THE EFFECTS OF CHIROPRACTIC SPINAL MANIPULATION ON DRIVER CLUB HEAD SPEEDS OF ASYMPTOMATIC AMATEUR GOLFERS

BY

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DISSERTATION

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DECLARATION

I, Roy Aharon Sery, do hereby declare that this dissertation, which I herewith submit for the research qualification of Master Technology degree in Chiropractic to the Technikon Witwatersrand is, apart from the recognized assistance, my own work and has not previously been submitted by me to another institution to obtain a research diploma or degree.

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Roy Aharon Sery

DEDICATION

To my parents, Dror and Ettie, I dedicate this work to you. Without your love and support none of this would seem possible.

Thank you for directing me in my search to find the love and passion I have today for both the chiropractic profession as well as the game of golf.

ACKNOWLEDGEMENTS

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- To the team at the Golfer's Club Store in Fourways, thank you for allowing me to use your facilities in order to conduct this study.
- To the "World of Golf" in Woodmead, thank you for sponsoring the necessary measuring machinery in order to conduct this study.

ABSTRACT

OBJECTIVE: To determine the immediate effects of chiropractic spinal manipulation of the thoracic spine, lumbar spine and sacroiliac joints on club head speeds of asymptomatic, amateur golfers.

STUDY DESIGN: The study was designed to compare two groups of forty participants in each group; the one group acting as a control and the other as an experimental or manipulation group. The groups were designed for a comparative study so as to determine the influence of chiropractic spinal manipulation on club head speeds.

SETTING: The "Golfer's Club" Golf Store, Fourways, Johannesburg, South Africa

SUBJECTS: A total of 80 participants were included in the trial. All participants were between the ages of 18 years and 50 years. Participants were right-handed golfers and played from a handicap in golf of 8 or less.

METHODS: Participants were asked to hit ten golf balls as a simple warm-up in order to facilitate hand-eye co-ordination before measurements of club head speeds were recorded. Participants were asked to hit golf balls into an indoor nylon net using their own drivers. Participants hit 30 golf balls before and 30 golf balls after a rest period (break) for participants in the control group, or manipulation of motion restricted thoracic, lumbar and sacroiliac joints for participants in the manipulation group.

RESULTS: The increase in club head speeds when comparing the control group and the manipulation group on the 30 golf balls hit prior to the 30 golf balls hit after the manipulation shows a statistically significant rise in favour of the manipulation group. However, the pattern of changes could have been ascribed to the difference between the two groups on handicaps. Once the club head speed means were adjusted for handicaps, the results proved to show that there

were no statistically significant changes in club head speed means between the two groups.

However, the pattern of changes between the two groups remained the same. The manipulation group showed a pattern of increased club head speed means both before and after the manipulation, while the control group's club head speed means remained consistent.

CONCLUSION: There is evidence to suggest that chiropractic spinal manipulation of the thoracic spine, lumbar spine and sacroiliac joints, by virtue of its mechanical, reflexogenic and neurological effects, may have an effect on club head speeds in asymptomatic, amateur golfers in the short-term. However, variables such as handicap and age as well as psychological factors which may have played a role in influencing the results should be considered before this is completely conclusive. The trends shown in this study could be used for comparison in future similar studies of this nature.

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CHAPTER ONE – INTRODUCTION

1.1 General Introduction

Golf has become a very popular sport for both men and women across all age groups throughout the world (24). Golf is a popular recreational and competitive sport, however, there is limited scientific literature that describes or evaluates the biomechanics of the golf swing (1, 27).

1.2 Aim of the Study

The aim of the study was to determine if the immediate responses to chiropractic spinal manipulation of the thoracic spine, lumbar spine and sacroiliac joints, would cause an increase in club head speed in asymptomatic amateur golfers.

1.3 Purpose of the Study

The purpose of the study was to demonstrate whether chiropractic spinal manipulation offers a treatment of dysfunctional biomechanics in a golf swing. Spinal manipulation offers biomechanical, reflexogenic and neurological effects on joints, muscles and nerves which function in a co-ordinated manner to produce complex movements such as the golf swing. Changes in joint range of motion and muscle tone are factors that promote an increase in flexibility. These factors would promote a more efficient golf swing in terms of muscle activity and therefore the ability to increase club head speed.

Club head speed is required in order to compress the golf ball against the club face. The more you compress the golf ball, the further it goes (18). It can therefore be said that club head speed influences driving distances, provided that the direction in which the ball is hit is perfectly straight every time the golf ball is hit.

Golf equipment technological factors, including the make of club, type of face of the club, loft of the club and type of shaft in the club all play a role in affecting ball flight in golf. Furthermore, the type of ball used (due to different compressions) and the direction of spin of the ball produced by the club pathway during the golf swing, also play a part in distance of ball travel.

Environmental factors such as wind, humidity in the air, and temperature of the air may also affect distance of ball travel. It is for these reasons that it was decided to objectively measure club head speed rather than driving distances.

1.4 Study Hypothesis

The study hypothesis is based on the premise that chiropractic spinal manipulation by virtue of its biomechanical, reflexogenic and neurological effects on the co-ordinated kinematics of the golf swing, would cause a positive change in driver club head speeds when comparing two groups equal in size, with one group acting as a control and therefore not being subjected to chiropractic spinal manipulation.

However, should no significant difference between the groups be observed, it would be realistic to conclude that chiropractic spinal manipulation has no effect on changes in driver club head speeds during the golf swing.

CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

A successful golf swing depends on the performance of a well co-ordinated action involving the feet and knees, the hips, trunk and movements of the arms, wrists and hands respectively (1).

Each shot in golf has two requirements – distance and direction (1). This can only be achieved by delivering the correct swing action as well as the required club head speed.

The main objective of the tee shot in golf is to achieve maximum distance with the most accurate direction possible. To accomplish this, the club head must be travelling at maximum speed at impact with the ball and the club face must strike the ball on the correct target line (2).

In order to swing a golf club over 100 miles per hour and thus hit a ball further than 200 yards in the correct direction, there needs to be a delicate balance between muscle strength, co-ordination and timing (3).

Research has shown that the most noticeable differences between the professional and amateur golf swing is the degree of trunk rotation. These researchers also reported that older and less skilled golfers had less than half of the trunk rotation than that of younger and more skilled golfers (4). These findings were noticeable to the researchers by cinematographic analysis during a study to describe and compare the trunk muscle firing patterns during the golf swing.

Trunk movement is thus an important factor to consider in understanding the golf swing (4).

The root cause of decreased trunk rotation may be due to spinal facet joint restrictions or joint fixation. Such joint restrictions may be alleviated through chiropractic manipulative procedures (5).

The manipulative thrust re-introduces movement to a spinal joint segment displaying decreased mobility (6). This increased range of motion of the joints enhances the functional ability of muscles to contract as well as stretch and thus improving the lever arm system of the muscle (7). Furthermore, a manipulative thrust promotes a change in muscle tone (8, 9). The mechanisms responsible for the mechanical changes will be discussed further.

2.2 Biomechanics of the Vertebral Column

Movements of the vertebral column take place at two joints. The first is between the vertebral bodies and the intervertebral disc, and the second is at the joints between the zygapophyseal facets located between the articular processes of adjacent vertebrae (10).

The zygapophyseal or facet joints are synovial joints between the inferior articular process of a superior vertebra and the superior articulating process of the vertebra inferior to it. The anatomy of the facet joints is such that the flat surfaces of the articular facets are covered with hyaline cartilage. Each joint is surrounded by a thin, loose articular capsule. The fibrous capsule of each joint is lined with a synovial membrane. The facet joints of the thoracic and lumbar spine are plane type synovial joints that permit gliding movements between the vertebrae (11).

For the purpose of this research, movements of the thoracic and lumbar facet joints will be described, as well as those of the sacroiliac joints.

2.2.1 The Planes of Motion

The system of planes and axes provides a simple way of describing the motions that are available at a given joint (10).

Motion at a joint may be described as occurring in the transverse (horizontal) plane, frontal (coronal) plane, or sagittal (anterior-posterior) plane (10).

The universal X - co-ordinate corresponds to the cardinal transverse plane. This plane divides the body into upper and lower halves. Movements in the transverse plane occur parallel to the ground. Rotary motions in the transverse plane occur around a vertical or longitudinal axis of motion (10).

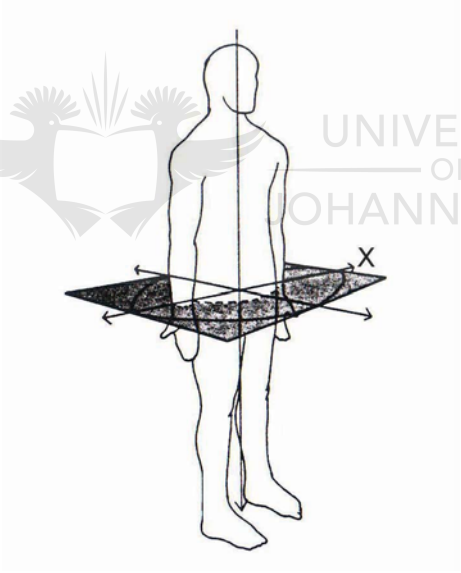


***Figure 2-1*: The Planes of Motion: The X – Co-ordinate (10)**

The Y - co-ordinate corresponds to the frontal (coronal) plane. The frontal plane divides the body into front and back halves. Movements in the frontal plane occur as side-to-side movements. Rotary motion in the frontal plane occurs around an anterior-posterior axis (10).

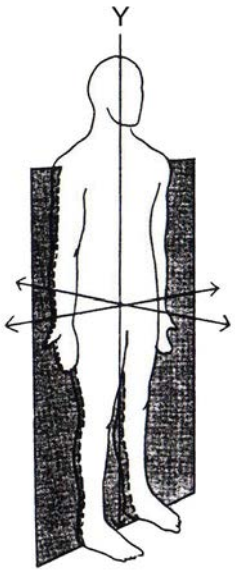


Figure 2-2: ***The Planes of Motion: The Y – Co-ordinate (10)***

The Z - co-ordinate corresponds to the sagittal plane and divides the body into right and left halves. Movements in this plane include forward and backward motions. Rotary motion in the sagittal plane occurs around a coronal axis (10).

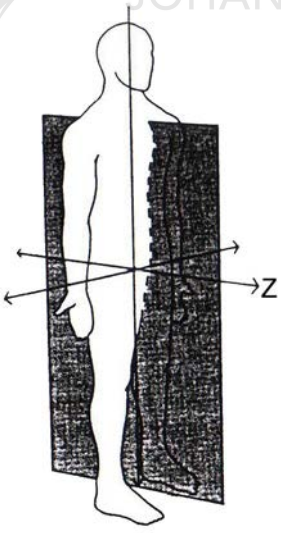


Figure 2-3: ***The Planes of Motion: The Z – Co-ordinate (10)***

2.2.2 Biomechanics of the Thoracic Spine

Movements that take place in the thoracic spine relate to the orientation of the facet joints in this region. The articular processes in the thoracic spine of typical thoracic articulations T2-T11 lie at a 60° inclination from the horizontal plane and approximately 20° medially from the coronal plane. In general, the superior articulating facets of the superior articular processes of the thoracic spine have a postero-lateral direction. These facets face superiorly, posteriorly and slightly laterally. The inferior articulating facets of the inferior articular processes face in an antero-medial direction. They face inferiorly, anteriorly and slightly medially. These articular planes facilitate a greater amount of rotation and less flexion and extension movements (12).

Thoracic spine movements are further restricted as the thoracic cage, formed by the ribs and their costal cartilages, add an additional mechanical barrier (6).

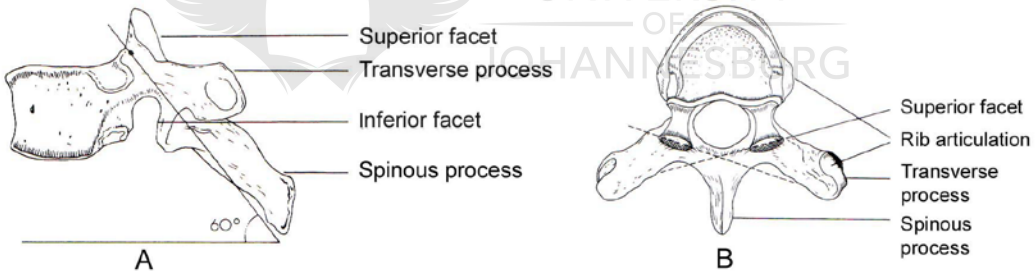


Figure 2-4: Orientation of Typical Thoracic Spine Facet Joints in Lateral View (A) and Superior View (B) (12)

Flexion and extension of the thoracic spine takes place in the sagittal plane. During flexion, the articular surfaces slide upwards and the inferior articular processes of the vertebra above 'overhang' the superior articular processes of the vertebra below. Flexion is limited by tension developing in the interspinous ligament, the ligamenta flava, the capsular ligaments of the facet joints and the posterior longitudinal ligament. During extension, the vertebrae and therefore the facet joints are approximated posteriorly. Extension is limited by the impact of the

articular processes and spinous processes of adjacent vertebrae with one another (13).

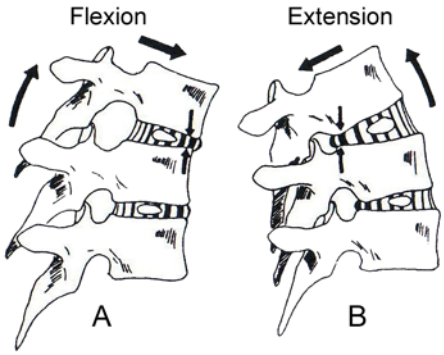


Figure 2-5: ***Flexion (A) and Extension (B) Movements of the Thoracic Spine (10)***

The range of movement of the thoracic spine cannot be calculated when isolated from the lumbar spine. Range of motion of flexion of the thoraco-lumbar spine as a whole is approximately 105°. The range of motion of extension of the thoraco-lumbar spine as a whole is approximately 60° (13).

Lateral flexion of the thoracic spine takes place in the frontal plane. During lateral flexion, the articular facets of adjacent vertebrae slide relative to one another. On the contralateral side the facets slide upwards as in flexion, and on the ipsilateral side the facets slide downwards as in extension. Lateral flexion is limited by the impact of the articular processes on the ipsilateral side and by increased tension in the ligamenta flava and intertransverse ligaments on the contralateral side. The range of motion of lateral flexion of the thoracic spine as a whole is approximately 20° (13).

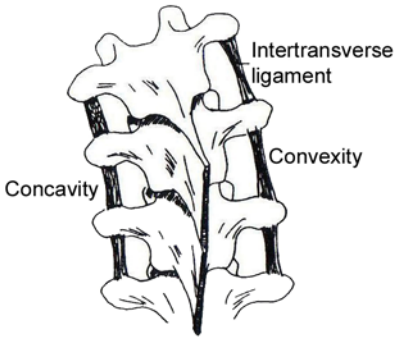


Figure 2-6: Lateral Flexion of the Thoracic Spine (10)

Axial rotation of the thoracic vertebral column as a whole is approximately 35°. When one vertebra rotates on another, the articular facets, due to their orientation, are allowed to slide relative to each other (13).

Schafer and Faye describe approximate intersegmental ranges of motion of the thoracic spine:

- T1-T2 allows 4° flexion/extension, 6° lateral flexion and 10° rotation.
- T2-T3 allows 4° flexion/extension, 6° lateral flexion and 9° rotation.
- T3-T4 to T5-T6 allow 4° flexion/extension, 6° lateral flexion and 8° rotation.
- T6-T7 and T7-T8 allow 6° flexion/extension, 6° lateral flexion and 7° rotation.
- T8-T9 allows 6° flexion/extension, 6° lateral flexion and 6° rotation.
- T9-T10 allows 6° flexion/extension, 6° lateral flexion and 4° rotation.
- T10-T11 allows 10° flexion/extension, 7° lateral flexion and 3° rotation.
- T11-T12 allows 12° flexion/extension, 9° lateral flexion, 2° rotation.
- T12-L1 allows 12° flexion/extension, 8° lateral flexion and 2° rotation (6).

From this information it is possible to deduce that flexion and extension movements increase from the top of the thoracic spine to the bottom of the thoracic spine, the motion of lateral flexion is relatively consistent in the thoracic

spine, and rotational movements decrease from the top of the thoracic spine to the bottom of the thoracic spine.

2.2.3 Biomechanics of the Lumbar Spine

The facet joints direct the movement that occurs in the lumbar spine. The lumbar facet joints have moderately curved surfaces rather than a single-plane angle as seen in the thoracic spine (6). The facet joints in the lumbar spine are in general near parallel to the vertical plane and face outwards approximately 45° from the coronal plane. The superior articulating facets face posteriorly and medially, and in general, have a concave shape. The inferior articulating facets face anteriorly and laterally, and in general, have a convex shape. Flexion, extension and lateral flexion movements are readily achievable in the lumbar spine, whereas rotation in the lumbar spine is minimal due to the shape of the facet joints, and is accomplished only by shearing forces across the discovertebral joints. Such shearing forces limit rotation of the lumbar spine both segmentally and globally (12, 13).

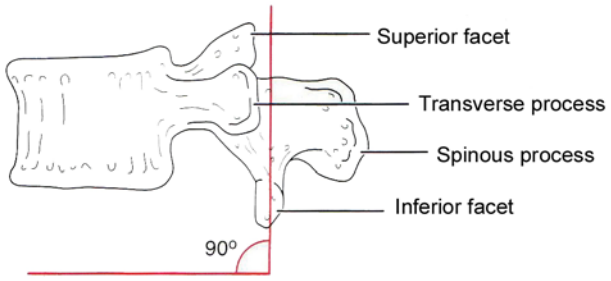


Figure 2-7: ***Orientation of Typical Lumbar Spine Facet Joints (12)***

During flexion, the body of the upper vertebra tilts and slides gently anteriorly. The inferior articular processes of the upper vertebra slide superiorly and tend to move away from the superior articular processes of the lower vertebra. The movement of flexion is limited by the increase in tension in the ligamenta flava, the interspinous ligament, the supraspinous ligament and the posterior

longitudinal ligament. During extension, the body of the upper vertebra tilts and moves posteriorly. The articular processes of the lower and upper vertebrae become more tightly interlocked and the spinous processes touch one another. Extension is limited by the bony structures of the vertebral arch and the tension developed in the anterior longitudinal ligament (13).

The maximal movement of flexion associated with flattening of the lumbar curve has an approximate range of 40°. The range of flexion and extension motion is maximal at the L4/L5 segmental level, and decreases progressively at higher levels. The maximal movement of extension of the lumbar spine, which is associated with accentuation of the lumbar lordosis has an approximate range of 30° (13).

During lateral flexion, the body of the upper vertebra tilts ipsilaterally. The articular processes slide relative to each other so that the ipsilateral articular process of the upper vertebra is lowered while the contralateral articular process is raised. On average, the total range of lateral flexion movements of the lumbar spine falls between 20° and 30° (13).

The segmental range of lateral flexion at L5/S1 is notably minimal. This may be explained due to the more coronal orientation of the articular facets of the fifth lumbar vertebra as well as the checkrein action of the iliolumbar ligament (10,13). The iliolumbar ligament extends from the transverse processes of L4 and L5 vertebrae, and attach to the iliac crests of the pelvis. They are very strong ligaments and play a significant role in stabilizing the fifth lumbar vertebra, resisting flexion, extension, lateral flexion and rotation of L5 on the sacrum (10).

