured by looking at the first and second assessment (pre-and post-adjustment respectively) on the side that was not adjusted in order to test whether or not the examiners found the same joint restrictions at both assessments. In theory, the non-adjusted side should have remained the same, whether it was the symptomatic side or not, as it received no intervention. The only change in palpatory findings might be a slight increase in mobility due to repetitive motion palpation (Wolff and Lonquich, 2000; Huijbregts, 2002; Liebenson and Lewit, 2003; Bergman and Petersen, 2011). Whether this change can be regarded as therapeutic change (and therefore an effect on the outcomes of this study) remains untested (Bergman and Petersen, 2011).

The results for Objective 1 varied between the examiners, with some being slightly more reliable than others. In order to contextualise the discussion, it should be noted that a *p*-value between 0.00 and 0.05 was considered statistically significant, indicating that the smaller the *p*-value, the less reliable the result was for intra-examiner reliability.

For Examiner A, there was no significant difference found between the first and the second assessment. When assessing the right hips of the non-intervention sides, Examiner A found 6 changes between the first and second assessment, which gave a *p*-value of 0.180 on the right side. Specifically, when assessing the restrictions found, it was noted that there were four restrictions found prior to an “intervention” as compared to ten found post adjustment. This implies that for the right hand side, the examiner was not able to achieve a replication of the restrictions first noted (Table

4.7). When assessing the left hips of the non-intervention sides, Examiner A found only three changes between the first and second assessment (initially finding one and subsequently finding four) (Table 4.7), which resulted in a p-value of 0.375. As the results show, Examiner A found more restrictions of movement on the second assessment of the participants than the first (more on the right (6) than on the left (3)). This should not have occurred as there should have been no change found in these participants as the hip assessed was the hip that did not receive an intervention.

As Table 4.7. shows, there were 81 restrictions that were not found on the right hip pre manipulation, that were still not present post manipulation; similarly 9 restrictions were found pre and post manipulation. On the left hip 17 restrictions were not found on the first assessment and subsequently at the second assessment. Similarly 4 restrictions were found pre and post manipulation. Thus 81+9+17+4 = 111 out of the 130 (104 + 26) which makes an 85% agreement for examiner A for inter-examiner reliability.

In a similar manner to Examiner A, Examiner B found fewer overall restrictions on the left compared to the right. By contrast however, Examiner B, found a decrease of eight restrictions on the right (10 at the initial assessment and two at the second assessment) and a similar trend is seen on the left with a 50% reduction in the number of restricted motion parameters. However, Examiner B's results differed from Examiner A's as there were more restrictions found on the right hand side at the first assessment and these were significantly less on the second assessment. This gave examiner B a result of p = 0.687 on the left and a significant result of 0.039 on the right. This indicates that although the examiners have similar trends in terms of the sidedness of the restriction, Examiner A tended to increase reporting of restrictions at the second assessment as compared to Examiner B who decreased the reporting of restrictions at the second assessment.

As Table 4.9. shows, there were 91 restrictions that were not found on the right hip pre manipulation, that were still not present post manipulation; similarly 1 restriction was found pre and post manipulation. On the left hip 20 restrictions were not found on the first assessment and subsequently at the second assessment. No restrictions were found pre and post manipulation on the left. Thus 91+1+20+0 = 111 out of the 130 (104 + 26) which makes an 86% agreement for examiner B for inter-examiner reliability.

As was found for Examiners A and B, Examiner C too found that there were / seemed to be fewer restrictions on the left when compared to the right hips. However, the trend in determining changes in restrictions followed the trend of Examiner B, where the number of restrictions decreased from six to one on the right and from one to zero on the left. This translated to a perfect statistical *p*-value of 1.000 on the left and a *p*-value of 0.125 on the right.

As Table 4.11. shows, there were 94 restrictions that were not found on the right hip pre manipulation, that were still not present post manipulation; similarly 3 restrictions were found pre and post manipulation. On the left hip 22 restrictions were not found on the first assessment and subsequently at the second assessment. Similarly 3 restrictions were found pre and post manipulation. Thus 94+3+22+3 = 111 out of the 130 (104 + 26) which makes a 94% agreement for examiner C for inter-examiner reliability.

The results would therefore seem to suggest that Examiners B and C were expecting that the participants where receiving an intervention and therefore assuming that there would be fewer restrictions. This assumption was not supported by the research methodology, where neither the researcher nor the examiners would have been able to predict the outcome of the coin toss or the motion parameters that they would have agreed to, in order for anyone to have been privy to whether the patient was adjusted or not (refer to Section 3.5.2). In addition, the participants were asked not to divulge any information about hip symptoms to the examiners and / or whether they had been adjusted and if so on which hip (Section 3.5.1). Thus there was effective blinding available to the examiners to test their skill.

Therefore, if the results reflect examiner skill, it is interesting to note that all three examiners had markedly fewer restrictions left side, and interestingly, all three of these examiners were right hand dominant. This may lend itself to the assumption that the examiners are more sensitive to the subtleties of joint motion when using their non-dominant hands as compared to their dominant hands which has been shown to be a greater torque producer (Bagesteiro and Sainburg, 2002). Bagesteiro and Sainburg (2002) suggest that this may be due to the use of the right hand as a more forceful "indirect-hand" when applying the forces to move an object (e.g. a limb when assessing the hip joint), or due to the idea that one might rely more on technique when using one's non-dominant hand as opposed to the benefit of more strength on the dominant side.

