THE PREDICTIVE VALUE OF THE SACRAL BASE PRESSURE TEST IN DETECTING SPECIFIC TYPES OF SACROILIAC DYSFUNCTION

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DECLARATION

I, Travis Dylan Mitchell, declare that this dissertation is my own, unaided work. It is being submitted in partial fulfilment for the Master’s degree in Technology, in the programme of Chiropractic, at the Technikon Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other Technikon or University.

__________________________
TRAVIS DYLAN MITCHELL

Signed at ________________,
On this day the ________ of the month of ______________ 2004.
ABSTRACT

The sacroiliac joints are a source of low back pain (1) and sacroiliac joint disorders are a common occurrence in clinical practice (2). Sacroiliac dysfunction is considered to be the most common cause of sacroiliac joint pain and subsequent lower back pain (3). However, the anatomical location of these joints and the lack of a satisfactory criterion standard (the “gold standard”) make the diagnosis of sacroiliac joint dysfunction difficult (4). Nevertheless, many different sacroiliac joint tests have been described to detect the sacroiliac dysfunction however none have been validated against any independent criterion standard (5). Furthermore, numerous invalidated tests attempt to diagnose the type of sacroiliac joint dysfunction although they also lack that satisfactory criterion standard (4, 5). The Sacral Base Pressure Test has been shown in a previous study to have good validity as an indicator of sacroiliac dysfunction (6).

This study aimed to reconfirm the validity of the Sacral Base Pressure Test in diagnosing sacroiliac joint dysfunction. It also determined the predictive powers of the test in determining which type of sacroiliac joint dysfunction was present.

Sixty-two participants underwent a double-blind experimental study where the results from the Sacral Base Pressure Test were compared against a cluster of previously validated tests of sacroiliac joint dysfunction. The cluster of tests gave the diagnosis against which the Sacral Base Pressure Test’s validity and predictive powers were determined. The cluster of tests included Standing Flexion Test, the Iliac Springing Test, Spine Test and Supine Long-Sitting Test. The former two tests only determined the presence of the sacroiliac joint dysfunction, whilst the latter tests also determined the type of dysfunction present. The results occurring in the Sacral Base Pressure Test, namely the external rotation of the feet, were measured using a digital inclinometer.

There was no statistically significant difference in the results of the Sacral Base Pressure Test between the types of sacroiliac joint dysfunction. Only when the Sacral Base Pressure Test was performed on the right of the patient and when it analysed right-sided dysfunction types, was there a slight statistically significant difference ($P = 0.0529$) evident in the results. In terms of the results of validity, the Sacral Base Pressure Test was useful in identifying positive values of sacroiliac joint dysfunction but was not useful in identifying the negative values. The Sacral Base Pressure Test did not accurately diagnose patients with positive test
results, however it was fairly helpful in correctly diagnosing patients with negative test results. The Sacral Base Pressure Test had only a “slight” agreement with the diagnosis according to the Landis and Koch Guidelines for Kappa interpretation.

At this stage of research into the Sacral Base Pressure Test, the results are varied. In this study, the test was not a clinically useful test for determining the presence of sacroiliac joint dysfunction or the type of dysfunction present. Further research comparing the agreement of the Sacral Base Pressure Test or other sacroiliac joint dysfunction tests with a gold standard of diagnosis is necessary.
DEDICATION

My research project must be dedicated to my loving parents and family. You are the ones who backed me when nobody else believed I could achieve. To my mother whose nurturing and healing qualities aids me in helping others. Dad, your choice words of wisdom at those crucial moments when I knew I was giving up. To Brandon, you are my best friend and my greatest rival and to Colette, my sister. I love and thank all of you more than you know.
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To the profession that enabled me to believe in myself and develop a passion not only to succeed but also to obtain my finest. Chiropractic is the greatest profession.
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CHAPTER 1: INTRODUCTION
1.1 General Introduction

It has been well documented that 80% of people will suffer from lower back pain at some time in their life. Much research is directed at the origin of this pain but any skeletal, muscular, ligamentous, visceral and/or nervous tissue in the surrounding area can be involved. In 1905, Goldthwaite and Osgood considered the sacroiliac joint to be the main cause of lower back pain. However in 1934, Mixter and Barr changed the focus to the herniated disc and surrounding structures as the cause of lower back pain (7). Since then, the sacroiliac joint has had a mixed participation in the cause of lower back pain (7) and has been exposed to considerable controversy (8).

Currently the clinical interest is shifting back to the pelvic joints because sacroiliac joint disorders are a common occurrence in clinical practice (2) and the sacroiliac joints are re-emerging as a lower back pain source (1). The sacroiliac joints have been reported to cause buttock and leg pain (sciatica), as well as compensational dysfunction throughout the spine (9).

The sacroiliac joints can be affected by a variety of pathological processes including inflammation, infection, malignancy and crystal deposits that can cause pain. Many medical and alternative health care professionals describe sacroiliac dysfunction as the most common cause of sacroiliac joint pain and subsequent lower back pain (3).

Sacroiliac joint dysfunction has been defined as a state of altered mobility within a portion of the sacroiliac joint’s range of motion, either unilaterally or bilaterally, which causes changes in the structural relationships between the sacrum and the ilium (10). Joint dysfunction (such as sacroiliac joint dysfunction) has been described as an osteopathic lesion, hypomobility, malalignment, fixation, malrotation, joint binding or subluxations (11), however in this study it will be termed as “dysfunction” and shall imply joint hypomobility, which is a malfunction of the normal mechanics of the joint. Therefore, it does not include sacroiliac joint hypermobility (an increase in joint motion) (12).

Sacroiliac joint dysfunction can be divided into two dysfunction types, namely a flexion and an extension dysfunction. These dysfunctions are an alteration in the structural position between the ilium and the neutrally positioned stable sacrum and result in an asymmetry of the paired pelvic and lower extremity landmarks (11). Aside from these asymmetries, each
dysfunction type has a specific direction of hypomobility and clinical features related to this hypomobility (13).

Medical literature has noted the prevalence of sacroiliac joint dysfunction to be between 19.3% and 47.9% depending on the study group (14). In a study of failed back surgery syndrome patients, 62.8% demonstrated sacroiliac joint symptoms (15). According to a lower back pain workshop, it was estimated that 80% of all patients with low back pain exhibit no known pathological antecedents (16). This has been verified by other sources (17), some even commenting that in lower back pain cases, 90% of the problem is aberrant function rather than overt structural disease or pathology (2). There are no specific prevalence values for the different types of sacroiliac joint dysfunctions (18).

However, the lack of knowledge about the true pathophysiologic mechanisms involved has created [a] a variety of hypothetical diagnostic criteria for sacroiliac joint dysfunction and [b] a vast difference in prevalence values between studies performed on the sacroiliac joint (19).

The sacroiliac joint satisfies certain criteria in order to be considered as a pain-generating structure: it has an identifiable nerve supply, it is susceptible to disease and injury, and it is capable of causing pain similar to that seen clinically (15). Sacroiliac joint injections and pain mapping have proved that injury to the joint can mimic a wide range of conditions including intervertebral disc syndromes (20). This proves that the sacroiliac joint is a cause of low back pain and this is supported by recent research that reports success of sacroiliac joint blocks and manipulative treatment in the management of lower back pain (4).

Pain is caused by mechanical irritations of the joint itself and / or surrounding structures as a result of lost motion within the sacroiliac joint (12). Pain is either felt on the same side of the dysfunction or contralaterally (21). Although the sacroiliac joint is a pain-generating structure, it has been established that sacroiliac dysfunction can be present in the absence of pain. The factors that cause a dysfunctional joint to cause pain remain unknown (11).

1.2 The Problem Statement

A proper assessment of all lower back pain generators and an accurate diagnosis is crucial for the chiropractic profession before appropriate manipulative therapy can be administered (20). In the cases of suspected sacroiliac joint dysfunction, the examination is problematic because
of the anatomical location of these joints and the lack of a “gold standard” makes diagnosis
difficult (4).

Nevertheless, many different sacroiliac joint tests have been described to diagnose sacroiliac
dysfunction. However, none of these tests have been validated against the independent
criterion standard or the gold standard, because one does not exist. At best these tests have
been compared with other clinical tests, the validity of which are unknown (5). Also, most of
these tests are subjected to a high inter-observer error or inter- / intra-tester reliability (5) and
are very subjective in the manner in which they are performed and in their interpretation (22).

1.3 Aims and Hypotheses

This study aims to reconfirm the validity of the Sacral Base Pressure Test, as determined by a
previous study done at Technikon Witwatersrand, by predicting the presence or absence of a
sacroiliac joint dysfunction. The previous study achieved a good agreement between the
Sacral Base Pressure Test and the control tests used. This study will try to reproduce those
results by adding further objectivity to application of the Sacral Base Pressure Test.

The study’s second aim is to establish whether the Sacral Base Pressure Test can determine
the type of sacroiliac joint dysfunction, which is present as defined by this study. It is
hypothesized that the results obtained by the Sacral Base Pressure Test will differ between the
two types of sacroiliac joint dysfunctions, therefore the Sacral Base Pressure Test will be able
to determine not only the presence of a sacroiliac joint dysfunction but also the type of
dysfunction.

The Sacral Base Pressure Test is relatively unknown, however it is more objective regarding
its interpretation and the manner in which it is performed. It therefore brings a new, relatively
objective measure into sacroiliac joint examination and will improve the diagnosis of
sacroiliac dysfunction as well as identify specific types of dysfunction. Many other related
topics could be based on this and the previous research study, in order to further increase the
limited knowledge regarding this joint and the Sacral Base Pressure Test.
CHAPTER 2: LITERATURE REVIEW
2.1 Introduction

The sacroiliac joint has been historically subjected to much controversy regarding its structure, function and pathological features (23, 24, 25, 26). However, as discussed above, the sacroiliac joints do play a fundamental role in causing lower back and buttock pain as well as leg pain (sciatica) (9). Sacroiliac joint dysfunction is now a well-defined and common type of dysfunction and therefore a thorough understanding of the sacroiliac joint structure and function is essential to provide a framework for logical evaluation and treatment processes (27).

This literature review will give an overview of the following:
The anatomy of the sacroiliac joint, including the osteology, sacroiliac joint stability and biomechanics thereof;
Sacroiliac dysfunction, its presenting signs and symptoms, types of dysfunction, current diagnosis and current management thereof;
The four control tests used in the diagnosis of sacroiliac joint dysfunction, namely: Standing Flexion Test, Iliac Springing Test, Spine / Gillet test and Supine Long-Sitting Test; and
The Sacral Base Pressure test, which for the purpose of this research, is used as the experimental test and shall be referred to as the S.B.P.T.

2.2 The Sacroiliac Joint Anatomy

2.2.1 General Anatomy

The sacroiliac joint is a unique articulation with a highly individualized and unique structure (27). The sacroiliac joints are true atypical diarthrodial (synovial) joints (9), thus consisting of a joint cavity with synovial fluid, articular cartilage on both surfaces, a joint capsule lined with synovial membrane (28), ligamentous connections between the two bones and a mobile articulation (9). There is a left and a right joint (28), that lie at ten o’ clock and two o’ clock respectively (9), within the pelvic ring. These joints are at an oblique angle to the sagittal plane (28), the sacral surface facing laterally, inferiorly and posteriorly (27). The joint is an articulation between the articular surface of the lateral aspect of the sacrum and the auricular surface of the medial aspect of the ilium (29). The iliac auricular surface is longer and narrower than the sacral surface, which is larger (24).
In studies of cadavers, large variations were found in the joint surface configurations and its orientation to the sagittal plane between individuals. Differences between left and right-sided joints in the same specimen were also present (30).

For further information regarding the osteology of the sacrum and the innominate, refer to Gray, H. Anatomy of the human body. 20th edition, New York: Bartleby.com, Inc., 2000 (or similar anatomy text) or to DeFranca, G.G., 1996 (24).

### 2.2.2 The Anatomy of the Sacroiliac Joint Articulation

The joint can be subdivided into two components, a synovial portion and a syndesmotic portion (figure 2.1). The synovial portion is anterior (namely the lower two thirds of the joint (8)) and consists of the auricular surfaces of the sacrum and the ilium (7). The syndesmotic portion is more posterior in position (namely the upper third (8)) and consists of the roughened sacral and iliac tuberosities that attach the interosseous sacroiliac ligaments (7).

Figure 2.1. The sacroiliac joint consists of a ligamentous compartment posteriorly and an articular compartment anteriorly (31).

The joint is large, with an average surface area of seventeen and a half centimetres (11). Over 80% of the articular surface is formed by the first, second and third sacral segments (27). The lateral view of the sacrum presents two areas: a smooth surface, the auricular surface (that has the shape of an ear) which is the articular surface for the sacroiliac joint; and an irregular, rougher area behind that which is a ligamentous area for fibres of the interosseous sacroiliac ligament (32).
The sacral articular surface consists of two arms (32): a broader (7) superior arm, extending across the lateral surface of the first sacral segment (32) orientated postero-superiorly (7) yet more vertical (24); and an elongated (7) inferior arm, extending across the second sacral segment and a variable distance across the third sacral segment (32), orientated postero-inferiorly (7), yet more horizontal (24). The anterior edge of these two arms coincides with the anterior edge of the sacral lateral surface. Thus the anterior edge of the sacroiliac joint coincides with the anterior sacral surface (32).

2.2.2.1 The Articular Surfaces and Cartilage

The joint surfaces are marked by a roughened appearance showing several symmetric and reciprocal depressions and raised ridges on the sacral and iliac articular surfaces respectively (29). In most preparations, the ridges can be seen to involve both bone and cartilage. The roughened texture results in a higher friction co-efficient, which adds to the joint stability along with the two different interfacing surfaces and the different cartilage thickness (33).

The sacral component of the joint has a more concave profile, while the iliac component is more convex (27). On the sacral surface there is a central saddle-shaped depression at the junction of two arms and an elevation at the end of each arm (24). With the iliac articular surface being a reciprocal design to the sacral surface, the joint appears to be sinuous in the frontal view (figure 2.2) (25). In certain anatomy texts, the sacral articular surface is described as being twisted from above downwards. Therefore opposite the first sacral segment, the articular surface’s dorsal edge projects slightly further laterally than the ventral edge. The converse architecture occurs at the third sacral segment. This gives the sacrum a wedge-shape when viewed in transverse section (25). Both the iliac and the sacral surfaces are nearly parallel at the first and second sacral segments, yet course medially at about the third sacral segment level (24).

There is also a sacral groove that runs along the centre of the sacral articular surface (extending from the upper to the lower end) and corresponds with a longitudinal ridge or crest on the iliac articular surface (29). This groove and ridge interlock for stability and help to guide the movement (29).
The interfacing cartilages are of a thicker (one to three millimetre in thickness (25)) hyaline variety on the sacral side (27), which has a white and smooth appearance (25), and a thinner (usually less than one millimetre thick (25)), more fibrous composition on the ilium side (27). The iliac cartilage is duller in appearance and is marked by dense bundles of collagen, which gives it the appearance of fibrocartilage, but it is hyaline in nature (27). The sacral cartilage is often three to five times thicker than the iliac cartilage (27) and this variability in composition and thickness may result in earlier and greater wear of the iliac surface (34). Differences in thickness of the two surface cartilages are observed even in fetal specimens, which suggests that the disparity is not a result of differential life stresses and strains on the two surfaces (34). The two kinds of articular cartilage present on opposing sides of this joint suggests a disparity in function between the two articular surfaces, however this theory is poorly investigated (7).

2.2.3 The Sacroiliac Joint Development and Degenerative Changes

The joint space forms between the tenth and twelfth week of gestation (12) and a synovial membrane appears by the thirty-seventh week (25). Subsequently, a well-formed auricular-shaped joint is present from two months gestational age (23). The articular surfaces start off smooth and flat, allowing a gliding motion (23). These joint surfaces are parallel to the long axis of the spine, in other words orientated vertically (1, 17).
The joint morphology becomes adult-like at puberty and has a complete adult form by the twenty-fifth year (figure 2.3) (7). A crest of interdigititation between the articular surfaces develops and limits motion to a postero-superior to antero-inferior nodding (nutation and counternutation) (27).

Early in the development, the capsule is thin and pliable anteriorly with most of the stability derived from the large posterior ligaments (23). The capsule becomes more defined and fibrous with two layers (a dense fibrous outer layer and a synovial inner lining) in the first decade (24). However in the second and third decades, it starts thickening and losing some of its pliability and these changes progress throughout life (23).

The two sides of the joint develop quite differently (12), have differences in appearance and texture, and undergo degeneration at different rates (23). By the middle of the third decade, there are signs of degeneration in the iliac surfaces (23). The sacral cartilage undergoes similar degenerative changes in the fourth and fifth decades (12). The degenerative changes are progressive and include: marked osteophyte interdigitations and fibrous connections across the joint surface; roughening and erosions (with occasional exposed subchondral bone) of articular surfaces; plaque formation; and flaky, yellow, amorphous debris in the joint spaces (23). In a study of forty paired sacroiliac joint specimens, true para-articular bony fusion was never found and only one of the specimens exhibited a true intra-articular bony ankylosis (23).

These degenerative changes have been thought to have a significant correlation with the production of pain (30). Yet, according to Slipman et. al., at least 24,5% of asymptomatic people over fifty years of age demonstrate degenerative sacroiliac joint changes on plain radiographs and on computed tomography. Thus it is often not possible to distinguish between the normal aging process and those degenerative changes that might be considered to be pathological. This uncertainty results in problematic interpretation of examination and affects the choices of intervention (27). These developmental changes do restrict the mobility in the joint (23) and predict the nature and ranges of possible movements of the sacroiliac joint (25). Nutation is the potential motion that occurs with the advent of depressions and reciprocal ridges (25).
2.2.4 Sex Differences and Pregnancy Changes

Many anatomical studies of sacroiliac joint surfaces have revealed differences between men and women. These studies have shown that the form of the sacroiliac joint changes dramatically between the female and male after puberty (33).

The male articular surface is more commonly shaped like an inverted “L” (29, 30), a rectangular form (35), whilst the female articular surface is more commonly a “C”-shape (29, 30) being generally smaller and more oblique (30) or obtuse angle form (35). The articular topography in females is more uniform, thereby indicating a uniform mobility pattern, namely nutation. The mobility pattern and the topography is more variable in males and their
degree of mobility is much more limited. Thus, when active forces pass across the joint, it induces a rotation in females’ joints and a translation in the male joints (35). The process of osteophytosis (7) and/or intra-articular elevations and depressions (34) appears to be more prominent in males as a means to further stabilize the joint, in response to strenuous physical activity (7) that generates greater amounts of torque in the joint (34). Therefore, the differences between the sexes are apparent concerning the overall structure of the pelvis and these differences are linked to function (especially regarding parturition in women) (30).

The following points are anatomical considerations of female differences that affect the sacroiliac joint function and stability: the lateral distance of the pelvic outlet is larger, the pelvis has less bone density, the sacroiliac joints are located farther from the hip joints therefore creating a longer lever arm, there are smaller and flatter sacroiliac joint surfaces, the iliac crests are farther apart and the vertical pelvic dimension is smaller (18).

The natural hormone Relaxin, released in pregnancy, causes a relaxation of the lumbar, sacroiliac joint and symphysis pubis ligaments, which results in a widening of the female pelvis in order to facilitate parturition (26). This results in sacroiliac and sacrococcygeal hypermobility and instability, which predispose the mother to chronic sacroiliac irritation (36). There is as much as a 250% increase in sacroiliac joint mobility during pregnancy and there is also an increased mobility during menstruation (26). Women may normally exhibit increased mobility of the sacroiliac joints when compared with men, however the differences are not large and no definitive consensus has been reached (30).

### 2.2.5 Sacroiliac Joint Stability

The sacroiliac joint is a weight-bearing joint (12) with the sacrum suspended between the ilia by strong, dense ligaments (18). There are several factors that contribute to sacroiliac joint stability and these include structural (osseous, cartilaginous and ligamentous) and dynamic (musculofascial) contributors (figure 2.4) (27). The terms “force closure” and “form closure” have been used to encompass these stability contributors (27) and form the self-locking mechanism (37). This mechanism maintains the integrity of the low back and the pelvis during the transfer of energy from the spine to the lower extremity (30).
Figure 2.4. Stability in the sacroiliac joint arises from combination of self-bracing and force closure mechanisms responsive to gravitational stress (39).