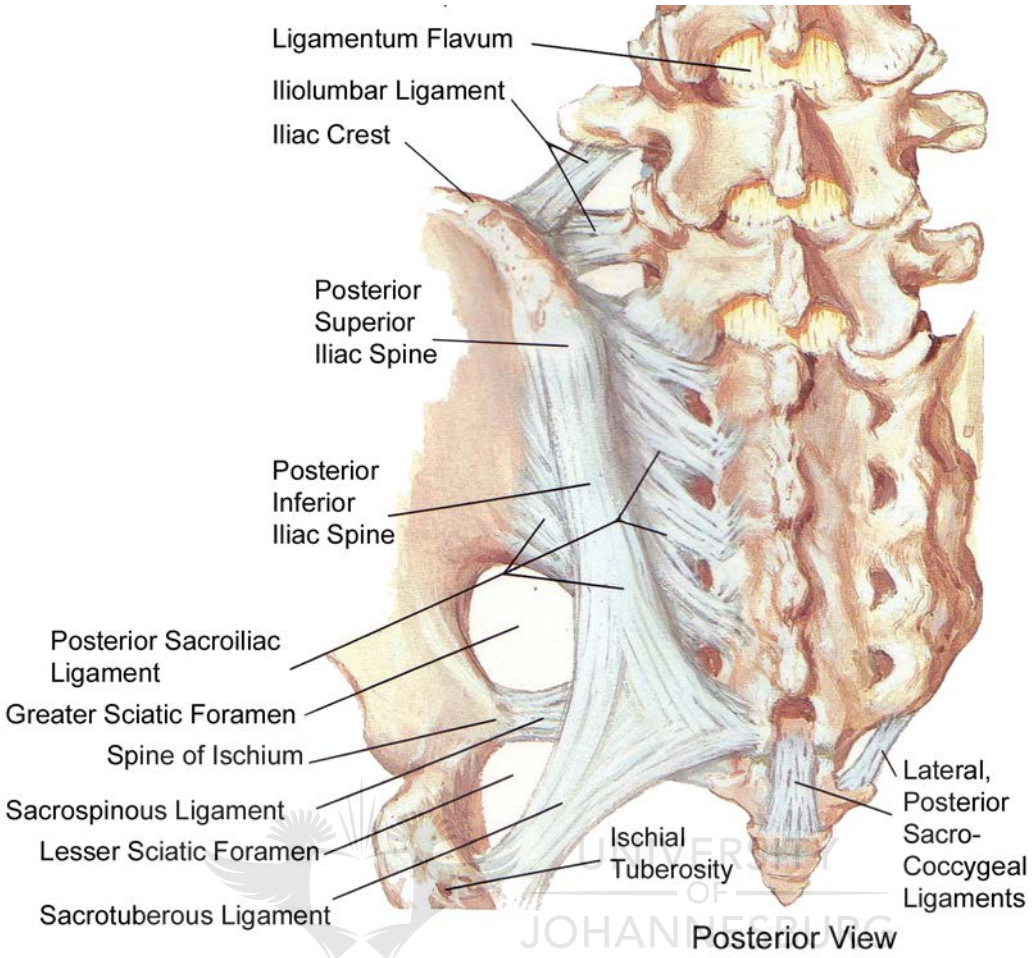


***Figure 2-8*: Posterior View of the Lumbosacral Region showing the Iliolumbar Ligament and the Ligaments Associated with the Sacroiliac Joints (37)**

The orientation of the articular facets in the lumbar spine strongly limit the movement of axial rotation. Furthermore, strong shearing forces related to the discovertebral joints also restrict this movement. Axial rotation of the lumbar vertebral column has an approximate total range bilaterally of 10°, and so a segmental range of 2° in total and a segmental range of 1° for unilateral rotation (13).

It is important to note that during lateral flexion of the lumbar spine, there is an automatic rotation that takes place. This is known as coupled motion. Rotation in an anterior direction occurs to the same side as lateral flexion (13).

From this it is possible to see that the facet joints of both the thoracic spine and the lumbar spine have three degrees of freedom, and movements take place to different extents in both these regions, depending on the orientation of the facets.

2.2.4 Biomechanics of the Sacroiliac Joints

The sacroiliac articulations are strong synovial joints between the surfaces of the sacrum and the ilium. These surfaces have irregular elevations and depressions, which result in a partial interlocking of the bones (11).

The two sacroiliac joints consist of the articulations between the left and right articular surfaces on the sacrum. The sacral surface of the sacroiliac joint is formed by the fused portions of the first, second and third sacral segments, and the left and right iliac bones (10). The articular surfaces of the sacrum are known as the auricular surfaces, and are located on the lateral aspects of the sacrum. The sacral auricular surface is covered by hyaline cartilage, which is up to three times thicker than the fibro- cartilage found on the iliac surfaces (12). The sacroiliac joints are part synovial and part syndesmosis. A syndesmosis is a type of fibrous joint in which the intervening fibrous connective tissue forms an interosseous membrane or ligament (12). The sacroiliac joints are supported and strengthened anteriorly by the anterior sacroiliac ligament, posteriorly by the posterior sacroiliac ligament and by the interosseous sacroiliac ligament (13). The anterior sacroiliac ligament is an anterior thickening of the joint capsule, the interosseous sacroiliac ligament is a very large ligament filling irregular spaces posterior and superior to the joint, and the posterior sacroiliac ligament covers the interosseous ligament and is continuous distally with the sacrotuberous ligament (11).

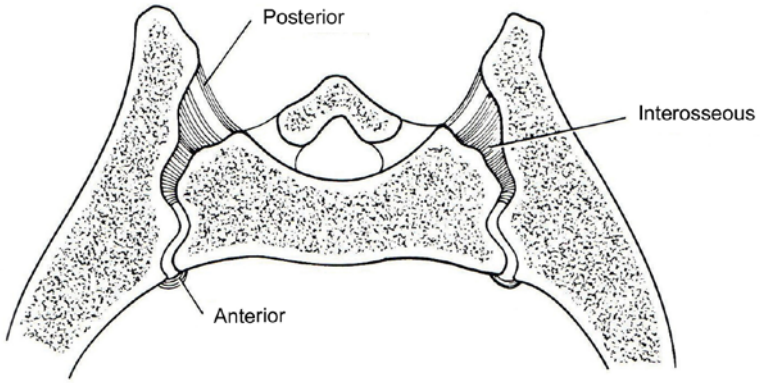


***Figure 2-9*: Horizontal Section Illustrating the Obliquity of the Sacroiliac Joints and its Associated Ligaments (38)**

The upper synovial portion of the sacroiliac joint is C-shaped, with the convex iliac surface of the **C** facing anteriorly and inferiorly. In males, the sacroiliac joint may be L-shaped. The sacral surface is concave (10, 12).

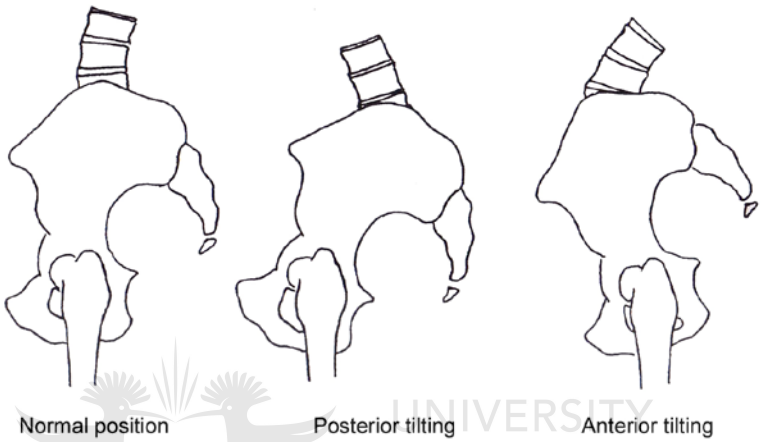
Sacroiliac motion is a consequence of trunk or hip motion and must be able to accommodate both of these movements at the same time (6).

The motions of the sacroiliac articulations include anterior and posterior pelvic tilting, lateral tilting, pelvic rotation, nutation and counternutation movements and sacral rotation. None of these motions are produced by intrinsic pelvic muscles, but rather produced by muscles of the trunk or hip that attach to the pelvis or sacrum (6, 10, 13). Examples of such type muscles include the abdominal muscles, the gluteal muscles, the hamstring muscle group and the quadriceps muscle group.

Anterior and posterior pelvic tilt are motions of the entire pelvis in the sagittal plane around a coronal axis (10). In the neutral standing position with the femurs fixed, anterior tilting or extension at the sacroiliac joints is related to lumbar hyperlordosis and hip flexion. The anterior thigh muscles (quadriceps muscle

group) play an important role in this motion by virtue of the attachment of the rectus femoris muscle to the anterior inferior iliac spine of the pelvis (6, 10).

Posterior tilting or flexion at the sacroiliac joints is associated with lumbar spine flattening and hip extension. The major actions come from the posterior pull of the hamstring muscle group and the anterior pull of the abdominal muscles (6).



<u>Figure 2-10</u>: Illustration of the Pelvis in the Neutral Position, Posterior Pelvic Tilt Movement and Anterior Pelvic Tilt Movement (10)

Lateral pelvic tilt is a frontal plane motion of the entire pelvis around an antero-posterior axis. Lateral tilt of the pelvis is seen in bilateral and unilateral stance. In unilateral stance, one hip joint is the pivot point or axis for motion of the opposite side of the pelvis as it elevates or drops (10). The pelvis on the unsupported side is restricted actively by the gluteus medius and gluteus minimus muscles (6).

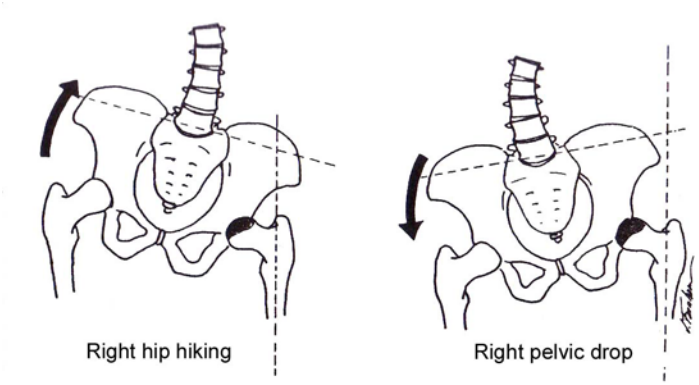


Figure 2-11: Lateral Pelvic Tilt Movements (10)

Pelvic rotation is motion of the entire pelvis in the transverse plane around a vertical axis. This type of motion occurs in single-limb support around the axis of the supporting hip joint. Forward rotation of the pelvis occurs when the side of the pelvis opposite to the supporting hip joint moves anteriorly. Forward rotation of the pelvis produces medial rotation of the supporting hip joint. Backward rotation of the pelvis occurs when the side of the pelvis opposite the supporting hip joint moves posteriorly. Posterior rotation of the pelvis produces lateral rotation of the supporting hip joint (10).

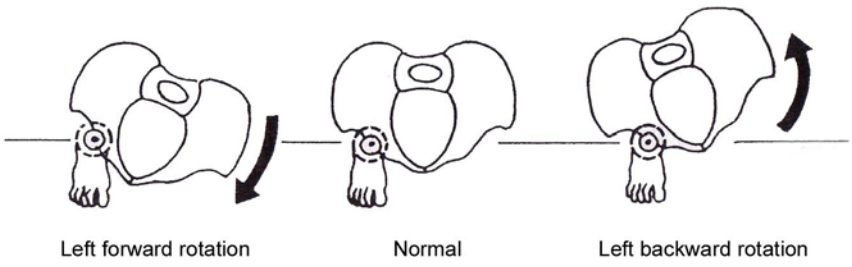


Figure 2-12: Pelvic Rotation Movements (10)

The movement of nutation refers to movement of the sacral promontory in an anterior and inferior direction while the sacral apex moves posteriorly in relation to the ilium. This movement is accompanied by approximation of the iliac bones (10, 13).

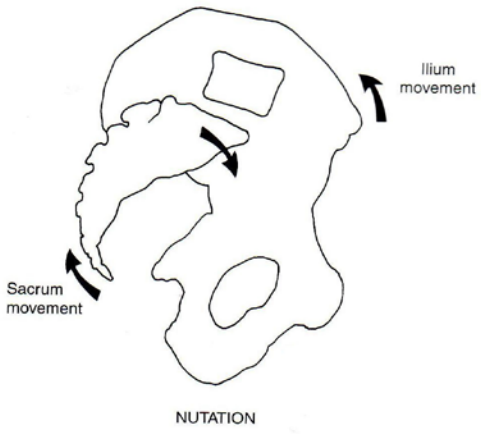


Figure 2-13: Movement of Nutation (12)

The movement of counternutation refers to the opposite movement in which the sacral promontory moves posteriorly and the sacral apex moves anteriorly in relation to the iliac bones. This movement is accompanied by separation or outflaring of the iliac bones (10, 13).

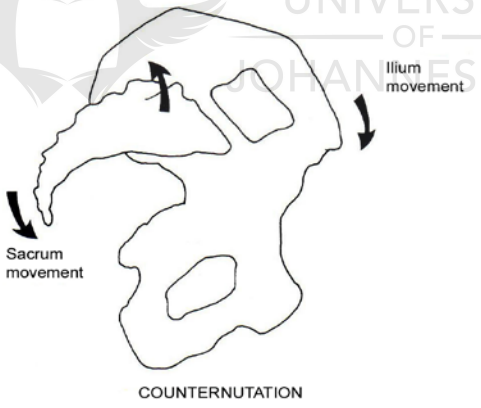


Figure 2-14: Movement of Counternutation (12)

Sacral rotation refers to movement of the sacrum within the iliac cavity around a vertical axis. This gives an impression of lateral flexion of the sacrum, with the sacral base moving more than the sacral apex. At the same time, the ilium will rotate on a horizontal axis, moving forward (anterior tilt) on the opposite side to sacral rotation, and moving backwards (posterior tilt) on the same side as sacral rotation (6).

2.3 Golf Swing Kinematics

The motion of the golf swing is divided into five segments (4). These segments are described, beginning in the address position, as follows:

***Figure 2-15**: The Address Position of the Golf Swing*

Segment 1: The takeaway or backswing. Includes the motion from ball address to the end of the backswing (4). This phase involves rotating the trunk, raising the arms, and cocking the wrists while pulling the club head away from the ball towards the trailing side (The golfer's leading side is towards the intended target and the trailing side is away from the target) (14).

***Figure 2-16*: Segment 1 of the Golf Swing: The Takeaway or Backswing**

Segment 2: The forward swing or downswing. Includes motion from the end of the backswing until the club becomes horizontal to the ground (4). The club is swung towards the ball by using the shoulder and wrist levers created in the backswing. The body turns towards the target, the arms swing down, and the wrists begin to uncock (14).

***Figure 2-17*: Segment 2 of the Golf Swing: The Forward Swing or Downswing**

Segment 3: Acceleration. Motion from the horizontal club to ball contact (4). This is the quickest part of the swing. The arm and trunk motions started in the downswing continue, and the wrists and forearms are rapidly uncocked, the leading wrist supinated, and the trailing wrist pronated to maximize the speed of the club head as it connects with the ball (14).

***Figure 2-18*: Segment 3 of the Golf Swing: Acceleration**

Segment 4: Early follow-through. From the point of ball contact until the club becomes horizontal with the ground (4).

***Figure 2-19*: Segment 4 of the Golf Swing: Early Follow-through**

Segment 5: Late follow-through. Motion from the horizontal club to the end of the swing (4). After the ball is struck, the natural momentum of the swing continues, with the club head ending above or behind the body (14).

***Figure 2-20**: Segment 5 of the Golf Swing: Late Follow-through*

Cochran and Stobbs use a “double pendulum” model of the golf swing to describe the kinematic characteristics of the upper body that result in a large club head speed at impact. They describe this double pendulum as a model consisting of two levers. The golfer’s shoulders and arms form the upper lever, and the lower lever corresponds to the club. A hinge represented by the golfer’s hands and wrists connects the two levers. This hinge works in a single plane in which the upper lever is swung about a fixed pivot corresponding to a point in the middle of the chest (15).

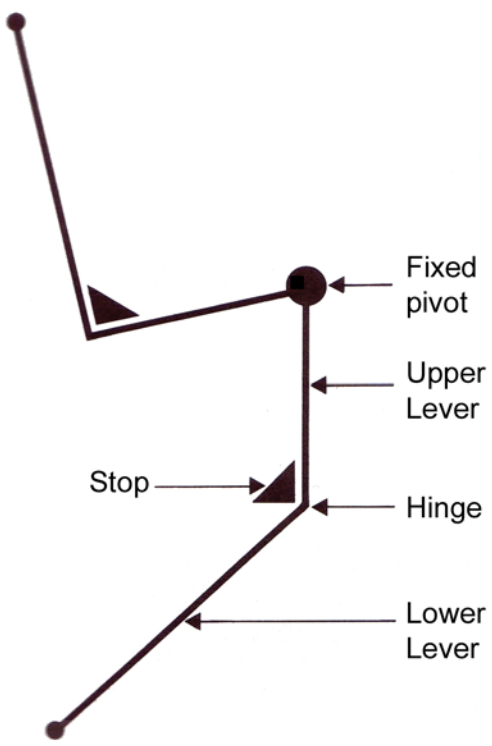


***Figure 2-21**: Double Pendulum Model of the Golf Swing (15)*

To hit the ball far and in the correct direction, one factor to consider is club head speed. To increase club head speed, it is necessary to use a two-lever system in the golf swing properly (16).

The secondary spinal curves relate to a golfer's ability to rotate for a powerful golf swing. At the address position, good posture requires the secondary spinal curve in the lumbar spine to be in lordosis. The secondary spinal curves are levers that provide mechanical advantage and strength for movement of the spinal column and thus facilitate the ability to rotate. Poor golf posture with a collapse of the secondary lumbar curve restricts spinal rotation (5).

Proper posture in the golf swing provides the platform from which to create speed with the club (16).

The backswing motion requires flexibility in the shoulders and hips. It requires an unrestricted ability of the spine to laterally flex, rotate and extend. In hitting the ball further, flexibility of the shoulders and hips are important. Adequate range of motion of the shoulders includes range of motion of the thoracic spine (17).

During the backswing, the shoulders and torso move together, and so should be considered as one functional unit. During the initial phase of the backswing, the scapula should glide freely across the torso. Once this elastic barrier has been reached, the glenohumeral joint is activated to allow continued movement of the arms in the vertical plane. Once this elastic barrier has also been reached, the thoracic spine completes the necessary rotation (17).

The sequence of musculo-ligamentous motion in the shoulders during the backswing is thus scapulothoracic, glenohumeral and thoracic rotation (17).

Club head speed and correct direction of ball flight are the main requirements needed to hit long and powerful golf shots. Club head speed is directly proportional to the width and length of the swing arc. The width and length of the swing arc is directly proportional to patient flexibility (18).

To hit the ball a great distance and in the correct direction, a golfer must be able to rotate into and maintain a wide arc through the swing (5).

The larger arc of the golf swing, to which trunk rotation contributes, allows a greater distance for the golfer to build up the club head velocity. This greater club head velocity at ball impact provides an increase in kinetic energy, and ultimately greater potential for further distance of ball travel. Players with less trunk rotation compensate for the decreased rotation or shorter distance of the arc by muscular substitution patterns, or the distance that they hit the ball will be diminished. Flexibility is thus a key to maintaining normal arc of motion (4).

For golfers to achieve maximum club head speeds, their spine and shoulders should be rotated as far as possible during the backswing. The shoulders must rotate at least 90° from the address position. Such a rotated position at the top of the backswing brings the club at least parallel to the ground. This is the ideal position for the club in order to develop optimal club head speed during the downswing. This rotated position at the top of the backswing has been referred to as the “power coil” (19).