A limitation however should be noted in terms of this intra-examiner reliability, as the number of patients was small in this study (n = 10), there were only 20 hips that were assessed, for each of these hips 13 motion parameters were assessed by each of the three examiners. In this analysis (intra-examiner), that would mean each motion parameter would only be reflected once in all 130 motion parameters per examiner. Therefore, it was not possible to match whether the changes in the motion restrictions pre- and post-adjustment actually reflected changes in the same motion parameters or whether new motion parameter changes in the second assessment were noted quite unrelated to those found at the first assessment. It is therefore suggested that a future study investigate decreasing the number of motions assessed, but increasing the frequency within which each motion is assessed. This however would need to be balanced with the effect of repetitive motion palpation of the joint which could be seen as a mobilisation, effectively decreasing the repeatability of detecting the motion restriction at a subsequent assessment (Brantingham *et al.,* 2012; Wolff and Lonquich, 2000; Liebenson and Lewit, 2003; Bergmann and Peterson, 2011; Huijbregts, 2002). One manner in which this could be overcome is by utilising a hip or group of hips that have a pathological change that would enable repeated restrictions to be found without being affected by mobilisation / motion palpation movement (a spinal analogy would be the use of a congenital block vertebra [Humphreys et al., 2004]). This would however prove more challenging in the hip as there are fewer pathologies that can be categorised into this sector (Norris, 2004; Hyde and Gengenbach, 2007).

5.2.2 Objective 2: To determine the inter-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain

Inter-examiner reliability was assessed by looking at and comparing the results of the examiners' assessments of both of the participants' hips both pre- and post-adjustment. This compared their ability to find the presence of a restriction of joint motion and identify whether or not motion palpation is useful as a tool to reliably find the presence of restrictions in practice.

In the post-adjustment phase, all the examiners should have found the same restrictions, when compared to each other, on both the adjusted and non-adjusted side. In order for this to be as "uniform" as possible, training sessions were held with the examiners in order to ensure that they all used the same techniques to find the presence of restriction (Patijn, 2004).

The Kappa scores for inter-examiner reliability ranged from no agreement to perfect agreement with the lowest score being for Internal rotation at 90^{o} right side pre-adjustment with a score of -0.3393 and with perfect scores of 1.000 for assessments of external rotation on the right with the leg straight, anterior to posterior on the right and left hips, posterior to anterior on the right and left hips, medial to lateral on the right and left hips, and lateral to medial on the right and left hips. These perfect scores were due to the fact that all examiners agreed that no joint restriction was present in any of these degrees of motion.

Fleiss' Kappa was used instead of Cohen's Kappa as there were more than two examiners and percentage agreement was also used as a secondary tool to support the primary data. Fleiss' Kappa is a chance-adjusted index of agreement used often by the medical and behavioural sciences as a tool to determine multi-rater categorization of nominal values (Randolph, 2005). It is commonly used in the fields of content analysis and meta-analysis when researchers seek to determine agreement between examiners on the coding of nominal values (Randolph, 2005). The statistics from this study as summarised in Table 5.2 found that although there was a high percentage agreement, 50% of the Kappa scores were less than the acceptable 0.2 (Randolph, 2005) (see Table 4.14; Table 5.1 and Table 5.2).

Table 5.1: Scale for interpretation of Kappa

κ	Interpretation
< 0	Poor agreement
0.01 – 0.20	Slight agreement
0.21 – 0.40	Fair agreement
0.41 – 0.60	Moderate agreement
0.61 – 0.80	Substantial agreement
0.81 – 1.00	Almost perfect agreement

Source: Landis and Koch (1977)

Table 5.2: Summary of pairwise agreement and Kappa

Agreements						Kappa
Reference	Number of recorded agreement changes	Description	Number of 100% agreement	Highest level of agreement	Total number of 100% agreements	
Table 4.15	6/26	Unchanged	5	100%	9/26 = 100%	9/26 showed a Kappa of greater than 0.2 (Table 4.14)
Table 4.16	16/26	Improved	4	100%		
Table 4.17	4/26	Decreased	0	100%		

One reason for 50% of the Kappa scores being less than 0.2, may be attributed to Randolph's (2005) suggestion that this may have occurred due to the Fleiss' Kappa being affected by prevalence, which is defined as "the [true] proportions of cases of various types in a population" (Banerjee, Capozzoli, McSweeney and Sinha, 1999; Randolph, 2005). This is not dissimilar to Haas (1991), who stated that results with high percentage agreement but low Kappa scores indicate limited variation. This may mean that although the study tried to apportion participants according to possible "pathology" types (Section 3.4), the types of patients should perhaps have presented with more distinct pathologies in order to enhance the results obtained by the examiners and thus provide a basis for a more accurate outcome.

As a result of the relatively low Kappa scores in this study, average pairwise agreement was also calculated with agreements ranging from 33.3% to 100% in the pre-phase and from 46.6% to 100% in the post-phase. The mean pairwise agreement was calculated for both pre- and post-adjustment assessments and showed an agreement of 80% for the pre-adjustment assessments and 86.1% agreement for the post-adjustment assessment of the participants. Although most measurements showed an increased agreement between the pre- and post-phase, the difference in agreement was only statistically significant for external rotation with the leg at 90° on the right (p = 0.037) and for specific long axis distraction on the right side (p = 0.015) the overall agreement was (p = .002).