2.2.5.1 Form Closure

Form closure describes the interlocking joint surface and those anatomical structures that supply passive stability (figure 2.5) (27). This is a stable situation with closely fitting joint surfaces, in which no additional forces are needed to maintain the state of the system, depending on the load situation. With perfect form closure, the sacrum would fit in the pelvis and no lateral forces would be needed. However in this situation, mobility of the sacroiliac joint would be practically impossible, thus a degree of additional forces are needed namely force closure. See 2.2.2.2 above for further discussion of force closure (40).

During infancy and childhood, stability is entirely dependent on its supporting ligaments. This is due to the planar articular surface, which allows freedom of movement in all directions. At puberty and throughout adolescence, the stability is enhanced by the appearance of the sacral sulcus and the iliac ridge. The sacroiliac joint continues to acquire stronger stabilizing elements throughout adult life. During the third decade, enlargement of the sacral and iliac tuberosities and fibrosis of the interosseous sacroiliac ligament occurs to strengthen the joint posteriorly. Eventually there is osteophytosis and occasionally bony or fibrous ankylosis that advances the stability of the joint (7).

In the adult spine, the wedge shape of the sacrum facilitates a self-locking mechanism of the sacrum within the ilia, as the trunk force further seats the sacrum deeper into the ilium. The
joint surface roughness results in a high friction coefficient and this increases the joint stability. Certain ligaments (sacro-tuberous, sacro-spinous and interosseous ligaments) increase in tension to aid this mechanism when stress is applied to the joint (in the form of trunk forces). This increased ligament tension decreases the ability of the sacrum to move within the pelvis (27).

Another factor that contributes to the unique stability of the sacroiliac joint is the variability and complexity of the orientation of the joint surfaces. The joint surfaces are described as being asymmetrical in size, shape and direction, lying on numerous planes. The variability significantly increases joint stability because it resembles a “jigsaw puzzle” and can be demonstrated between sides and at different sacral vertebral levels, in other words the middle third of the sacral surface is more vertically inclined and the lower third exhibits an outflaring. Vertical load bearing is facilitated, however the inverted wedged-shape sacrum limits motion (34).

Therefore, the surface orientation variability combines with the articular surface ridges and depressions to give form closure to the sacroiliac joint.

Figure 2.5. The object is held in place by (A) form closure, (B) force closure, and (C) a combination of form and force closure, less friction - and thus less compression - being needed than in (B). (D) shows the mechanism of an arch. Force F, may be raised by ligaments, muscles, or a pelvic belt just cranial to the greater trochanter and caudal to the sacroiliac joint. This force prevents lateral movement of the hip bones to secure the form of an arch (41).
2.2.5.2  Force Closure

Force closure refers to the dynamic stabilization of the sacroiliac joint offered by the musculofascial system and the ligaments surrounding the sacroiliac joint (figure 2.5) (27). With force closure, both a lateral force (provided by the musculofascial systems and the ligaments) and friction (form closure) are needed to withstand the impact of the vertical load on the pelvis. Muscles and ligaments prevent shear forces and allow effective force transfer by means of compression that can be adjusted to the specific loading situation (40).

2.2.5.2.a  Ligamentous Stability

In addition to the bony adaptations of the joint, several massive ligaments surround the area and this comprises the ligamentous two thirds of the joint. These ligaments provide stability and limit the mobility of the sacroiliac joint (30). These ligaments must oppose strong forces (responding against gravitational and ground forces (27)) for prolonged periods and thus play an important role in the self-bracing mechanism of the pelvis (30). It was shown in studies that the symphysis pubis and either the anterior or posterior sacroiliac joint ligaments must remain intact for the joint stability. Using the Cartesian co-ordinate system aids in describing the specific actions of ligaments and the directions of possible sacroiliac joint displacement (figure 2.6). This system has its origin at the second sacral tubercle for pelvic mechanics, where “x” is positive to the left, “y” is positive superiorly, and “z” is positive anteriorly (30).

![Cartesian Coordinate System](image)

Figure 2.6. The sacrum in a three-dimensional Cartesian co-ordinate system. A body can be described as rotating around the three axes, X, Y and Z, in one direction, positively (+), or the other, negatively (-). It also can be described as translating (+) or (-) in the XY, XZ, or YZ
planes. A body free to move in any direction is characterized as having twelve degrees of freedom (42).

A joint capsule lines the joint anteriorly and posteriorly and is strengthened by many ligaments (24). However, it is sometimes difficult to discern where capsule ends and ligaments begin. Many authors therefore state that the posterior capsule is rudimentary or absent and the anterior sacroiliac ligament is a thickening of the anterior capsule (25). The ligaments around the sacroiliac joint are divided into intrinsic and extrinsic ligaments (figure 2.7). The intrinsic ligaments are grouped into anterior ligaments and posterior ligaments (24).

2.2.5.2.a.i The Anterior Ligamentous Structures:

The anterior sacroiliac joint ligament is an antero-inferior thickening of the joint capsule (30), with horizontally directed fibres (7). It is very well developed near the arcuate line and the posterior inferior iliac spine (30). This ligament, like the interosseous ligament, binds the ilium to the sacrum and prevents anterior diastasis of the joint (25). It also opposes translation of the sacrum (superiorly and inferiorly) and separation of the joint surfaces (30).

![Anterior, Inlet, Posterior](image-url)

Figure 2.7. The ventral (anterior) and dorsal (posterior) sacroiliac ligaments (7).
The interosseous sacroiliac ligament fills the spaces posterior and superior to the joint (30) and is one of the strongest ligaments in the human body (27). It is the main restraint connecting the sacrum to the ilium (24), strongly resisting joint separation (postero-superior gapping (7)) and translation along the “y” and “z” axes (30). During sacral nutation, this ligament is wound tight, which pulls the sacroiliac joint surfaces together, further increasing the frictional force between the sacrum and the ilium (27). However, this ligament does permit small translational movements of the ilium and the sacrum on each other as trunk and ground forces converge into the region. The joint capsule blends with the interosseous ligament (24).

The dorsal sacroiliac joint ligament is divided into two components: short and long dorsal ligament. This ligament occupies the deep recess between the sacrum and the ilium posteriorly, called the sacroiliac fissure. The dorsal sacroiliac ligament serves to provide attachment for the deep fibres of the multifidus and the gluteus maximus muscles (7). The short component is a continuation of the interosseous ligament with fibres that course laterally and superiorly (7). Together, these two ligaments make up the posterior two thirds of the joint (30) and act together to bind the ilium to the sacrum. Moreover, its posterior location allows it to prevent posterior flaring or diastasis of the joint (25). The long component of the ligament has more vertical fibres, which blend inferiorly with fibres of the sacrotuberous ligament (7). This component prevents backward rocking (counternutation) of the sacrum with respect to the ilium (25).

Both the anterior and posterior sacroiliac joint ligaments function to counteract gravitational forces and prevent distraction of the joint, particularly during upright posture and through the gait cycle (7).

Certain dissecting studies have revealed the presence of a superior intracapsular ligament (Illi’s ligament) in about 75% of dissections (figure 2.8). This ligament passes from postero-superior on the ilium to antero-inferior on sacrum, inserting directly into the sacral cartilage (24). It may be an extension of the interosseous sacroiliac ligament (7). The ligament’s biomechanical function is still in question (24), although it has been found to strengthen the sacroiliac joint capsule superiorly because of its attachment across the margins of the articular surface (7).
Figure 2.8. A cross-section of the sacroiliac joint illustrating the intimate relationship between the anterior and posterior ligaments (7).

2.2.5.2.a.iii The Extrinsic Ligaments:

The extrinsic ligaments assist the intrinsic ligaments in stabilizing the joint (7). The sacrotuberous ligament, which is partly blended to the posterior ligament (30), has fibres running from the sacral crest inferiorly, laterally and anteriorly to the ischial tuberosity (7). It functions to oppose sacral rotation around the “x” axis, namely nutation. Theoretically, rotation of the sacrum around the “y” axis would stress this ligament on the ipsilateral side (30). The sacrotuberous ligament also has some connection with the sacrospinous ligament at the lateral margin of the sacrum, the biceps femoris tendon (25), gluteus maximus and piriformis (8).

The sacrospinous ligament is a thin triangular ligament (30) that courses laterally and anteriorly from sacrum to the ischial spine (7). This ligament also functions to counteract a rotation around the “x” and “y” axes (30). Both the sacrotuberous and the sacrospinous ligaments also function to prevent posterior displacement of the sacral apex during nutation (7) by anchoring it to the ischium (25).
The iliolumbar ligaments run from the transverse processes of the fourth lumbar and fifth lumbar vertebrae to the iliac crests and merges with the interosseous ligament (30). The ligament fibres are orientated laterally with some vertical fibres that blend anteriorly and posteriorly with the intrinsic ligaments (7). It functions primarily to limit all motion between the distal lumbar spine and the sacrum, also preventing a translation or distraction of the sacrum superiorly out of the pelvic girdle and the separation of the ilia from the sacrum (30). The downward and forward rotation tendency of the sacral promontory during nutation is checked by the iliolumbar ligaments (38).

The pubic symphysis is composed of three ligaments: superior pubic, arcuate pubic and the interpubic, which resist shear stresses, “y” axis rotation of the sacrum and joint separation (30).

2.2.5.2.b Musculofascial Systems of the Lumbopelvic Complex

No typical intrinsic muscle exists for the sacroiliac joint (7), in other words no muscle crosses the joint thereby acting as the primary mover (30). However, about forty muscles can influence the sacroiliac joint motion (7). The musculature surrounding the sacroiliac joint functions not to generate motion at the sacroiliac articulation but rather braces the area, causing compression of the sacroiliac joint surfaces, thereby creating stability for effective load transfer (30). Fascial networks of the lumbopelvic region connect to muscular system of the back, abdomen and lower extremities and contribute to the self-bracing mechanism of the pelvis (43). This complex, integrated, self-bracing mechanism aids in the transfer of forces during static and dynamic activities and provides stability while allowing limited motion during activities such as walking, running and sitting. The lumbopelvic musculature is anatomically and mechanically linked through the fascial systems (30). The individual muscle’s structure and function, with relationship to these fascial systems is not explained fully in this text, however it is explained in the subsequent references, Porterfield and De Rosa (44) or Richardson, C. Jull, G. Hodgen, P. Hides, J. Therapeutic Exercise for Spinal Segmental Stabilisation in Low Back Pain. New York: Mosby, 1999.
Figure 2.9. A schematic illustration of the numerous and powerful muscles that attach to the pelvis and which can directly or indirectly affect the function of the sacroiliac joint (7).

The stability of the lumbopelvic region is dependent on three musculofascial systems: the thoracolumbar fascia, fascia lata and abdominal fascial systems. Forces are transferred through these systems from the upper extremity to the lower and vice versa. There are two important similarities in each of these fascial systems: there are muscles attached to the fascia which pull on the fascia thereby exerting a tensile force, and there are muscles encased within the fascial envelope, which broaden within this fascial envelope in turn exerting a “pushing” force which will also increase tension on the fascia (44). Therefore the muscle’s resultant activity and active contraction causes compression of the sacroiliac joint surfaces (30) and through these mechanisms causes an increase in sacroiliac joint stability (figure 2.10) (36).
2.2.5.2.b.i The Thoracolumbar Fascial System and its Associated Musculature

The thoracolumbar fascia is a network of non-contractile tissue. Its attachment and relationship to several powerful muscles of the lumbopelvic region helps it play an essential role in the function of the lumbar spine (figure 2.11) (44).

The tension in the thoracolumbar fascia can be engaged dynamically as a result of the contractile tissues attached to it. The latissimus dorsi, transversus abdominis, internal abdominal oblique and gluteus maximus function through their contractions to pull on the fascial network superolaterally, laterally and inferolaterally respectively. The latissimus dorsi and contralateral gluteus maximus muscles are mechanically linked through the thoracolumbar fascia and function to increase the compressive force across the joint by virtue of their attachments, thus increasing the stability of the sacroiliac joints (44).
Figure 2.11. The contralateral latissimus dorsi and ipsilateral gluteus maximus are linked through the thoracolumbar fascia system. Contraction of the muscles increases tension in the fascia helping to increase joint compression (27).

The thoracolumbar fascia tension can be further engaged as a result of the contractile tissues contained within it. The superficial and deep erector spinae and the multifidus muscles are contained within the fascia and their contraction results in broadening of the muscle, thus creating a “pushing” force on the fascia (44).

The thoracolumbar fascia is directly attached to the pelvis. It therefore spans, among other joints, the sacroiliac articulations. When there is an increase in tension of the thoracolumbar fascia, it potentially minimizes aberrational motion between the sacrum and the ilium (44).
Lastly, tension can also be indirectly imparted to the thoracolumbar fascia as a result of movement of the pelvis. Contraction of gluteus maximus, hamstring, or the abdominal muscles, results in a posterior rotation of the pelvis. Posterior rotation of the pelvis is essentially a flexion moment at the lumbosacral junction, which results in passive engagement of the fascia (44).

2.2.5.2.b.ii The Abdominal Musculature and its Related Fascial System

The abdominal wall mechanism is a key muscle unit contributing to mobility and stability of the lumbar spine and pelvis. The abdominal wall consists of the external abdominal oblique, internal abdominal oblique, transversus abdominis, rectus abdominis muscles and the fascial contributions of these muscles (figure 2.12) (44).

![Figure 2.12. Attachments of the hip adductor muscles and abdominal muscles to the pubic rami (27).](image)
The abdominal fascial contributors include several layers of superficial fascia that lie above the anterior abdominal wall, the aponeuroses of the external and internal abdominal oblique and transverse abdominis muscles, and the rectus sheath related to the rectus abdominus muscle. The muscle aponeuroses and the rectus sheath are directly related because the aponeuroses of the three muscles enclose the rectus abdominis as they course anteriorly, to form the rectus sheath. The abdominal fascia latticework arrangement is similar to the posteriorly placed thoracolumbar fascia latticework (44).

One function of the abdominal system is to increase compression at the sacroiliac joints and pubic symphysis, due to the muscle-fascial units, which cross perpendicular to the joint plane (44).

2.2.5.2.b.iii The Fascia Lata System and its Related Musculature

As with the thoracolumbar and abdominal fascia there are direct attachments of muscles to the fascia lata. The contractions of these muscles increase the fascial tension, however these muscles are also encased within the fascia and therefore the broadening effect of contraction will also increase tension. The fascia lata encloses the gluteus maximus muscle, covers the gluteus medius muscle and blends with an aponeurotic expansion from the vastus lateralis. These muscles therefore provide the fascial tension (44).

Two septa subdivide the fascia lata and ultimately form three compartments within the thigh that house the adductor muscles, the hamstring, and the quadriceps (figure 2.13). These muscles are essentially encased within this fascial envelope, therefore contraction and broadening of these muscles results in a consequent “pushing” effect on the fascia lata walls (44).

Apart from these fascial systems, there are certain muscles that generate sacroiliac joint stability through fibrous expansions that blend with the anterior and posterior sacroiliac joint ligaments (34). These muscles contribute indirectly to the strength of the joint capsule and the ligaments (34), thus forming a self-bracing mechanism (30) and aiding the joint stability (34). For example, the gluteus maximus, biceps femoris and piriformis have an attachment to the sacrotuberous ligament. Through these attachments, muscle contraction increases tension in the sacrotuberous ligament. This increased ligament tension limits the motion between the
ilia and the sacrum, which contributes to the dynamic stabilization of the sacroiliac joint (44).

Figure 2.13. The Iliotibial Band (24).

All these structures (ligaments, muscles, musculofascial systems) are grouped together to produce force closure and subsequently stability of the sacroiliac joint. In a study of elite rowers, the cause of sacroiliac joint dysfunction involved a disturbance of the stabilizing action of the thoracolumbar fascia. This disturbance disrupted the actions of the posterior oblique system and also diminished muscle activity, which in turn allowed a decrease in joint surface contact and promoted joint instability (10). This shows the importance of the force closure in preventing sacroiliac joint dysfunction.

2.2.6 Sacroiliac Joint Biomechanics

Regarding sacroiliac joint motion, two things are certain: firstly, the sacroiliac joints are considered to be diarthrodial and therefore move; secondly, the exact nature of this movement is controversial. This movement does play an important role in the overall functioning of the pelvis and the lower back (26).
Numerous motion patterns have been proposed for the sacroiliac joint (27). Both in-vitro and in-vivo kinematic studies have shown a variable degree of mobility in the sacroiliac joints, thus the following trends have emerged: the range of motion is small and decreases with age; the range of motion is greater in women and increased during pregnancy; the motions are coupled and dependent on some degree of joint separation; and the predominant motion is x-axis rotation coupled with some degree of z-axis translation (12). According to certain authors, the opposing joint surfaces (corresponding iliac ridge and sacral depression) direct the movement in a track-bound motion (28).

Although numerous motion patterns and axes of rotation have been described in many studies (see Appendix A), symmetrical sacral motion and asymmetrical antagonistic iliac motion, as described below, is more accepted and most commonly used clinically. Therefore, for the purpose of this study, these movements are considered to be important and primary particularly when discussing the S.B.P.T. and the four control tests.

2.2.6.1 Symmetrical Motion

This is a paired joint motion that occurs when changing from a seated to prone position (28) or during forward flexion or extension while sitting or standing (8), during which time both ilia move symmetrically and some degree of sacral nutation or counternutation occurs concurrently (8).

2.2.6.1.a Sacral Nutation / Counternutation

The sacrum approaches static equilibrium (where superior and inferior forces are removed) in the slightly flexed, prone position (8). The typical positions of the sacrum with respect to the iliac bones are nutation, counternutation and an intermediate position (41). The movement of nutation and counternutation occurs around a transverse axis posterior to the joint at the sacral tuberosity where the sacroiliac ligaments insert (figure 2.14) (18).

When the spine moves from a supine position to a standing position or during forward flexion, the sacrum nutates between the ilia. Associated with this sacral nutation is an approximation of the iliac crests and a separation of the ischial tuberosities. Nutation is described as anterior-inferior movement or tilting of the sacral base and a posterior
movement of the sacral apex relative to the iliac bones. The movement of nutation is resisted by the sacrotuberous and the sacrospinous ligament (figure 2.15) (26).

Figure 2.14. The physiologic motion in the normal sacroiliac joint is a composite of x-axis rotation and z-axis translation. This allows sacral nutation (negative or positive rotation) about the x-axis (B and C) (31).

During extension of the trunk or a positional change from standing to supine, the opposite movement occurs to that of nutation (26). This movement is called counternutation (26) and is a backward or postero-superior tilting of the sacral base relative to the iliac bones (29, 46).

Nutation and counternutation is described above as occurring independent of iliac movement, however when nutation occurs there is a posterior torsion or rotary movement of the ilium on the sacrum. Counternutation occurs with an anterior torsion or rotary movement of the ilium. Both the sacral and the iliac motion result in the same relative sacroiliac joint positioning (27).

Nutation is increased in a standing position, particularly in the case of an increased lumbar lordosis. Counternutation occurs in an unloaded position (namely prone or supine) and is
increased in situations when the lumbar spine is flattened. Counternutation in the supine position can be altered by maximal flexion of the hips (46). The combined movement of nutation and counternutation can amount to four degrees, even in old age (46), with an average of two degrees (27).

![Figure 2.15. Schematic drawing of the controlling effect of the long ligament in counternutation (A) and of the sacrotuberous ligament in nutation (B) (47).](image)

2.2.6.1.b Iliac Motion

Symmetrical iliac motion occurs with changes in position. Whilst sitting, the ischial tuberosities are separated slightly to broaden the pelvic base and the iliac crests approximate each other. During the transition from sitting to a prone position, the posterior superior iliac spines separate by as much as three quarters of an inch. Upon standing from a seated
position, the iliac crests separate and the ischial tuberosities approximate. The reverse occurs with the transition from standing to sitting. There is a degree of posterior iliac rotation when the position changes from supine to sitting or standing (26).