Spinal rotation begins at the lumbosacral junction. Rotation in the lumbar spine and lower thoracic spine is limited by the sagittal orientation of the facet joints that, instead, permit a great deal of flexion and extension (19). The limits of rotation for the lumbar spine and thoracic spine facet joints have been discussed (refer to biomechanics of the vertebral column).

As the backswing is initiated with spinal rotation, pelvic rotation also takes place. This movement is described as the pivot. “Pivot” is defined as a “shaft about which related parts rotate”. In the case of the golf swing, the shaft is the trailing leg, and the related parts are the hips and shoulders (20). The pivot is associated with a shift in weight onto the trailing leg during the initial phase of the backswing (19). The pivot is essential for the build up of kinetic energy or power into the golf swing. Kinetic energy translates to club head speed, which is necessary to compress the golf ball, provided that the club face strikes the ball on the correct swing path, allowing for pure direction of ball flight. The more you compress a golf ball, the further it goes (18).

The sacroiliac joints are closely linked functionally to the hip joint, and are affected by movements of the trunk and lower extremities. Weight shifting from one leg to another is accompanied by motion at the sacroiliac joints (10). The movements of pelvic tilting and pelvic rotation have been described earlier under the biomechanics of the sacroiliac joints.

For the body weight to coil inside of the back foot, the ilium on the trailing side must be able to release slightly anterior-superior, the lumbar spine must be able to maintain dynamic lordosis, and the rotators of the ilium (gluteus medius, gluteus minimus and piriformis) must stretch to receive the transfer of body weight. Pre-existing sacroiliac restriction, loss of or failure to maintain the lumbar lordosis and/or tight hip rotators (gluteus medius, gluteus minimus and piriformis) will prevent the golfer from making a complete weight-shift during the backswing (21). The lumbar curve is an essential source of mechanical leverage for rotating the hips when swinging the golf club during both the backswing and forward swing (20).

At the top of the backswing, 45° of pelvic rotation around the hip joint has taken place (18). In this position, a stable platform is required, since 75% of the body weight has been transferred onto the trailing quadriceps muscle. This platform that supports the body weight is made up of the quadriceps muscle group as well as the gluteal muscles, predominantly the gluteus maximus. Weak quadriceps muscles in the trailing leg will thus result in an inability to hold the coil required to deliver a powerful golf swing (22). Recent research showed that sacroiliac joint manipulation causes a short-term increase in quadriceps muscle strength. A possible explanation for improvement in quadriceps strength, is that the manipulation may have increased quadriceps strength by normalising the lever system of the muscle across the pelvis (23). It is postulated that restoring normalised mechanics of the pelvis may have an effect on any muscle acting about the pelvis (the quadriceps crosses the pelvis by virtue of the rectus femoris muscle attaching to the anterior inferior iliac spine). The effects described are mainly to do with more efficient muscle contraction (10).

During the forward swing, high levels of activity of the gluteus maximus muscle, especially in the trailing side, as determined by EMG analysis, indicates the role of the hip stabilizers (gluteus medius, gluteus minimus and piriformis) and the initiation of power to start the drive of the golf club into acceleration (24).

From the position at the top of the backswing, a golfer will strongly contract certain torso and shoulder muscles that will initiate the downswing and end in a follow-through. The downswing requires lateral flexion of the spine, and the follow-through is characterized by maximal spinal rotation to the leading side. The finish position is often characterized by rotation and hyperextension of the spine. This is typically referred to as the “reverse C” position (19).

The backswing phase is a loading of the body that enhances the distance travelled in the forward arc of motion. The distance travelled contributes to both club head velocity and the kinetic energy that will be passed on to the ball (4). The role of the backswing is thus to coil the body into a position that stores power to be released during the downswing (19).

The true source of power generation in the golf swing involves the creation of elastic energy. Elastic energy is created by imparting a short, quick stretch on the muscles involved in performing a particular movement (25).

The top of the backswing may stretch the trunk muscles, thus facilitating their action in the forward swing. During the forward swing, trunk forward rotational movement is initiated. Throughout this movement, gravitational forces are resisted to maintain body position. Counteraction of the gravitational forces is maintained primarily by the back muscles (4).

Trunk strength and stability allows the extremes of range of motion as well as the synchrony of timing in muscle firing as the trunk travels through the arc and the club meets the ball (4).

The paraspinal muscles are primarily responsible for stabilizing posture, and the abdominal oblique muscles function for flexion and rotation of the trunk (4).

These two muscle groups thus function to initiate and control the forward rotation of the body, transmit the power initiated in the hips, and decelerate the body after ball impact. The bilateral activity is a function of total postural control for stability and movement (4).

The abdominal oblique muscles have both a horizontal and vertical component. The horizontal component (the external and internal abdominal oblique muscles) is able to turn the thoracic cage in the horizontal plane and thereby impart axial rotation to the lumbar spine. Contraction of the vertical component (rectus abdominis) serves to cause flexion of the trunk and lumbar spine. In order to achieve pure axial rotation, it is necessary to counteract this flexion, which is accomplished by the extensors of the lumbar spine, particularly the multifidus muscle acting bilaterally (19).

As the torso rotates during the backswing, there is a linked biscapular motion that helps to maximize loading and the swing arc. Movements of the scapulae include rotation and retraction as well as protraction. The golf swing with its uncoiling action requires that the scapular muscles work in a synchronized manner in order to maximize the swing arc and club head speed (3).

Seaman and DeFranca note that the shoulder muscles are an important factor in producing a powerful swing (26). In the case of the golf swing, it is generally thought that the rotator cuff, latissimus dorsi and pectoralis major muscles are the “power muscles” (25).

Electromyographic studies have given a better understanding of shoulder muscle function during the golf swing. These studies demonstrate the importance of the rotator cuff muscles and other scapular stabilizing muscles including the rhomboids and trapezius muscles, as well as the lattisimus dorsi in the production of a powerful golf swing (3, 27, 28).

The upper, middle and lower portions of the trapezius muscle all work together to help retract the scapulae. The rhomboid muscles also aid with scapular retraction, as well as playing a vital role in scapular stabilization (3).

The power in the shoulder for the drive comes from the latissimus dorsi and pectoralis major. The latissimus dorsi contributes its power earlier in the downswing and acceleration phase. The reason for the earlier activity from the latissimus dorsi lies in its principal role of internal rotation of the trailing arm, which occurs in the forward swing (27).

Any muscle tightness or other limitations of movement will greatly affect the action of producing a full swing arc in the golf swing and thus maximal club head speed would not be achieved (3).

2.4 Anatomy

2.4.1 Anatomy of the Trunk Muscles that Function During the Golf Swing

2.4.1.1 EXTERNAL ABDOMINAL OBLIQUE

Origin: External surfaces and inferior borders of the lower eight ribs (rib 5 to rib 12) (11, 29).

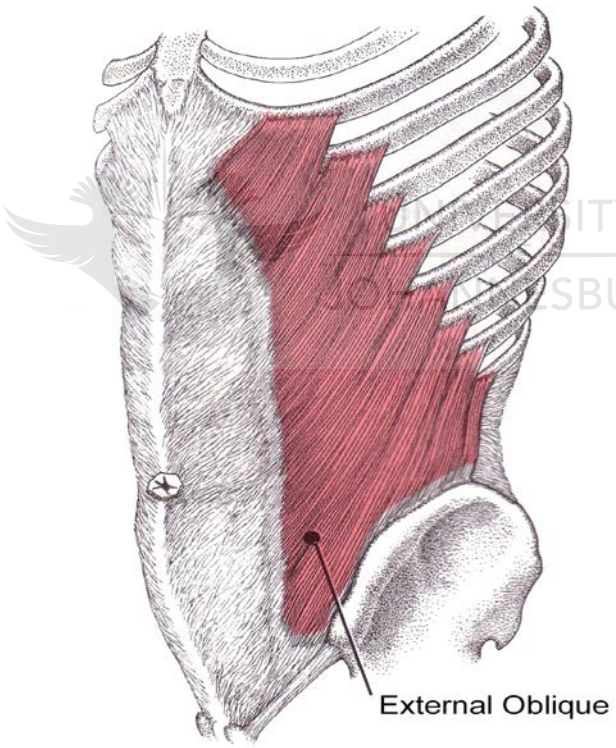
Insertion: Fibres run diagonally downwards and forwards to join the abdominal aponeurosis attaching anteriorly to the linea alba in the midline, the pubic tubercle and the anterior half of the iliac crest (11, 29).

Action: The external and internal abdominal oblique muscles function bilaterally to flex the vertebral column, unilaterally to laterally flex the vertebral column to the same side, and unilaterally to assist vertebral column rotation (29).

The external abdominal oblique rotates the vertebral column towards the contralateral side, whereas the internal abdominal oblique muscle rotates the vertebral column towards the same side. Therefore, one external abdominal oblique muscle and its contralateral internal abdominal oblique muscle affect trunk rotation to the same side (29).

The two abdominal oblique muscles may also function by eccentric contractions in order to control trunk rotation, by providing a braking action in the opposite direction (29).

Innervation: Ventral primary divisions of T8 – T12 intercostal nerves (29).



<u>Figure 2-22</u>: External Abdominal Oblique Muscle (29)

2.4.1.2 INTERNAL ABDOMINAL OBLIQUE

Origin: Thoracolumbar fascia, anterior two-thirds of the iliac crest, and the lateral half of the inguinal ligament (11).

Insertion: Inferior borders of ribs 10 to ribs 12, linea alba, and the pubis via the conjoint tendon (11).

Action: As for External abdominal oblique muscle (29).

Innervation: Ventral primary divisions of T8 – T12 intercostal nerves. Also may be supplied by branches of the iliohypogastric and ilioinguinal nerves which stem from the L1 nerve (29).

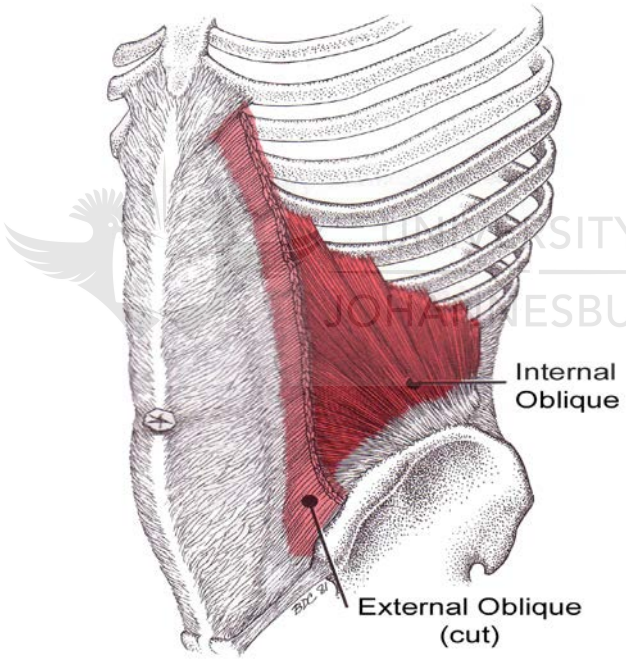


***Figure 2-23*: Internal Abdominal Oblique Muscle (29)**

2.4.1.3 RECTUS ABDOMINIS

Origin: Pubic symphysis and the pubic crest (11).

Insertion: Xiphoid process and the 5th to 7th costal cartilages (11).

Action: Serves as the prime mover for spinal flexion, especially of the lower thoracic and lumbar spine (29).

Innervation: Ventral primary divisions of T7 – T12 intercostal nerves (11).

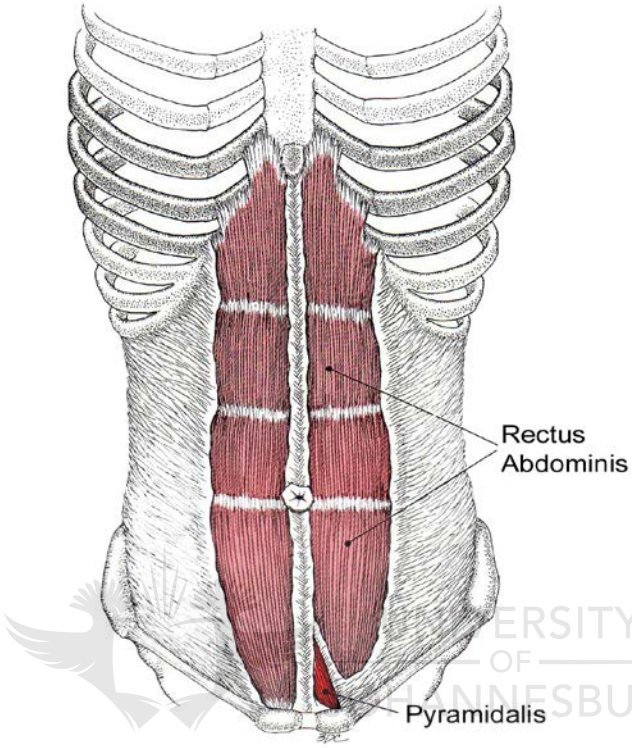


***Figure 2-24*: Rectus Abdominis Muscle (29)**

2.4.1.4 ERECTOR SPINAE MUSCLE GROUP

The erector spinae muscle group is arranged in three vertical columns: Iliocostalis (lateral column); longissimus (intermediate column); and spinalis (medial column) (11).

Origin: The common origin of the three columns is through a tendon attached inferiorly to the posterior aspect of the iliac crest, the posterior aspect of the sacrum, the sacroiliac ligaments, and the sacral and inferior lumbar spinous processes (11).

Insertion: The iliocostalis muscle group inserts into the angles of the ribs. It is divided into three parts: iliocostalis lumborum inserts into the inferior six ribs, the iliocostalis thoracis inserts into the all the ribs, and iliocostalis cervicis inserts into the superior six ribs and the posterior tubercles of C4 to C6 vertebrae (11).

The Longissimus muscle group inserts into the transverse processes of the thoracic and cervical vertebrae as well as the mastoid process of the temporal bone. It is divided into three parts: longissimus thoracis, longissimus cervicis and longissimus capitis. The insertion of the longissimus thoracis is to the tips of the transverse processes of all the thoracic vertebrae and to the tubercles of the inferior ten ribs (11).

The spinalis muscle group inserts into the spinous processes of the superior lumbar spine and inferior thoracic vertebrae and extends to the spinous processes of the upper thoracic region. This muscle group is also divided into three parts: spinalis thoracic, spinalis cervicis and spinalis capitis (11).

Action: Acting bilaterally, the erector spinae muscle group produces extension of the spine. Acting unilaterally, the erector spinae muscle group produces lateral flexion and rotation of the spine to the same side, though the contribution to rotation is minor (29).

Innervation: Dorsal primary divisions of spinal nerves in the thoracic and lumbar spines (29).

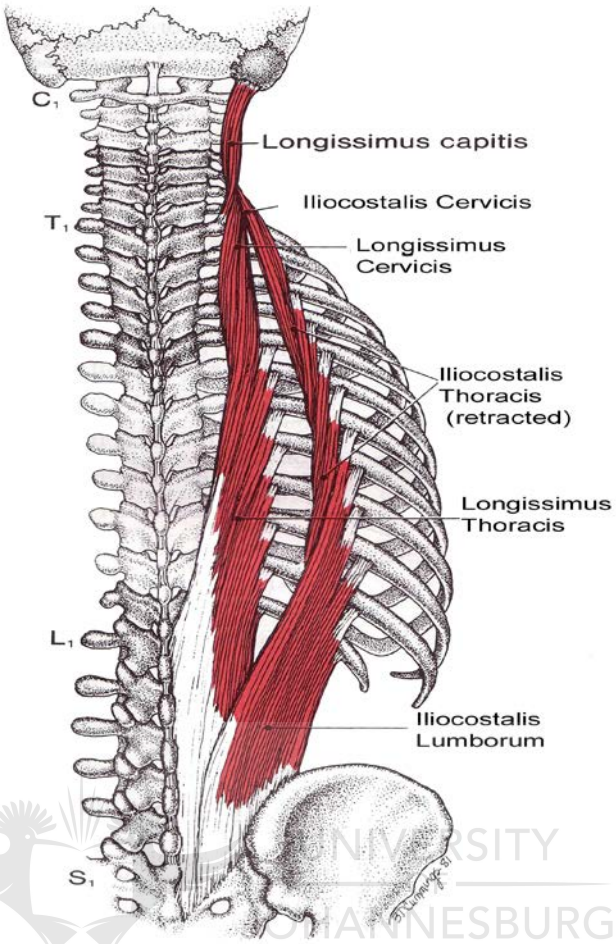


***Figure 2-25**: Erector Spinae Muscle Group (29)*

2.4.1.5 GLUTEUS MAXIMUS

Origin: External surface of the ala of the ilium, including the posterior aspect of the iliac crest; posterolateral surface of the sacrum and coccyx; the aponeurosis of the erector spinae muscles, the length of the sacrotuberous ligament; and the fascia overlying the gluteus medius muscle (11, 30).

Insertion: The upper fibres and the lower superficial fibres attach to the thick tendinous aponeurotic sheet that crosses the greater trochanter of the femur and joins the iliotibial band of the tensor fascia lata

muscle. The deep lower fibres attach to the gluteal tuberosity of the femur between the attachments of the vastus lateralis and adductor magnus muscles (30).

Action: Extends the thigh and assists in lateral rotation. Also assists in raising the trunk from a forward flexed position (11).

Innervation: Inferior glureal nerve (L5, S1 and S2) (11).

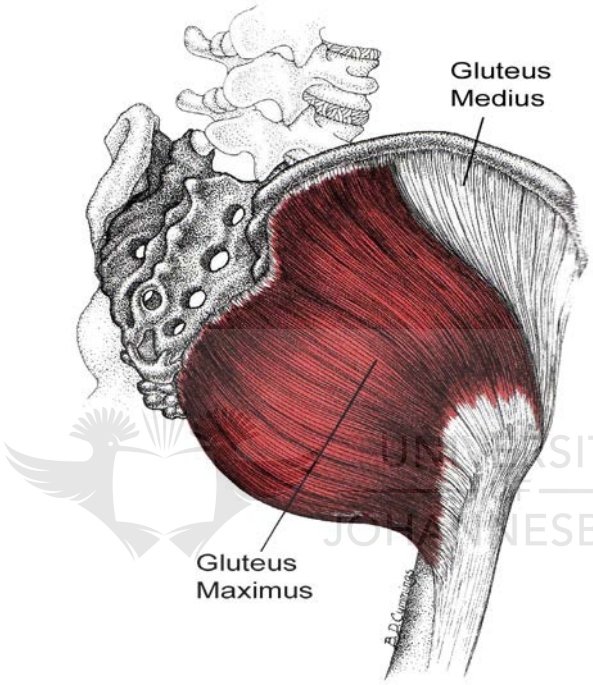


Figure 2-26: Gluteus Maximus Muscle (30)

2.4.2 Anatomy of the Scapular Stabilizing Muscles that Function During the Golf Swing

2.4.2.1 RHOMBOID MAJOR AND RHOMBOID MINOR

Origin: Rhomboid minor attaches medially to the nuchal ligament, and the spinous processes of C7 and T1 vertebrae (11).