The mean and standard deviation were calculated for the average pairwise agreement both pre- and post-adjustment (at the first and second assessment respectively) and as can be seen in Table 4.16, the mean increases from a value of 80.0% agreement to 86.1% agreement. The mean can be compared to sensitivity, thus, the sensitivity of inter-examiner reliability increased between the first and second assessments. The standard deviation showed a decrease in value from 30.6% to 27.1%. Therefore, despite the fact that the examiners agreed more, the standard deviation indicates that this was not just per chance as it becomes stronger in the second assessments as opposed to the first. This means that specificity for inter-examiner reliability is good.

Thus, the results of this study seem to represent a relatively high proportion of agreement between the examiners (Table 5.2), despite the relatively low Kappa scores (Table 5.2) and that there is increased sensitivity and specificity.

Farrimond (2010) conducted an inter-examiner reliability study on the knee joint and found reliability for inter-examiner reliability to be poor, whereas Williams (2010), who conducted a similar study on the mid- and hindfoot joints, found fair agreement for inter-examiner reliability on the symptomatic side. Vaghmaria (2006), who conducted a similar study on the patella, found MP to show fair inter-examiner reliability on the symptomatic side. Thus, this study lies in agreement with Stochkendahl (2006), Williams (2010) and Vaghmaria (2006) in showing "fair" agreement of inter-examiner reliability of MP of the hip joint. This is even though there are some motion parameters that seem to attain both a higher kappa values as well as higher agreement values. When assessing the type of motion parameter, it would seem that these motion parameters tend to be the “joint play” assessments as defined by Hyde and Gengenbach (2007) (see Table 5.3). This implies that there seems to be better agreement between the examiners when the joint is in the neutral position and then “sprung” in this neutral position as compared to taking the hip joint to its end range of motion and then palpating the end feel.

This outcome may suggest that in this study motion palpation, as a means of assessing the joint, had an effect on changing the motion parameters assessed by the examiners in this study. This is based on the fact that the neutral joint springing is not effected to the same degree as the end feel in joints (Bergmann and Peterson, 2011). Furthermore, more complex end feel movements may have been more difficult to detect because, for example, the iliopsoas muscle may adhere to the anterior capsule of the hip and could become painful due to repetitive motion palpation, thus causing a change in palpatory findings between the examiners (Magee, 2014), as opposed to end feel which would not be affected. Perhaps a longer training period may have created a more standardised method of motion palpation which may have led to higher agreement in end feel.

Patient discomfort, as a result of the repeated motion palpation, may also have played a role in influencing the outcomes, as repetitive motion palpation may have caused them discomfort. This may have made them unconsciously resist the examiners motion palpation attempts erratically, changing the examiners’ perception of which motions are / are not restricted.

These arguments would imply decreased reliability for end feel as opposed to joint play within this study (Huijbregts, 2002).

In addition, this outcome may correlate with the findings regarding intra-examiner reliability where it has been suggested that dominance may have had an impact on the outcome of the results (Section 5.2.1). It could therefore be suggested that a future study consider the impact of practitioner handedness on the outcome of motion palpation findings, as this underlying variable may inadvertently affect the outcomes of these studies and its impact has not been discussed in the literature.

Table 5.3: Joint play / end feel

Right			PWA1	PWA2	
IR90R1	-0.3393	No agreement	33.3%	53.3%	end feel
ER90R1	-0.3043	No agreement	53.3%	80%	end feel
ERSR1	**1.0000**	**Almost perfect agreement**	**100%**	**86.7%**	**end feel**
APR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***	***Joint play***
PAR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***	***Joint play***
MLR1	**1.0000**	**Almost perfect agreement**	**100%**	**93.3%**	**Joint play**
LMR1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***	***Joint play***

Left			PWA1	PWA2	
IR90L1	-0.2217	No agreement	40%	46.6%	end feel
IRSL1	-0.2500	No agreement	60%	73.3%	end feel
APL1	**1.0000**	**Almost perfect agreement**	**100%**	**93.3%**	**Joint play**
PAL1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***	***Joint play***
MLL1	***1.0000***	***Almost perfect agreement***	***100%***	***100%***	***Joint play***
LML1	1.0000	Almost perfect agreement	93.3%	100%	Joint play

Last column source: Hyde and Gengenbach (2007)

Based on the results in Table 5.2 and Table 5.3, even though certain motion palpation parameters show good Kappa scores and pairwise, about 50% do not show this. This may be as a result of the study design (Stochkendahl *et al*., 2006). This study performed partially well in terms of these previous criticisms, which include:

- This study utilised symptomatic subjects, as opposed to Hestbaek and Leboeuf-Yde (2000) and Huijbregts (2002).
- This study utilised partially experienced instead of inexperienced examiners (Huijbregts, 2002).
- This study utilised training with unclear definitions of positive findings and rating scales (Hestbaek and Leboeuf-Yde, 2000; van der Wurff, Hagmeijer and Maeyne 2000).
- This study attempted to describe the study results fully (Hestbaek and Leboeuf-Yde, 2000; Huijbregts, 2002; Seffinger *et al.,* 2004).
- This study dealt only with motion palpation.
- This study did not do parallel testing (Hestbaek and Leboeuf-Yde, 2000).
- This study could have done with improvement – based on the discussion of sample size (see Section 5.2.1).

- This study could have done with improvement in overall study quality (more distinct patient pathologies, greater balance between male:female participants (Hestbaek and Leboeuf-Yde 2000; Seffinger *et al.,* 2004).