2.2.6.2 Asymmetrical Motion

This is a paired reciprocal or antagonistic motion. There is either antagonistic sacral motion relative to the ilia, or antagonistic motion of the ilia relative to the sacrum (26). This paired reciprocal motion occurs during walking (28).

2.2.6.2.a Sacral Motion Relative to the Ilium

During the movements of nutation and counternutation, there is an accompanying translation of the sacrum around a variable transverse axis and a twisting of the sacrum (48). Certain chiropractic authors describe the translatory motion as a gyroscopic action where the sacrum generates a figure-of-eight movement between the ilia (28).

2.2.6.2.b Iliac Motion Relative to Each Other and to the Sacrum

In terms of the asymmetrical motions stated above, the motion of the ilium relative to one another and to the sacrum is important to this study. This motion is pertinent to the Spine / Gillet test which will be fully explained in 2.4.3.3 below. While standing, hip flexion of one leg causes the ipsilateral ilium to rotate posteriorly around the x-axis. This movement is known as sacroiliac joint flexion. The sacrum is seen to nutate on the side of the flexed hip and counternutates on the weight-bearing leg. When the ilium on the side of the flexed hip reaches its end range of motion, further hip flexion will cause the pelvis to rotate posteriorly on the weight-bearing leg. Therefore, the flexed ilium will leverage the sacrum posteriorly and inferiorly relative to the weight-bearing ilium and this causes extension of the weight-bearing ilium and that sacroiliac joint (figure 2.16 (A) – (C)) (26).

The sacroiliac joint extension is thus an antero-superior motion of the ilium relative to the sacrum and flexion is a postero-inferior motion of the ilium (28). Because of the axis of rotation about which iliac flexion and extension occur, a degree of out- and inflaring occurs. With flexion, the posterior superior iliac spines move posteriorly, inferiorly and medially and the ischia move anteriorly, superiorly and laterally. The medial component of this movement
results in outflaring, where the anterior superior iliac spines move laterally. The reverse occurs with iliac extension (8).

Figure 2.16.A. Graphic representation of sacroiliac joint motion. Right sacroiliac joint in neutral position (26).

Figure 2.16.B. Motion during right knee raising or flexion of the right sacroiliac joint (26).
2.2.6.2.c Sacroiliac Joint Motion During Gait

During gait there is a rhythmic motion of the pelvis in different plains, there is superior-inferior oscillations, lateral translations and rotational movements. This all occurs in addition to the linear progression of the body’s centre of gravity (26).

During the swing phase of gait, the advancing limb’s pelvis rotates anteriorly in the horizontal plane. With heel strike, the weight-bearing ilium rotates posteriorly and the sacrum nutates on that side. Simultaneously, there is posterior rotation of the ipsilateral fifth lumbar vertebra transverse process (26). This pelvic movement cushions the ground reaction forces travelling up the femur shaft (28). During midstance, there is a pelvic sway towards the weight-bearing limb. The posterior rotated ilium returns towards a neutral position and by toe-off, the ilium is anteriorly rotated as the limb extends. The sacral base undergoes similar changes as the body moves over the weight-bearing leg, moving from the nutated position at heel-strike to counternutation at toe-off. The process is repeated on the opposite side as that limb moves through the gait cycle (26).

2.2.6.3 Factors Influencing Sacroiliac Joint Movement

The sacroiliac joint movement is influenced by muscular action and by many external forces. The muscular action is derived from the multitude of muscles surrounding the joint, most of
which are discussed in 2.2.5.2.b above. The external forces include gravity and ground reaction forces (7).

The pelvic joints act to afford shock-absorbency and pliability to the pelvis itself (26) and to attenuate the trunk and ground forces (49). The sacrum provides the base on which the spine rests. As a result, the sacroiliac joint transmits the loads from the trunk to the lower extremities. The ilium transmits ground reaction forces through the sacroiliac joint to the trunk. Therefore the sacroiliac joint lies at the intersection of trunk and ground forces (27).

The trunk forces in the standing position, acting through the long axis of the spine, causes nutation of the sacrum and causes an inferiorly directed shear stress on the sacrum. The ground forces at heel strike, acting through the long axis of the lower extremity, results in a posterior rotary torque and a superior shear of the ilium (27). The force of gravity, which passes behind the axis of the hip joint, aids the posterior rotary torque and accentuates the sacral nutation (26). As the trunk and ground forces are accepted and transferred by the lumbopelvic region, the cartilaginous surfaces compress and seat into each other. Therefore, the sacroiliac joint motion can be described as a result of cartilage deformation (27).

2.3 Sacroiliac Joint Dysfunction

Joint dysfunction is the term for hypomobility (6) and features painful restriction to movement, impaired function and pain (50). In sacroiliac joint dysfunction, normal function of the joint is interrupted. Some of the earliest changes on examination are hypertonic segmental muscles with restriction of normal movement of the joint (51), which is hence referred to as a hypomobile or dysfunctional joint.

Sacroiliac joint dysfunction is described in some texts as an altered structural relationship between the sacrum and ilium (11), while other texts discuss alteration in the joint’s normal biomechanics (12).

2.3.1 Causes

Joint dysfunction can be the result of trauma (intrinsic or extrinsic), disuse, postural indiscretions and pre-existing inflammation or disease (50). Most commonly, sacroiliac joint pain and dysfunction is mechanical in nature, particularly with regards to altered mobility.
This mechanical lesion develops through the loss of sacroiliac joint stability where the self-bracing mechanism (as described in 2.2.5 above) is affected or altered. This joint is predisposed to an increased shear force, which leads to injury of cartilaginous and ligamentous structures (7). These structures are richly innervated and are capable of producing pain (30).

The hypomobile joint can be the product of altered positions of the joint surfaces, where the ridges and depressions are no longer corresponding. This altered position is created by repetitive stresses and is maintained by compressive and elastic forces of the ligaments and the muscles (7). Small displacement of the sacroiliac joint may be responsible for the symptoms according to certain authors. The success of manipulation in the treatment of sacroiliac dysfunction confirms this notion further (12).

Ventral capsular tears have been identified to underlie the pain in many sacroiliac joints (52) and indicate some form of traumatic disruption to the joint (5). Another cause of the pain is chronic low-grade inflammation, as determined by bone scans (12). In this theory, mild synovial irritation (undetectable) progresses to an inflammatory response with eventual involvement of the adjacent cartilaginous and osseous structures. At this point there will be an acceleration of osteoblastic activity and this can be detected with nuclear imaging (53).

2.3.2 Types of Sacroiliac Joint Dysfunctions

The sacroiliac joint has been considered to be two joints in literature, even though they are the same articulation. This division is important for function and treatment indications. There is the iliosacral joint – the innominate moving on the sacrum and the sacroiliac joint – the sacrum moving within the ilia (18).

Therefore, iliosacral dysfunction is a structural positional relationship alteration between the ilium and the “normally” positioned stable sacrum and the sacroiliac dysfunction is an abnormal relationship between the sacrum and the “normally” positioned stable ilium. A unilateral positional alteration will result in an asymmetry of the paired pelvic and lower extremity landmarks (11).

For purposes of this study, the types of dysfunction will be indicative of iliosacral joint dysfunction, however will be termed as sacroiliac joint dysfunction.
The school of thought which one subscribes to will dictate the nomenclature used to describe sacroiliac dysfunction. For purposes of this study, we will only be concerned with flexion and extension dysfunctions. These descriptions of the two types of dysfunctions are very similar because an extension dysfunction occurs in the exact opposite direction as the flexion dysfunction and therefore a majority of the clinical features are the same yet occur as an exact opposite.

2.3.2.1 Flexion (Postero-Inferior Ilium or PI) Dysfunction

In this state, there is counter-clockwise rotation of the ilium around the x-axis (-θx) and is posterior on the z-axis (-z) (figure 2.21). The outflaring causes an external rotation of the ilium around the y-axis (-θy on left or +y on right) (8). Therefore the posterior superior iliac spine is relatively fixed in a postero-inferior position (28) and some degree of outflaring (21). The innominate bone on that side is relatively fixed in flexion (28) and lateral rotation (21) relative to the sacrum (figure 2.17). The axis of rotation then shifts superiorly (28) and there is a decreased anterior rotation of that ilium (13). This dysfunction induces a relative anterior inferior shift of the ipsilateral sacral base (8).

![Figure 2.17. Flexed / laterally rotated right innominate bone (21).](image)

On examination, a chiropractic text reports the finding of a separation and localized oedema in the postero-superior area (figure 2.18) and temperature differences in the upper part of the sacroiliac joint, associated with this dysfunction. The outflaring component will cause oedema throughout the posterior aspect of the joint. There may be an increased lumbar
lordosis, a lowered gluteal fold and a functional short leg ipsilaterally. The functional short leg is associated with ipsilateral tender psoas, piriformis and gluteal muscles (8).

Figure 2.18. A flexion dysfunction showing the palpable oedematous and tender area of the sacroiliac joint (8).

A flexion dysfunction has been described as being the most common dysfunction (17, 18, 28) occurring particularly on the left side (18). Repeated unilateral standing, a fall onto the ischial tuberosity, a vertical thrust onto an extended leg, lifting an object from a forward bent position with extended knees, and positions of hip hyperflexion and abduction can cause these dysfunctions (18). It has been noted that a long leg can also cause a flexion dysfunction, resulting in an elevated ipsilateral pubis (8).

2.3.2.2 Extension (Antero-Superior Ilium or AS) Dysfunction

In the case of this dysfunction, the rotation of the ilium around the x-axis is in a clockwise direction (+ θx) and the ilium is anterior on the z-axis (+ z) (figure 2.21). There is inflaring of the ilium in extension dysfunctions that causes an internal rotation of the ilium around the y-axis (+ θy on left or - y on right) (8). The posterior superior iliac spine in this dysfunction is relatively fixed in an antero-superior position (28) with some degree of inflaring (21). The innominate bone on that side will be relatively fixed in extension (28) and medial rotation relative to the sacrum (figure 2.19) (21). There is an inferior shift of the axis of rotation (28) with a decreased posterior rotation of that ilium (13). This dysfunction induces a relative postero-superior shift of the ipsilateral sacral base (8).
As found on the examination of a flexion dysfunction, extension dysfunctions also present with separation of the joint and localized oedema. However, this occurs in the postero-inferior area of the sacroiliac joint (figure 2.20). Temperature differences are also found, yet it occurs in the lower part of the joint. There may also be a degree of separation in the antero-superior aspect of the joint, which may cause damage to the anterior ligaments and associated groin pain. In these extension dysfunctions, there may be a decreased lumbar lordosis, a higher gluteal fold and an ipsilateral functional long leg (8).

A right extension dysfunction is the second most common type of dysfunction. These dysfunctions can be caused by a golf or baseball swing, dashboard injury with a horizontal thrust onto the knee, and a forceful movement on a diagonal (ventral) pattern (example is
chopping wood) (18). A shortened iliacus muscle is a major cause of this dysfunction and ipsilateral shortness of hip adductors increases anterior innominate rotation (16).

Figure 2.21. In the flexed position (FL), the line of gravity (LG) is posterior to the acetabula and causes a posterior rotational force around the acetabula. As the line of gravity moves anteriorly to the acetabula in the extension position (EX), the pelvis rotates anteriorly around the acetabula. The top of the acetabula (K) to the base (DD) remains constant. Although the height of the posterior superior iliac spine (PD) and of the anterior superior iliac spine (AD) changes considerably, the level of the crest of the ilia (CL) may not change much. As the level of the sacroiliac joint (S) rises, apparent leg length is increased in both supine and standing positions. The horizontal distance from K to S becomes shorter, thus in the patient with sacroiliac joint dysfunction, leg length may be shorter during sitting but longer when positioned supine (17).

The sacroiliac joint behaves like other bicondylar joints as movement of the one side results in movement of the opposite side, thereby causing bilateral dysfunction (54). Bilateral dysfunctions present as a flexion dysfunction on one side and an extension dysfunction on the opposite side, or vice-versa (55).
2.3.3 History

There may be either an insidious or traumatic onset of sacroiliac dysfunction. It is not uncommon to find a history of a fall onto the buttocks or a sudden lift with a twist. A traumatic incident is often reported such as a sudden step off a curb, a fall involving sudden flexion of one leg or a kick against a missed target. At the time of the injury, a sudden twinge of pain may be felt localized to the sacroiliac joint (21).

2.3.4 Symptoms

The patient might complain of mechanical backache, which may or may not refer pain into the lower extremity (12). Initial pain diagrams are useful in evaluating sacroiliac dysfunction (56).

The sacroiliac syndrome may present with pain over the sacroiliac joint in the region of the posterior superior iliac spine and this may be accompanied by referred pain to the buttock, groin, over the greater trochanter, along the posterior thigh to the knee, occasionally referring further down the lower extremity, to the calf and foot (51).

No conventional clinical features that are predictive of sacroiliac pain have been found. Lack of pain above the level of the fifth lumbar vertebra would seem to be the only distinguishing feature for sacroiliac joint pain (figure 2.22) (57).

The pain is typically unilateral and dull, sharp or aching (31) in character, radiations may occur, however neurological examinations are unremarkable (51). Acuteness of pain in a sacroiliac joint is not always indicative of the site of causation. A hypomobile or dysfunctional sacroiliac joint may result in increased motion demands on the opposite side, in turn causing pain and inflammation of that joint. The most severe tenderness is often found in the sacroiliac joint contralateral to the one that is dysfunctional (28). It has been established that sacroiliac dysfunction can be present in the absence of pain. The factors that cause a dysfunctional joint to cause pain remain elusive (11).

Complications of sacroiliac dysfunction may occur, which include: disc protrusion and potential rupture from excessive rotary forces in the lumbar spine; an adaptive lumbar scoliosis away from the side of pain, which may lead to compensatory biomechanical
changes throughout the spine; stress in the hip joint from compensations leading to hip pain and eventual arthritis; and stress in the knee joint from widening the base of support, leading to chronic sprain (26, 36).

Figure 2.22. The sacroiliac joint pain referral map produced by injection (7).

The pain is aggravated by activities which include walking, stair climbing / descent, rolling over in bed, getting in or out of a chair and standing on one leg. Sacroiliac dysfunction is further aggravated by one position or one activity for prolonged periods of time and therefore relief is achieved by frequent alterations of posture and activity. Sleeping with one hip flexed to a greater degree than the other is the most comfortable position (10, 21).
2.3.5 Signs

Weight-bearing on the affected side is difficult, therefore the patient might present with a slight limp. There is usually tenderness over the posterior superior iliac spine and the posterior sacroiliac ligament with muscle spasm and trigger points present in the lumbar paraspinal and gluteal muscles unilaterally. If there is associated lumbar dysfunction, there will be midline lumbar tenderness and decreased lumbar range of motion. Reductions in the straight-leg raising are due to the associated back pain and hamstring tightness. Sacroiliac dysfunction is not associated with signs of nerve root tension and neurological deficit and any muscle weakness in the lower extremities is due to painful inhibition rather than neurological deficit (12). Movement of the joint is restricted. The direction of restriction and associated feature is discussed above in types of dysfunction (27). Radiographic features are generally unremarkable except if severe degenerative changes are present (51).

2.3.6 Management

In most cases, acute symptomatic sacroiliac dysfunction is a benign self-limiting disorder and therefore after a short period of rest, most patients will have fully recovered without medical intervention (chiropractic or allopathic). Unfortunately, recurrence is high with about 60% of these patients suffering from a second episode of back pain within the next two years (12, 15).

The chiropractic management of sacroiliac syndrome consists of relieving local and reflex pain and muscle spasm, as well as applying specific adjustments or manipulations to restore movement (9). Sacroiliac dysfunction responds rapidly to appropriate manipulative therapy (28). The type of adjustment delivered depends on the type of dysfunction present, therefore it is important to be able to detect the type of dysfunction so that the correct adjustment can be delivered. The adjustment is changed for the type of dysfunction in terms of patient position, contact point and vector of the thrust (28).
2.4 Diagnosis of a Sacroiliac Joint Dysfunction

2.4.1 The Current Diagnosis and its Dilemmas

The current diagnosis of a sacroiliac dysfunction is based on previous medical history in particular and on examination through the use of manual tests for the sacroiliac joint. There are no pathognomonic, radiographic, or laboratory investigations available, therefore the manual examination is the standard method used for diagnosis (58).

However, the following factors make manual examination and diagnosis difficult: the location and oblique orientation of the sacroiliac joint (7); the lack of a “gold standard” for sacroiliac joint diagnosis (4); and the variation in the anatomy and the movement of the joint (7). Therefore the diagnosis may result from exclusion of other diagnoses (7).

2.4.2 Manual Diagnostic Tests

In an assessment of the sacroiliac joint, there are three groups of manual tests: positional tests, which determine flexion or extension dysfunctions (19); functional tests, which assess mobility and joint play and subjectively assess the qualitative and quantitative nature of movement between ilia and sacrum as well as the influence of the surrounding structures (7); and pain provocation tests, which reproduce and locate the pain (19).

These static and dynamic physical examination manoeuvres are present in much medical, manual therapy, osteopathic and chiropractic literature. These tests are assumed to be reliable and diagnostically useful, however none of these tests have been validated in research (57). It is important that sacroiliac joint tests are validated because the results of these tests are used for diagnosis and treatment. Accuracy is needed especially for diagnosis of sacroiliac joint dysfunction where specific manipulative procedures are applied to correct the dysfunction (7).

The current agreement in research is that there is no single test that can confirm the diagnosis of sacroiliac joint dysfunction. Therefore many researchers believe that a diagnosis for sacroiliac joint dysfunction can be accepted when three out of four tests used produce positive results (4, 19, 55). When this is done, the individual tests results become
contributory rather than surrogate (55) and produce good inter-tester reliability (16). This principle is used in this study to diagnose sacroiliac joint dysfunction.

However, it must be presumed that the different tests used detect either varied functional phenomena of the sacroiliac dysfunction or evaluate identical effects of the dysfunction in different ways (58).

2.4.2.1 Studies Evaluating Manual Diagnostic Tests

The following are criteria for evaluating a diagnostic accuracy study: [a] independent blinded comparison of the diagnostic test with a gold standard test for that specific condition; [b] inclusion of the appropriate population of patients to whom the diagnostic test will be applied in clinical practice; [c] the diagnostic test results must not influence the decision to perform the gold standard test; [d] adequate description of the test to allow replication (4).

Studies on diagnostic tests for sacroiliac joint dysfunction have poor reliability and validity outcomes, which may be attributed to the lack of precise definitions for what constitutes a positive test result (16). According to DonTigny, the unreliable sacroiliac joint tests indicate inappropriate application and interpretation of the tests and a lack of knowledge for the structure and function of the joint (17).

There is considerable discrepancy between researchers and clinicians regarding clinical utility of diagnostic findings and tests in accurately diagnosing sacroiliac joint pain (7). However it was determined through a literature survey that agreement among therapists does not relate to the years of experience (3). See appendix B for literature summary.

2.4.2.2 Performing Pitfalls

When performing palpatory or functional tests, there are pitfalls that the examiner must be aware of. Firstly, there are soft tissue changes associated with pain, which can cause palpatory illusions because the bony landmark is palpated through different tensions of soft tissue. Secondly, the bony landmarks have a dome-shape, therefore the examiner is unable to palpate sharp edges to compare identical points of palpation. The third pitfall occurs when testing iliac springing. With repetitive springing, the physiological barrier (the limit of active motion) of the joint may be lost and any springing palpated is not due to the intrinsic joint
force. It is important to spring with minimal force and let the joint spring back, then take up slack before springing again (59). It is important to consider that the examination tests themselves may affect changes in the musculoskeletal system, resulting in distorted results during experimental study (50).

2.4.3 The Manual Tests Used in this Study as the Control for Sacroiliac Joint Dysfunction Diagnosis

In a 1999 study, a moderate consistency and a good agreement of three palpatory tests (namely Standing Flexion Test, Spine Test and Iliac Springing Test) was found. From this study it was assumed that the tests identified a similar dysfunction of the sacroiliac joint (58).