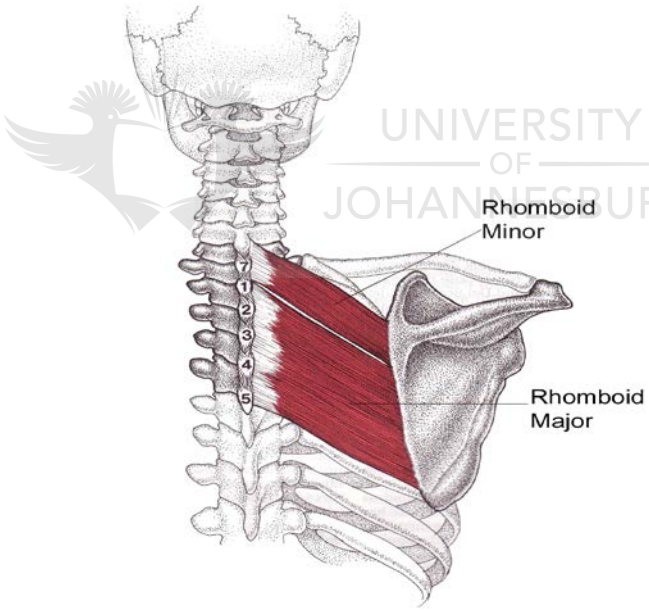
Rhomboid major attaches medially to the spinous processes of T2 to T5 vertebrae (11).

Insertion: Rhomboid minor attaches laterally on the medial border of the scapula, at the root of the spine of the scapula (11, 29).

Rhomboid major attaches laterally to the medial border of the scapula, between the spine of the scapula, and the inferior angle (11, 29).

Action: Both rhomboid muscles function to retract the scapula and fix the scapula to the thoracic wall. The rhomboid major muscle functions to ratate the scapula such that the glenoid fossa faces downwards (11, 29).

Innervation: Dorsal scapular nerve – C5 (11).



<u>Figure 2-27</u>: Rhomboid Muscles (29)

2.4.2.2 TRAPEZIUS

Origin: Upper fibres arise from the medial third of the superior nuchal line. In the midline, they arise from the nuchal ligamentum (29).

Middle fibres attach medially to the spinous processes and interspinous ligaments of C6 through T3 vertebrae (29).

Lower fibres attach medially to the spinous processes and interspinous ligaments from T4 through T12 vertebrae (29).

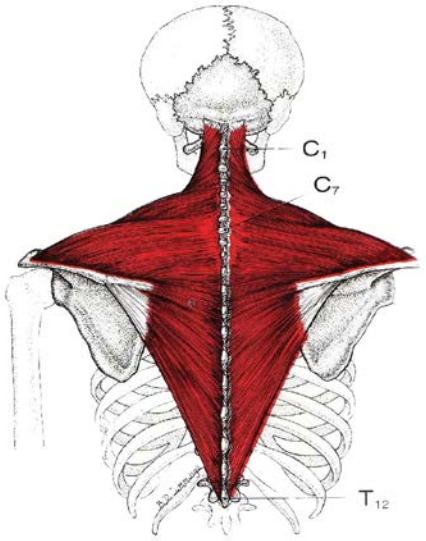
Insertion: Upper fibres converge laterally and forwards and attach to the posterior border of the lateral third of the clavicle (29).

Middle fibres attach laterally to the medial margin of the acromion process of the scapula and the superior lip of the spine of the scapula (29).

Lower fibres converge laterally and insert in the region of the tubercle at the medial end of the spine of the scapula, just lateral to the insertion of the levator scapulae muscle (29)

Action: Elevation of the scapula activates both upper and middle trapezius fibres. Adduction or retraction activates all fibres, but depends primarily on the middle fibres. Depression of the scapula employs the lower trapezius fibres. Rotation of the glenoid cavity involves chiefly the upper fibres when rotation is upwards and the lower fibres when rotation is downwards (29).

Innervation: Spinal root of the Accessory nerve [CN XI] and cervical nerves C3 and C4 (11).



<u>Figure 2-28</u>: Trapezius Muscle (29)

2.4.2.3 LATISSIMUS DORSI

Origin: Spinous processes of the lower six thoracic vertebrae (T7-T12) and all the lumbar vertebrae. Attaches to the sacrum via the thoracolumbar fascia and to the posterior surface of the iliac crest externally, as well as the external surfaces of the most inferior three or four ribs (11, 29).

Insertion: Floor of the intertubercular groove of the humerus (11).

Action: The latissimus dorsi primarily acts to extend the arm at the shoulder joint, to adduct the arm, and assist in medial rotation of the humerus, as well as depressing the humerus. The combination of humeral depression and extension by the latissimus dorsi, retracts the scapula and draws the shoulder girdle downwards and backwards. When the muscles contract bilaterally, the retraction of the scapulae causes extension of the thoracic spine. Medial rotation of the humerus is greatest when the arm is placed in an abducted position (29).

Innervation: Thoracodorsal nerve – anterior rami C6, C7, C8 (11).

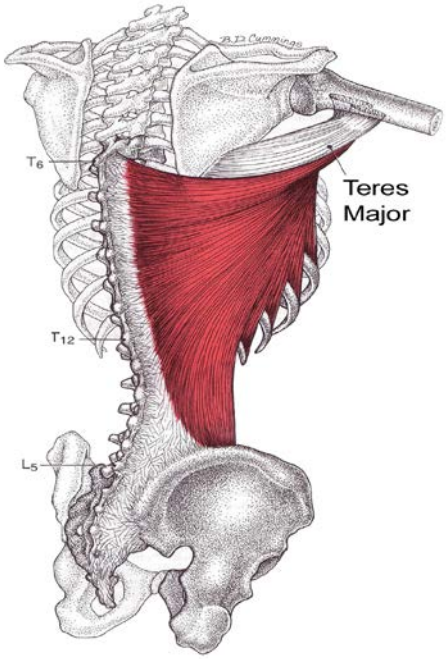


Figure 2-29: Latissimus Dorsi Muscle (29)

2.4.3 Anatomy of the Deep Muscles of the Back that Function for Intersegmental Movements During the Golf Swing

2.4.3.1 MULTIFIDUS AND ROTATORES

Attachments: The multifidi and rotatores muscles attach medially and above near the base of a vertebral spinous process, and laterally and below they attach to a transverse process (29). The multifidus fibres cross two to four segments throughout the thoracic and lumbar spines, and may extend to the S4 segment. The short rotators attach to adjacent vertebrae. The long rotators span one segment throughout the spine, but ordinarily do not include sacral segments (29).

Action: These two muscles function primarily for fine adjustments between vertebrae, rather than for gross spinal movements (29).

Acting unilaterally, the multifidus muscle laterally flexes the trunk and rotates it to the opposite side. Acting bilaterally, the multifidus extends the trunk and stabilizes the vertebral column (11).

The rotators muscles function by rotating the vertebra superior to it to the opposite side (11).

Innervation: The multifidus and rotatores muscles are innervated by dorsal rami of spinal nerves (11).

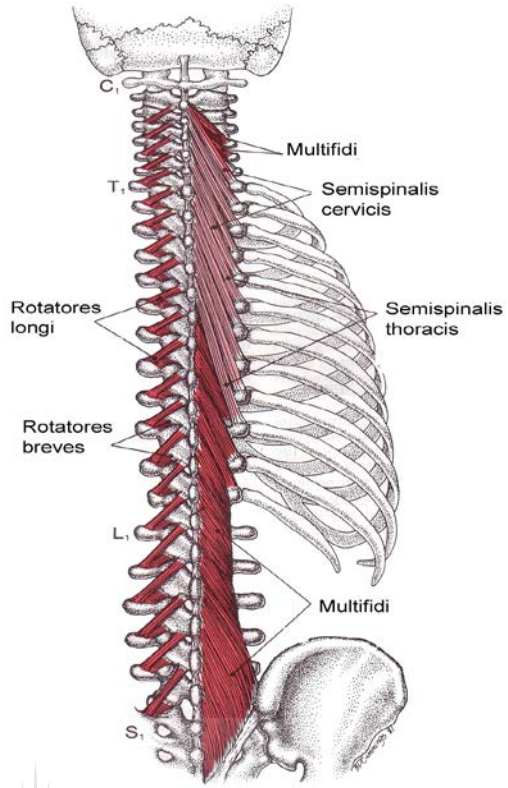


***Figure 2-30**: Multifidus and Rotatores Muscles (29)*

2.5 Muscular Activities During the Golf Swing as Determined by EMG Studies

All functions have been described for right-handed golfers.

2.5.1 Activity of the Trunk Muscles

2.5.1.1 ABDOMINAL OBLIQUE MUSCLES

There is equivalent activity between the right and left sides during the takeaway phase. During the forward swing, there is only slightly less activity in the right side compared to the left side. During acceleration and follow-through, there is considerably more muscle activity in the right than the left side. During late follow-through, there is equivalent activity between both sides (4, 24).

2.5.1.2 RECTUS ABDOMINIS MUSCLE

The lower portion of the rectus abdominis muscle has more activity during the takeaway and late follow-through than the upper portion of the muscle. Activity of this muscle increases with the progression of the swing until it reaches its zenith during the acceleration phase and then it continues to decline through the late follow-through phase (24).

2.5.1.3 ERECTOR SPINAE MUSCLE GROUP

Activity in the right erector spinae muscles increases from the takeaway, reaching its maximal activity at forward swing, after which it begins to fall at late follow-through. Activity of the left erector spinae muscles increases steadily during the initial phases, with its maximal activity during the acceleraion phase, after which there is a decline through the late follow through (4, 24).

2.5.1.4 GLUTEUS MAXIMUS MUSCLE

Activity of the right gluteus maximus muscle produces a relatively low baseline during all swing phases, except for a spike during the forward swing phase. The left gluteus maximus muscle activity increases as the swing progresses, with the maximum activity reached during the acceleration phase, and subsequently declines up to the late follow through phase (24).

2.5.2 Activity of the Scapular Stabilizing Muscles

2.5.2.1 RHOMBOID MUSCLES

Peak activity in the leading arm occurs during the forward swing and acceleration phases, with less activity during early follow-through, late follow-through and the takeaway phases. In the trailing arm, maximal activity is demonstrated during takeaway and acceleration (3).

2.5.2.2 TRAPEZIUS MUSCLE

The trapezius muscle in the leading arm shows peak activity during acceleration, and lower levels of activity during forward swing, early follow through and late follow-through. Takeaway reveals the lowest activity. In the trailing arm, the trapezius muscle demonstrates peak activity during takeaway and early follow-through, with much lower activity during forward swing, acceleration and late follow-through (3).

2.5.2.3 LATISSIMUS DORSI MUSCLE

The latissimus dorsi muscle on both sides demonstrates peak activity during the forward swing and acceleration phases, with a slight gradual decrease in activity during early follow-through and late follow-through. The takeaway phase reveals the lowest activity (27).

2.6 The Vertebral Subluxation Complex

2.6.1 Introduction

Central to the philosophy, science and practice of chiropractic is the vertebral subluxation complex. According to the definition agreed on by the Consortium for Chiropractic research, subluxation is defined as a motion segment in which the alignment, movement integrity, and/or physiologic function are altered although contact between the facet joint surfaces remains intact (31).

The vertebral subluxation complex, as described by Lantz, is a model of motion segment dysfunction from a chiropractic clinical perspective. Central to Lantz's concept of subluxation is some form of kinesiological dysfunction. The primary form of kinesiopathology is hypomobility, often referred to as a fixation or motion restriction (31).

The kinesiological component is placed at the apex of the organizational model of the vertebral subluxation, as the restoration of motion to a restricted articulation is central to chiropractic manipulative therapy. Below the kinesiological component are the tissue-level components of the vertebral subluxation complex. Each tissue level works in co-ordination with the others to allow for and to maintain correct and adequate segmental motion. Movement is brought about by muscle function (the myologic component). Movement is guided, limited and stabilized by connective tissues including ligaments and joint capsules (the connective tissue component). The vascular system provides the necessary nutrition for all tissue components (the vascular component). The co-ordinated function of all the tissue components are controlled largely by the nervous system (the neurological component) (31).

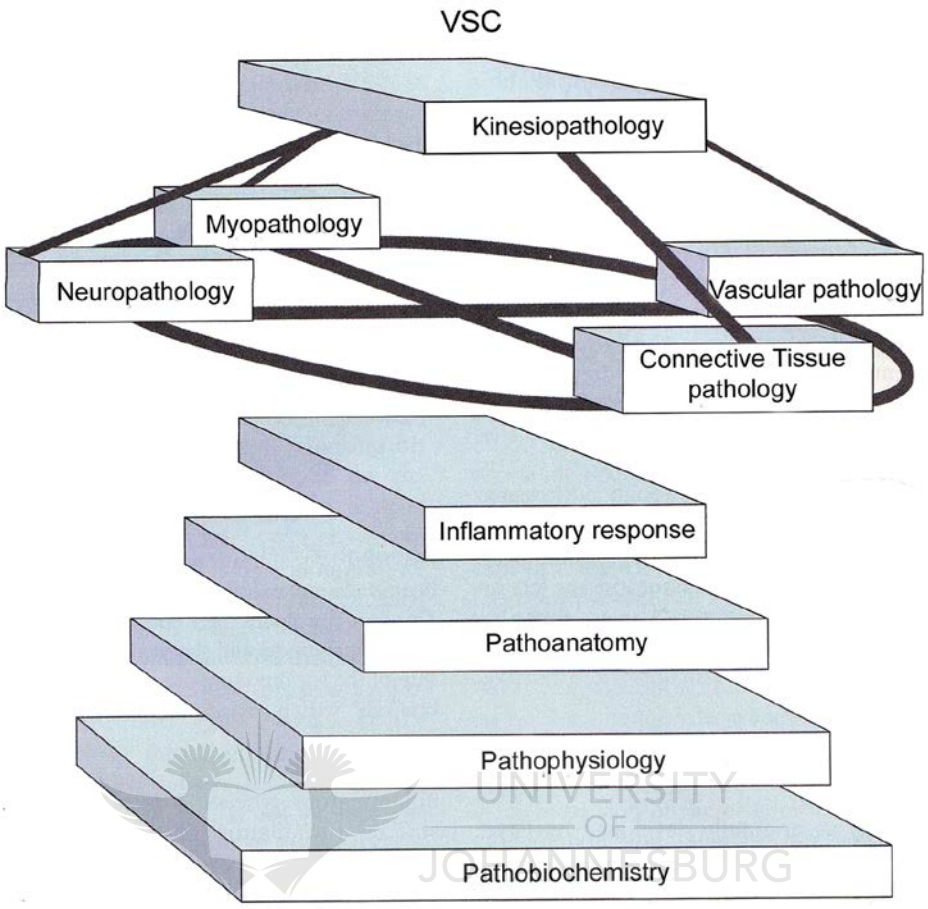


Figure 2-31: The Vertebral Subluxation Complex (31)

For the purpose of this research, only the relevant components will be discussed in more detail.

2.6.2 The Kinesiological Component

The basic unit of spinal mobility is the three-joint complex. It is considered to be a single, compound joint with three articulations – the intervertebral disc and the two zygapophyseal joints. A typical motion segment consists of two adjacent vertebrae joined by an intervertebral disc, and the two pairs of posterior articulations which includes their capsules and several ligaments (31).

The types of movements that take place in this three-joint complex has been described earlier in biomechanics of the thoracic and lumbar spines.

Chiropractic evaluation procedures are directed at determining specific intersegmental motion or positional abnormalities and correcting these through corrective adjustive procedures directed to those segments (31).

2.6.3 The Connective Tissue Component

When joints are immobilized, adhesions form between adjacent connective tissue structures. Adhesions may form between adjacent osseous and capsular structures, between tendons and articular capsules, or between any two connective tissue structures that come into contact with one another, but do not move relative to each other. Forced motion leads to a physical disruption of these adhesions (31).

After immobilization, joints become stiff. Although some stiffness results from intra-articular adhesions to surfaces that normally glide past one another, there is evidence that ligamentous structures shorten or contract and hence limit joint motion (8).

2.6.4 The Myological Component

Muscles function to maintain osseous relationships as well as moving bones at their articulations or joints. When joints are immobilized, the muscles associated with them undergo a degenerative process known as disuse atrophy (31).

Muscle spindles are adversely affected by immobilization, showing significant morphologic, physiologic and biomechanical changes. Morphologic changes include shortening, thickening and tightening, degeneration of the primary muscle spindle endings, swollen capsules and loss of cross-striations (31).

Physiologic alterations include increased sensitivity to stretch. A consequence of such an increase in muscle spindle activity could lead to the over-stimulation of muscle groups that respond to the stretch reflex, leading, in the end state, to muscle spasm and myofascial trigger points (31).

2.7 Effects of Chiropractic Spinal Manipulation on Asymptomatic Subjects

There are two factors that are predominantly important with regards to spinal manipulative therapy. The first is range of motion of the facet joints, and the second is change in muscle tone.

2.7.1 Mechanical Effects of Manipulation

The mechanical force introduced into the vertebral column during a spinal manipulation may directly alter segmental biomechanics (32). Lehman and McGill (1999) found that spinal manipulation resulted in increases in total range of motion for each plane of movement during a golf swing. The three axes are those that allow for flexion-extension, axial twist to the right and left and lateral bending to the right and left (33).

The mechanical effects of an adjustment will be on derangements of the somatic structures of the body that have altered joint function and resulted in dysfunctional joint motion (8). Schafer and Faye refer to this dysfunctional joint motion as a “fixation”. They define the fixation as any physical, functional or psychic mechanism that produces a loss of segmental mobility within its normal physiologic range of motion (6).

2.7.2 Reflexogenic Effects of Manipulation

Mechanoreceptors initiate the afferent loop of proprioceptive feedback to the brain. They are specialized end-organs (neurosensory cells) that convert a physical stimulus into a neurologic signal that can be deciphered by the central nervous system to modulate joint position and movement. Mechanoreceptors have important roles in joint position sense as well as in controlling muscle tone and generating reflex responses (34).

These important receptors are thought to be within joint capsules, muscles and ligaments. The articular and muscle receptors are considered the two important mechanoreceptor classes in joint stability; they contribute to joint position sense. The articular receptors are located within the joint capsule, ligaments and intra-articular structures. Muscle receptors are found in the muscle spindle and golgi tendon organ, and are important for both proprioception and motor control of the muscles (34).

Proper control of muscle function requires feedback of information from each muscle to the spinal cord, giving the status of the muscle at each instant. To provide this information, the muscles and their tendons are supplied abundantly with two types of sensory receptors. The first, muscle spindles, send information to the nervous system about either the muscle length or rate of change of its length. The second, golgi tendon organs, transmit information about tendon tension (35).

All receptors require a stimulus for activation. Mechanoreceptors can be stimulated by muscle-length change, including the rate of change in tension and length (34).

A spinal adjustment with its sudden eruption into the paraphysiological space and the stretching of the articular capsule to the limit of anatomical integrity represents an intense stimulation of the joint proprioceptors (9). These proprioceptors include the muscle spindles and golgi tendon organs (32). This proprioceptive information exerts a regulating function on the tone of the corresponding and adjacent musculature (9).

The action of an adjustment on a particular vertebral level, can stretch those segmental muscles, causing spindle and golgi tendon reflexes that decrease the state of hypertonicity and resolve latent trigger points within the muscles that function at those particular segmental levels (8). Travell and Simons define a latent trigger point as a myofascial trigger point that is clinically quiescent with respect to spontaneous pain; it is painful only when palpated. A latent trigger point always has a taut band that increases muscle tension and restricts range of motion of both the muscle itself as well as the joint that is moved by that muscle (29).

The normal pattern of discharge of the proprioceptors would be altered in the case of spinal joint motion restriction and would bring about a modification of the tone of the muscle (9). This was described under the vertebral subluxation complex.

The adjustment, by normalizing joint movement, would bring about a normalization of muscle tone by virtue of the stretch reflex on muscle and the golgi tendon reflex (9).