In addition to the above, the dependence on the Kappa statistical method Cohen's / Fleiss on the prevalence of positive findings, and the relationship to the composition of the study population has been under discussion (Haas, 1991; Vach, 2005). Unfortunately, this latter debate is an ongoing debate as it seems to underscore some of the concerns around reliability studies (Stochkendahl *et al*., 2006).

5.2.3 Objective 3: To determine the clinical responsiveness of the hip joint after manipulation of the present restrictions

Clinical responsiveness was measured by determining whether the examiners found a difference when motion palpating the side that was adjusted (i.e. pre-measurements versus post-measurements). In theory, they should all have agreed that specific restrictions were no longer present on their second assessment of a specific participant.

The results for clinical responsiveness ranged from no evidence of responsiveness to good evidence of responsiveness. For Examiner A, it was found that there was no greater tendency for restrictions to be absent in the second assessment compared to the first on either side. This examiner actually found more restrictions to be present on the right hand side in the second assessment compared to the first. This is shown on Table 4.17 where it shows that the examiner found two restrictions on the right side during the first assessments and three on the right during the second assessments. This gave a p-value of 1.000 which shows no clinical responsiveness. On the left side the rating was slightly better with the examiner finding only half of the previously found restrictions on the second assessment when compared to the first. This is shown on Table 4.17 by showing that the examiner found 12 restrictions at the first assessments and only six at the second assessments on the left. This gave a p-value of 0.238 on the left, which is average for clinical responsiveness but not good.

For Examiner B, it was found that there was no greater tendency for restrictions to be absent post- rather than pre-adjustment on either side. Table 4.19 shows that Examiner B found four restrictions on the right side in the first assessment and none on the right in the second assessment. This gave Examiner B a *p*-value of 0.125 on the right which is fair. On the left, Table 4.19 shows Examiner B finding four restrictions in the first assessment on the left and only one in the second assessment. This gave a slightly less accurate rating for clinical responsiveness on the left, with an average *p*-value of 0.375 on the left. Of the participants that were adjusted on the right hand side, Examiner C did not find any restrictions for these specific participants. Thus, clinical responsiveness could not be assessed for this examiner on the right hand side. However, despite the fact that this examiner did not find any restrictions on the right in the first assessment, they also did not find any on the second. This is good, as it means their results were consistent. On the left hand side, there was a significantly greater tendency to find an absence of restrictions in the second assessment when compared to the first. This can be seen on Table 4.21 where it shows Examiner C finding seven restrictions on the left hand side in the first assessment and none in the second assessment. This gave Examiner C a *p*-value of 0.016 on the left which is good.

It is evident that clinical responsiveness was widely varied between the three examiners. The reasons for this is are not clear but may include the following:

- Factors that the researcher considered in order to improve the chances of increasing the clinical responsiveness:
    - The participants all wore loose clothing. Participants that did not arrive dressed in loose enough clothing were given clinic issued shorts to wear that are loose fitting.
    - The participants were prepared by the researcher, making sure that they did not move from the bed while they were waiting between examiners or for their adjustment in order not to skew the results by moving the hip joint too much.
    - The order of the examiners assessments of the participants was randomised by the researcher to ensure they all got to palpate the participants first and last at some point.

    - All the examiners wore formal attire with white clinic coats so the participants could not react to the examiners' appearances (Richardson, 2007).

- It may, however be likely that there is a link between hand-dominance, as was stated under Objective 1 (see Section 5.2.1.1.) as both Examiner A and C had better ratings on the left when compared to themselves.
- It may be linked to gender of the examiners, as there were two females and one male.
- It may also be a reflection on self-practice – only one training session was held with the examiners but perhaps one or more of them practiced on their own without being prompted to do so by the researcher.
- It might be linked to interpersonal interaction between the examiners and the participants – some examiners may have more experience and thus, potentially a better way of communicating and interacting with the participants which may have influenced the way the participants reacted physically (better communication of how to allow body to relax/position the body of the participant causing physical relaxation of the participants body allowing easier joint motion) and personally (the participants feeling more psychologically relaxed in that examiner's presence).
- And finally the variation in clinical responsiveness could be due to the fact that the examiners regressed to using their own clinical practice habits once behind the closed door with the participants despite having had training meant to standardise their application of the motion palpation of the hip joints.

A non-examiner related possibility that may have affected the outcomes of the clinical responsiveness is that fact that the researcher only manipulated one direction, but the examiners were expected to motion thirteen different motion palpation parameters. Therefore, it is unlikely that the examiners would have been able to achieve a 100% reduction in the number of restrictions seen post adjustment. This would have made the mathematical change from the pre- and post-assessment differences a lot smaller and more difficult to detect.

In order to decrease the patient influence in confounding the clinical responsiveness, the researcher recommends that if this study were to be repeated, both participants and examiners should be given a brief questionnaire after they have completed each assessment to try to determine which of the afore-mentioned variables may have caused the variance in results.

5.3 Conclusion

The findings of this study are in partial agreement with the literature, finding that, contrary to the expectations of many clinicians, motion palpation has limited to unacceptable levels of reproducibility in terms of intra-examiner reliability, inter-examiner reliability and clinical responsiveness. Therefore, the value of palpation as a diagnostic tool is, at present, unconfirmed for the hip and so the abilities of practitioners of manual therapy to reliably diagnose hip dysfunctions using palpation may be limited. This outcome however needs to be contextualised in the fact that motion palpation was utilised as one manner of clinical assessment (in this study) and thus it was not utilised as would have been in clinical practice where it would have been only one of a number of different clinical tests used to triangulate information in order to arrive at an accurate diagnosis.