In another study in 1999, a cluster of tests (namely the Standing Flexion Test, the Sitting Posterior-Superior Iliac Spines Palpation, the Supine Long-Sitting Test and the Prone Knee Flexion Test) appeared to be a clinically useful method to determine the presence or absence of sacroiliac dysfunction in patients with lower back pain. Therefore this study is relying on the principle that using a cluster of tests usually improves the specificity of a test, thereby reducing the number of false-positive results (4).

In an 1998 study, the Standing Flexion Test and the Supine Long-Sitting Test were part of a four test entourage that were considered to be commonly used sacroiliac joint tests and received a good intertester reliability (55).

The Spine Test (synonymous with Gillet’s Test) has demonstrated mixed findings in reliability investigations, with reliability ranging from slight to good. Better results were achieved when evaluating the posterior superior iliac spine movement rather than the posterior inferior iliac spine (60). The former method was used in this study. Intra-examiner reliability appeared better than inter-examiner reliability in literature and Herzog et al. reported a 60% inter-examiner reliability for Gillet’s Test (60) and suggested that the Gillet’s Test is useful in clinical settings because intra-examiner reliability is more important in this setting (50).

The Supine Long-Sitting Test, the Standing Flexion Test, the Spine Test and the Iliac Springing Test were used as the control tests in this study (see 3.4 chapter 3 – methodology for an explanation of each test). These tests rely on accurate identification and palpation of
pelvic landmarks. Reliability could possibly be decreased due to intervening soft tissue, therefore each participant must have a Quetelet-index score less than twenty seven (13).

The Quetelet-index score is also known as body mass index (BMI) and it correlates with estimates of fatness. It is an acceptable index of obesity but it cannot distinguish between excessive weight produced by adiposity, muscularity or oedema (61). The index is given by the weight (in kilograms) divided by double the height (in meters), therefore kilograms per metre squared. The internationally accepted ranges are: normal between eighteen and a half and twenty-five; overweight between twenty-five and thirty; obese between thirty and forty and morbidly obese greater than forty (62).

The four control tests used are functional tests, in other words dynamic manual examination tests that are used to detect unilateral hypomobility and asymmetry or dysfunction present within the sacroiliac joint. They are considered to be adequate screening tests for sacroiliac joint dysfunction and are designed to detect iliosacral dysfunction (11).

2.4.3.1 Standing Flexion Test

This test was found to be a valuable tool in the diagnosis of sacroiliac dysfunction (58). During the forward flexion of the trunk, the sacrum nutates initially within the ilia. However, as progressive flexion occurs and more lumbar spine motion is recruited, the pelvis (ilia) rotates anteriorly over the hips. The sacrum begins to counternutate within the ilia simultaneously (figure 2.23) (18). A positive result indicates a limited movement of the ilium (posterior superior iliac spine) on the sacrum, therefore when there is sacral nutation during flexion, the ilium on the side of dysfunction moves with the sacrum (55).

False positives can be the result of restricted flexion unilaterally of the fourth or fifth lumbar vertebrae or the hip articulations. Hypertonicity of erector spinae, hamstring, piriformis, quadratus lumborum, gluteus maximus or the posterior iliotibial band can cause a false positive result (3).

The overtake phenomenon occurs when one posterior superior iliac spine is lower than the other when the patient is standing, yet during flexion it moves more to ends higher than the other posterior superior iliac spine. As the spine flexes forward, the sacrum follows. If there is a dysfunction in one of the sacroiliac joints, the ilium (represented by the posterior
superior iliac spine) will follow the sacrum and move further cephalad than the other posterior superior iliac spine. This test serves as a quick screening test (figure 2.24) (63).

Figure 2.23. Lumbo-pelvic rhythm: A) Normal standing posture with lumbar concavity; body weight directly over hip joints; normal pelvic inclination angle with respect to horizontal. B) Flattening of the lumbar spine; pelvis begins to rotate anteriorly around the hips; hips and pelvis move posteriorly in the horizontal plane. C) Reversal of the lumbar spine into lumbar convexity; pelvis rotates anteriorly to the fullest extent; hips and pelvis are posteriorly displaced in the horizontal plane (18).
2.4.3.2 Iliac Springing Test

This test accomplishes sagittal plane shearing of the sacroiliac joint. The test is positive if no distraction is felt. This test was found to be a valuable tool in diagnosis of sacroiliac dysfunction (58).

2.4.3.3 Spine Test (Synonymous with Gillet’s Test)

This test is found to be a valuable tool in the diagnosis of a sacroiliac dysfunction (58). It evaluates x-axis rotation at the sacroiliac joint when the subject flexes the contra- and ipsilateral hip joints while in the standing position (12) and is designed to accentuate the normal gait cycle occurring in the sacroiliac joint (63). This rotation is small yet is amplified at the posterior superior iliac spine because the posterior superior iliac spine is posterior to the axial centre of rotation (12).

When flexing the ipsilateral hip, biomechanically the ilium rotates posteriorly on the sacrum and the posterior superior iliac spine is felt to rotate posterior and inferiorly with respect to the second sacral tubercle (58). This movement is referred to as sacroiliac joint flexion and is therefore testing for a flexion dysfunction (63). No movement of the posterior superior iliac
spine relative to the sacrum indicates dysfunction or restriction (figure 2.25) (63). If there is lumbar paravertebral muscle spasm, false positive results occur (12).

Figure 2.25. Test for sacroiliac joint dysfunction. To test left side: A. Place thumb of right hand over second sacral tubercle and thumb of left hand over the posterior superior iliac spine. Instruct the patient to flex the left hip and knee to ninety degrees. B. In the functional joint the thumb will move caudally. C. In the dysfunctional joint the thumb will move cephalad (64).

When flexing the contralateral ilium until it reaches its end range of motion with the sacrum, further raising of that leg causes a posterior and inferior movement of the sacrum relative to the weight-bearing ilium (36). This manoeuvre is biomechanically similar to lunging forward with the contralateral leg (knee and hip flexion) with the ipsilateral leg extending backwards (63). If no movement is detected or if both contact thumbs move together as a unit, joint dysfunction can be suspected (63). Some authors also consider a positive result when the posterior superior iliac spine moves upward or moves less than the posterior superior iliac spine on the other side (19).

2.4.3.4 Supine Long-Sitting Test

This is a sacroiliac test that compares apparent leg lengths (lengths of the inferior aspects of both medial malleoli are compared) in the supine and long-sitting positions (figure 2.26). This test was found to be a valuable tool in the diagnosis of a sacroiliac dysfunction (4). It
has been stated that with a functional leg length inequality, the ilium rotates posteriorly on the short leg side and the sacral base on that side rotates anteriorly and inferiorly (50).

It has been noted about 30 to 40% of anterior dysfunctions are compromised by a downward wedging of the sacrum. This allows for a vertically upward slip of the innominate on the sacrum after the innominate has locked in an anteriorly rotated position on the sacrum. The sacrum can instead slip vertically downward on the ilium. This vertical slipping can cause the leg that should appear long in this test to appear abnormally shortened. The leg will either appear to be its normal length or slightly shorter, resulting in false negatives and false positives respectively (65).

Figure 2.26. Relative changes observed in functional leg length during change from supine to sitting when a simple sacroiliac subluxation / fixation is present. Leg A represents the side of the flexion dysfunction (flexion malposition) and leg B the extension dysfunction (extension malposition). Because of the relative anterior displacement of the acetabulum resulting from the flexion dysfunction (and opposite for the extension dysfunction), the leg that is functionally short reverses as the patient sits and the hip joint is flexed to ninety degrees (32).
2.5 The Experimental Test: the Sacral Base Pressure Test (S.B.P.T.)

The S.B.P.T. applies pressure directly to the base of the sacrum (through the first / second sacral tubercle as described in 3.3 of chapter 3 - Methodology) in a direct attempt to induce the motion of sacral nutation. The nutation creates external rotation of the foot by the transference of force through the muscular mechanisms of the pelvis and hip. Therefore theoretically, the movement of nutation does not occur if there is a sacroiliac joint dysfunction present. This results in a lack of external rotation of the lower limb, which is manifested by a lack of external foot rotation on that side (6). This is regarded to be a positive S.B.P.T. The presence of external rotation of the lower limb and therefore external rotation of the foot is a normal response or a negative finding (6, 8).

The confirmation for this theory arises from the link between unilateral limitation of hip rotation (where the rotation is unequal between the left and right sides) and disorders of the sacroiliac joint (55). Further support is derived from the findings that in a non-weight bearing patient, movement at the sacroiliac joint causes an outflaring movement at the hip joint, which results in external rotation at the feet (36). It can therefore be reasoned that in a dysfunctional sacroiliac joint, the movements described above can not take place. It has also been stated that sacroiliac joint disorders are associated with hip muscle imbalances, which will cause hip rotation asymmetry (44).

In the case of flexion dysfunction, the sacrum is going to be in a position of nutation, therefore it is hypothesized that the S.B.P.T. is going to be facilitated and there will therefore be no significant decrease in the external rotation between the feet. However, in the case of the extension dysfunction and the counternutated sacrum, the test will be hampered by the counternutated sacrum, thus there will be a significantly decreased external rotation on the dysfunctional side. This is evident because posteriorly rotated ilia were noted to have significant greater external hip rotation compared with internal rotation on the same side, whereas anteriorly rotated ilia showed far less asymmetry (55).

The following explanations for the observations mentioned above are hypothetical and discuss the structural and functional factors that provide stability and movement to the sacroiliac joint. These explanations do not detract from the clinical significance of the S.B.P.T. being an indicator of sacroiliac dysfunction as determined by Breitenbach et. al. (6).
Stability and movement of the sacroiliac joint is provided structurally by the irregular surface of the articulation (form closure), (discussed in section 2.2.5.1 above) (30). When the joint is functioning properly, this articulation allows the movements of nutation and counternutation to occur (26). When pressure is applied to the sacral base (first / second sacral tubercle) of a prone subject, in a posterior to anterior direction, passive movement of nutation will occur (66). The innominates will undergo the following movements accompanying this nutation (66): a posterior, inferior and obliquely medial movement of the ilia and a lateral outflaring of the ischia (36). We can thus see that in the case of a flexion dysfunction, this movement has already occurred, thereby preventing any further movement (8, 28).

Functionally, sacroiliac joint stability is derived from the fascial tissue, ligaments and muscular components that provide force closure as discussed in section 2.2.5.2 above (44). When hypertonicity occurs within these tissues, the sacroiliac articulation is stabilized and motion is restricted (30). Mobility of the femur also undergoes restrictive influences (67). In most cases, the muscles surrounding the sacroiliac dysfunction become hypertonic (30). Therefore it is conceivable that a positive S.B.P.T. could be the result of these hypertonic muscles, which restrict femoral movement (6).

2.6 Conclusion

It has been shown that the sacroiliac joint is subjected to much controversy regarding its movement and the diagnosis of sacroiliac joint dysfunction (23, 24, 25, 26). Sacroiliac joint dysfunction is a common clinical entity (27) that needs a gold standard of diagnosis in order for proper treatment to be administered, in the form of manipulative therapy.

The diagnostic tests for sacroiliac joint dysfunction which have been described, have varied results in terms of validity and predictive powers. Most of these tests rely on clinical experience and their reliability may be affected by many factors, one of which is excessive adipose tissue deposited around the joint. Further complications arise when types of dysfunction need to be differentiated. Tests used to determine the types of dysfunction are also subjective in nature as they rely on the clinician’s experience (57).

This research is part of the continual search for that “gold standard” of sacroiliac joint assessment, diagnosis and management. The S.B.P.T. is relatively easy to perform and is
more objective as it relies on the measurement of external rotation of the feet (6). Therefore it
was the test of choice for the purpose of this study.
CHAPTER 3 – METHODOLOGY
3.1 Participant Selection

Sixty participants were randomly selected for this study. The participants were either patients under the care of the chiropractic health clinic at Technikon Witwatersrand, chiropractic students currently studying at Technikon Witwatersrand, or people from the general public. Each potential participant was given a research information sheet and a consent form that was filled out at the onset of their participation. Refer to Appendix C.

In order to be selected, participants had to be between the ages of eighteen and sixty-five years of age. The subjects could be of either gender and the gender ratio was unspecific. The participants did not have to have lower back pain of any description.

Participants were excluded from the study if they presented and/or were diagnosed with any disorder that was organic in nature including: traumatic, infectious, rheumatic, pathological, metabolic, space-occupying and anomalous lesions. Pregnant participants were excluded and those subjects with a Quetelet-index score (weight per height squared) greater than twenty-seven were also excluded, as a favourable score ensured that the contact points were easily palpable.

Any participants with lower limb pathology that influenced the outcome of the various orthopaedic tests used in this research were also excluded. Therefore conditions (except for sacroiliac dysfunction) that cause limb length inequalities, external or internal rotation of the hip, or malposition of the foot / ankle in the resting position, were detected in the modified lumbar regional and these patients were excluded.

Radiographic examinations of the sacroiliac joints and the lumbar spine were performed at the Technikon Witwatersrand Radiographic department, when required, in order to rule out organic pathologies.

3.2 Procedure

The potential participants underwent a screening process in order to determine whether they would be included in the study. This and the entire consultation was performed at Technikon Witwatersrand health clinic, under the supervision of the qualified clinicians on duty, by the
researcher. The entire consultation for the participant was concluded in a single one hour session.

3.2.1 The Screening Process

This involved an initial case history performed by the clinician on duty before the experiment was conducted, without the researcher being present. The rest of the case history, pertinent physical examination and modified lumbar spine regional examination was completed at the end of the experiment by the researcher. In this way, the performing examiner and the participant had no preconceived idea of the participant’s status, therefore it limited any bias, which could affect the objectivity of this study.

Any patient of the Technikon Witwatersrand Health Clinic (chiropractic department) who had undergone a case history or pertinent physical examination at the clinic within the last two years was not required to complete another. The modified lumbar spine regional was completed in all cases, in order to allow for accurate assessment of the inclusion and exclusion criteria.

3.2.2 The Examination Procedure

The participant underwent the S.B.P.T., followed by the four control orthopaedic tests (Standing Flexion Test, Iliac Springing Test, Spine Test or the modified Gillet Test and Supine Long-Sitting Test). The S.B.P.T. was conducted with the examiner on the right and then the left side of the patient with the external examiner ensuring that the pressure on the sacrum was in a true posterior to anterior direction. The external examiner was present throughout the entire examination to standardize the procedure.

In a double-blind fashion, an independent external observer noted and recorded the result of the S.B.P.T. The performing examiner (the researcher) did not observe the results. In this way, when the examiner performed the other four tests, he had no preconceived idea of the patient’s status, again limiting any bias, which could have affected the objectivity of the study. All results were recorded on a results sheet (Appendix F).

Sixty-two participants fulfilled these requirements and of these thirty-one were males and thirty-one were females. There were only twenty-two participants with lower back pain on the
day of their appointment, however thirty-nine participants had had some form of lower back pain history. The ages of the participants ranged from the youngest at twenty to the oldest at thirty-four, therefore the average age was twenty-four. The Quetelet-index score was used to aid in palpation of bony landmarks, the average being 22.65 kg/m². The highest value was 32.27 kg/m² and the lowest was 17.36 kg/cm².

3.3 The Sacral Base Pressure Test

The patient is placed prone with their medial malleoli of the tibia the same distance apart as the mastoid processes of the occiput. Their feet must hang loosely off the end of the table and their legs should be able to move freely. Clothing must not be too tight as this would hinder the movement of the legs. The patient’s head must not be turned to either side, instead it must face straight downward. The examiner stands on either side of the patient at the level of the pelvis, facing caudally (refer to figure 3.1 below). A calcaneal contact is placed on the sacral base between the first and second sacral tubercles in order to apply a straight posterior to anterior force (refer to figure 3.2 below). The right hand is used if on the right side of the patient, and the left if on the left side. The force applied should be about four to five kilograms (these values are only guidelines, as sufficient movement can occur at the feet with a one kilogram force alone). This force should take two seconds to reach maximal intensity. While the force is being applied, any movement that occurs at the feet should be recorded (6).

Figure 3.1. Performing the S.B.P.T. on the participant’s right.
Figure 3.2. The calcaneal contact must be placed on the second sacral tubercle. Each “x” on the patient represents the left and right posterior superior iliac spines. The second sacral tubercle is situated between the right and left posterior superior iliac spines.

A positive test is a lack of external rotation of the lower limb, manifested by a lack of external foot rotation, which is regarded as a positive finding for sacroiliac joint dysfunction on that side. A negative finding (the normal response) is indicated by the presence of external rotation of the lower limb, seen as external rotation of the foot (6). Two other movements have been described, although no explanation regarding the meaning of these movements has been offered. These movements are a slight lateral shift of the lower extremity and a slight lifting of the lower extremity, which occurs on the dysfunctional side (8).

When the S.B.P.T. was performed, the resting amount of external rotation of the foot was assessed. The amount of external rotation was measured using a digital inclinometer. The inclinometer was placed on the lateral aspect of the foot, resting from the tubercle of the fifth metatarsal to the lateral aspect of the calcaneus (refer to figure 3.3 below). The measurement was therefore a deviation from 0 degrees, where 0 degrees indicated the horizontal to the ground and 90 degrees indicated the vertical from the ground in the horizontal plane to the body. By doing, this any movement other than external rotation of the foot did not affect the measurements.
The digital inclinometer was placed on the lateral aspect of the participant’s foot, resting from the tubercle of the fifth metatarsal to the lateral aspect of the calcaneus, in order to measure the degree of external rotation.

The test was performed on the participant’s right and then left side. On both occasions, the resting external rotation and the external rotation occurring during the test was measured in both legs. The external examiner observed the feet closely throughout the application of the force, in order to determine the presence and magnitude of other movements which occurred.

Therefore, at the end of the test, three results were known: whether external rotation occurred; to what degree it occurred; and what other movements occurred. A comparison was made with the test results conducted on the other side.

### 3.4 Diagnosis of the Sacroiliac Joint Dysfunction

The four control orthopaedic tests used in this study to diagnose sacroiliac joint dysfunction were: the Standing Flexion Test; the Iliac Spring Test; the Spine Test; and the Supine Long-Sitting Test.

The Standing Flexion Test and the Iliac Springing Test only detected the presence or absence of a sacroiliac dysfunction and they were conducted first to identify the side on which the dysfunction was present. The Spine Test and Supine Long-Sitting Test detected the presence or absence of a sacroiliac dysfunction and also exposed the type of dysfunction. A diagnosis of a sacroiliac dysfunction was concluded if the Spine Test and at least one of the other tests
was positive on the same side. If none or only one test was positive, the patient was regarded as being ‘clear’ of sacroiliac dysfunction. The diagnosis of the type of sacroiliac dysfunction was concluded if both the Spine Test and the Supine Long-Sitting Test were positive on the same side.

These four tests were used because it has been shown that using three out of four tests produces positive results (4, 19, 55). When this is done, the individual tests results become contributory rather than surrogate (55) and produce good inter-tester reliability (16). This principle is used in this study to diagnose sacroiliac joint dysfunction. It has been determined that these tests identify a similar dysfunction of the sacroiliac joint (4, 58).

The following is a description of the four control orthopaedic tests. The tests described here may have different names depending on the nomenclature used. The subjects must disrobe sufficiently to reveal the necessary landmarks (58) and in order to ensure that the contact points will be easily palpable, the subjects have to have a Quetelet-index score (weight per height squared) lower than twenty-seven (68).

3.4.1 Standing Flexion Test

The subject stands with feet approximately twelve inches apart (3). The examiner palpates directly under each posterior superior iliac spine with his thumbs, while the patient then bends forwards as far as possible, keeping their knees extended (refer to figure 3.4 below). The examiner palpates the extent of cephalad movement of each posterior superior iliac spine. Normally, each posterior superior iliac spine moves the same distance in a cranial direction. If unequal motion occurs, the side that moves first and demonstrates the largest cranial excursion is a positive sign of sacroiliac dysfunction (58).