The high-velocity, short-amplitude impulse thrust of a spinal manipulation stimulates muscle spindles and golgi tendon organs. Pickar and Wheeler demonstrated that muscle spindles and golgi tendon organs with receptive endings in the paraspinal muscles respond to spinal manipulation due to the elongation of the spindles and golgi tendon organs (32).

Joint stimulation has been found to be intimately related to reflexogenic muscular reactions. According to Keller and Colloca, spinal manipulation improves the functional ability of trunk muscles by virtue of the reflexogenic effects that promote a change in muscle tone. They suggest that a potential beneficial effect derived from spinal manipulation may be acute improvement in a muscle's ability to contract effectively due to correction of the lever arm system of the muscle (7).

2.7.2.1 The Stretch Reflex / Myotatic Reflex

Sudden stretch of a muscle excites the muscle spindle and this in turn sends strong signals to the spinal cord, which then transmits reflex signals through the alpha motor nerve fibres, causing reflex contraction of the same muscle that had been stretched, and this opposes further stretch of the muscle (35).

2.7.2.2 The Golgi Tendon Reflex

When the golgi tendon organs of a muscle are stimulated by increased muscle tension, as in spinal manipulation, the reflex provides a negative feedback mechanism that prevents the development of too much tension on the muscle (35).

2.7.3 Neurological Effects of Manipulation

Pickar and Wheeler postulate that spinal manipulation affects impulse-based neural activity by altering the inflow of sensory information to the spinal cord. Spinal manipulation may remove an aberrant sensory input, or possibly add a new input. The manipulation-induced changes in sensory input are thought to affect central neural integration within motor, nociceptive, and/or autonomic neuronal pools and thereby elicit changes in afferent somatomotor and visceromotor activity (32).

Pickar and Wheeler have described a hypothetical mechanism for the neurological effects of spinal manipulation:

- Spinal manipulation increases joint mobility by producing a barrage of impulses in muscle spindle afferents, decreasing the activity of facilitated γ-motoneurons (32).
- γ- motoneuron discharge is elevated to muscles of vertebral segments in need of spinal manipulation. This impairs joint mobility by allowing the myotatic / stretch reflex to detect very small changes in muscle length (32).
- The impulses from muscle spindle afferents in response to the spinal manipulation reduce the gain of the γ-loop through an undetermined neural pathway (32).
- This resets the γ-bias by producing a high frequency discharge in the muscle spindle and golgi tendon organ afferent (32).
- Muscle spindles and golgi tendon organs therefore respond to spinal manipulative-like loads. The chiropractic motion restriction is thought to affect reflex neural activity. Stimulation of muscle spindles from a given muscle evokes a monosynaptic excitatory potential in all α-motoneurons to the same muscle (32).

CHAPTER THREE - METHODOLOGY

3.1 Study Design

This study was designed to determine the possible effects of chiropractic spinal manipulation on the ability of golfers to achieve greater club head speeds and possibly longer driving distances through the effects of chiropractic spinal manipulation previously described.

A total of 80 participants were used in this research study. There were two groups. The first group (control group) consisted of 40 participants, while the second group (manipulation group) consisted of 40 participants.

Participants in the control group were not assessed physically, nor were they given any spinal manipulative therapy. However, the participants in this group were asked a pertinent history (Appendix B) in order to confirm that they were asymptomatic and were not suffering from back pain at the time.

Each participant in the manipulation group was required to sign the subject information and consent form (Appendix A), which described the procedure of testing.

Participants in the manipulation group were first asked a pertinent medical history (Appendix B) and then assessed physically (Pertinent physical – Appendix C), also including thoracic spine (Appendix D) and lumbar spine regional examinations (Appendix E) which included orthopaedic tests and neurological evaluation in order to rule out any contra-indications to spinal manipulative therapy (Appendix F).

All participants in both groups underwent the same routine, with the exception of participants in the manipulation group who also received spinal manipulative therapy to areas of motion restriction in their thoracic and lumbar spines as well as their sacroiliac joints.

Each participant was asked to hit ten golf balls as a simple warm-up. This was used to loosen up the muscles and aid in facilitating hand-eye co-ordination. Participants were then asked to hit 30 golf balls with the swing speeds measured. Club head speeds measured in miles per hour was used as the objective measurement. At this point, participants in the manipulation group received spinal manipulation to restricted motion segments, whereas participants in the control group were asked to rest for seven to ten minutes, this was the same time lag as it would have taken to treat participants in the manipulation group with spinal manipulative therapy. Participants were then asked to hit an additional 30 golf balls, and the club head speeds were measured.

3.2 Patient Selection

Patients were recruited by means of an advertisement poster (Appendix G) placed throughout Golf Clubs, Golf Stores and Golf Driving Ranges.

All participants were required to meet the following inclusion criteria:

- Only male subjects were used.
- Golfers were right-handed golfers only.
- Participants were between the ages of 18 and 50 years of age.
- All participants had a handicap in golf equal to or less than 8.
  (Handicap in golf is determined in the following way: the best 10 scores out of the last 20 rounds of golf played, averaged, and then reduced by 15%, and rounded-off to the nearest whole number. See www.handicaps.co.za).
- All participants were asymptomatic. They did not suffer from a current episode of back pain.
- Participants who presented with any contra-indications to spinal manipulative therapy were excluded from the study (Appendix F).

3.3 Treatment Schedule

Each research patient attended one consultation.

Only participants in the manipulation group were assessed physically, including thoracic spine and lumbar spine regional examinations. Their thoracic and lumbar spines as well as their sacroiliac joints were assessed for motion restrictions by motion palpation, and the joints were treated with chiropractic spinal manipulative therapy.

Areas in the thoracic and lumbar spines as well as the sacroiliac articulations of participants in the manipulation group were assessed for motion restrictions by motion palpation.

Motion palpation as determined by Schafer and Faye:
The thoracic and lumbar spines of participants were palpated in a seated position, and restrictions of motion were recorded in rotation, lateral flexion, flexion or extension (6).

3.3.1 Motion Palpation of the Thoracic Spine

With the subject seated and their arms crossed over their chest, flexion and extension motions are assessed by the examiner placing the pads of the index and middle fingers within the interspinous spaces of adjacent vertebrae of the thoracic spine. The subject is passively brought up from full flexion to full extension, and back into flexion. As the subject is extended, the gap between the spinous processes should close, and as the subject is flexed, the gap between the spinous processes should open. A fixation is indicated if no springy end-feel exists at the extreme range of intersegmental motion (6).

A **B**

Figure 3-1: ***Motion Palpation of the Thoracic Spine in Flexion (A) and Extension (B)***

With the subject seated and their arms crossed over their chest, lateral flexion motion is assessed by the examiner placing their thumb on the lateral aspect of adjacent thoracic spinous processes. The remaining fingers cross over the spine and rest on the contralateral paraspinal muscles. The examiner, with their opposite arm over the subject's shoulders, laterally flexes the subject towards the side of palpation. The subject is also asked to look to the same side as lateral flexion. The palpating hand feels for the top segment moving away from the segment below. The loss of a springy end-feel indicates a fixation (6).

Figure 3-2: ***Motion Palpation of the Thoracic Spine in Lateral Flexion***

With the subject seated and their arms crossed over their chest, rotation motion is assessed by the examiner placing a thumb contact on the lateral aspect of adjacent thoracic spinous processes. The remaining fingers cross over the spine and rest on the contralateral paraspinal muscles. The examiner, with their opposite hand, grasps the subject's shoulder from the anterior. This hand is used to rotate the subject to the side being investigated. The palpating hand feels for the spinous process above moving away relative to the spinous process below. The loss of a springy end-feel indicates a fixation (6).

Figure 3-3: ***Motion Palpation of the Thoracic Spine in Rotation***

3.3.2 Motion Palpation of the Lumbar Spine

Flexion and extension motions in the lumbar spine are assessed as for flexion and extension motions in the thoracic spine (6).

With the subject seated and their arms crossed over their chest, lateral flexion motion is assessed by the examiner placing their thumb on the lateral aspect of the interspinous space between two adjacent lumbar vertebrae. The remaining fingers cross over the spine and rest on the contralateral paraspinal muscles. The examiner, with their opposite arm over the subject's shoulders, laterally flexes the subject towards the side of palpation (6).

The palpating hand feels for the vertebral segment being palpated moving towards the palpating thumb. The loss of a springy end-feel indicates a fixation (6).

Figure 3-4: Motion Palpation of the Lumbar Spine in Lateral Flexion

With the subject seated and their arms crossed over their chest, rotation motion is assessed by the examiner placing a thumb contact on the lateral aspect of adjacent lumbar spinous processes. The remaining fingers cross over the spine and rest on the contralateral paraspinal muscles. The examiner, with their opposite hand, grasps the subject's shoulder from anterior. This hand is used to rotate the subject to the side being investigated. The palpating hand feels for the spinous process above moving towards the palpating thumb. The loss of a springy end-feel indicates a fixation (6).

Figure 3-5: Motion Palpation of the Lumbar Spine in Rotation

Coupled motion is induced from the movements of lateral flexion and rotation and causes the top segment to move towards the palpating thumb relative to the segment below (6).

Schafer and Faye also describe Gillet's method for motion palpation of the sacroiliac joints. Participants' sacroiliac joints were palpated in the standing position, and motion restrictions were recorded as restrictions of motion in flexion or extension (6).

3.3.3 Motion Palpation of the Upper Sacroiliac Joint in Flexion

The subject stands facing a wall with their hands against the wall to maintain balance. Their feet are slightly apart. Examiner kneels behind the patient and takes a thumb contact inferior to the posterior superior iliac spine (P.S.I.S.) on the side being investigated. The examiner contacts the second sacral tubercle in the midline with the other thumb. The subject is asked to slowly flex their hip in the sagittal plane. The P.S.I.S contac is felt to move posteriorly and inferiorly and then anteriorly, while the sacral contact is felt to arc anteriorly and inferiorly. The thumb contacts are seen to separate. If the sacroiliac joint is restricted, the thumb contacts will not separate appreciably (6).

Figure 3-6: ***Motion Palpation of the Upper Sacroiliac Joint in Flexion***

3.3.4 Motion Palpation of the Upper Sacroiliac Joint in Extension

The subject stands facing a wall with their hands against the wall to maintain balance. Their feet are slightly apart. Examiner kneels behind the patient and takes a thumb contact inferior to the posterior superior iliac spine (P.S.I.S.) on the side being investigated. The examiner contacts the second sacral tubercle in the midline with the other thumb. The subject is asked to slowly extend their hip in the sagittal plane. The P.S.I.S contact is felt to move superiorly. The thumb contacts are seen to approximate one another. If the sacroiliac joint is restricted, the thumb contacts will not approximate appreciably (6).

Figure 3-7: ***Motion Palpation of the Upper Sacroiliac Joint in Extension***

Restricted motion segments in the spine as identified by motion palpation were corrected using chiropractic spinal manipulation or adjustments. All adjustments were delivered as low amplitude, high velocity thrusts using diversified chiropractic techniques.

3.4 Chiropractic Manipulative Therapy

3.4.1 The Chiropractic Adjustment Theory

A spinal joint adjustment is defined as a passive, manual maneuver during which an articular element is suddenly carried beyond the usual physiological limit of joint movement without however exceeding the boundaries of anatomical integrity (9).

The usual characteristic of an adjustment is the thrust which is a brief, sudden and carefully dosed impulse delivered at the end of the normal passive range of movement and which is usually accompanied by a cracking noise called a cavitation (9).

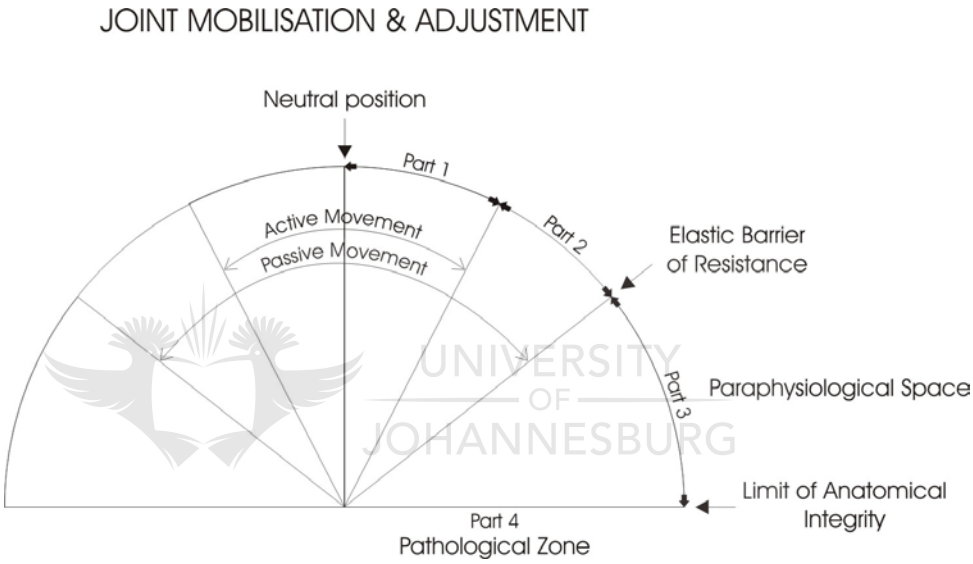
The zygopophyseal or facet joints are adjusted by taking contact and exerting a physical force to the vertebra (9).

3.4.2 The Phases of a Chiropractic Adjustment

The chiropractic adjustment delivered to a spinal facet joint or sacroiliac joint is a manual, passive maneuver which moves that joint in the direction of most restriction and is described in four stages.

The first part describes active movement of a joint in one plane. When the joint is mobilized passively, the range of motion is increased in both directions along that plane (part one and part two). At the end of the passive range of motion, when joint slack is removed, a resistance is felt. This resistance is called the elastic barrier of resistance. If mobilization is forced beyond the elastic barrier of resistance, a sudden give is felt, a cavitation is perceived and the range of motion is slightly increased beyond the physiologic limit. This added range of movement is called the paraphysiological space (part three). At the end of this

reserve space of movement, a second ultimate barrier of resistance is encountered. This barrier is called the limit of anatomical integrity and is represented by stretched muscles, ligaments and articular capsules (9).
Forcing the movement beyond this barrier would produce ligamentous damage, allowing the joint spaces to dislocate. This is the pathological zone of movement (part four) (9).



<u>Figure 3-8</u>: Phases of a Chiropractic Adjustment (9)

The qualities of a chiropractic adjustment should be such so as to permit overcoming the elastic barrier of resistance without however exceeding the barrier of anatomical integrity (9).

When the force of an adjustment is sufficient, and the joint is separated and forced beyond the elastic barrier of resistance, gases are liberated from the synovial and tissue fluids surrounding the joint. This extraction of gases is known as cavitation. The energy released by this phenomenon is responsible for the cracking noise. After cavitation, the joint surfaces are maximally separated (9).

After an adjustment, the range of active and passive movements of the joint is temporarily increased, the paraphysiological space being added to the passive range of movement. This gain in the range of motion does not only occur in the direction in which the joint was adjusted, but in all directions (9).

3.4.3 Chiropractic Adjustment Techniques

Diversified Techniques were used for the correction of joint motion restrictions. This was indicated by specific orthopaedic and chiropractic assessment, which included the assessment of motion palpation.

States Manual describes the Diversified techniques which were used (36).

3.4.3.1 Adjustment Technique used for Sacroiliac Joint Motion Restrictions

3.4.3.1.1 THIGH-ILIO-DELTOID

- Indications

Flexion and extension restrictions of the sacroiliac joints.

- Subject's Position

Lateral recumbent position. Lesion side uppermost. Pelvis positioned close to the edge of the table. Dorsum of uppermost foot placed in popliteal fossa of lower limb which is kept straight. Arms placed so as to balance the patient.

- Examiner's Position

Facing the patient. Grasp patient's knee between thighs. At the point where the correct amount of hip flexion is achieved, adduct the patient's thigh, and assume a fencer's stance.

- Contact Hand

Caudad hand. Specific pisiform contact is taken inferior and medial to the posterior superior iliac spine (P.S.I.S) with a chiropractic arch. Forearm is perpendicular to the contact hand.

Broad skin slack is taken from infero-medial to supero-lateral from the inferior aspect of the P.S.I.S.

- Indifferent Hand

Contacts the upper shoulder and provides cephalad traction.

- Thrust

Rotate the inominate anteriorly. Adjustment is delivered at the end of expiration as a body drop with impulse. Line of drive is posterior-to-anterior and slightly superiorly for extension restrictions or inferiorly for flexion restrictions.

Figure 3-9: ***Thigh-Ilio-Deltoid Adjustment Technique (36)***

3.4.3.2 Adjustment Techniques used for Lumbar Spine Motion Restrictions

3.4.3.2.1 THIGH-TRANSVERSO-DELTOID

- Indications

Anterior rotary restrictions of the lower thoracic and all lumbar facet joints.

- Subject's Position

In the lateral recumbent position with the lesion side uppermost. Pelvis is positioned close to the edge of the table. Dorsum of foot of uppermost leg is placed in the popliteal fossa of the lower limb which is kept straight. Arms are placed so as to balance the patient.

- Examiner's Position

Grasps patient's knee between thighs, and when correct amount of hip flexion is achieved, doctor turns into a fencer's stance and adducts the patient's leg.

- Contact Hand

Caudad hand. Pisiform contact with a chiropractic arch is taken on the involved transverse process (thoracics) or mamillary process (lumbars). Skin slack is removed from inferior to superior. Fingers are parallel to the spine and do not cross it. Forearm is perpendicular to the contact hand.

- Indifferent hand

Cephalad hand. Contacts upper shoulder and provides cephalad traction.

- Thrust

Adjustment is delivered at the end of expiration as a body drop with sudden impulse. Line of drive is posterior-to-anterior and slightly superiorly.

***Figure 3-10**: Thigh-Transverso-Deltoid Adjustment Technique (36)*

3.4.3.2.2 SPINO-DELTOID

- Indications

Anterior rotary restrictions of lower thoracic and all lumbar facet joints.

- Subject's Position

Sitting at the edge of the table, straddling the table, knees held tight against the table. Arms are crossed with hands on opposite shoulders. Arm that is homolateral to the doctor (side of rotation) is placed on top.

- Examiner's Position

Posterior at 90° to the patient. Arm contralateral to the listing reaches around the patient. Elbow of doctor's contact arm is held in the inguinal region for support.

- Contact Hand

Hand homolateral to the listing. Calcaneal contact against the spinous processes contralateral to the side of the listing. Fingers point transversely lateral.

- Indifferent Hand

Hand contralateral to the listing. Grasps the patient's shoulder. Forearm on top of the patient's crossed arms.

- Thrust

Torso rotated until joint slack is removed. Indifferent hand continues to rotate the patient's torso and contact hand thrusts anteriorly with body weight.

***Figure 3-11**: Spino-Deltoid Adjustment Technique (36)*

3.4.3.3 Adjustment Techniques used for Thoracic Spine Motion Restrictions

3.4.3.3.1 ANTERIOR THORACIC TECHNIQUE

- Indications

Anteriors (extension restrictions) T1 – T12.

- Subject's Position

Supine.

Arm positions include:

1) Arms crossed over the chest, with the arm contralateral to the doctor on top. Elbows are positioned so as to be on top of each other in the midline.
2) Pump handle position – patient clasps fingers together behind their neck. Elbows are positioned together. Patient is to be instructed to keep their elbows locked together.

- Examiner's Position

Standing in a fencer's stance facing cephalad on either side of the table, at the level of the patient's waist.

Doctor can be in one of two positions:

1) Doctor reaches across the anterior aspect of the patient to place caudad hand as the contact hand.
2) Doctor places cephalad hand as the contact hand from the homolateral side when the patient is too large for the first position.