CHAPTER 6 : CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This chapter revisits the objectives that were outlined in Chapter 1 considering that the results of this study have been recorded and discussed.

The aim:

- This research was to determine the intra- and inter-examiner reliability and clinical responsiveness of motion palpation of the hip joint to detect joint dysfunction in non-specific anterior hip pain and in symptomatic hip joints.

Objective 1:

- This objective was to determine the intra-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain. Intra-examiner reliability for motion palpation of the hip joints in patients with one symptomatic and one asymptomatic hip ranged from fair to perfect for Examiners A, B and C.
- Some examiners were slightly more reliable than others. The results showed that a *p*-value between 0.00 and 0.05 was considered statistically significant; the only significant *p*-value was 0.039 on the right for Examiner B indicating that for this side, the examiner had a significant difference between the pre- and post-assessments. Therefore, it would seem that although the examiners were not able to reproduce the findings exactly, they did not achieve significance for the sides consistently. This implies that they were in some manner able to reproduce, but they could not attain a *p* value of 1, indicating that they were 100% the same from pre- to the post-assessment.

Objective 2:

- This objective was to determine the inter-examiner reliability of motion palpation of the hip joint in patients with non-specific anterior hip pain and in patients with unilateral hip pain. Kappa scores for inter-examiner reliability of motion palpation of the hip joints in patients with one symptomatic and one asymptomatic hip ranged from -0.3393 to perfect scores of 1.000. The mean pairwise agreement was calculated to be 80% for the pre-adjustment assessment and 86.1% for the post-adjustment assessment. The mean translates directly to the ***sensitivity of motion palpation which shows an increase*** between the first and second assessments. The specificity of motion palpation can be compared directly to the standard deviation (SD) which was calculated to be 30.6 at the first assessment and 27.1 at the second assessment. This decrease in SD shows an ***increase in the specificity of motion palpation***.

Objective 3:

- To determine the clinical responsiveness of the hip joint after manipulation of the present restrictions. Clinical responsiveness for Examiners A, B and C ranged from no evidence of clinical responsiveness to good. Therefore, it is likely to conclude that the utility of motion palpation as a stand-alone tool for patient assessment is not recommended.

To conclude, despite the wide variance in results, the data shows fair reliability for intra- and inter-examiner reliability of motion palpation of the hip joint and limited clinical responsiveness. This indicates that motion palpation of the hip may be a sensitive and specific tool in patients who are both asymptomatic and who have anterior hip pain. However, this researcher suggests that motion palpation should be used in conjunction with a variety of assessment tools to aid in clinical decision making and determining response to treatment as it is not a gold standard against which all clinical decision making tools might be compared.

6.2 Recommendations:

- This study only used a sample of 10 participants and therefore 20 hips. Future studies should use a larger sample size in line with Patijn (2004), with specific reference to both symptomatic and asymptomatic hips. Due to the small sample size in this study it was not possible to perform the analyses per each measurement using Chi-Square Test of Independence and the McNemar's test to compare intra-examiner reliability. This reiterates the suggestion that a bigger sample size should be used, or alternatively, a different statistical test should be used to analyse the data. This limitation may have contributed to the reduced likelihood that Objective 3 could achieve its outcome

- Due to the many directions of motion of the hip (13) that were utilised, it was not possible to match the restrictions of motion directions found by the examiners to the intervention. This prevented the researcher from using the Etiological Fractions Equation to generate *p* values on clinical responsiveness. The researcher suggests future studies look at only a few directions of motion with matched interventions/non-interventions and have more examiners.

- Ensuring more varied pathology, not just differences in mobility of the hips.

- This study did not use any kind of "gold standard" against which motion palpation could be compared. Future studies could include a "gold standard" test and compare it against motion palpation in order to truly compare reliability. An example of this would be using participants who present with a certain restriction in motion like Humphries, Delahaye and Petersen (2004) used in their study. That study used participants with congenital block vertebra as a gold standard (Humphreys, Delahaye and Petersen, 2004).

- This study included seven females and three males as participants. This was not intentional but just per chance. Future studies should try to ensure equal numbers of males and females Patijn (2004)

- It is unclear whether any of the examiners leaned on their clinical experience when motion palpating the participants. They may have not only felt for restrictions in joint motion but also muscle tonicity and increased joint bogginess as examples which may have skewed their results. This may have been done by "second-nature", not intentionally. Future studies should include a brief questionnaire on the examiners' feelings after they have motion palpated each patient.

- Two of the examiners used in this study were students and the third had been qualified for three years. Future studies should attempt to have a wider range of examiner experience (although there is literature arguing against this [Hansen, Simonsen and LeBoeuf-Yde*,* 2006]). Another suggestion for future studies may be to use examiners of equal experience to see if their similarity in training and experience plays a significant role in the results of the study (Hansen, Simonsen and LeBoeuf-Yde, 2006). Future studies could also compare male and female examiners, and examiners with different hand dominance in order to see if gender or hand dominance plays a role in the results.

- Only three examiners were used in this study. Future studies could consider using more than three examiners in order to obtain more specific results.