It is recommended to use the pointed notch located on the lateral aspect of the ilium as the reliable indicator and to give a short period of latency at the end of the motion, to allow for the lesion to become more evident (59).
3.4.2 Iliac Springing Test

The test subject lies on the examination bed in a lateral recumbent position with their hips flexed to forty-five degrees and their knees to ninety degrees. The examiner faces the subject at hip level. The examiner has a bent arm and places the soft part of the forearm on the cephalad side of the patient’s iliac crest, with the palm of the hand facing downward. The other hand’s index finger is placed on the posterior superior iliac spine and the ring finger is placed on the second sacral tubercle, with the middle finger over the sacroiliac joint (refer to figure 3.4 below). A slightly springing pressure on the ilium is exerted by the cephalad forearm without moving the pelvis. This causes movement at the sacroiliac joint, which is felt as a posterior distraction of the ilium at the sacroiliac joint. The test is positive if no distraction is felt (58).
Figure 3.5. When performing the Iliac Springing Test, palpation is accomplished by placing the index finger on the posterior superior iliac spine (indicated by an “x” on the participant), the ring finger is placed on the second sacral tubercle (represented by a “line”) and the middle finger is placed over the sacroiliac joint.

3.4.3 Spine Test (Synonymous with Gillet’s Test)

The subject stands with feet approximately twelve inches apart (3). The doctor’s one thumb is placed directly under the posterior superior iliac spine on the side to be tested and the other thumb is placed directly on the second sacral tubercle. The subject is then asked to flex the hip of the test (ipsilateral) side with a flexed knee, lifting the thigh to the abdomen, similar to a large marching step (58) (refer to figure 3.6 below). This tests for an extension dysfunction (63). The movement is felt as a slight shifting or gliding motion of the posterior superior iliac spine relative to the sacral tubercle. The inferior movement of the posterior superior iliac spine is more obvious. No movement of the posterior superior iliac spine relative to the sacrum indicates dysfunction or restriction (63).

To detect a flexion dysfunction, the above contacts are maintained and the examiner asks the patient to flex the knee and hip of the contralateral leg (36). During this part of the test, the sacral tubercle is monitored relative to the posterior superior iliac spine. If no movement is detected or if both contact thumbs move together as a unit, joint dysfunction can be suspected, which constitutes a positive Spine Test (63).
During the Spine Test or Gillet’s Test, the participant lifts the leg ipsilateral to the examiner’s contact to detect an extension dysfunction. To detect a flexion dysfunction, the contralateral leg is then lifted. The leg is lifted similar to a large marching step.

There is a compensatory movement that occurs during the knee-raising manoeuvre in reaction to sacroiliac joint or hip joint dysfunction. The weight-bearing leg bends slightly at the knee and extends at the hip as the patient raises the contralateral leg to increase the motion (63). The patient also pushes their buttock out laterally (63) and rotates it inferiorly and anteriorly to increase the knee raising (28).

While performing the Spine Test, Lewit et. al. suggests dropping the hip rather than lifting the knee to allow an increase in distance between bony landmarks that are palpated, which requires no muscle contraction and therefore causes no alteration in soft tissue tension. It is also recommended to use the pointed notch located on the lateral aspect of the ilium as the reliable indicator and to give a short period of latency at the end of the motion, in order to allow for the lesion to become more evident (59).
3.4.4 **Supine Long-Sitting Test**

In the supine position, the finding of a shorter leg when compared to the opposite side suggests (but does not confirm) a flexion dysfunction. The therapist holds the inferior aspect of the medial border of the medial malleoli with his or her thumbs and asks the patient to rise to a long-sitting position (4) (refer to figure 3.7 A and B below). The patients may use their hands to push themselves up, however they must push evenly (3). Any apparent lengthening of the short leg implies the presence of a sacroiliac joint dysfunction and a flexion dysfunction (4). Conversely, a long leg that appears to shorten relative to the other indicates an extension dysfunction on that side. One leg remaining consistently shorter or longer relative to the other is indicative of an anatomical leg-length difference (3). In the case of a vertically upward slip of the innominate on the sacrum, it is recommended to give the leg on the affected side a sharp tug in the long axis while the patient is supine and then to reassess (65).

![Figure 3.7.A](image)

Figure 3.7.A. Before performing the Supine Long-Sitting Test, it is recommended to give each leg a sharp tug in the long axis to prevent false positive results caused by a vertically upward slip of the innominate on the sacrum. After the sharp tug, the relative lengths of the medial malleoli are compared against the other to determine whether there is any difference.
Figure 3.7.B. When the participant is instructed to rise into the long-sitting position, they must sit straight up without any deviations to either side. The relative lengths of the medial malleoli are once again compared against the other for any differences.

3.5 Statistical Methodology

This study, as already stated, is a follow-up to similar research conducted at Technikon Witwatersrand and will therefore use similar statistical methodology.

3.5.1 Methodology for Determining whether the Sacral Base Pressure Test can Differentiate Between Types of Dysfunction

This aim of the study is to establish whether the S.B.P.T. can determine what type of sacroiliac joint dysfunction is present, as defined by this study. As discussed in 2.5 of chapter 2 – Literature Review, it is hypothesized that there will be a difference in the amount of external rotation between flexion and extension sacroiliac joint dysfunction. In order to determine whether this was true, we used tests of hypotheses on population means, simply stated as one-sided t-tests. We tested for equality of the means and more importantly determined if the two population means were significantly different (69).
Therefore the hypothesis statement was,

\[ H_0: \mu_1 = \mu_2, \]

Where \( H_0 = \) null hypothesis, \( \mu_1 = \) population 1 and \( \mu_2 = \) population 2.

And \( H_a: \mu_1 > \mu_2, \)

Where \( H_a = \) alternative hypothesis (69).

In the case of this study,

\[ H_0: \mu_{AS} = \mu_{PI}, \]

Where \( H_0 = \) null hypothesis, \( \mu_{AS} = \) population designated as extension dysfunction and \( \mu_{PI} = \) population designated as flexion dysfunction.

And \( H_a: \mu_{AS} > \mu_{PI}, \)

Where \( H_a = \) alternative hypothesis (69).

When performing this test, it must be assumed that simple random samples were chosen independently from two populations and that the observations in each population were normally distributed with equal variance. The test is used either when samples are taken from two distinct populations or when samples are taken from a single population and subjects are randomly assigned to two treatment groups. In this study, the latter is true where samples were taken from a single population and were assigned as either a flexion or an extension sacroiliac joint dysfunction. The test statistic is given as (69):

\[
t = \frac{\bar{x}_1 - \bar{x}_2 - (\mu_1 - \mu_2)}{S_p \sqrt{1/n_1 + 1/n_2}}
\]

Or

\[
t = \frac{\bar{x}_1 - \bar{x}_2 - 0}{S_p \sqrt{1/n_1 + 1/n_2}}
\]

Where \( \bar{x} \) = means for population, \( S_p = \) pooled standard deviation and \( n = \) sample size

Pooled standard deviation is the square root of pooled variance. Pooled variance is given as (69):

\[
S_p^2 = \frac{(n_1 - 1) S_1^2 + (n_2 - 1) S_2^2}{n_1 + n_2 - 2}
\]
It was decided that the level of significance would be set at 0,05 ($\alpha = 0,05$). This means that there is at most a 5% chance of error on the hypothesis (70). The student $t$ Distribution table (Appendix H) was then consulted to find the $t$ critical value ($t_{crit}$). The degrees of freedom value (d.f.) is given as (69):

$$d.f. = n_1 + n_2 - 2$$

The null hypothesis is rejected if the t-test value is greater than the $t$ critical value. If the null hypothesis is rejected it means that the alternative hypothesis is accepted and the results are significant (69). A probability value is expressed as $p$ and ranges in values form zero to one. A probability of zero means that the outcome or hypothesis will never happen, therefore in this study this will refute Ho: $\mu_{AS} = \mu_{PI}$ which means that our alternative hypothesis (Ha: $\mu_{AS} > \mu_{PI}$) is accepted. A probability of one means that the outcome or hypothesis will definitely occur. The closer the probability to one, the more likely the outcome or hypothesis will be accepted (71).

### 3.5.2 Methodology for Reconfirming the Validity of the Sacral Base Pressure Test

This aim of the research is to reconfirm the results from the previous study (Breitenbach et. al. (6)) in order to determine whether the S.B.P.T. is reliable as an indicator of sacroiliac joint dysfunction. In order to achieve this, a validity analysis was performed. Validity is concerned with whether a test correlates with another test or other tests, which claim to measure or detect the same entity (72). The components of validity that will be used in this study include sensitivity and specificity, positive and negative predictive value, the misclassification rate, and the prevalence of the disorder in question. Consult Table 4.1 below for explanation of the following definitions for the components of validity.

Sensitivity is the proportions of positive values that the test correctly identifies. Specificity is the proportions of negative values that the test correctly identifies. The terms positive and negative indicate the presence and absence of the specific condition respectively (73).

Positive predictive value is the proportion of patients with positive test results who are correctly diagnosed. Negative predictive value is the proportion of patients with negative test results who are correctly diagnosed. This gives a direct assessment of the test’s usefulness in practice and is dependant upon the prevalence of the condition (73).
The misclassification rate is the percentage error rate. Prevalence is the proportion of the subjects that currently suffer from the specific condition (6). The nature of the prevalence is such that when it decreases, so does the positive predictive value and the negative predictive value increases. The opposite occurs when it increases. Therefore, the usefulness of a diagnostic test is greatest when the prevalence is between 40% and 60% and this is where the predictive values are at their highest (4).

From table 4.1 the equations for the validity components are:

Sensitivity \[= \frac{a}{a+c} \times 100\]

Specificity \[= \frac{d}{b+d} \times 100\]

Positive predictive value \[= \frac{a}{a+b} \times 100\]

Negative predictive value \[= \frac{d}{c+d} \times 100\]

Misclassification rate \[= \frac{(b+c)}{n} \times 100\]

Prevalence \[= \frac{(a+c)}{n} \times 100\]

<table>
<thead>
<tr>
<th>TEST Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRUE PICTURE</strong></td>
</tr>
<tr>
<td><strong>Result detected by the test</strong></td>
</tr>
<tr>
<td>Positive test</td>
</tr>
<tr>
<td>Negative test</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

Table 3.1. Validity components (4, 71).
To overcome the problem of agreement between the tests, which could be due to chance, the Kappa coefficient is used (60). Kappa (K) is a preferable measure of agreement between the S.B.P.T. and the control tests used to diagnose the condition. Kappa is expressed as:

\[ K = \frac{2(ad - bc)}{(d + c)(a + c) + (b + a)(b + d)}. \]

The same set of symbols is used above in the table.

Kappa is the ratio of two quantities. The first quantity is the difference between the observed proportion of agreements (Po) and the expected proportion (Pc) due to chance, where

\[ Po = \frac{a + d}{N} \]

\[ Pc = \frac{(b + a)(a + c) + (b + d)(d + c)}{N^2}. \]

The second quantity is the expected proportion of agreements not due to chance \((1 - Pc)\). Therefore

\[ K = \frac{Po - Pc}{1 - Pc} \]

The guidelines of Landis and Koch are used to interpret the obtained Kappa values and are presented in table 4.2 below. Kappa ranges in value from positive one to negative one. Positive values signify agreement better than chance, a zero value signifies an agreement no better than chance and negative values signify agreement worse than chance (75).

A paradox of high percentage agreement with a low Kappa value can occur because this represents the proportion of agreement after chance agreement is excluded (75).
<table>
<thead>
<tr>
<th>Value of K</th>
<th>Strength of agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.00</td>
<td>Poor agreement</td>
</tr>
<tr>
<td>0.00 – 0.20</td>
<td>Slight agreement</td>
</tr>
<tr>
<td>0.21 – 0.40</td>
<td>Fair agreement</td>
</tr>
<tr>
<td>0.41 – 0.60</td>
<td>Moderate agreement</td>
</tr>
<tr>
<td>0.61 – 0.80</td>
<td>Substantial agreement</td>
</tr>
<tr>
<td>0.81 – 1.00</td>
<td>Almost perfect agreement</td>
</tr>
<tr>
<td>1.00</td>
<td>Perfect agreement</td>
</tr>
</tbody>
</table>

Table 3.2. Landis and Koch Guidelines for Kappa interpretation (75).
CHAPTER 4 – RESULTS
4.1 Results
4.1.1 Descriptive Statistics

Of the sixty-two participants (thirty-one males and thirty-one females) twenty-two participants had some form of lower back pain at the time of their session and forty had no lower back pain of any sort. When questioned regarding previous episodes of lower back pain, thirty-one participants had previously experienced low back pain, six had no history of back pain and seventeen either did not know or were not questioned about it by the clinician who took the history.

In this chapter, if a test is described as giving a correct diagnosis, it indicates a true positive result (according to diagnosis it is supposed to represent), alternatively an incorrect diagnosis signifies a false positive diagnosis. In all the following tables, the Y-axis represents the number of participants and the X-axis represents the diagnosis groups.

Table 4.1. Side of sacroiliac joint dysfunction as diagnosed by the control tests.

The control tests diagnosed, according to 3.4 of chapter 3 - Methodology, a sacroiliac joint dysfunction in forty-eight of the participants, therefore only fourteen had no dysfunction on the day of their assessment. There where twenty-one left-sided problems, sixteen right and eleven bilateral problems (see table 4.1). Out of the thirty-six unilateral dysfunctional joints,
nineteen were flexion dysfunctions and eighteen were extension dysfunctions. From the eleven bilateral problems, nine were seen as left-sided extension dysfunctions and right-sided flexion dysfunctions, therefore the other two were left-sided flexion dysfunctions and right-sided extension dysfunctions (see table 4.2).

Table 4.2. Types of sacroiliac joint dysfunctions as diagnosed by the control tests.

When performing the S.B.P.T. on the left, the test detected forty-eight sacroiliac joint dysfunctions (38,71%), nineteen of which were left-sided (39,58%) and the other twenty-nine were right-sided (60,42%). With the test performed on the right, there were fifty-one detected sacroiliac joint dysfunctions (41,13%), thirty-seven being left-sided (72,55%) and fourteen being right-sided (27,45%). Therefore out of the one hundred and twenty-four joints assessed, as each person has two sacroiliac joints, the S.B.P.T. together detected fifty-six left-sided dysfunctions (45,16%) and forty-three right-sided dysfunctions (34,68%). Only on twenty-seven participants did the S.B.P.T. detect the same-sided lesion bilaterally. Refer to tables 4.3 and 4.4.
Table 4.3. Results of the S.B.P.T. in the detection of a sacroiliac joint dysfunction. The “present group” is the positive S.B.P.T. results, the “absent group” is the negative S.B.P.T. results and the “total group” is the present and the absent groups added together. The yellow column is the blue column added to the purple column.

Table 4.4. Results of the S.B.P.T., side of sacroiliac joint dysfunction. The “left group” is the positive S.B.P.T. for left-sided dysfunction, the “right group” is the positive S.B.P.T. for right-sided dysfunction, the “non group” is the negative S.B.P.T. results and the “total group” is all three groups added together. The yellow column is the blue column added to the purple column.
Of the twenty-seven participants where the S.B.P.T. was the same bilaterally, fourteen were the same as the control tests and thirteen were incorrect compared to the control tests. Of the fourteen correct S.B.P.T., one was a flexion dysfunction on the left, five were extension dysfunctions on the left, five were flexion dysfunctions on the right, one was an extension dysfunction on the left and two detected no dysfunction (see table 4.5). This was seen as a trend in the distribution of diagnosed dysfunction types.

![Correct S.B.P.T. Types](image)

Table 4.5. The type of dysfunctions diagnosed by the S.B.P.T. that matched each other and the control diagnosis. All four columns added together correlates to the 14 “correct” diagnoses by the S.B.P.T.

When comparing the results of the S.B.P.T. to those of the control tests, there were fourteen occasions when the results of the S.B.P.T. were the same bilaterally and produced the same results as the control tests. However, on seventeen occasions there was no correlation between the S.B.P.T. and the control tests. On the other thirty-one participants, the S.B.P.T. on the right compared positively to the controls sixteen times and on the left twelve times (refer to table 4.6). On the other three participants, the control tests detected a bilateral dysfunction. According to interpretation of the S.B.P.T. in this study, bilateral dysfunctions were not detected, as even slight differences in values were assumed to represent dysfunction and equal values were assumed to be normal. Therefore in those three above-mentioned cases of bilateral dysfunctions, there was no correlation with the results of the S.B.P.T. The S.B.P.T.
correctly detected eighteen right-sided problems, twenty-seven left-sided problems and no dysfunction in fourteen participants, refer to table 4.7.

**RESULTS SBPT VS CONTROL TESTS**

![Chart showing results of SBPT vs control tests]

Table 4.6. A comparison between the S.B.P.T. and the control tests. When performing the S.B.P.T. on the right, it produced the same diagnosis as the control on more occasions. All sixty-two participants fall into one of these columns.

**SIDES OF DYSFUNCTION DETECTED BY THE SBPT**

![Chart showing sides of dysfunction detected]

Table 4.7. The side of dysfunction correctly detected by the S.B.P.T.. Left-sided dysfunctions were diagnosed correctly by the S.B.P.T. most often.
Of the eighteen right-sided problems, five were extension dysfunctions and thirteen were flexion dysfunctions. From the twenty-seven left-sided problems, eighteen were extension dysfunctions and nine were flexion dysfunctions. Two of the “bilateral dysfunctions” were a left-sided extension dysfunction and right-sided flexion dysfunction, and on the other occasion it was a left-sided flexion dysfunction and a right-sided extension dysfunction. Refer to table 4.8 below. These results were also seen as trends in the distribution of diagnosed dysfunction types.

Table 4.8. The types of dysfunction correctly identified by the S.B.P.T.. The most common dysfunction type correctly diagnosed by the S.B.P.T. was left-sided extension dysfunction and then right-sided flexion dysfunction.

4.1.2 Results for Determining whether the Sacral Base Pressure Test can Differentiate Between Types of Dysfunction

As stated in 3.5.1 of chapter 3 - Methodology, this study’s hypothesis statement is,

\[ H_0: \mu_{AS} = \mu_{PI} \]

Where \( H_0 \) = null hypothesis, \( \mu_{AS} \) = population designated as extension dysfunction and \( \mu_{PI} \) = population designated as flexion dysfunction.

And \( H_a: \mu_{AS} > \mu_{PI} \)

Where \( H_a \) = alternative hypothesis. (69)
The S.B.P.T. was performed on both the right side and the left side of the patient. These results were compared against the control tests, which rendered the type of sacroiliac joint dysfunction present. Only the true positive results (as compared to the control tests) of the S.B.P.T. were used in this analysis. This narrowed down the values of external rotation down to the most accurate value.

4.1.2.1 Sacral Base Pressure Test Performed on the Left

On this side, there were seven participants who had left-sided sacroiliac joint extension dysfunction, four had left-sided flexion dysfunctions, three had right-sided extension dysfunctions and nine had right-sided flexion dysfunctions.

The first t-test was comparing left-sided extension dysfunctions to left-sided flexion dysfunctions.

<table>
<thead>
<tr>
<th></th>
<th>Left AS</th>
<th>Left PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Mean</td>
<td>2.57</td>
<td>3.25</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.72</td>
<td>2.06</td>
</tr>
<tr>
<td>Variance</td>
<td>2.95</td>
<td>4.25</td>
</tr>
<tr>
<td>T-test</td>
<td>-0.59</td>
<td></td>
</tr>
<tr>
<td>d.f</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>T-critical value</td>
<td></td>
<td>1.833</td>
</tr>
</tbody>
</table>

Table 4.9. T-test and probability for left-sided dysfunctions when the S.B.P.T. was performed on the left.

The conclusion is that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is not a statistically significant difference between the input groups, therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 57.1% the same (P = 0.5707).
Next, the right-sided extension dysfunctions were compared with the right-sided flexion dysfunctions.

<table>
<thead>
<tr>
<th>Sample size</th>
<th>Right AS</th>
<th>Right PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>2</td>
<td>3.33</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0</td>
<td>3.04</td>
</tr>
<tr>
<td>Variance</td>
<td>0</td>
<td>9.25</td>
</tr>
<tr>
<td>T-test</td>
<td>-0.74</td>
<td></td>
</tr>
<tr>
<td>d.f</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>T-critical value</td>
<td>1.812</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.10. T-test and probability for right-sided dysfunctions when the S.B.P.T. was performed on the left.