- Contact Hand

Placed over the spinous process of the vertebra directly below the listed segment using 1 of 3 contacts:

1) Flat hand: spinous processes placed in the palm just proximal to the metacarpophalangeal joints. Fingers point transversely lateral. Thumb must not float. Used for slender body types.
2) Flexed interphalangeal joints: The distal and proximal interphalangeal joints of digits 2 – 5 are fully flexed. Spinous processes are placed between the calcaneal region and the flexed fingers. Used for medium body types.
3) Fist: The distal and proximal interphalangeal joints as well as the metacarpophalangeal joints are flexed. Spinous processes are placed between the calcaneal region and the row of flexed fingers. Used for large body types. Skin slack is removed from inferior to superior.

- Indifferent Hand

Doctor's hand grasps patient's superior arm. Doctor's forearm contacts the patient's flexed arms. Doctor's sternum contacts own forearm. Indifferent hand can also be used to control the patient's head.

- Thrust

Ask patient to turn their head away. During expiration, doctor tractions arms caudally and in a posterior direction, passively flexing the patient's thoracic spine. At the end of expiration, thrust is applied as a body drop. Line of drive of the thrust is anterior-to-posterior and slightly cephalad.

***Figure 3-12*: Anterior Thoracic Adjustment Technique (36)**

3.4.3.3.2 CROSSED BILATERAL BODY DROP

- Indications

Rotary restrictions T3 – T12.

- Subject's Position

Prone. Head is kept in slight flexion for patient comfort.

- Examiner's Position

Fencer's stance facing cephalad, homolateral to the listing. Shoulders square to the patient.

- Contact Hand

Caudad hand. Pisiform contact with a chiropractic arch on the ipsilateral transverse process of the involved vertebra. Elbow is locked in extension with cubital fossa facing anteriorly. Skin slack is removed from inferior to superior.

- Indifferent Hand

Flat cephalad hand on the contralateral transverse process of the vertebra below. Has a stabilizing function.

- Thrust

Adjustment is delivered as a body drop through the contact hand only. Doctor sways body weight backwards onto caudal foot as patient inspires. During expiration, doctor sways body weight forward onto the cephalad foot, dropping the weight onto the contact hand by collapsing the cephalad leg. Neither of the elbows must buckle during the thrust.

Line of drive changes according to the area of the thoracic spine being adjusted:

For upper thoracic spine: posterior-to-anterior and slightly inferior.

For middle thoracic spine: straight posterior-to-anterior.

For lower thoracic spine: posterior-to-anterior and slightly superior.

3.4.3.3.3 MALAR POSTERIOR TRANSVERSE

- Indications

Rotary restrictions T1 – T3

- Subject's Position

Prone. Patient's head is rotated towards the side of rotation to a maximum of 60°.

- Examiner's Position

Contralateral to the lesion in a fencer's stance facing cephalad.

- Contact Hand

Caudad hand. Index contact is taken on to the transverse process of the involved segment with the thumb pointing towards the doctor. Skin slack is taken out

infero-medial to supero-lateral. Wrist is in ulnar deviation with the forearm being 45° to the floor and 45° to the contact hand contact.

- Indifferent Hand

Cephalad hand. Palmar contact cupping the patient's ear and tractioning the head cephalad and into further rotation.

- Thrust

Thrust is a pectoral impulse thrust. The line of drive is medially, inferiorly and anteriorly.

***Figure 3-13**: Malar Posterior Transverse Adjustment Technique (36)*

3.5 Monitoring

Objective Measurements

The machine that was used to take measurements is the “Swing Mate”. The Swing Mate forms part of the Titleist custom fitting apparatus in South Africa. “Titleist” is one of the worlds leading companies in golf equipment. The Swing Mate (Beltronics, Ltd. Canada) is an electronic swing made detector device that measures the club head speed at impact with the ball, by virtue of an antenna opening which calculates the club head speed and immediately shows the reading on the digital display screen. (This was the same device used by Egret, Vincent, Weber, Dujardin and Chollet in: *Analysis of 3D Kinematics Concerning Three Different Clubs in the Golf Swing* (1)).

***Figure 3-14*: The “Swing Mate”**

The Swing Mate was placed three feet behind the ball which was on an indoor synthetic mat. Each participant was asked to hit golf balls, swinging as they normally would. The ball was then hit into an indoor nylon net.

All participants were asked to use their own drivers (1 wood) for all measurements taken. The effect of the type of club used was an insignificant factor in the study, as each participant used the same club for all measurements taken, and in addition, participants were only compared to themselves and not to others within the same group.

All measurements of club head speed for every ball hit, with exception of the initial ten warm-up shots were recorded on a data-capturing sheet (Appendix H).

3.6 Statistical Analysis

The raw data was captured in text format (Appendix I), reformatted (Appendix J) and imported into the statistical programme “Statistica” (StatSoft, Inc. (2004). STATISTICA (data analysis software system), version 6. www.statsoft.com).

The analysis described in the following chapter was designed to compare the two groups (control and manipulation) on a dependant variable, club head speed, that is repeated over time (repeated measures design). The logic of the analysis was to assess whether the difference between the groups on these repeated measures was more than within the groups.

The following guidelines were used for results analysis:

- At the outset it was necessary to compare the control and manipulation groups on handicap and age.

- Following graphical representation in the form of histograms of the handicap and age distributions of the two groups, comparisons were made, by means of a t-test for unrelated groups, for the handicaps and ages of the control and manipulation groups showing the means of the ages and handicaps, standard deviations and significance of age and handicap between the groups.

- The club head speeds were described for all golf balls hit (total of 60 shots) both before and after the break (for control group) or manipulation (for manipulation group). In order to identify patterns in the repeated club head speeds for both the control and manipulation groups, the club head speeds were divided into two sets of 15 shots each before and after the break or manipulation. A further analysis, by means of a t-test for related groups, was then conducted in order to determine the significance in any pattern change within the groups.

- The Pearson Product Moment Correlation Coefficient was used to identify any linear relation between age and club head speed and handicap and club head speed, and ascertain the proportion of variation in club head speeds due to age and handicap.

- Given the strongly significant relation between handicap and club head speed and the statistically significant difference between the control and manipulation groups on handicap (as described in the following chapter), an Analysis of Covariance (ANCOVA) was performed in order to statistically remove the effect of handicap from the results of club head speed.

  Inclusion of additional factors can reduce the error of within group variability and increase the statistical power (sensitivity) of the design. This idea is extended to continuous variables and when such variables are included as factors in the design, they are called covariates (www.statsoft.com).

  When the covariate is affected by the between-groups factor, then it is appropriate to compute adjusted-means. These are the means that one would get after removing all differences that could be accounted for by the covariate.

- The effect of age on the results of the ANCOVA was analysed in order to determine the stability of the results of the effect of age on club head speeds on groups restricted on age.

CHAPTER FOUR – RESULTS

4.1 Group Descriptions

4.1.1 Description of the Groups According to Handicap

The following is the histogram (Figure 4-1) of the handicaps of all the participants in the research for both the control and manipulation groups.

The numbers on the Y axis of the two graphs indicate the number of participants of each group of 40 golfers with their respective handicaps corresponding to the values on the X axis of the graph. The percentages on the top of each of the bars indicate the corresponding percentages.

As the sample sizes of the control and manipulation groups are equal, these percentages are comparable for the two groups.

It is also important to understand handicap in golfing terms. A handicap of –8 is considered worse than a handicap of +3 which indicates the better golfer.

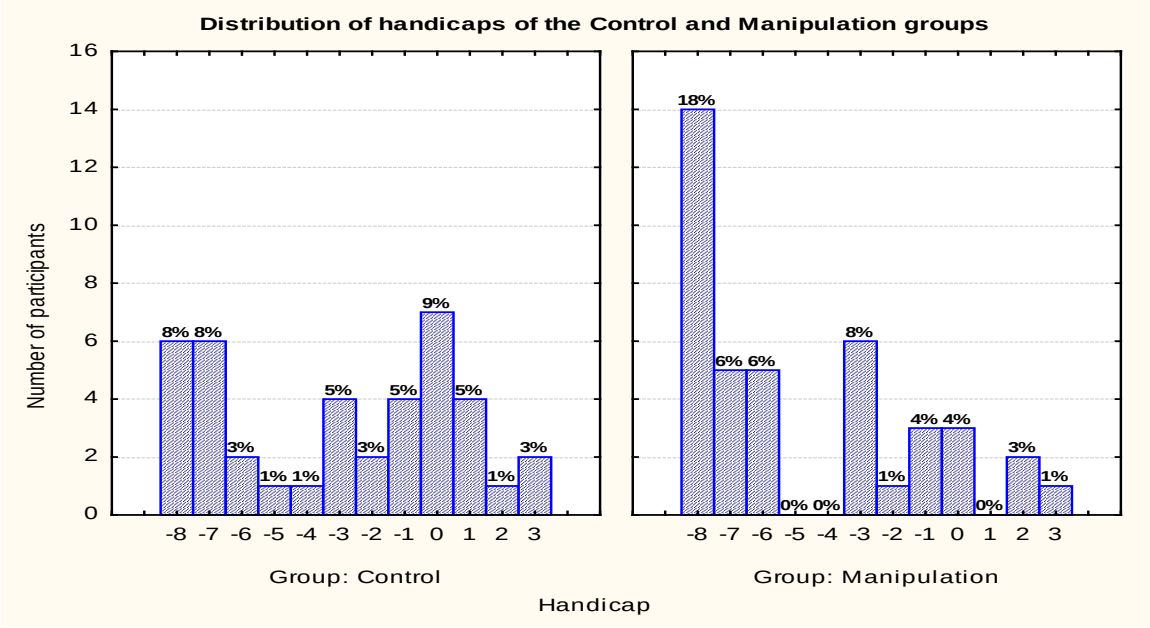


Figure 4-1: ***Histogram of Handicaps***

4.1.2 Description of the Groups According to Age

The following is the histogram (Figure 4-2) of the ages of all the participants in the research for both the control and manipulation groups.

The numbers on the Y axis of the two graphs indicate the number of participants of each group of 40 golfers with their respective ages corresponding to the values on the X axis of the graph. The percentages on the top of each of the bars indicate the corresponding percentages.

As the sample sizes of the control and manipulation groups are equal, these percentages are comparable for the two groups.

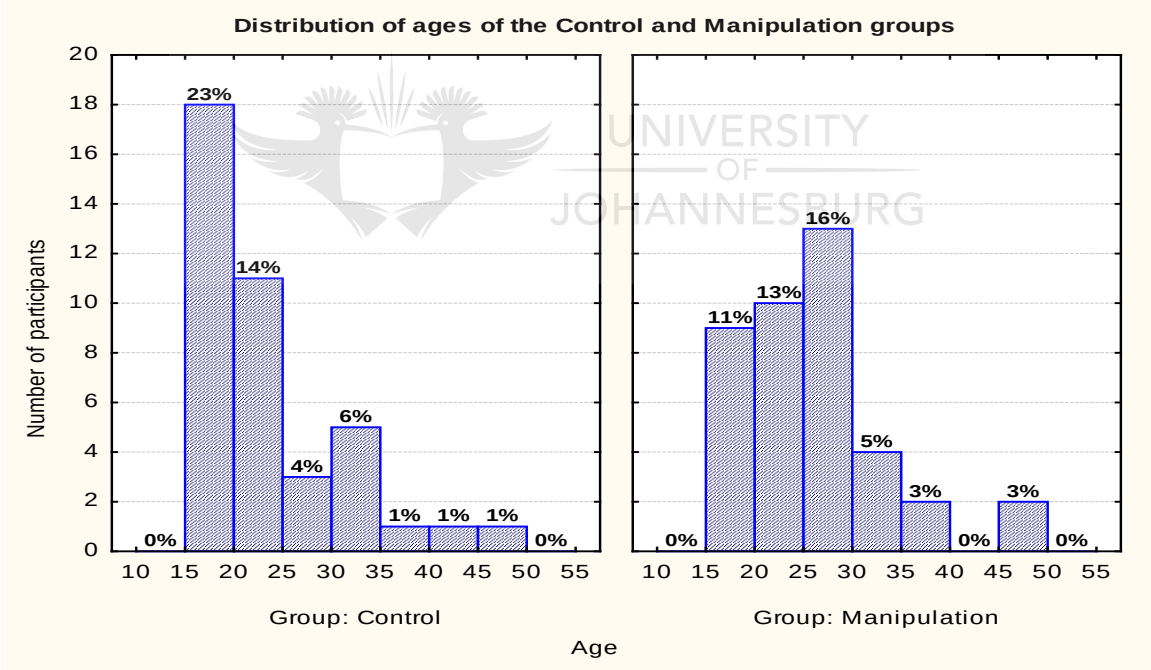


Figure 4-2: ***Histogram of Ages***

4.1.3 Comparison of the Control and Manipulation Groups on Handicap and Age

The result of comparing the control group and the manipulation group on age and handicap using the t-test analysis for unrelated groups, is detailed below:

Table 4-1: ***t-test Analysis for Unrelated Groups on Age and Handicap***

	Control		Manipulation				
	Mean	**Std Dev**	**Mean**	**Std Dev**	**t**	**P**	* P<0.05
Age	24.13	7.25	27.08	7.45	1.794	0.077	** P<0.01
Handicap	-2.98	3.62	-4.83	3.46	2.336	0.022*	*** P<0.001

Statistically, there is no significant difference between the ages of the two groups (t=1.794; df=78; p>0.05).

Statistically, there is a significant difference between the handicaps of the two groups (t=2.336; df=78; p<0.05) even though this difference of 2.95 strokes is not considered a meaningful one in golfing terms (see chapter three). The significant difference is due to the dominance of high negative handicaps in the manipulation group only (Figure 4-1).

4.2 Description of Club Head Speeds

4.2.1 Rationale for the Sets of 15 Golf Balls Hit

A graph of the 60 golf balls hit (30 before the break for the control group or manipulation for the manipulation group and 30 after the break or manipulation) for the two groups in relation to the club head speeds is detailed in Figure 4-3. All club head speeds were measured in miles per hour.

Figure 4-3 shows a general increasing trend in the measured club head speeds in the case of the manipulation group.

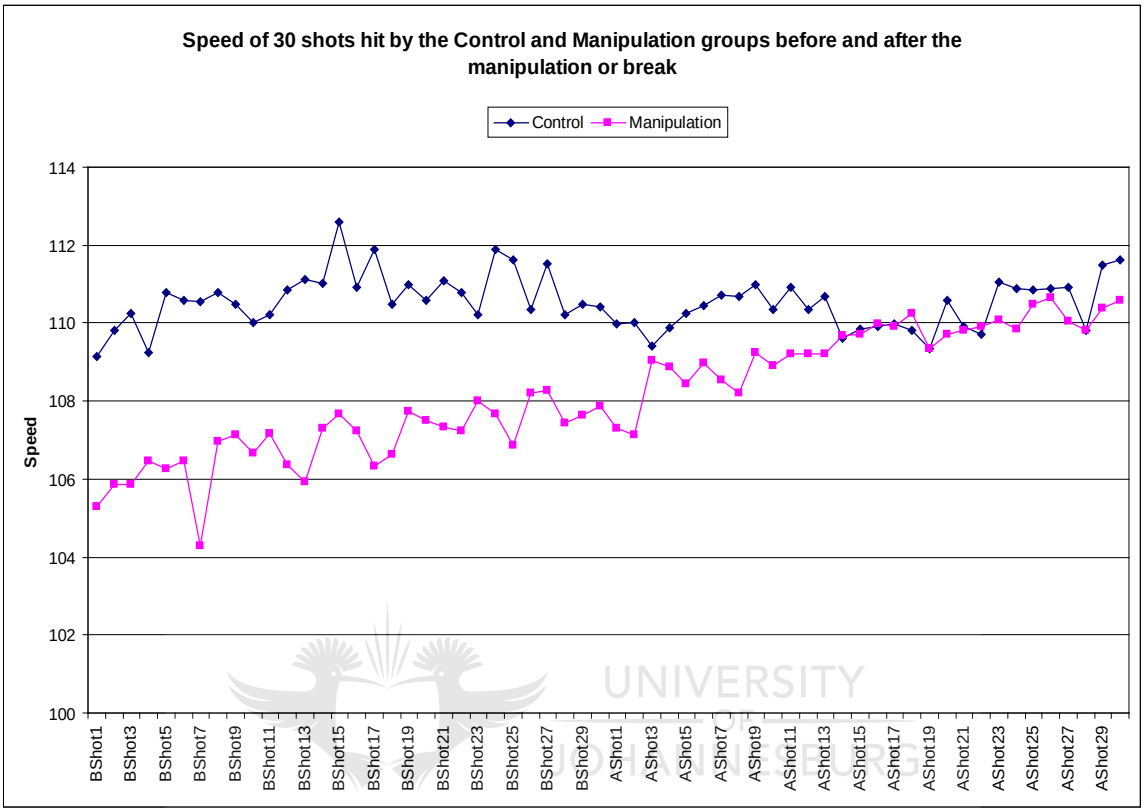


***Figure 4-3*: Pattern of Club Head Speeds for Both the Control and Manipulation Groups for all Golf Balls Hit Before and After the Break or Manipulation**

As a simple mean of the 30 golf balls hit (shots) before and the 30 shots after the break or manipulation would have hidden this trend, it was decided to split the 30 balls hit into two sets of 15 shots each for the remainder of the analysis.

4.2.2 Comparison of the Sets of 15 Golf Balls Hit within each of the Groups Before and After the Break or Manipulation

The club head speeds for both the control and manipulation groups were divided into two sets of 15 shots each before and after the break or manipulation for each of the groups respectively. The results of these t-tests for related groups are shown in Table 4-2.

Table 4-2: ***t-test Analyses for Related Groups Comparing the Club Head Speeds of each Set of 15 Shots Before and After the Break or Manipulation within the Control and Manipulation Groups***

		Before							
	Shot #	**Mean**	**Std.Dev.**	**N**	**Mean Diff.**	**Std.Dev Diff**	**t**	**df**	**p**
Shots 1_15	Manipulation	106.38	9.12						
	Control	107.47	9.56	40	-1.09	2.21	-3.10	39	0.00***
Shots 16_30	Manipulation	110.50	8.33						
	Control	110.90	8.25	40	-0.40	1.52	-1.66	39	0.10
		After							
	Shot #	**Mean**	**Std.Dev.**	**N**	**Mean Diff.**	**Std.Dev Diff**	**t**	**df**	**p**
Shots 1_15	Manipulation	108.78	9.34						
	Control	110.06	8.88	40	-1.27	1.26	-6.40	39	0.00***
Shots 16_30	Manipulation	110.28	7.63						
	Control	110.45	7.72	40	-0.18	1.30	-0.86	39	0.40

The results of the t-tests show that in the manipulation group there is a statistically significant change between the first and the second sets of 15 balls hit before and after the manipulation ($t=-3.10$; $df=39$; $p<0.001$ and $t=-6.40$; $df=39$; $p<0.001$ respectively), while in the control group there is no statistically significant change ($t=-1.66$; $df= 39$; $p>0.05$ and $t=-0.86$; $df=39$; $p>0.05$ respectively).

These results are illustrated in Figure 4-4.