- This study included no feedback from the participants. A future study might replicate this study but with the addition of a qualitative questionnaire to acquire the feelings of the participants regarding their feelings after each examiner as this may shine a light on the reasons for the variances in the data. This may assist in determining whether pain or muscle spasm / post adjustment stiffness / discomfort may have affected the results for the adjusted segments

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APPENDIXES

Appendix A1

DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P.O. Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

21 January 2016

IREC Reference Number: **REC 143/15**

Ms G L Bertolotti
29 Fernleigh Drive
Kloof
3610

Dear Ms Bertolotti

Examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint

I am pleased to inform you that Full Approval has been granted to your proposal REC 143/15.

The Proposal has been allocated the following Ethical Clearance number **IREC 0[illegible]/16**. Please use this number in all communication with this office.

Approval has been granted for a period of two years, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2016 -01- 21
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix A2

MEMORANDUM

To : Prof Puckree
Chair : RHDC

Prof Adam
Chair : IREC

From : Dr Charmaine Korporaal
Clinic Director : FoHS Clinic

Date : 09.06.2015

Re : Request for permission to use the Chiropractic Day Clinic for research purposes

---

Permission is hereby granted to :

Ms Gina Bertolotti (Student Number: 21010080**)**

Research title : "Intra- and inter-examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint in symptomatic patients".

It is requested that Ms Bertolotti submit a copy of her RHDC / IREC approved proposal to the Clinic Administrators before she starts with her research in order that any special procedures with regards to her research can be implemented prior to the commencement of her seeing patients.

Thank you for your time.

Kind regards

[redacted]

Dr Charmaine Korporaal

Clinic Director : FoHS Clinic

Cc: Mrs Pat van den Berg : Chiropractic Day Clinic
Dr L O'Connor : Research co-ordinator
Dr G Harpham : Research supervisor

Appendix A 3

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

VICE-CHANCELLOR
& PRINCIPAL

Vice-Chancellor and Principal
Durban University of Technology
79 Steve Biko Road, Steve Biko Campus,
Durban, 4001

P O Box 1334
DURBAN
4000

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Email: vicechancellor@dut.ac.za
www.dut.ac.za

30 October 2015

PERMISSION TO CONDUCT COURSE-WORK MASTERS CLINICAL RESEARCH WITHIN THE DUT CLINIC 2015-2016

In line with a decision taken by the Institutional Research Committee on 27 October 2015, I hereby grant a blanket permission for the use of the DUT Clinic as a site for data collection within the context of coursework Masters (M.Tech Chiropractic and M.Tech Homoeopathy) clinical research projects. Such permission is granted upon the following conditions:

1) The respective clinical research project is approved by the Faculty Research Committee (RHDC);

2) The clinical research project is approved by the Institutional Research Ethics Committee (IREC);

3) Permission to conduct the clinical research project within the DUT Clinic has been sought and granted by the Clinic Director, or other authorised person;

4) A copy of the written permission of the Clinic Director, or other authorised person, is to be submitted to the secretary of the RHDC for inclusion in the respective student's proposal record and included in the dissertation as an appendix;

5) The Clinic Director is to submit a summary of clinical research projects [qualification, student name/number, title of study, any AE/SAE reports] conducted within the DUT Clinic to the IRC on an annual basis (the last meeting of each year) for noting.

Please note that this permission relates only to clinical research conducted on-site at the DUT Clinic, and separate relevant gatekeeper permission would still be required for clinical research intended to be conducted off-site.

Dr Aadil Docrat	Acting HOP: Chiropractic
Dr Corne Hall	HOD: Homoeopathy
Dr Laura O'Connor	Research Co-ordinator: Chiropractic
Dr David Naude	Research Co-ordinator: Homoeopathy
Dr Charmaine Korporaal	DUT Clinic Director
Prof. Ashley Ross	Chair: RHDC
Prof. Jamila Adam	Chair: IREC

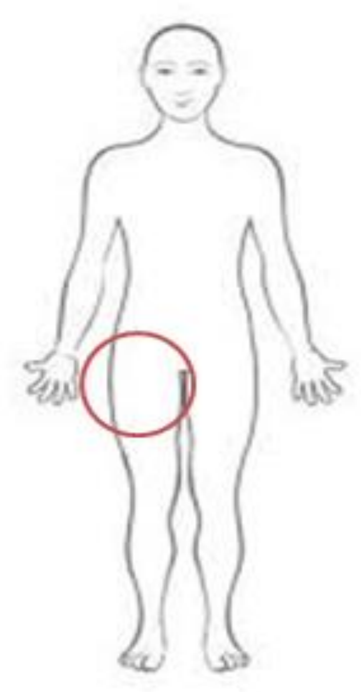
Yours sincerely,

[redacted]

Professor A C Bawa
IRC Chairperson
Vice-Chancellor and Principal

Appendix B

Do you suffer from anterior HIP or GROIN pain?



Are you between the ages of 18 and 60?

You may be eligible to be in a research project at the D.U.T Chiropractic Day Clinic.

Please contact Gina on 031 373 2205 or 074 899 6740

APPENDIX C

LETTER OF INFORMATION

<u>Dear Sir/Madam,</u>

Thank you for your time taken to participate in this study. This letter serves to inform you a little more about this study and the guidelines that need to be followed by you in order for the results to be as accurate as possible.

Title of the Research Study: Examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint.

Principal Investigator/s/researcher: Gina Bertolotti (Chiropractic intern)

Co-Investigator/s/supervisor/s: Dr Graeme Harpham (M.Tech: Chiropractic)

Brief Introduction and Purpose of the Study: The aim of this research is to determine the intra- and inter-examiner reliability and clinical responsiveness of motion palpation of the hip joint to detect joint dysfunction in non-specific anterior hip pain.