The conclusion is that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is not a statistically significant difference between the input groups therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 48% the same (P = 0.4791).

These results were not statistically significant and therefore our analysis was taken one step further. All the extension dysfunctions were compared to all the flexion dysfunctions, regardless of whether they were right or left-sided.

Once again, it can be concluded that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is no statistically significant difference between the input groups, therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 35% the same (P = 0.3459).
Table 4.11. T-test and probability for all dysfunctions when the S.B.P.T. was performed on the left.

4.1.2.2 Sacral Base Pressure Test Performed on the Right

On this side, there were fifteen participants dedicated as left-sided sacroiliac joint extension dysfunction, five as left-sided flexion dysfunctions, two right-sided extension dysfunctions and six right-sided flexion dysfunctions.

The first t-test was comparing left-sided extension dysfunctions to left-sided flexion dysfunctions.

Table 4.12. T-test and probability for left-sided dysfunctions when the S.B.P.T. was performed on the right.
The conclusion is that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is no statistically significant difference between the input groups, therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 48.6% the same ($P = 0.4863$).

The right-sided extension dysfunctions were compared to the right-sided flexion dysfunctions.

<table>
<thead>
<tr>
<th>Sample size</th>
<th>Right AS</th>
<th>Right PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0</td>
<td>0.84</td>
</tr>
<tr>
<td>Variance</td>
<td>0</td>
<td>0.7</td>
</tr>
<tr>
<td>T-test</td>
<td>2.41</td>
<td></td>
</tr>
<tr>
<td>t.f</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>T-critical value</td>
<td>1.943</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.13. T-test and probability for right-sided dysfunctions when the S.B.P.T. was performed on the right.

It is evident that the difference in the mean values (amount of external rotation) of the two groups is great enough to reject the possibility that the difference is due to random sampling variability. There is a statistically significant difference between the input groups, therefore the null hypothesis is rejected and the alternative hypothesis is accepted. The values of external rotation between extension dysfunction and flexion dysfunction are 5.3% the same ($P = 0.0529$).

Even though these results are statistically significant (table 4.18), the results for the rest are not, therefore the analysis was taken one step further. All the extension dysfunctions were compared to all the flexion dysfunctions, regardless of whether they were right or left-sided.
### Table 4.14. T-test and probability for all dysfunctions when the S.B.P.T. was performed on the right.

<table>
<thead>
<tr>
<th></th>
<th>All AS (right &amp; left)</th>
<th>All PI (right &amp; left)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>17</td>
<td>11</td>
</tr>
<tr>
<td>Mean</td>
<td>2.82</td>
<td>1.82</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>2.07</td>
<td>1.08</td>
</tr>
<tr>
<td>Variance</td>
<td>4.28</td>
<td>1.16</td>
</tr>
<tr>
<td>T-test</td>
<td></td>
<td>1.48</td>
</tr>
<tr>
<td>d.f</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>T-critical value</td>
<td></td>
<td>1.706</td>
</tr>
</tbody>
</table>

It is noted that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is not a statistically significant difference between the input groups, therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 15.1% the same (P = 0.1508).

**4.1.2.3 Values from the Sacral Base Pressure Test (Combined Left-sided and Right-sided Test)**

Throughout the analysis of the first aim, the majority of the results have not been statistically significant. A further analysis was thus performed, which compared the values between all the extension dysfunctions and the flexion dysfunctions, regardless of whether the values were from the test performed on the participant’s left or right and also regardless of whether the values were for a right-sided or left-sided dysfunction.

The conclusion is that the difference in the mean values (amount of external rotation) of the two groups is not great enough to reject the possibility that the difference is due to random sampling variability. There is no statistically significant difference between the input groups, therefore the null hypothesis is not rejected. The values of external rotation between extension dysfunction and flexion dysfunction are 94.2% the same (P = 0.9416).
Table 4.15. T-test and probability for all dysfunctions from all results from the S.B.P.T.

### 4.1.3 Results for Reconfirming the Validity of the Sacral Base Pressure Test

There were considerable differences detected in the results of the S.B.P.T. when it was performed on the right and then on the left. The validity analysis was thus carried out for the S.B.P.T. when performed on the right, the left and finally, when the S.B.P.T. gave the same results on the left and right.

#### 4.1.3.1 Sacral Base Pressure Test Performed on the Right

The S.B.P.T. when performed on the right diagnosed thirty-six joints correctly and diagnosed twenty-six joints incorrectly. This results in a specificity of 24,14%, a sensitivity of 87,88%, a positive predictive value of 56,86%, negative predictive value of 63,64%, a misclassification rate of 41,94% and a prevalence of 53,23%.

<table>
<thead>
<tr>
<th>SBPT performed on the Right</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TRUE PICTURE</strong></td>
</tr>
<tr>
<td><strong>Result detected by S.B.P.T.</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

Table 4.16. The validity table for the S.B.P.T. performed on the right.
The Kappa coefficient was 0.12, where observed proportion of agreements (Po) was 0.58 and the expected proportion (Pc) was 0.52. Therefore, according to the Landis and Koch Guidelines for Kappa interpretation, the agreement between the S.B.P.T. and the control tests for sacroiliac joint dysfunction diagnosis was slight and therefore not statistically significant.

4.1.3.2 Sacral Base Pressure Test Performed on the Left

The S.B.P.T. when performed on the left diagnosed thirty-three joints correctly and diagnosed twenty-nine joints incorrectly. This produced a specificity of 27.27%, a sensitivity of 82.76%, a positive predictive value of 50%, a negative predictive value of 64.29%, a misclassification rate of 46.77% and a prevalence of 46.77%.

<table>
<thead>
<tr>
<th>SBPT performed on the Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRUE PICTURE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Result detected by S.B.P.T.</th>
<th>Patient has a S.I.J.D.</th>
<th>Patient is clear</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>24</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Negative</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>33</td>
<td>62</td>
</tr>
</tbody>
</table>

Table 4.17. The validity table for the S.B.P.T. performed on the left.

The Kappa coefficient was 0.10, where observed proportion of agreements (Po) was 0.53 and the expected proportion (Pc) was 0.48. Therefore, according to the Landis and Koch Guidelines for Kappa interpretation, the agreement between the S.B.P.T. and the control tests for sacroiliac joint dysfunction diagnosis was also slight and therefore statistically insignificant.

4.1.3.3 Sacral Base Pressure Test Producing the Same Results on the Left and Right

When the S.B.P.T. produced the same results on both the left and the right, the test diagnosed fourteen joints correctly and diagnosed thirteen joints incorrectly and produced a specificity of 14.29%, a sensitivity of 92.31%, a positive predictive value of 50%, and negative predictive value of 66.67%, a misclassification rate of 48.15% and a prevalence of 48.15%.
The Kappa coefficient was 0.06, where observed proportion of agreements (Po) was 0.52 and the expected proportion (Pc) was 0.49. Therefore, according to the Landis and Koch Guidelines for Kappa interpretation, the agreement between the S.B.P.T. and the control tests for sacroiliac joint dysfunction diagnosis was again slight and therefore statistically insignificant.
CHAPTER 5 – DISCUSSION
5.1 Discussion of the Results

5.1.1 Comparison Between the Types of Dysfunction and the Differences in External Rotation

According to the statistical analysis, these results were not statistically or clinically significant. Only the results from the S.B.P.T. performed on the right where the right-sided dysfunctions were compared, achieved statistical significance. In this case, the values of external rotation between extension dysfunction and flexion dysfunction were 5.3% the same (P = 0.0529). It was discussed that a P-value of less than 0.05 would be significant (70). From this we can see that even though this result is statistically significant, it is marginally significant.

Considering these results, it can be seen that some are plotted around the P-value of 50% with some of the values being larger on the side of the flexion dysfunction and others being larger on the side of extension dysfunction. However, when all the results were considered together, flexion dysfunctions were 94.2% the same as extension dysfunctions, therefore the difference in rotations was minute, with the average external rotation for extension dysfunction being 2.67 degrees and that for the flexion dysfunction being 2.62 degrees.

When discussing these results, the following explanations must be considered:

5.1.1.1 External Rotation Difference Between Dysfunction Types

It was hypothesised that in the case of posteriorly rotated ilia, the sacrum was going to be in a position of nutation, thereby facilitating the S.B.P.T. and there would therefore be no significant decrease in the external rotation between the dysfunctional and the functional side. However, in the case of the extension dysfunction and the counternutated sacrum, the test would be hampered by the counternutated sacrum and therefore there would be significantly decreased external rotation. It is perceivable that even if this situation occurred, the effect this would have on the external rotation occurring at the feet would be minimal and not nearly sufficient to provide objective results. Support for this statement is derived from the majority of the results averages (differences between the functional and the dysfunctional side) being larger for the extension dysfunction, albeit marginally so. However these results were statistically and clinically insignificant.
Three problems arose when diagnosing the participants with types of sacroiliac joint dysfunctions. Firstly, it was presumed that the two tests used for this diagnosis, namely Spine Test and Supine Long-Sitting Test, were able to detect the same dysfunctions. Previous studies had determined this (4, 58), however the possibility still exists that they were in fact detecting different dysfunctions. One is able to deduce this when examining the contradictions presented in appendix B. Although this study bases its literature review on certain studies which established validity for tests of sacroiliac joint dysfunctions (4, 58), other studies prove poor reliability (3, 68). A study such as this has to decide on which information to base itself on, however one must still be acquainted with the contradictions of the study, especially when dealing with the diagnosis of sacroiliac joint dysfunction.

Secondly, because there is no single test that can confirm the diagnosis of sacroiliac joint dysfunction, a diagnosis for sacroiliac joint dysfunction can be accepted when three out of four tests used produce positive results (4, 19, 55). When this is done, the individual test results become contributory rather than surrogate (55) and produce good inter-tester reliability (16). In this study, four tests were used to detect sacroiliac joint dysfunction, however only two of these four tests could determine specific types of dysfunction as described in 2.3.2 of chapter 2 –Literature Review (in other words Spine Test and Supine Long-Sitting Test). This caused problems when there were conflicting results between the two tests, not only in terms of accuracy of diagnosis, but with regards to sample sizes.

Thirdly, in the literature, the possibility of a bilateral type of dysfunction is occasionally discussed. A bilateral dysfunction is considered to be more common and occurs as a flexion dysfunction on the one side and an extension dysfunction on the opposite side (55, 65). The possibility of a bilateral dysfunction was not considered as part of this study. The implications of this were that the control tests only diagnosed unilateral dysfunctions. More importantly, from the study’s hypothesis (the difference in rotation between the types of dysfunction), it is obvious that on certain occasions where the results were marginally different and were taken as a dysfunction on the smaller value side, this could have potentially been a bilateral dysfunction.
5.1.1.3 Insignificant Sample Size

Finally, a main reason for the lack of statistically significant results may arise from the small sample sizes. Although the initial number of participants was sixty-two, by the time of diagnosis into types of dysfunctions, the number of true positives was significantly reduced. Due to the explanation offered in the second point above, only the diagnosis that agreed with both the tests (Spine Test and Supine Long-Sitting Test) was used as a true positive result. Once these true positives had been separated into left and right sides, as well as flexion and extension dysfunctions, the sample sizes were extremely small within each group.

5.1.2 The Strength of Agreement Between the Sacral Base Pressure Test and the Control Tests

In the research that this study is based on as well as previous research done in similar fields, the criterion for clinical usefulness regarding the validity has been placed at 70% (6, 68). In all the analyses done in this study, only the sensitivity for the S.B.P.T. is above the criterion for clinical usefulness, therefore the S.B.P.T. is useful in identifying positive values of sacroiliac joint dysfunction only. In summary, the S.B.P.T. in this study had only a “slight” agreement with the diagnosis, according to the Landis and Koch Guidelines for Kappa interpretation (75).

In a previous study, Breitenbach et. al. (2003), there was a ‘good’ strength of agreement between the S.B.P.T. and the diagnosis and it was concluded by results from the components of validity, that it is clinically useful as an indicator of sacroiliac dysfunction (6).

There is great discrepancy between the results of Breitenbach et. al. (2003) and those obtained in this study. However, the differences in the results between the studies could not be due to the differences in the sample sizes, as the same amount of subjects was used in both studies.

Explanation for the differences in results could be that there were changes in the methodology between these two studies. The differences in the methodology were that this study was done double-blinded, the external rotation of the foot was measured using a digital inclinometer instead of “eyeballing”, and the S.B.P.T. was performed on the participant’s left and right sides. All of these differences were included so as to further objectify the S.B.P.T. and reduce
bias. It can be explained that the results from this study are potentially more objective and less likely to involve bias than those obtained by the previous study.

It is also plausible that the differences resulted due to the manner in which the tests were performed (either the control tests and / or the S.B.P.T.) or because each clinician performed the test differently. Although there are set guidelines as to how each test should be performed, they are manual tests and clinicians tend to alter or simplify the procedure to suit themselves. The results also depend on the clinician for interpretation. Although Hestboek and Leboeuf-Yde (2000), after a critical literature review, reported that expertise is not a guarantee for success, it is important to realise that this could have an influence (22).

5.2 Alternative Explanations Offered by a Previous Study

Breitenbach et. al. (2003) gave some insight into plausible theories as to why the S.B.P.T. would not accurately detect sacroiliac joint dysfunction. This study does acknowledge these theories as possible explanations.

Firstly, Breitenbach et. al. (2003) points out that the results must be considered to be explorative because there is no independent criterion standard of diagnosis in other words the “gold standard” against which these tests can be compared, therefore the exact tests necessary to diagnose sacroiliac dysfunction cannot be determined (6). Refer to 5.1.2 of this chapter for further discussion in this regard.

In the discussion of false positive and false negative results, Breitenbach et. al. (2003) indicated that some mechanism other than sacroiliac dysfunction was causing the external rotation of the feet, but also preventing the rotation of the femur. This could either be due to a misdiagnosis by the diagnostic procedure and / or the fact that the movements could be expressions of other types of sacroiliac joint dysfunction (namely extension or flexion dysfunction) (6).

They also hypothesised that in certain individuals where there was a dysfunction, the downward pressure applied to the sacrum would create an upward vector on the femur thereby causing the external rotation, which would give a false negative result. Their other thought was that the movements of nutation and counternutation were not transferred to the femur and this would result in a false positive (6).
Breitenbach et al. (2003) also described the potential effects that pathology and abnormalities of the myofascial systems and ligaments of the pelvis would have on the movements produced by the S.B.P.T. (6). The myofascial systems play an important role in providing the form closure needed for stability of the sacroiliac joint. The sacroiliac joints need this stability for optimal functioning and if there are abnormalities, pathology or even muscular imbalances present in the myofascial and ligamentous systems, dysfunction will result.

They queried whether congenital bony anomalies (such as a unilateral or bilateral sacralization) or pathologies within the lumbar spine, pelvis or femur would also have an effect (6). These abnormalities or pathologies might cause different magnitudes of the ground reactive forces into the sacroiliac joints. As stated in 2.2.5.3 of the literature review, these external forces influence the joint movement (7), however may also alter the resting position of the limb before and during the application of the S.B.P.T., leading to either false positives or false negatives, as this altered position may be seen as a difference in movement from the opposite side.

5.3 Sacroiliac Joint Dysfunction Diagnosis

Manual examination of the sacroiliac joint is the standard method used for its diagnosis, as there are no pathognomonic, radiographic, or laboratory investigations available (58). Unfortunately however, there is not one manual examination test that is considered to be the “gold standard” of sacroiliac joint dysfunction diagnosis (4). At best, when three out of four tests used produce positive results (4, 19, 55), the individual tests results become contributory rather than surrogate (55) and together produce good inter-tester reliability (16). The diagnosis for types of dysfunction also presents a similar problem, which is the lack of the “gold standard”.

There is considerable controversy surrounding the reliability and validity of these manual examination tests (see appendix B). Each study that uses these tests uses those, which are prescribed to by a similar school of thought. The tests used in this study are no exceptions, although they have been proven to be reliable. (4, 58)

It must also be considered that the control tests which are used are not as reliable and valid as they are thought to be. Maybe they do not represent sacroiliac joint dysfunction or the same
sacroiliac joint dysfunction as what the S.B.P.T. is testing for. The so-called “true picture” of
diagnosis as given by the control tests will not be that true after all, instead the control tests
would be giving an undetermined percentage or a fraction of the “true picture”. This would
evidently equate to “poor” agreement between the S.B.P.T. and the control tests, according to
the Landis and Koch Guidelines for Kappa interpretation (75). Therefore, the results are a
percentage agreement of an undetermined fraction of the “true picture” or diagnosis.

This study was performed in a double-blinded fashion, however the control tests used in this
study were performed on the participant one after the other. This means that the outcome from
the S.B.P.T. was double-blinded, but this did not apply to the performance of the control tests.
It would be easy for the performing examiner to bias the control tests by making them equate
to the same diagnosis. This would lead to a potentially false positive and false negative
diagnosis.

Another aspect to the diagnosis of sacroiliac joint pathology that is not considered by this
study, which was expressed by Breitenbach et. al. 2003, is its complex nature. Pathology in
the sacroiliac joint can cause pain (although not addressed in this study) and this pain has its
origin in one or many structures. Any skeletal, muscular, ligamentous, visceral and / or
nervous tissue in the surrounding area can be involved (7) and can be affected by a variety of
pathological processes including inflammation, infection, malignancy and crystal deposits
that can cause pain (3).

Manipulative therapists’ primary diagnosis is a functional lesion, namely sacroiliac joint
dysfunction. However, other lesions that are not functional lesions may be present in isolation
or in combination with the functional lesions. When in isolation, they may mimic the
sacroiliac joint dysfunction (therefore a false positive) or when in combination they might
prevent sacroiliac joint dysfunction from being detected (therefore a false negative diagnosis).
Examples of this are when pathology such as sacroilitis or even ankylosing spondylitis
affects the sacroiliac joint resulting in varying degrees of restricted movement in the sacroiliac
joint, either unilaterally or bilaterally. The effect of myofascial or ligamentous pathology on
the outcomes of the S.B.P.T. has been discussed above in 5.2, however it must again be
considered here.
5.4 Performance of the Sacral Base Pressure Test

While performing the S.B.P.T., a few issues arose that could alter the results of the test and thus alter the agreement between the S.B.P.T. and the diagnosis. Although the S.B.P.T. has more objectivity than the other tests for sacroiliac joint dysfunction, there is still some degree of subjectivity. It should be the focus of any study of diagnostic tests to make the experimental test as objective as possible with limited variables so that it can reliable, valid, sensitive and specific to the diagnosis.

5.4.1 Amount of Force Needed During the Performance of the SBPT.

During the test, the force applied to the sacrum should be about four to five kilograms and this force should take two seconds to reach maximal intensity. These values are only guidelines, as sufficient movement can occur at the feet with a one kilogram force alone (6). It has been difficult to measure the exact force directed through the sacrum. In this study, the performing examiner practised the force needed on a normal bathroom scale before applying the force to the participant.

It is reasoned that the use of more force will result in a greater movement of the feet in external rotation. In the case of a dysfunctional sacroiliac joint, there will be greater movement on the non-dysfunctional side, which would result in a greater difference between the two sides. This would result in a false positive when trying to determine the type of dysfunction present, in other words the difference would be greater than expected for the specific type of dysfunction (either flexion or extension dysfunction). For further elaboration of this refer to 2.5 of chapter 2 – Literature Review.

It may be questioned that depending on the size of the sacroiliac joint, in other words surface area and surrounding supporting structures, more force would be needed to overcome the stabilizing structures in order to induce nutation. Therefore a table must be formulated providing a relationship between the forces required relative to the size of patient. However, a method needs to be devised which could measure the force used, so that these variables can be eliminated and a standardization formed.
5.4.2  Direction of the Force Applied to the Sacrum

The examiner must apply a straight posterior to anterior force to the sacral base between the first and second sacral tubercles, so as to directly induce nutation to the sacrum (6). During this study, the external examiner directed the performing examiner’s force in a straight posterior to anterior direction before and during the application of the force. This was accomplished by “eye-balling”, so there was possibly some deviation from this direction. A second potential complication regarding the direction of the force would be when the sacrum is not in a parallel plane to the bed, namely when there is a change in the lumbosacral angle.