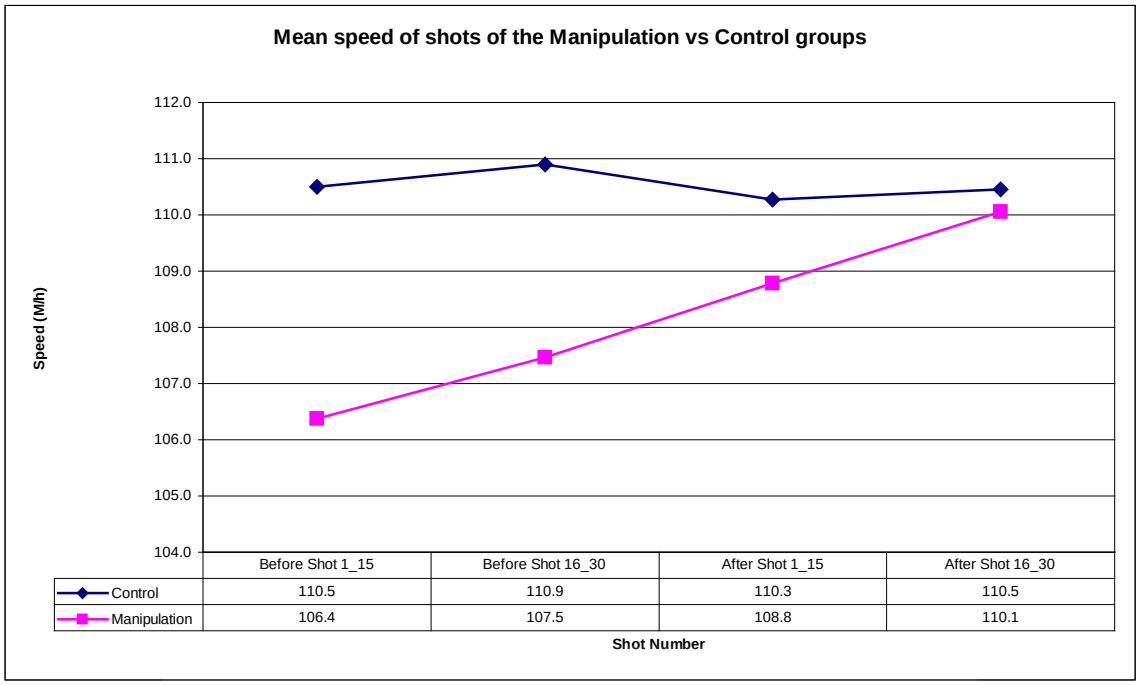


Figure 4-4: ***A Comparison Between the First 15 Shots to the Second 15 Shots for both Groups Before and After the Break or Manipulation***

4.2.3 Comparison of the Sets of 15 Golf Balls Hit between each of the Groups Before and After the Break or Manipulation

The results of the t-tests for unrelated groups, comparing the club head speeds of the control and manipulation groups on sets of 15 golf balls hit (shots) before and after the break or manipulation, are shown in table 4-3.

Table 4-3: ***t-test Analyses for Unrelated Groups Comparing the Club Head Speeds of each Set of 15 Shots Before and After the Break or Manipulation Between the Control and Manipulation Groups***

		Before							
	Shot #	**Mean**	**Std.Dev.**	**N**	**Mean Diff.**	**Std.Dev Diff**	**t**	**df**	**p**
Shots 1_15	Manipulation	106.38	9.12						
	Control	107.47	9.56	40	-1.09	2.21	2.11	78	0.038*
Shots 16_30	Manipulation	110.50	8.33						
	Control	110.90	8.25	40	-0.40	1.52	1.72	78	0.090
		After							
	Shot #	**Mean**	**Std.Dev.**	**N**	**Mean Diff.**	**Std.Dev Diff**	**t**	**df**	**p**
Shots 1_15	Manipulation	108.78	9.34						
	Control	110.06	8.88	40	-1.27	1.26	0.78	78	0.435
Shots 16_30	Manipulation	110.28	7.63						
	Control	110.45	7.72	40	-0.18	1.30	0.21	78	0.831

The results show that the only statistically significant difference between the control and manipulation groups lies in the difference of the means of club head speeds on the first set of 15 golf balls hit before the break or manipulation ($t=2.11$; $df=78$; $p<0.038$). This difference is illustrated in Figure 4-4.

4.3 Correlations Between Club Head Speed and Age and Handicap of Participating Golfers

4.3.1 Age and Club Head Speed

The Pearson Product Moment Correlation Coefficient was used to examine the linear relation between the age of the participating golfers and their club head speeds. Correlation between age and speed was performed for all 40 participants in each of the control and manipulation groups (80 participants in total) both before the break or manipulation (Figure 4-5) and after the break or manipulation (Figure 4-6).

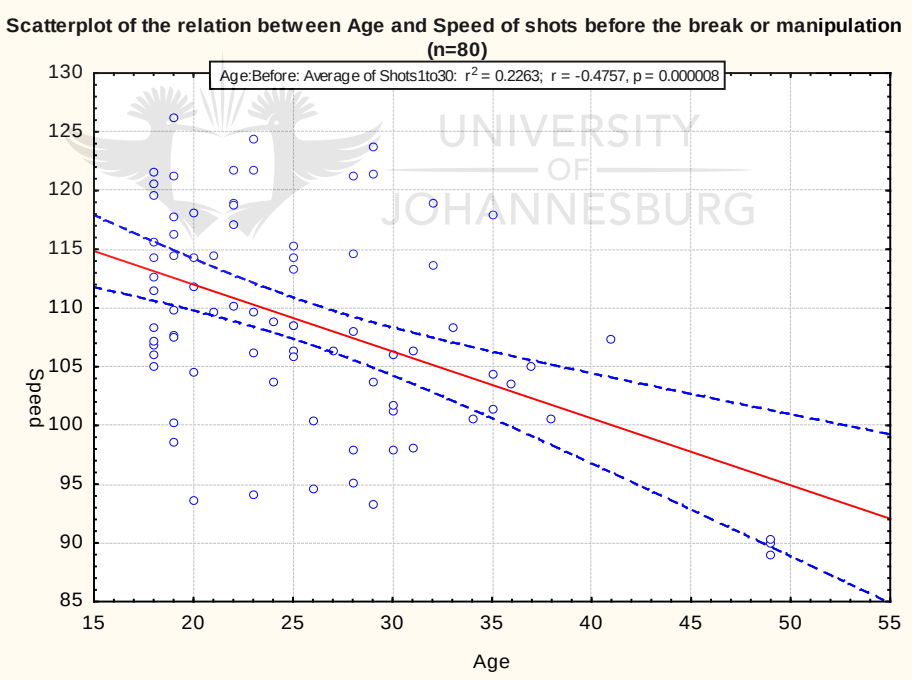


Figure 4-5: ***Scatterplot Showing the Relation Between Age of Participants and Club Head Speed Before the Break or Manipulation***

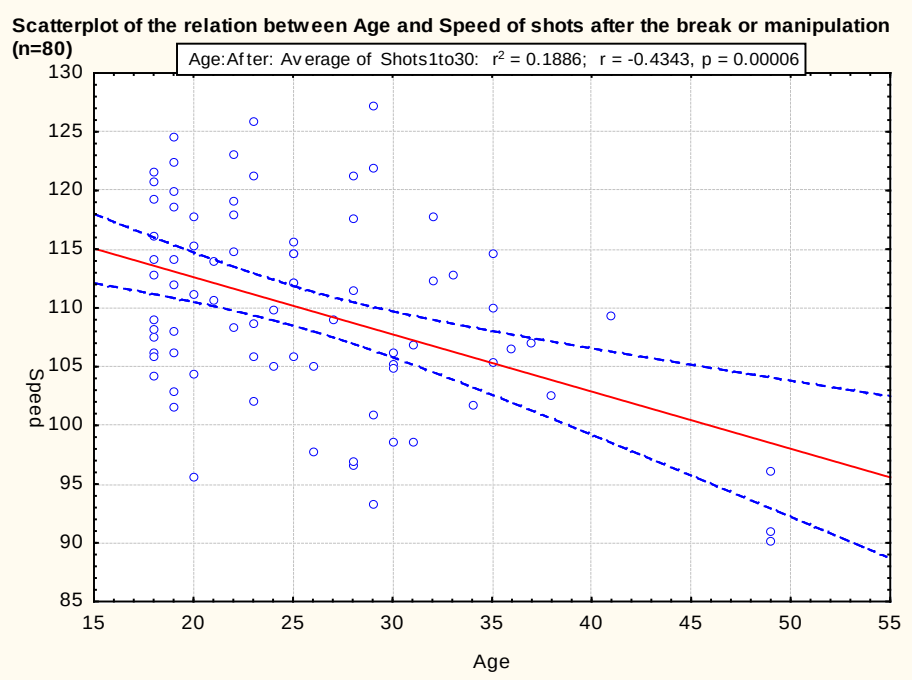


Figure 4-6: ***Scatterplot Showing the Relation Between Age of Participants and Club Head Speed After the Break or Manipulation***

Both scatterplots show a significant negative linear relation, shown in Figure 4-5, (r=-0.48; p<0.001) between age of participating golfers and their club head speeds recorded on the first set of 30 golf balls hit before the break or manipulation. This is partly due to the effect of the outliers in the data. If these outliers are removed, the correlation drops to (r=-0.30; p<0.01). It is therefore realistic to conclude that 9% of the variation in club head speeds is determined by the variation in age. The scatterplot (Figure 4-6) of the relation between the age of participating golfers and their club head speeds recorded on the second set of 30 shots after the break or manipulation shows a similar pattern.

4.3.2 Handicap and Club Head Speed

The Pearson Product Moment Correlation Coefficient was used to examine the linear relation between the handicaps of the participating golfers and their club head speeds. Correlation between handicap and club head speed was performed for all 40 participants in each of the control and manipulation groups

(80 participants in total) both before the break or manipulation (Figure 4-7) and after the break or manipulation (Figure 4-8).

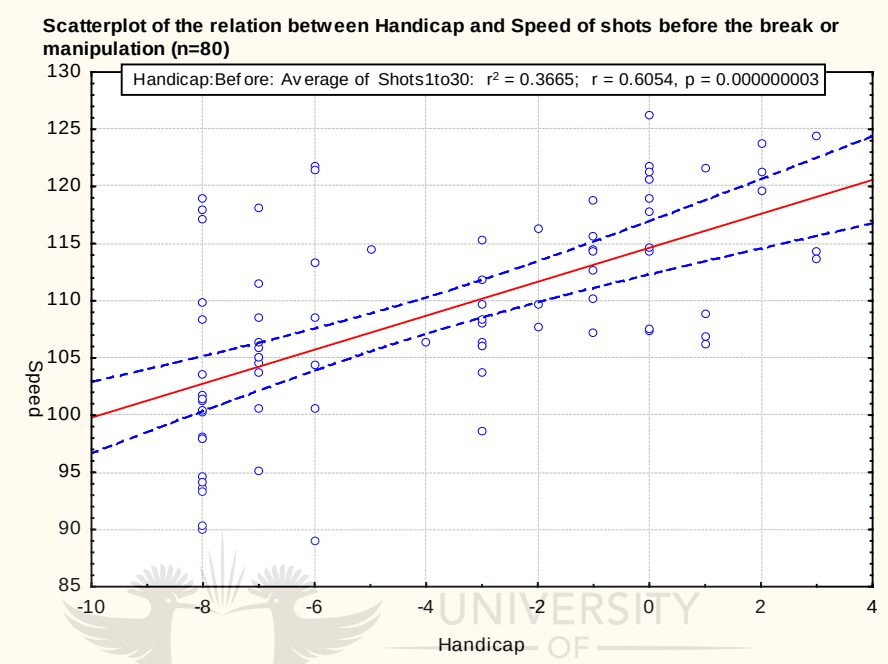


Figure 4-7: ***Scatterplot Showing the Relation Between Handicap of Participating Golfers and Club Head Speed Before the Break or Manipulation***

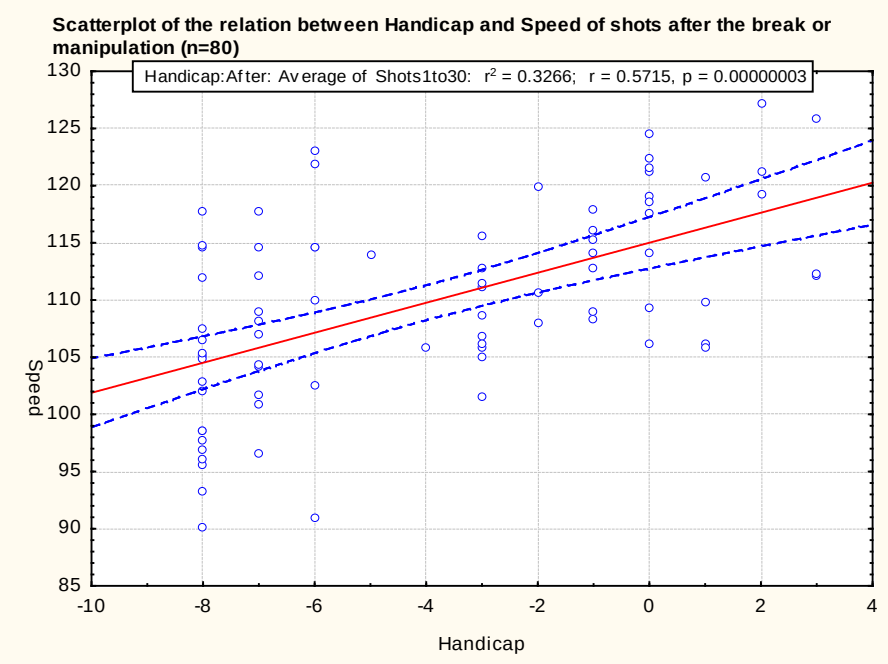


Figure 4-8: ***Scatterplot Showing the Relation Between Handicap of Participating Golfers and Club Head Speed After the Break or Manipulation***

The correlation between handicap and club head speed for the control and manipulation groups both before and after the manipulation or break, is highly significant as shown in Figures 4-7 and 4-8. The correlations of 0.61 and 0.57 and their respective coefficients of determination (r^2=0.37 and r^2=0.33) indicate that approximately one third of the variation in club head speeds is accounted for by the variation in handicaps.

4.4 Controlling for the Difference in Handicaps of the Control and Manipulation Groups

In view of the significant difference in handicaps between the control and manipulation groups (t=2.34; p<0.05) and the highly significant correlation between handicap and club head speeds, the effect of handicap on club head

speed was controlled (adjusted) by treating handicap as a covariate in the following Analysis of Covariance (ANCOVA).

The results of the Analysis of Covariance (ANCOVA) on club head speed means adjusted for handicap (Table 4-4) give a different pattern of means from those unadjusted for handicap.

Table 4-4: ***Results of the ANCOVA test Adjusted for Handicap***

Means adjusted for handicap covariate	Before the break/ manipulation		After the break/ manipulation	
	First set of 15 shots	Second set of 15 shots	First set of 15 shots	Second set of 15 shots
Control versus Manipulation Groups	F=0.864; p=0.35	F=0.143; p=0.71	F=0.416; p=0.52	F=1.8; p=0.18

The results of the ANCOVA test adjusted for handicap are illustrated in Figures 4-9 and 4-10.

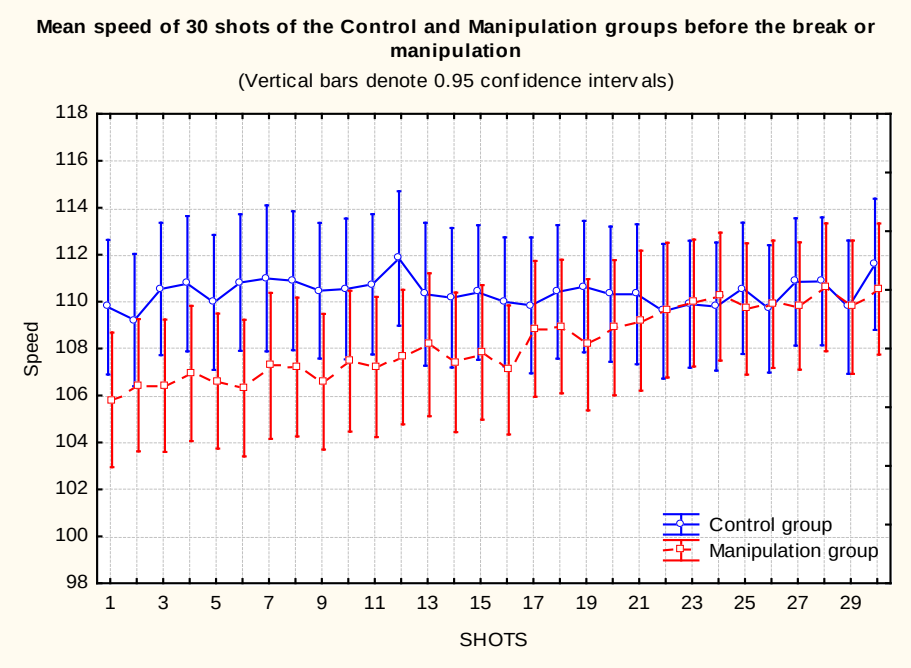


***Figure 4-9*: Means of Club Head Speeds for the Control and Manipulation Groups for All Golf Balls Hit Before the Break or Manipulation Adjusted for Handicaps**

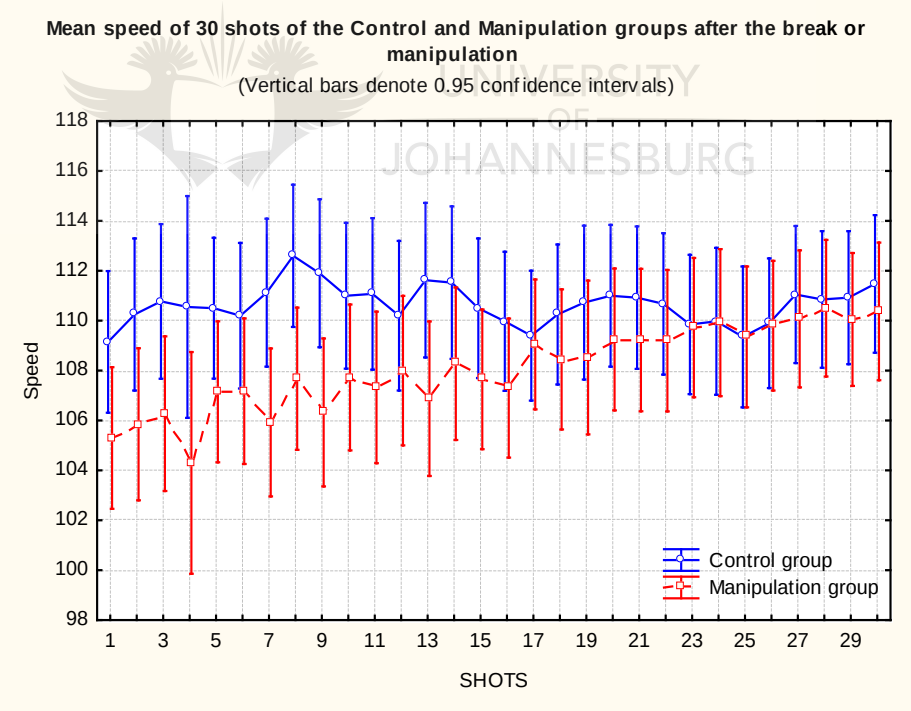


***Figure 4-10*: Means of Club Head Speeds for the Control and Manipulation Groups for All Golf Balls Hit After the Break or Manipulation Adjusted for Handicaps**

After the means have been adjusted for handicap, there are no statistically significant differences between the two groups on the first set of 15 golf balls hit and the second set of 15 golf balls hit before the break or manipulation took place, or between the first and second set of 15 golf balls hit after the break or manipulation took place.