Outline of the Procedures: 10 volunteers will be required to complete this study involving two visits. At the initial consultation you will be screened for suitability against pre-set criteria. In order to do this you will undergo: a case history, physical examination and hip regional examination. These procedures will occur at the first visit to the clinic which will take up to two and a half hours. At the second appointment you will have your hips assessed by 3 examiners who are blinded for validity purposes.

Once the examiners complete the assessment the researcher may then adjust the hip in whatever restrictions were found to be most agreed upon by the examiners. The examiners will then be called back to re-assess your hips. This second appointment will be, at most, an hour long.

It is important that during the procedure with the blinded examiners, that you remain silent and do not allow them to know which of your hips is painful. Also, please refrain as much as possible from displaying pain if present (i.e. through wincing or grimacing) and do not move from the bed or sit or stand up at any stage during the examination as this would skew the results.

Risks or Discomforts to the Participant: There are no major risks with the palpation or the treatment of your hip joint. Minor things that you may experience are some slight pain or discomfort on palpation by the examiners and some mild pain on adjustment. You may experience some slight stiffness up to 48 hours post-treatment, but this is normal. It is important that you report any major pain you may experience post-treatment to the examiner.

Benefits:
The benefits outweigh the risks. If you are eligible for treatment, after the research assessment you will be referred to a 6th year student for one free treatment. All participants will receive one free voucher for treatment of any one region of the body.

Reason/s why the Participant May Be Withdrawn from the Study: You are free to withdraw from this study at any stage, without giving reasons for doing so and you shall not suffer any adverse consequences. If you do not meet the inclusion criteria you will not be admitted into the research. If you are found to have been dishonest in the history provided and / or fail to comply with the treatment protocol and follow up consultations you will be excluded from the study. You will have to withdraw from the research if you have a major trauma between visit one and two for your protections and as this may skew the results of this research.

Remuneration: You will NOT receive a travel allowance or any remuneration for participating in the study. However you will, as a participant in the study, not be charged for your consultations, as well as receiving a voucher for one free treatment at the DUT Chiropractic Day Clinic for any one region of the body with the researcher, Gina Bertolotti.

Costs of the Study: You will not be expected to contribute towards any costs involved in the research process, (transport not included).

Confidentiality: All patient information is confidential and will be kept in a patient file at the Chiropractic Day Clinic for five years after which all research information will be destroyed. The results from this study will be used for research purposes only and will be made available in the Durban University of Technology Library in the form of a mini-dissertation.

Research-related Injury: Should you be injured during the research process, although this is highly unlikely, please note that there will be no form of compensation given to you by the researcher or the institution.

Persons to Contact in the Event of Any Problems or Queries:

Researcher: Gina Bertolotti 031 373 2205 (D.U.T. Chiropractic Day Clinic)

Supervisor: Dr Graeme Harpham M. Tech: Chiropractic 031 205 6534

Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

CONSENT

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, ____________ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

______________________ ___________ _______ ________________
Full Name of Participant Date Time Signature /Right Thumbprint

I, _______________ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

__________________ ___________ ____________________
Full Name of Researcher Date Signature

__________________ ___________ ____________________
Full Name of Witness Date Signature
(If applicable)

__________________ ___________ ____________________
Full Name of Legal Guardian Date Signature
(If applicable)

Appendix D

DUT DURBAN UNIVERSITY OF TECHNOLOGY | DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC CASE HISTORY

Patient: ____________________ Date: __________

File #: __________ Age: __________

Sex: __________ Occupation: ____________________

Student: ____________________ Signature ____________________

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:

Previous: Current:

X-Ray Studies:

Previous: Current:

Clinical Path. lab:

Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:

Reason for Conditional:

....

....

Signature: Date:

Conditions met in Visit No: Signed into PTT: Date:

Case Summary signed off: Date:

Appendix E

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

Patient Name: ____________________ **File no:** __________ **Date:** __________

Student: **Signature:**

VITALS:					
Pulse rate:			Respiratory rate:		
Blood pressure:	R	L	Medication if hypertensive:		
Temperature:			Height:		
Weight:	Any recent change?	Y / N	If Yes: How much gain/loss	Over what period	

GENERAL EXAMINATION:		
General Impression		
Skin		
Jaundice		
Pallor		
Clubbing		
Cyanosis (Central/Peripheral)		
Oedema		
Lymph nodes	Head and neck	
	Axillary	
	Epitrochlear	
	Inguinal	
Pulses		
Urinalysis		

SYSTEM SPECIFIC EXAMINATION:
CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION
ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
COMMENTS

Clinician: **Signature:**

Page 1

Appendix F

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

HIP REGIONAL EXAMINATION

Patient: ______________________ File no: ________ Date: ________

Student: ______________________ Signature: ________

Clinician: ______________________ Signature: ________

Hip with complaint: Right ☐ Left ☐

OBSERVATION

- Gait: ____________
- Posture: ____________
- Weight-bearing symmetry: ____________
- Balance and proprioception (Stork-standing test): ____________
- Bony / soft tissue contours: Buttock contour ____________
  Hip flexion contracture ____________
  Lumbar lordosis ____________
  Scoliosis ____________
- Skin: ____________
- Swelling: ____________

PALPATION

• Anterior aspect			Right	Left
1.	Iliac crests			
2.	Greater trochanter			
3.	Pubic symphysis and tubercle			
4.	Femoral head			
5.	Femoral triangle	Femoral artery		
		Lymph nodes		
6.	ASIS's			
7.	Inguinal ligament			
8.	Inguinal hernia			
9.	Muscles -	Quadriceps		
		Adductors		
		Abductors		
		Psoas		