As seen in the results chapter, there were differences in the results obtained when the S.B.P.T. was performed between the participant’s left and their right sides. It can therefore be contemplated (hypothetically) that when applying the force on the participant’s left side, the direction of force might have been directed along the line of the sacroiliac joint either ipsilaterally or contralaterally. This would therefore facilitate and accentuate the nutation on that side, resulting in a greater rotation on that side. If that side was the dysfunctional side, it could possibly facilitate enough to make it appear to have normal function.

If the force applied was not directly perpendicular to the sacrum from a lateral view, but was perpendicular from an inferior to superior view, this would cause a similar scenario to that described in 5.4.1. There might be more or less force needed to accomplish the sacral nutation, depending on whether the force was greater or less than ninety degrees to the sacrum. This would therefore cause differences in the external rotation between the dysfunctional side and the functional side, considering that on the dysfunctional side the sacrum would be in a position of relative nutation or counternutation (flexion dysfunction or extension dysfunction respectively).

5.4.3  Sacral Motion During Respiration

Many clinicians in the chiropractic and osteopathic fields have postulated sacral motion occurring with the respiratory cycle and the primary respiratory mechanism. They have termed it the craniosacral rhythm. The sacrum nutates with exhalation and counternutates with inhalation. This occurs in a cyclic rhythm at a frequency of eight to twelve cycles per second (18).
In this study, this phenomenon was not considered and patients were free to breathe as the test was being performed. If the force was applied when the patient was inhaling, then the force was directed against the conterminating sacrum and this would decrease the magnitude of the force, thereby creating up the mechanism discussed in 5.4.1 above. The opposite would obviously occur if the patient exhaled during application of the force and the sacrum would be in a relative nutated position.

5.4.4 The Test Performed on Different Age Groups

This study was primarily performed on participants in their third decade of life. When referring to 2.2.3.1. of chapter 2 – Literature review, there are differences in degeneration and stability of the sacroiliac joints in the different decades of life and these difference result in altered mobility. The mobility is initially a gliding motion (23), which becomes a nodding motion with degeneration, directed by the interdigitations of the joint (27). In the third decade, the joint has finally achieved adult status (7) and there is only marginal degeneration, if any (12, 23). If participants were chosen from different age groups, the degrees of degeneration would differ and thus the mobility would also differ. This would result in the different results obtained by using the SBPT, which is dependent on the type of mobility present.

5.5 Trends in the Distribution of Types of Dysfunctions

When analysing the distribution of dysfunctions as diagnosed by the control diagnostic tests, and even when the S.B.P.T. produced the same results as the controls, the most common trend of diagnosis observed was a right-sided flexion dysfunction and left-sided extension dysfunction. These results could indicate possible prevalence values for the different types of dysfunctions.

5.6 Limitations of the Study

- The diagnosis of the types of dysfunction was limited to two tests and not four tests, where two or three need to be positive for the formulation of a diagnosis.

- Due to the diagnosis problems, as only two tests were used, many participants were not diagnosed as having a type of dysfunction. This resulted in a small sample size, which made statistical analysis difficult.
- No bilateral dysfunctions were considered, which again influenced the sample size.

- The control tests were not subjected to a double-blind environment.

- No imaging studies were done in order to detect structural lesions that would influence the diagnosis and the results. A modified lumbar regional (appendix G) was performed in order to rule out these pathologies, however asymptomatic or sub-clinical entities such as congenital defects or abnormalities might not have been excluded in this manner.

- The effects of respiration on the movements of the sacrum and on the results of the S.B.P.T. were not considered. Patients were allowed to breathe freely during testing.

- There was no objective means to standardise the amount of force used and / or the true direction of the force whilst performing the S.B.P.T.
CHAPTER 6 – CONCLUSION AND RECOMMENDATIONS
6.1 Recommendations

6.1.1 Recommendations for Future Studies on the Sacral Base Pressure Test

- In future studies when diagnosing sacroiliac joint dysfunctions, one must use a cluster of diagnostic tests that includes at least four tests and then another cluster of tests (at least four) when diagnosing the types of dysfunction. This study used four to diagnose the dysfunction but only two to diagnose the type of dysfunction. When performing these control tests, each test must be performed without the knowledge of the results achieved from the other tests. This would be a true double-blinded environment, which would eliminate any bias.

- Bilateral dysfunctions of the sacroiliac joint must not be excluded as a possible result from the cluster of diagnostic tests. The possibility of bilateral dysfunctions as detected by the S.B.P.T. must also be accepted, even if the values of rotation are different. Majority of bilateral restrictions occur as a flexion dysfunction on the one side and an extension on the opposite side. Therefore, results will either be a unilateral dysfunction on the right or the left or a bilateral dysfunction and these can subsequently be compared for agreement.

- Imaging studies must be performed on all patients in order to detect structural lesions that could influence the diagnosis and the results. A more strict regional examination must be performed to rule out all pathologies that would affect the outcome of the S.B.P.T. The examination must determine whether there is any instability in the joint (ligamentous or myofascial), and also determine the nature of the surrounding musculature, comparing sides (namely either hypertonic or hypotonic and / or the relative strength).

- A study could split the sample population into two groups, one in which the S.B.P.T. is performed when the participant has fully inhaled and the other group in which the participant has exhaled completely. This would compare the effect of sacral movement during respiration on the S.B.P.T.

- Some form of device needs to be used in order to measure the amount of force applied to the participant. Either a sensor can be placed under the participant or under the contact that allows the examiner to determine the amount of force that is required. Other objective means must be used to standardise the true direction of the force in relation to the sacrum, in other words in a true perpendicular direction to the sacrum in the sagittal plane and the
transverse plane, whilst performing the S.B.P.T. The exact contact on the sacrum also needs to be more specific.

- The S.B.P.T. could be performed on different age groups in order to assess the negative effect that degeneration of the sacroiliac joints has on the mobility of the joint. The certain age groups could therefore be categorised according to the amount of degeneration present. The amount of degeneration must be quantified objectively for each participant and then the results compared.

- Considering the differences between the genders structurally and functionally, further studies can be directed at determining the differences that gender has on the S.B.P.T. Results can be compared between males, females, females that are pregnant and those that are post-partum.

- In order to allow a greater chance of statistically significant results, a larger sample size should be drawn from the population.

- This study had a majority of participants that were asymptomatic and although it has been stated that the sacroiliac joint is a pain-generating structure, it has been established that sacroiliac dysfunction can be present in the absence of pain. The factors that cause a dysfunctional joint to become symptomatic may involve those surrounding structures that will affect mobility (for example: muscles, ligaments or joint capsule). The influence that these factors have on the results obtained from the S.B.P.T. can be studied by comparing a symptomatic group to an asymptomatic group.

6.1.2 Recommendations for Future Studies Trying to Identify the “Gold Standard” for the Diagnosis of Sacroiliac Joint Dysfunction

- The independent criterion standard must be determined so that this myriad of diagnostic tests can be validated against a reliable standard. Until then, these tests have to be compared with other clinical tests of limited validity.

- Certain studies recommend that inter- and intra-examiner reliability studies should be performed on these diagnostic tests. This would possibly provide a better understanding into the differences in results obtained between the similar studies (such as this one compared to
Breitenbach et al., where differences could be due to unreliability on the part of the performing examiner (either inter- and or intra-examiner) or extrinsic factors such as those already discussed. Further studies could branch off from this, determining the factors which make the performance of a diagnostic test unreliable, thereby attempting to objectify these tests.

- In a 1999 study, the three palpatory tests used (namely Standing Flexion Test, Spine Test and Iliac Springing Test) were assumed to identify a similar dysfunction of the sacroiliac joint (58). This study determined whether there was agreement between the tests of sacroiliac joint dysfunction. It is recommended that future studies also be directed more specifically at determining the agreement between two tests of sacroiliac joint dysfunction. This would provide answers to the comparative strength of agreement between tests and whether certain tests detected the same sacroiliac joint dysfunction or not. From this one would know which tests to use in the cluster of diagnostic tests.

- Regardless of the nature of the study, future researchers should perhaps bear in mind, when performing functional tests, that excessive springing could possibly mobilise the dysfunctional joint enough to produce a false negative result.

6.2 Conclusion

At this stage in this study, the results for the S.B.P.T. indicate that it does not have a “good” agreement with the control diagnostic test as the previous research on this topic showed. The S.B.P.T. was also not statistically or clinically significant in determining which type of sacroiliac joint dysfunction the test favoured. Certain of the previous study’s limitations supplemented this research in order to further the knowledge regarding the S.B.P.T. and the diagnosis of sacroiliac joint dysfunction. It is the conclusion from these results that the S.B.P.T. is not a clinically useful test in order to determine sacroiliac joint dysfunction.

Amidst all the controversy and contradictory thoughts regarding every aspect of the sacroiliac joint, many similar studies are completing the puzzles surrounding this joint. Future studies should draw from the results and conclusions of this study and search for that “gold standard” of sacroiliac joint assessment. Possible outcomes of this search would include finding one test that fulfilled the criteria to be the “gold standard” or a cluster of tests that becomes the “gold
standard”. Possibly this “gold standard” will be one test that incorporates the positive aspects of each of the many manual tests currently used.
REFERENCES


APPENDICES
### Appendix A: Literature Review of Described Biomechanics and Kinematics of the Sacroiliac Joint

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colachis</td>
<td>1963</td>
<td>Photogrammetry with Kirschner wires</td>
<td>PSIS moves in frontal plane max 1,5mm (35).</td>
</tr>
<tr>
<td>Egund et. al.</td>
<td>1978</td>
<td>Radiostereophotogrammetry</td>
<td>Approx 2°, 6 movements available (34).</td>
</tr>
<tr>
<td>Sturesson</td>
<td>1989</td>
<td>Radiostereophotogrammetry</td>
<td>0,2-3,2° with a mean of 2.5° during functional movements (34).</td>
</tr>
<tr>
<td>Kissling et. al.</td>
<td>1990</td>
<td>Photogrammetry</td>
<td>(Males) 0,6-1,2°; (females) 1,9-2,8° (35).</td>
</tr>
<tr>
<td>Pitkin &amp; Pheasant</td>
<td>1936</td>
<td>Roentgenography/inclinometer</td>
<td>Average 7°, range of 3-19° (34).</td>
</tr>
<tr>
<td>Sashin</td>
<td>1930</td>
<td>Manual pressure</td>
<td>Average 4° (34).</td>
</tr>
<tr>
<td>Reynolds</td>
<td>1980</td>
<td>Stereoradiography</td>
<td>Average 2,3° in flexion (34).</td>
</tr>
<tr>
<td>Clayson et. al.</td>
<td>1962</td>
<td>Radiography</td>
<td>Average 8° using the pelvic sacral angle (34).</td>
</tr>
<tr>
<td>Pierrynowski</td>
<td>1988</td>
<td>Kinematics</td>
<td>Average 3° during gait (34).</td>
</tr>
<tr>
<td>Lavignolle et. al.</td>
<td>1983</td>
<td>Stereoradiography</td>
<td>10-12° (34).</td>
</tr>
<tr>
<td>Scholten et. al.</td>
<td>1988</td>
<td>Computer</td>
<td>1° relative rotation (76).</td>
</tr>
<tr>
<td>Miller et. al.</td>
<td>1987</td>
<td>Static loading</td>
<td>1 ilia fixed translation &amp; rotation motion 3-5 times larger compared to both ilia fixed (76).</td>
</tr>
<tr>
<td>Smidt et. al.</td>
<td>1997</td>
<td>Computed tomography</td>
<td>Largest motion occurred in sagittal plane (7° on left &amp; 8° on right) (77).</td>
</tr>
<tr>
<td>Lavignolle et. al.</td>
<td>1983</td>
<td>Spatial analysis (in-vivo), photogrammetry</td>
<td>Young adults rotational average 10-12° (78).</td>
</tr>
</tbody>
</table>

Table A.1. The reported values of sacroiliac joint rotatory motion (in degrees).
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weisl</td>
<td>1955</td>
<td>Conventional radiography</td>
<td>Max translation 7mm, mean 5.6mm when rising from supine (34).</td>
</tr>
<tr>
<td>Colachis</td>
<td>1963</td>
<td>Photogrammetry with Kirschner wires</td>
<td>Max translation 5mm functional movement (34).</td>
</tr>
<tr>
<td>Sturesson</td>
<td>1988</td>
<td>Radiostereophotogrammetry</td>
<td>0.7mm mean translation (35).</td>
</tr>
<tr>
<td>Egund <em>et. al.</em></td>
<td>1978</td>
<td>Radiostereophotogrammetry</td>
<td>Approx 2mm (34).</td>
</tr>
<tr>
<td>Grieve</td>
<td>1983</td>
<td>Stereophotogrammetry</td>
<td>1-16mm all subjects, 5-8mm in pain-free subjects (34).</td>
</tr>
<tr>
<td>Pierrynowski <em>et. al.</em></td>
<td>1988</td>
<td>Kinematics</td>
<td>2.9mm anterior/posterior motion in gait (34).</td>
</tr>
<tr>
<td>Miller <em>et. al.</em></td>
<td>1987</td>
<td>Static loading</td>
<td>0.5 iliac torsion &amp; 2.7 sacral displacement (34). 1 ilia fixed translation &amp; rotation motion 3-5 times larger compared to both ilia fixed (76).</td>
</tr>
<tr>
<td>Wilder <em>et. al.</em></td>
<td>1980</td>
<td>Topography model</td>
<td>7.25mm in median plane, 3.4mm in frontal plane (34).</td>
</tr>
<tr>
<td>Frigerio <em>et. al.</em></td>
<td>1981</td>
<td>Stereoradiography</td>
<td>2.7mm sacral apex movement (34).</td>
</tr>
<tr>
<td>Goldthwaite &amp; Osgood</td>
<td>1905</td>
<td>Gross observation</td>
<td>Average 3mm with hip flexion (34).</td>
</tr>
<tr>
<td>Scholten <em>et. al.</em></td>
<td>1988</td>
<td>Computer</td>
<td>&lt;3mm “prime node” translation (34).</td>
</tr>
<tr>
<td>Smidt <em>et. al.</em></td>
<td>1997</td>
<td>Computed tomography</td>
<td>4-8mm P.S.I.S translation in respect to the sacrum in all directions no detectable trends (77).</td>
</tr>
<tr>
<td>Lavignolle <em>et. al.</em></td>
<td>1983</td>
<td>Spatial analysis (in-vivo), photogrammetry</td>
<td>Young adults translation average 6mm (78).</td>
</tr>
</tbody>
</table>

Table A.2. The reported values of sacroiliac joint translatory motion (in millimetres).
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duncan</td>
<td>1854</td>
<td>Topographical description of</td>
<td>Nutation – horizontal axis through the 2 iliac tuberosities (35).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>surfaces</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weisl</td>
<td>1955</td>
<td>Conventional radiography</td>
<td>Variable axes at Bonnaire’s tubercle (5-10cm inferior to the promontory) (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wilder</td>
<td>1980</td>
<td>Topography model</td>
<td>Translation around a “rough axis” if surface separates (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vukicevic et al.</td>
<td>1988</td>
<td>Holographic analysis</td>
<td>There is sacral translation &amp; rotation over an instantaneous axis, amount of loading influences the distance of the rotational axis from the promontory (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meyer</td>
<td>1878</td>
<td>Sacral dissection</td>
<td>Sacrum moves over a fixed axis (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mennell</td>
<td>1952</td>
<td>Unknown</td>
<td>Transverse axis resulting in flexion &amp; extension of the trunk on the pelvis in the sagittal plane (17).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bourdillon</td>
<td>1982</td>
<td>Unknown</td>
<td>Oblique axis with oblique trunk flexion (17).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lavignolle et al.</td>
<td>1983</td>
<td>Spatial analysis (in-vivo),</td>
<td>3 different oblique axes of rotation through the pubic symphysis with an anterior unlocking phenomena (78).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>photogrammetry</td>
<td></td>
</tr>
<tr>
<td>Mitchell et al.</td>
<td>1979</td>
<td>Unknown</td>
<td>Several axes, 4 transverse axes &amp; 1 oblique axis (on the left &amp; right). These axes give multiple of motions (18).</td>
</tr>
</tbody>
</table>

Table A.3. The reported sacroiliac joint axes of motion.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Method</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Klein</td>
<td>1891</td>
<td>Manual measurements</td>
<td>Conjugate changes on posture changes (35).</td>
</tr>
<tr>
<td>Weisl</td>
<td>1954</td>
<td>Dissection &amp; cartography</td>
<td>Only dorsoventral sacral rotation occurs (76). Conjugate changes on posture changes in 77%, Sacral base moves dorsally in trunk extension &amp; ventrally in flexion (76).</td>
</tr>
<tr>
<td></td>
<td>1955</td>
<td>Conventional radiography</td>
<td></td>
</tr>
<tr>
<td>Brunner et. al.</td>
<td>1991</td>
<td>Morphologic &amp; histopathologic</td>
<td>Different mobility patterns between males &amp; females, motion pattern is linked with surface topography, and degeneration has a variable effect on movement extent (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>features topographically (</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>photogrammetry)</td>
<td></td>
</tr>
<tr>
<td>Vukicevic et. al.</td>
<td>1988</td>
<td>Holographic analysis</td>
<td>With loading pelvis moves posteriorly &amp; pubic rami moves superiorly. The iliac show lateral flexion &amp; an outward protrusion (76).</td>
</tr>
<tr>
<td>Walker</td>
<td>1992</td>
<td>Article review</td>
<td>Motion is small &amp; is a coupling in 6 degrees of freedom (76).</td>
</tr>
<tr>
<td>Miller et. al.</td>
<td>1987</td>
<td>Load-displacement curves on</td>
<td>Rotation &amp; translation in all 6 degrees of freedom were larger with 1 leg fixed as opposed to 2 legs being fixed (76).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cadavers</td>
<td></td>
</tr>
</tbody>
</table>

Table A.4. The reported types of sacroiliac joint movements and other mobility observations.
### Appendix B: Literature Review of Described Examination Procedure of the Sacroiliac Joint

<table>
<thead>
<tr>
<th>AUTHOR</th>
<th>YEAR OF STUDY</th>
<th>TESTS STUDIED</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiles</td>
<td>1980</td>
<td>SI motion palpation</td>
<td>High specificity on students (79) &amp; appropriate screening test (64).</td>
</tr>
<tr>
<td>Brunarski</td>
<td>1982</td>
<td>SI motion palpation</td>
<td>Patients with LBP: high sensitivity but low specificity (79).</td>
</tr>
<tr>
<td>Carmichael</td>
<td>1987</td>
<td>SI motion palpation</td>
<td>Signficant intra-examiner correlation (79), Gillet’s Test had &gt; than 85% reliability (64).</td>
</tr>
<tr>
<td>Potter &amp; Rothstein</td>
<td>1985</td>
<td>13 tests for SI joint</td>
<td>Iliac gapping and compression only tests with acceptable reliability (&gt; 70% inter-examiner agreement) (60). Poor reliability for Gillet’s (47%), standing flexion (44%) &amp; Supine Long-Sitting Tests (40%) (3). Agreement does not relate to doctors years of experience (3).</td>
</tr>
<tr>
<td>Dreyfuss et. al..</td>
<td>1994</td>
<td>SI joint tests</td>
<td>20% asymptomatic patients have relative SI joint hypomobility as determined by standing flexion, seated flexion and Gillet’s Test (11). Ranked most likely reliable by an expert panel (57). No single or combination gave a worthwhile diagnostic value for SI joint pain (7). Fluoroscopically guided intra-articular diagnostic injections identified as the “gold standard” for SIJ pain diagnosis (15).</td>
</tr>
<tr>
<td>Laslett &amp; Williams</td>
<td>1995</td>
<td>Pain provocative tests</td>
<td>Predicted an abnormal-appearing SI joint radiograph (7).</td>
</tr>
<tr>
<td>Mierau</td>
<td>1995</td>
<td>Gaenslen’s Test</td>
<td>Questioned accuracy (7).</td>
</tr>
<tr>
<td>Maigne et. al..</td>
<td>1996</td>
<td>SIJ provocative tests</td>
<td>Questioned accuracy (7).</td>
</tr>
<tr>
<td>Paydar et. al..</td>
<td>1994</td>
<td>Several SIJ tests</td>
<td>PSIS tenderness acceptable inter- &amp; intra-tester reliability (7).</td>
</tr>
<tr>
<td>Mior &amp; McGregor</td>
<td>1990</td>
<td>Gillet’s Test</td>
<td>Slight to fair inter- &amp; intra-tester agreement (7).</td>
</tr>
<tr>
<td>Herzog et. al..</td>
<td>1989</td>
<td>Gillet’s Test</td>
<td>Significant inter-examiner reliability but only 60% agreement (7).</td>
</tr>
<tr>
<td>Fortin et. al..</td>
<td>1994</td>
<td>Pain referral maps</td>
<td>Area 10cm caudal and 3cm lateral to PSIS Successful for SIJ dysfunction screening (1).</td>
</tr>
</tbody>
</table>

Table B.1. A literature summary of sacroiliac joint diagnostic tests.
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Test(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Duersen et. al.</td>
<td>1990</td>
<td>6 commonly used palpatory tests</td>
<td>A fair inter-examiner reliability (60).</td>
</tr>
<tr>
<td>Colachis et. al.</td>
<td>1963</td>
<td>Standing Flexion Test</td>
<td>Correlation radiographically between SIJ motion &amp; the test (11).</td>
</tr>
<tr>
<td>Cibulka et. al.</td>
<td>1988</td>
<td>Palpatory tests (positional &amp; functional)</td>
<td>Reliable inter- and intra-tester correlation using 3 out of 4 tests as a positive result (60). Questioned validity and inter-tester reliability (16).</td>
</tr>
<tr>
<td></td>
<td>1992</td>
<td>Supine Long-Sitting Test</td>
<td>Asymmetries in hip rotation found in patients with SIJ regional pain (55). This cluster of tests was useful in detecting SIJ dysfunction; sensitivity was 0.82, specificity 0.88, prevalence 0.48, +ive predictive value 0.86, -ive predictive value 0.84 (4).</td>
</tr>
<tr>
<td></td>
<td>1998</td>
<td>Hip ROM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1999</td>
<td>Cluster of SIJ tests, including standing flexion &amp; Supine Long-Sitting Test</td>
<td></td>
</tr>
<tr>
<td>McCombe et. al.</td>
<td>1989</td>
<td>5 Pain provocative SI tests, inter-examiner reliability</td>
<td>Pain on hip flex reliable, pain resisted hip external rotation potentially reliable, distraction and compression unreliable (60). Kappa value of 0.4 for reproducibility of tests (60).</td>
</tr>
<tr>
<td>Ostgaard et. al.</td>
<td>1992</td>
<td>Thigh trust test</td>
<td>81% concordance with subjective complaint of pain. 70% +ive predictive value, 88% -ive predictive value, 81% sensitivity, 80% specificity (60).</td>
</tr>
<tr>
<td>Simmonds Janos</td>
<td>Unknown</td>
<td>Landmark palpation</td>
<td>High errors in bony landmark palpation (34).</td>
</tr>
<tr>
<td>Walker</td>
<td>1992</td>
<td>SIJ tests</td>
<td>Pain provocation tests show reliability, however pain palpation is only reliable method (34).</td>
</tr>
<tr>
<td>Oldrieve</td>
<td>1995</td>
<td>Review of all SIJ tests &amp; examinations</td>
<td>Lack of reliability &amp; validity (30), including a poor inter-tester reliability for Standing Flexion Test &amp; Supine Long-Sitting Test (16).</td>
</tr>
<tr>
<td>Landis &amp; Koch</td>
<td>1977</td>
<td>Gillet’s Test</td>
<td>&lt;0.4 Kappa value for observer agreement, therefore moderate strength (40).</td>
</tr>
<tr>
<td>Sturesson et. al.</td>
<td>2000</td>
<td>Gillet’s Test</td>
<td>RSA* proved SIJ movement too small to be detected manually. Gillet’s Test not recommended diagnostically (40).</td>
</tr>
<tr>
<td>Osterbauer et. al.</td>
<td>1993</td>
<td>Diagnosis SIJ syndrome</td>
<td>Possible with a careful selection of screening tests (80).</td>
</tr>
<tr>
<td>Slipman et. al.</td>
<td>1996</td>
<td>Radionuclide Imaging</td>
<td>Confirms SIJ syndrome presence with 100% specificity, however sensitivity is 13% (53).</td>
</tr>
<tr>
<td>Erhard et. al.</td>
<td>1994</td>
<td>Cluster of SIJ tests, same as in Cibulka 1999.</td>
<td>Successful at predicting favourable responses from treatment (53).</td>
</tr>
</tbody>
</table>

Table B.2. A continuation of Table B.1. A literature summary of sacroiliac joint diagnostic tests.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Year(s)</th>
<th>Test Descriptions</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toussaint et al.</td>
<td>1999</td>
<td>Standing flexion, Spine &amp; Iliac Springing Tests</td>
<td>Detect same SIJ dysfunction &amp; valuable in diagnosing SIJ dysfunction (58).</td>
</tr>
<tr>
<td>Kim Kirkaldy-Willis &amp; Hill</td>
<td>1984</td>
<td>Standing Flexion and Gillet’s Test</td>
<td>Ideal specificity (58).</td>
</tr>
<tr>
<td>Meijne et al.</td>
<td>1999</td>
<td>Gillet’s Test</td>
<td>Very low levels of reliability (68).</td>
</tr>
<tr>
<td>Russell et al.</td>
<td>1981</td>
<td>Pain provocation</td>
<td>Gaenslen’s, Yeoman’s &amp; other similar tests do not give discriminative information for LBP evaluation (81).</td>
</tr>
<tr>
<td>Hestboek &amp; Leboeuf-Yde</td>
<td>2000</td>
<td>A systematic critical literature review of: SIJ Motion Palpation studies</td>
<td>Reliability range from slight concordance to good agreement (22). Intra-examiner reliabilities were rated fair &amp; significant (22). Inter-examiner reliabilities had slight &amp; significant agreement (22). Excellent intra-examiner agreement for PSIS tenderness (22). The examiner experience did not alter the results, intra-examiner reliability is better, and pain provocation tests show better results than the functional tests (22).</td>
</tr>
<tr>
<td>Broadhurst &amp; Bond</td>
<td>1998</td>
<td>Pain provocation tests</td>
<td>FABER, POSH &amp; REAB tests have high predictive value for SIJ pain when tests used in combination (82).</td>
</tr>
<tr>
<td>French et al.</td>
<td>2000</td>
<td>Common chiropractic diagnostic tests</td>
<td>Slight reliability in detecting manipulative lesion in SIJ with a poor to moderate agreement (inter- / intra-examiner) (75).</td>
</tr>
</tbody>
</table>

*RSA – Radiostereometric Analysis

Table B.3. A continuation of Table B.1. A literature summary of sacroiliac joint diagnostic tests.
Appendix C: Copy of Participant Information and Consent Form

The Predictive Value of the Sacral Base Pressure Test in detecting specific types of sacroiliac Dysfunction.

Dear participant,

The purpose of this study is to determine whether the Sacral Base Pressure Test can detect a specific type of sacroiliac joint restriction. The sacroiliac joint is the joint between the “hipbone” and the sacrum, at the bottom of the spine. In chiropractic assessment of the sacroiliac joints, one determines whether a sacroiliac dysfunction exists, in other words a lack of motion in the joint and what is the specific restriction, or what motion is lacking. The Sacral Base Pressure Test is performed with the patient lying on his or her stomach and the chiropractor pushing down on the sacrum, noting what is happening to the patient’s feet.

There will be no specific groups, but certain variables will be noted including whether the patient is symptomatic or not. The total sample size is sixty people.

The benefits of this research for you as a patient, especially if you are a sufferer of lower back pain, is to alleviate your pain and also to increase your range of motion that you are potentially able to achieve. It will increase your understanding of chiropractic care, and so hopefully for your future musculoskeletal complaints you will be comfortable in seeking chiropractic care.

Participation in this study is voluntary, therefore you are free to refuse to participate or to withdraw your consent and thus discontinue your participation at any time. A signed copy of this consent form will be made available to you, upon your request.

Participant:
I _____________________________, have been fully informed as to the procedures that are to be followed, including those which are investigational. I have also been given the description of the attendant discomforts, risks, and benefits to be expected and the appropriate alternative procedures.
In signing this consent form, I agree to this method of treatment and I understand that I am free to withdraw my consent and discontinue my participation at any time within this research. I also understand that if at any time I have questions, that they will be answered.

Signature: ______________________________ Date: ________________________
Or Guardian: ______________________________

Researcher:
I _____________________________, have identified those, who are able to participate and have fully explained the procedures and their purpose in this research. I have also asked whether there are any questions that have arisen and have answered these questions to the best of my ability.

Signature: ______________________________ Date: ________________________
Appendix D: Copy of Case History Form

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: __________________

Patient: ___________________________ File No: _______

Age: _____  Sex: ________  Occupation: ________________

Intern: ___________________________ Signature: ________________

FOR CLINICIAN'S USE ONLY

Initial visit clinician: ________________ Signature: ________________

Case History: __________________________________________________

_________________________________________________________________

Examination:

Previous:  TWR  Current:  TWR
            Other

X-ray Studies:

Previous:  TWR  Current:  TWR
            Other

Clinical Path. Lab:

Previous:  TWR  Current:  TWR
            Other

Case status:

PTT:  Conditional:  Signed off:  Final sign out:

Recommendations:

_________________________________________________________________

_________________________________________________________________

_________________________________________________________________
Intern's case history

1. Source of history:

2. Chief complaint: (patient's own words)

3. Present illness:
   
   Location

   Onset

   Duration

   Frequency

   Pain (character)

   Progression

   Aggravating factors

   Relieving factors

   Associated Sx's and Sg's

   Previous occurrences

   Past treatment and outcome
4. *Other complaints:*

5. *Past history*
   - General health status
   - Childhood illnesses
   - Adult illnesses
   - Psychiatric illnesses
   - Accidents/injuries
   - Surgery
   - Hospitalisation

6. *Current health status and lifestyle*
   - Allergies
   - Immunizations
   - Screening tests
   - Environmental hazards
   - Safety measures
   - Exercise and leisure
Sleep patterns

Diet

Current medication

Tobacco

Alcohol

Social drugs

7. *Family history:*
   *Immediate family:*

   Cause of death
   DM
   Heart disease
   TB
   HBP
   Stroke
   Kidney disease
   CA
   Arthritis
   Anaemia
   Headaches
   Thyroid disease
   Epilepsy
   Mental illness
   Alcoholism
   Drug addiction
   Other

8. *Psychosocial history:*

   Home situation

   Daily life

   Important experiences
Religious beliefs

9. **Review of systems:**

General
Skin
Head
Eyes
Ears
Nose/sinuses
Mouth/throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematologic
Endocrine
Psychiatric
Appendix E: Copy of Pertinent Physical Examination Form

**Pertinent Physical**
(Note: This form may only be used when you have completed 35 new patients)

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Signature</th>
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<tbody>
<tr>
<td>Doctor name</td>
<td>Signature</td>
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**Patient Information**

<table>
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<th>Name</th>
<th>Occupation</th>
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<tr>
<td>Age</td>
<td>Sex</td>
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**Vitals:**

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<tr>
<th>Height</th>
<th>Weight</th>
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<tr>
<td>Pulse rate</td>
<td>Respiratory rate</td>
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Blood pressure

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<tr>
<th>Thorax</th>
<th>Inspection</th>
<th>Palpation</th>
<th>Percussion</th>
<th>Auscultation</th>
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</table>

<table>
<thead>
<tr>
<th>Abdomen</th>
<th>Inspection</th>
<th>Palpation</th>
<th>Percussion</th>
<th>Auscultation</th>
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<tr>
<td>Inspection</td>
<td>Palpation</td>
<td>Percussion</td>
<td>Auscultation</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------</td>
<td>------------</td>
<td>--------------</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cranial Nerves</td>
<td>Motor System</td>
<td>Sensory system</td>
<td>Cerebellar signs</td>
<td></td>
</tr>
<tr>
<td>Neurologic system</td>
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Appendix F: Copy of the Results Sheet

Patient Name: ________________________________
File no: _____________
Age: ____________ Gender: ____________

**Experiment Results:**

<table>
<thead>
<tr>
<th>Test</th>
<th>Left *S.I.J.D</th>
<th>Right S.I.J.D</th>
<th>No S.I.J.D</th>
<th>Foot *E.R. degree</th>
<th>Starting amount of E.R.</th>
<th>Other movement &amp; degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>*SBPT: performed on the left</td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>R</td>
<td>L</td>
</tr>
<tr>
<td>SBPT: performed on the right</td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>R</td>
<td>L</td>
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</table>

**Control Results:**

<table>
<thead>
<tr>
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<th>Left S.I.J.D</th>
<th>Right S.I.J.D</th>
<th>No S.I.J.D</th>
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<tbody>
<tr>
<td>Standing Flexion Test</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iliac Springing Test</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Test</th>
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<th>Right S.I.J.D</th>
<th>No S.I.J.D</th>
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<tr>
<td>Spine Test</td>
<td>*PI</td>
<td>*AS</td>
<td>PI</td>
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<tr>
<td>Supine Long-Sitting Test</td>
<td>PI</td>
<td>AS</td>
<td>PI</td>
</tr>
</tbody>
</table>

Appendix G: Copy of the Modified Lumbar Regional Form

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
LUMBAR SPINE

Date: _____________________  Patient: _____________________  File No: _____________________
Clinician: _____________________  Signature: _____________________
Intern: _____________________  Signature: _____________________

STANDING

1. Body Type (Quetelet-index score = weight/height\(^2\) < 27)

2. Posture (of Spine, Hips, knees and Ankles)

3. Observations

3.1. Muscle Tone
3.2. Bony and Soft tissue contours
3.3. Skin
3.4. Scars
3.5. Discolouration
3.6. Step deformity

4. Orthopaedic Tests

4.1. Schober’s test
4.2. Spinous percussion
4.3. Quick test

5. Range of Motion (Thoracolumbar Spine)

5.1. Flexion: 90°
5.2. Extension: 50°
5.3. Lateral Flexion: 30°
5.4. Rotation: 35°
6. Gait

6.1. Rhythm, pendulousness
6.2. On Toes (S1)
6.3. On Heels (L4, 5)
6.4. Half Squat on one Leg (L2, 3, 4)

**SITTING**

1. Orthopaedic Tests

1.1. Tripod Test
1.2. Kemp’s Test
1.3. Valsalva Manoeuvre

**SUPINE**

1. Muscle Circumference

<table>
<thead>
<tr>
<th></th>
<th>LEFT</th>
<th>RIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thigh</td>
<td>Cm</td>
<td>Cm</td>
</tr>
<tr>
<td>Calf</td>
<td>Cm</td>
<td>Cm</td>
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</table>

2. Leg Length

<table>
<thead>
<tr>
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<th>RIGHT</th>
</tr>
</thead>
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<tr>
<td>Actual</td>
<td>Cm</td>
<td>Cm</td>
</tr>
<tr>
<td>Apparent</td>
<td>Cm</td>
<td>Cm</td>
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</table>
3. Range of Motion (Lower Limb)

<table>
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<th>HIP</th>
<th>LEFT</th>
<th>RIGHT</th>
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<td>Flexion</td>
<td>(110 – 120°)</td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td>(10 – 15°)</td>
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</tr>
<tr>
<td>Abduction</td>
<td>(30 – 50°)</td>
<td></td>
</tr>
<tr>
<td>Adduction</td>
<td>(30°)</td>
<td></td>
</tr>
<tr>
<td>Lateral Rotation</td>
<td>(40 – 60°)</td>
<td></td>
</tr>
<tr>
<td>Medial Rotation</td>
<td>(30 – 40°)</td>
<td></td>
</tr>
<tr>
<td>Knee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexion</td>
<td>(135°)</td>
<td></td>
</tr>
<tr>
<td>Extension</td>
<td>(0 – 15°)</td>
<td></td>
</tr>
<tr>
<td>Medial Rotation</td>
<td>(20 – 30°)</td>
<td></td>
</tr>
<tr>
<td>Lateral Rotation</td>
<td>(30 – 40°)</td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
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<td></td>
</tr>
<tr>
<td>Plantar Flexion</td>
<td>(45 – 50°)</td>
<td></td>
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<tr>
<td>Dorsiflexion</td>
<td>(20°)</td>
<td></td>
</tr>
<tr>
<td>Inversion</td>
<td>(45 – 60°)</td>
<td></td>
</tr>
<tr>
<td>Eversion</td>
<td>(15 – 30°)</td>
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</tr>
</tbody>
</table>

4. Orthopaedic Tests
4.1. SLR
4.2. WLR
4.3. Braggard’s Test
4.4. Bowstring
4.5. Sciatic Notch Pressure
4.6. Sign of the Buttock
4.7. Bilateral SLR
4.8. Sacroiliac Joint Tests
   4.8.1. Patrick Faber
   4.8.2. Gaenslen’s Test
   4.8.3. Gapping Test
   4.8.4. “Squish” Test
4.9. Muscular Test
   4.9.1. Gluteus Maximus Stretch
   4.9.2. Thomas’ Test
   4.9.3. Rectus Femoris Contracture Test
   4.9.4. Hip Medial Rotation
   4.9.5. Psoas Test
   4.9.6. Adductor and Abductor Contracture test
4.10. Allis Hip Sign
LATERAL RECUMBENT

1. Orthopaedic Tests
   3.1. Sacroiliac Compression
   3.2. Ober’s Test
   3.3. Piriformis Test
   3.4. Femoral Nerve Stretch

4. Myotomes
   4.1. Quadratus Lumborum Strength
   4.2. Gluteus Medius Strength

PRONE

1. Observation
   1.1. Resting position and Alignment of feet
      1.1.1. Talus Neutral Position
      1.1.2. Leg-heel Alignment
      1.1.3. Forefoot-heel Alignment

2. Orthopaedic Tests
   2.1. Facet Joint Challenge
   2.2. Skin Rolling
   2.3. Erichsen’s Test
   2.4. Sacroiliac Tenderness
   2.5. Pheasant’s Test
   2.6. Gluteal Skyline
   2.7. Craig’s Test

3. Myofascial Trigger Points
   3.1. Quadratus Lumborum
   3.2. Iliopsoas
   3.3. Gluteal Muscles
   3.4. Piriformis and other short Lateral Rotators
   3.5. Tensor Fascia Lata
   3.6. Adductor Muscle Group (including Gracilis and Pectineus)
   3.7. Sartorius
   3.8. Hamstrings

4. Myotomes
   4.1. Gluteus Maximus Strength
### NEUROLOGICAL EXAMINATION

<table>
<thead>
<tr>
<th>DERMATOMES</th>
<th>L</th>
<th>R</th>
<th>MYOTOMES</th>
<th>L</th>
<th>R</th>
<th>REFLEXES</th>
<th>L</th>
<th>R</th>
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<tbody>
<tr>
<td>T12</td>
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<td></td>
<td>Hip Flexion (L1, 2)</td>
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<td></td>
<td>Patellar (L3, 4)</td>
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<tr>
<td>L1</td>
<td></td>
<td></td>
<td>Knee Extension (L2, 3, 4)</td>
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<td>Medial Hamstring (L5)</td>
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<td>Lateral Hamstring (S1)</td>
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<td>Tibialis Posterior (L4, 5)</td>
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<td>S2</td>
<td></td>
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<td>S3</td>
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<td>Eversion (S1)</td>
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<td>Hip Extension (L5, S1)</td>
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Appendix H: Copy of Student t Distribution Table

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<thead>
<tr>
<th>Level of confidence (1-α)</th>
<th>0.20</th>
<th>0.50</th>
<th>0.80</th>
<th>0.90</th>
<th>0.95</th>
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<th>0.99</th>
<th>0.999</th>
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<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
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<td>9</td>
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<td>645.981</td>
<td>635.333</td>
<td>624.680</td>
<td>614.024</td>
<td>603.363</td>
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PERCENTILE VALUES for STUDENT’S t DISTRIBUTION