• Posterior aspect			Right	Left
1.	Iliac crests posteriorly			
2.	Ischial tuberosity			
3.	Muscles	Piriformis		
		Gluteals		
		Hamstrings		
4.	PSIS's			
5.	Sciatic notch			
6.	SI joints			
7.	Lumbar Spine			
8.	Sacrum + coccyx			

Appendix G

DURBAN UNIVERSITY OF TECHNOLOGY

Patient Name: ***File #:*** ***Page:***

Visit: ***Intern:***

g Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***

Least 0 1 2 3 4 5 6 7 8 9 10 Worst

0: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***

Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***

Least ***0 1 2 3 4 5 6 7 8 9 10*** ***Worst***

O: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***

Attending Clinician: ***Signature***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***

Least ***0 1 2 3 4 5 6 7 8 9 10*** ***Worst***

O: ***P:***

E:

Special attention to: ***Next appointment:***

Appendix H

Examiner Findings:

Examiner Number: 1 2 3

Patient: ______________________________

First Examination:

	Right	Left
Quadrant Scouring		
Long Axis Distraction - General		
- Specific		
90° compression		
Internal Rotation: @ 90°:		
Straight:		
External Rotation @ 90°:		
Straight:		
Superior to Inferior		
Anterior to Posterior		
Posterior to Anterior		
Medial to Lateral		
Lateral to Medial		

Examiner Findings:

Examiner Number: 1 2 3

Patient: ___________________________

Second Examination:

	Right	Left
Quadrant Scouring		
Long Axis Distraction - General		
- Specific		
90° compression		
Internal Rotation: @ 90°:		
Straight:		
External Rotation @ 90°:		
Straight:		
Superior to Inferior		
Anterior to Posterior		
Posterior to Anterior		
Medial to Lateral		
Lateral to Medial		

Appendix I

Master Data Collection Sheet:

Patient's Name:			Age:	
Occupation:			Sex:	
Side affected: (circle)	L	R	Both	

Findings of Examiners: First Examination

Quadrant Scouring	1		2		3	
	Right	Left	Right	Left	Right	Left
Long Axis Distraction - General						
- Specific						
90° compression						
Internal Rotation @ 90°:						
Straight:						
External Rotation @ 90°:						
Straight:						
Superior to Inferior						
Anterior to Posterior						
Posterior to Anterior						

Medial to Lateral						
Lateral to Medial						

Adjusted: YES / NO

How:____

Findings of Examiners: Second Examination

Quadrant Scouring	1		2		3	
	Right	Left	Right	Left	Right	Left
Long Axis Distraction						
- General - Specific						
90° compression						
Internal Rotation @ 90°:						
Straight:						
External Rotation @ 90°:						
Straight:						
Superior to Inferior						
Anterior to Posterior						
Posterior to Anterior						
Medial to Lateral						
Lateral to Medial						

Appendix J

This voucher entitles you to **ONE** free Chiropractic

treatment

of any region of the body at the

D.U.T. Chiropractic Day Clinic

with Gina Bertolotti or another student if Gina Bertolotti is no longer student at D.U.T.

This voucher is valid for 3 years from the date you received it:

____

Signature of researcher:

____

Voucher Number: __________

Appendix K: Research Procedure Flow Diagram:

Telephonic/Face-to-face screening (interview)

Appointment 1 at the D.U.T. Chiropractic Day Clinic

Patient signs letter of Information and Consent

Researcher performs:

- Case History
- Physical
- Regional

Inclusion

Group 1 | Group 2 | Group 3

Appointment 2

Mini-screen – for any major Trauma

		Patient 1	Patient 2	Patient 3	Patient 4 …
Procedure A	{	Room 1	Room 2	Room 3	Room 4 …
		Examiner 1	Examiner 2	Examiner 3	

Researcher performs intervention

Procedure B: Repeat as procedure A

Researcher thanks patient, patient leaves, examiners leave.

Appendix L

Letter of Examiner Participation:

Dear Intern/Doctor,

Thank you for taking the time to participate in my study:

Examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint

This letter serves to inform you of your role and responsibilities whilst partaking in my study and as a contract binding you to see the study out to completion of data collection. This involves doing a few training sessions (a maximum of 5 sessions over 2 and a half weeks) on motion palpation of the hip joint, motion palpating ten patients, (twice each) and recording your findings. You will be blinded as to whether or not the patients will be adjusted between your two examinations.

By signing this contract you are also agreeing to keep all information regarding both the research and the patients confidential.

I, ______________________________________ (Name and Surname), hereby agree to partake in Gina Bertolotti's research: "Examiner reliability and clinical responsiveness of motion palpation to detect biomechanical dysfunction of the hip joint" until completion of data collection, including attending a maximum of 5 training sessions before data collection begins. I agree to keep all information pertaining to the research and the patients confidential.

Signed: _________________________ Date: _____________________ at _______________________

Researcher: _______________________________ (Name and Surname)
Signed: _________________________ Date: _____________________ at _______________________

Witness: ______________________________ (Name and Surname)

Signed: ________________________ Date: ____________________ at ______________________

Appendix M

Dear Gina Leigh Bertolotti

We hereby grant you permission to reproduce the material detailed below at no charge **in your thesis, in print** and **on DUT institutional repository** and subject to the following conditions:

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Jennifer Jones
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