However, the pattern of the change in means in club head speeds of the two groups is significantly different with the means of the control group remaining stable from the first to the second set of 15 golf balls hit before the break, while the means of the manipulation group increased slightly before the manipulation took place (Figure 4-11). This difference in pattern was the same for the first and second sets of 15 golf balls hit after the break or manipulation as seen in Figure 4-12 (F=37.275; df=1; 77; p<0.001; F=19; df=1; 77; p<0.001).

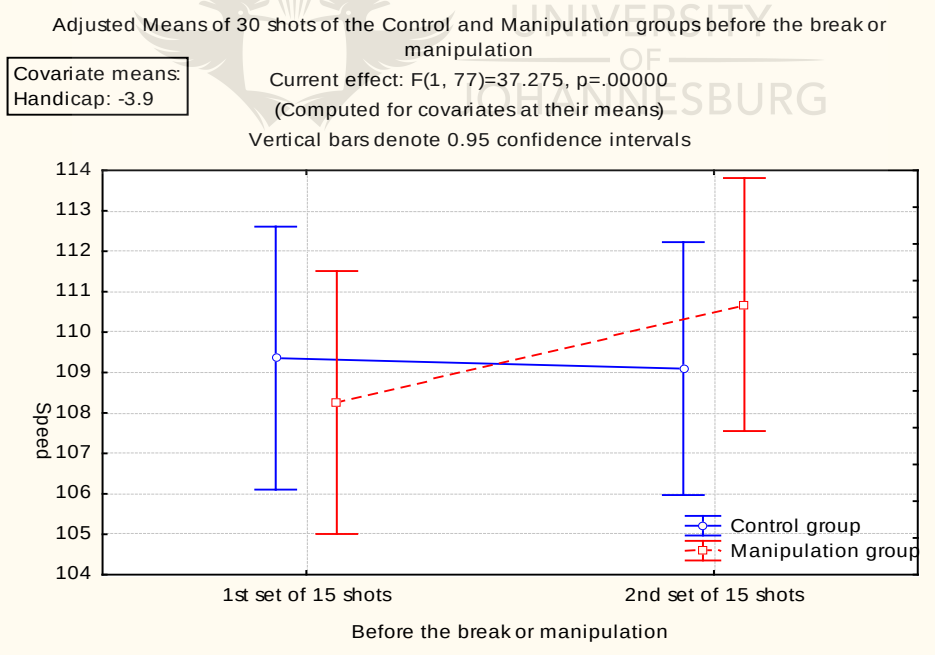


***Figure 4-11*: Pattern Differences in the Club Head Speed Means Between the Control and Manipulation Groups Before the Break or Manipulation Adjusted for Handicaps**

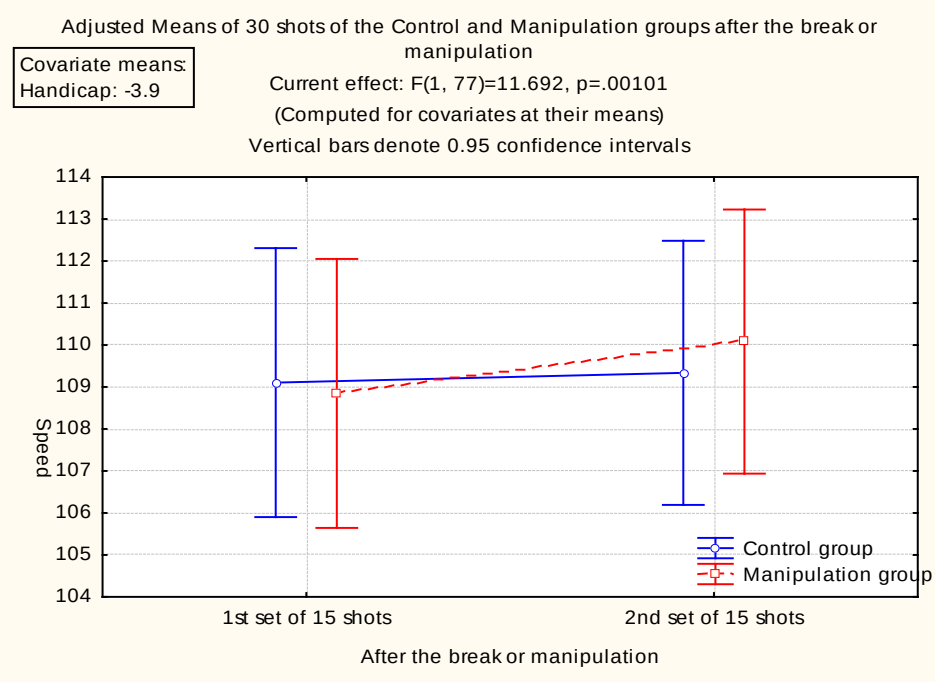


***Figure 4-12**: Pattern Differences in the Club Head Speed Means Between the Control and Manipulation Groups After the Break or Manipulation Adjusted for Handicaps*

4.5 The Effect of Age on the ANCOVA Results on Club Head Speeds Adjusted for Handicap

The effect of age on the ANCOVA results on club head speeds can be considered after the effect of handicap is removed by examining the stability of the results on the control and manipulation groups restricted on age.

The approach in the analysis was first to remove the effect of the handicap through Analysis of Covariance (section 4.4) regarding handicap as a covariate, and secondly, by analyzing if the results of the Analysis of Covariance (ANCOVA) still hold for groups restricted on age.

Although the two groups do not differ significantly on age (t=1.794; p>0.05), age is significantly though weakly correlated with club head speed (r=-0.3; p<0.05). It is therefore necessary to examine the effect of age on the ANCOVA results (with the effect of handicap removed).

The approach used is to re-analyse the data on the two groups (control and manipulation) restricted on age – the participating golfers younger than 36 years of age and those younger than 30 years of age respectively – and then compare these results with those obtained on the full sample of golfers of all ages. Lack of stability in the pattern and significance of the results across these age groups would indicate the need to consider age in interpreting the results (see also Appendix K).

Table 4-5: ***Comparison Between Club Head Speeds of Sets of 15 Shots Before and After the Break or Manipulation with the Effect of Handicap Removed: Control and Manipulation Groups Restricted on Age***

	Control versus Manipulation Groups Before the break / manipulation		**Control versus Manipulation Groups After the break / manipulation**	
	First set of 15 shots	Second set of 15 shots	First set of 15 shots	Second set of 15 shots
Full sample ages 18-49 years (n=80)	F=0.864; p=0.35	F=0.143; p=0.71	F=0.416; p=0.52	F=1.8; p=0.18
Restricted sample ages 18-36 (n=73)	F=1.576; p=0.21	F=0.37; p=0.54	F=0.31; p=0.58	F=1.26; p=0.26
Restricted sample ages 18-30 (n=60)	F=0.237; p=0.63	F=0.031; p=0.86	F=1.137; p=0.29	**F=2.751; p=0.10**

According to the tabulated results (Table 4-4), no statistically significant differences in club head speeds are evident between the first and second sets of 15 balls hit (shots) for either group neither before nor after the break or manipulation. However, in the case of the 60 golfers under 30 years of age, the difference in club head speeds between the control and the manipulation groups on the second set of 15 golf balls hit after the manipulation, approaches the 10% level of significance in the manipulation group (F=2.751; p=0.10).

CHAPTER FIVE – DISCUSSION

5.1 Introduction

This chapter discusses the various results obtained from chapter four in relation to the hypothesis proposed. Results which may be statistically significant are highlighted, and possible explanations are provided to explain such results as well as the implications thereof.

5.2 Descriptive Data

The objective of the study was to assess two groups of comparable golfers, one of which would receive chiropractic spinal manipulation, and the other would not.

5.2.1 Handicap

For inclusion into the research, participants had to have a handicap in golf of 8 or less. Sub-8 handicap golfers were chosen for the sake of golf swing consistency.

Although it was never intended for the groups to differ significantly on age or handicap, the groups did differ significantly on handicap ($P<0.05$). The magnitude of this difference, a mere 2.95 strokes, was not a meaningful one in golfing terms. This meaningfulness is deduced by the way in which handicap is worked out (see chapter three). Figure 4-1 shows the histogram of handicaps comparing the two groups, and shows that there is a significantly higher number of –8 handicap golfers in the manipulation group as compared to the control group.

Nevertheless, handicap needed to be taken into account so that the results of the study could not be attributed to handicap.

5.2.2 Age

For inclusion into the research, participants had to be between the ages of 18 years and 50 years. Statistically, the two groups did not differ significantly on age ($P>0.05$).

5.3 Club Head Speed

According to Blanchard (2002), club head speed is required in order to compress the golf ball against the club face. The more you compress the golf ball, the more potential the ball has to travel further (18).

All club head speed readings were measured in miles per hour using the "SwingMate" electronic detector.

Every participant hit 60 golf balls (30 before the break for the control group or manipulation for the manipulation group and 30 after the break or manipulation). As indicated by Figure 4-3, there was a general increasing trend in the club head speeds of participants in the manipulation group. It was for this reason that it was decided to split each of the two sets of 30 golf balls hit into four sets of 15 golf balls hit (two sets before and two sets after a break or manipulation).

The results showed that there was a statistically significant change (increase in club head speed) between the first set of 15 golf balls hit and the second set of 15 golf balls hit before and after the manipulation ($P<0.001$). The control group showed no such statistically significant changes neither before nor after the break or rest period ($P>0.05$).

5.4 Factors that Affected the Trends in Club Head Speeds of the Control and Manipulation Groups

Figure 4-4 illustrates the trends between the control group and the manipulation group on club head speeds. Analysis of this graph showed the following:

The means of the club head speeds for all participants in the control and manipulation groups have been plotted at intervals of 15 shots hit. The significant difference in the means between the control group (110.5 Mph) and the manipulation group (106.4 Mph) on the first 15 golf balls hit before the break or manipulation may be ascribed to the difference between the two groups on handicap (Table 4-3). It would be logical to consider that the better golfers (those with lower handicaps), as seen in the control group, produce a higher club head speed. This assumption was confirmed and was illustrated in Figure 4-7 and Figure 4-8. There was a positive linear correlation between handicap and club head speed. In other words, participants with lower handicaps, showed higher club head speeds.

The means of the club head speeds of the second 15 golf balls hit for all participants in both the control and manipulation groups before the break or manipulation were plotted. For both the control group and the manipulation group, an increase in the means of the club head speeds occurred. The increase that took place occurred to different extents between the two groups. The control group increased from 110.5 Mph to 110.9 Mph. The manipulation group increased from 106.4 Mph to 107.5 Mph. The increase in the manipulation group was statistically significant ($P<0.001$), whereas the increase that took place in the control group was statistically insignificant ($P>0.05$). This again may be attributed to the difference between the two groups on handicap. Since the control group consisted of lower handicap golfers, and lower handicap golfers are considered to have more consistent swings, it would be expected that the increase would not be as significant as in the manipulation group.

Higher handicap amateur golfers lack the organized muscle firing patterns characteristic of lower handicap and professional golfers. Lower handicap golfers have a swing that is virtually the same every time. This is indicative of refinement, countless repetitions, and co-ordinated muscle firing (14).

The increase that took place in the manipulation group is statistically significant ($P<0.001$). Since the manipulation group consisted of higher handicap golfers, and higher handicap golfers are considered less consistent in producing the same or similar swing, a logical explanation would be that as these golfers repeated the swings, there was a tendency for them to improve, and therefore the club head speeds increased.

Another factor that must be considered is a psychological factor. Participants were told whether they were in the control or manipulation (experimental) group. This factor may have played a part in producing the statistically significant difference ($P<0.001$) that occurred between the two groups on the second set of 15 golf balls hit before any intervention, whether rest or manipulation, and possibly even after the manipulation. Participants in the manipulation group may have had a pre-determined expectation that an increase in the club head speed was expected, and therefore they attempted to strike harder at the ball.

The volunteer subject seems to have a vested interest in the successful outcome of the experiment. The mere act of volunteering is an implicit commitment to comply with whatever demands are inherent in the experimental situation. Inasmuch as volunteer subjects are generally concerned about the outcome of the experiment, they will be intrinsically motivated to play the role of ”the good subject” who responds to overt and implicit cues in ways designed to validate the experimenter’s hypothesis (40).

The means of the club head speeds for the first 15 golf balls hit after intervention, whether rest or manipulation, were plotted for the control group (110.3 Mph) and the manipulation group (108.8 Mph). This shows that the means of the participants in the control group after the break or rest had decreased slightly, whereas the means of participants in the manipulation group had increased.

The means of the club head speeds of the second 15 golf balls hit after intervention, whether rest or manipulation, for both the control and manipulation groups was plotted. The control group showed no statistically significant change ($P>0.05$) from a mean of 110.3 Mph to a mean of 110.5 Mph, whereas the manipulation group showed a statistically significant difference ($P<0.038$), with a continuing increase in the means of club head speeds from 107.5 Mph to 108.8 Mph and from 108.8 Mph to 110.1 Mph.

This pattern is assumed to be attributed to two factors. The first factor is that the effects of chiropractic spinal manipulation of the thoracic spine, lumbar spine and sacroiliac joints, being mechanical, reflexogenic and neurological in nature, as proposed in the main hypothesis, play an important factor in improving club head speed as seen in the manipulation group. The second factor to consider would be the effects of fatigue on those subjects in the control group who did not receive chiropractic spinal manipulation.

Amateur golfers achieve approximately 90% of their peak muscular activity when driving a golf ball. This is the same intensity as picking up a weight that can only be lifted four times before total fatigue (5).

Another explanation to fatigue of participants in the control group relates to myofascial trigger points. The effects of manipulation (as described in chapter two) are such that there may be resolution of trigger points in muscles that are associated with the golf swing and that have a direct response to manipulation by virtue of the stretch and golgi tendon organ reflex responses.

Travell and Simons (1999) state that the averaged amplitude and mean power frequency of an electromyographic recording from a muscle with trigger points starts as if the muscle is already fatigued, and the muscle reaches exhaustion more quickly and is slower to recover than a muscle without trigger points. These changes are accompanied by accelerated fatigue and weakness of the muscle with trigger points (29).

Guyton (1997) includes that transmission of the nerve signal through the neuromuscular junction can occasionally diminish following prolonged muscle activity, thus further diminishing muscle contraction (35).

The neurological effects of manipulation (as described in chapter two) may therefore presumably be a means of restoring the nerve signals at the neuromuscular junction and therefore prevent fatigue of those participants in the manipulation group.

5.5 The Effect of Handicap on Club Head Speed

A positive linear relation between handicap and club head speed was evident. Figures 4-7 and 4-8 illustrate that the lower handicap participants show higher club head speeds. As mentioned previously, this pattern may be ascribed to consistency of the golf swing.

Since there was a statistically significant difference between the control and manipulation groups on handicap ($P<0.001$), the club head speed means were examined by way of Analysis of Covariance (ANCOVA), adjusting the means of the handicaps for both groups. Stated differently, the groups are equated statistically on handicap via this analysis.

The results proved that the pattern of changes that took place for both the control group and the manipulation group on both sets of 15 golf balls hit both before and after any form of intervention, whether rest or manipulation, though statistically insignificant, is similar to the trends previously described. The control group's club head speed means remains relatively constant, while the club head speed means of the manipulation group increase slightly. These patterns are seen in Figures 4-11 and 4-12. It is this very difference in the patterns that suggests that spinal manipulation may be indicated to increase club head speed although this possibility requires further explorations as will be discussed.

5.6 The Effect of Age on the Results of the Analysis

Figures 4-5 and 4-6 illustrate that there was a negative linear relation between age and club head speed. The relation indicates that there is a decrease in club head speed with an increase in age of participants. One factor to consider in terms of age and club head speed is muscular and joint flexibility due to age.

Muscular flexibility and flexibility of the spinal facet joints are evident in the golf swing by virtue of the degree of trunk rotation that takes place.

Trunk rotation, associated with the arc of the golf swing, allows for the build up of club head speed and therefore increased distance of ball travel. Previous research had found that the most noticeable cinematographic differences between professional and amateur golfers was found to be in the degree of trunk rotation. These researchers also reported that older and less skilled golfers had less than half of the trunk rotation of younger and more skilled golfers (4).

It is therefore possible that a study based on younger golfers only – say those under 36 or under 30 years of age would have produced a different outcome. Thus the analysis was repeated on two groups restricted on age.

The first analysis was restricted to 18-36 year olds, and the second analysis was restricted to 18-30 year olds.

The effect of age on club head speed was considered after the handicap means of the two groups was adjusted. It was found that there was no statistical significance (P>0.05) of age on club head speed for either the control or the manipulation groups, however, there was a move towards significance (significance level approached 10%) in golfers under the age of 30 years in the manipulation group (Table 4-5). This suggests a possible positive effect of chiropractic spinal manipulation on club head speed in younger golfers with increasing number of golf balls hit.

CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The purpose of the study was to determine the effects of chiropractic spinal manipulation on club head speeds of asymptomatic amateur golfers. This was achieved by objectively measuring club head speeds of the participants, repeated before and after a break or rest period for participants in the control group, and manipulation of the restricted thoracic spine and lumbar spine facet joints as well as the sacroiliac articulations, for participants in the manipulation group.

The results showed, and therefore there is evidence to suggest, that chiropractic spinal manipulation by virtue of mechanical, reflexogenic and neurological effects, may have an effect on club head speeds in asymptomatic amateur golfers in the short-term. However, there are factors that need to be considered before this is completely conclusive. Such factors include psychological factors that may have influenced the results and the effect of handicap on club head speed. Due to the statistically significant difference in handicaps between the control and manipulation groups, the means of the club head speed measurements were adjusted for the handicap means. There was a distinct change of the results from a level of statistical significance to a level in which there was no statistical significance. It is thus conclusive to say that handicap was an important variable to consider.

The results also suggested that the younger (under 30 years), asymptomatic golfers within the manipulation group would benefit most from chiropractic spinal manipulation to achieve increased club head speeds.

6.2 Recommendations

Validation and improvements to the initial results of this trial may be achieved through the following recommendations:

- The research may be repeated using a sample group limited to a narrower and lower handicap. For example, using handicaps of –2 to +2.

- The research may be repeated with a sample group limited to a younger age group. For example, using golfers between the ages of 18 years and 30 years.

- The research may be repeated using a smaller number of golf balls hit for both sets, before and after rest or manipulation, so as to reduce the effects of fatigue.

- The same study could be performed using the same participants for both the control and the manipulation group, assessing them on two separate occasions, with a short time-lag between the two assessments, such that on one day, all measurements are taken for control readings, and three days later, measurements are taken for those same participants for manipulation readings.

- The study could be repeated using additional treatments, not just a once-off trial. This may aid in identifying the long-term effects of chiropractic spinal manipulation on club head speeds.

- A comparative study between symptomatic and asymptomatic subjects could provide more information with regards to the effects of chiropractic spinal manipulation between two different groups of participants.

- A group of female golfers could be included into a similar trial, and responses to chiropractic treatment between male and female golfers could be compared.

- The addition of cervical spine manipulation could be introduced into the study to determine not only the effects of thoracic, lumbar and sacroiliac joint manipulation on club head speeds, but also that of cervical spine. This may be introduced as a comparison between regions.

- A sham technique may be introduced for the control group as a placebo, so as to eliminate any psychological expectancies that participants may have with regards to the results.

- Randomized selection of participants into control and manipulation groups may also aid in eliminating any psychological factors that may influence the results.

- In order to effectively measure driving distances objectively rather than simply using an objective measurement of club head speeds, it would be ideal to change the setting for such a trial, such that the trial would be performed on a proper golf driving range with a demarcated hitting area, allowing for true measurement of distance, as direction could be properly considered.

- The golf equipment used in a study of this nature could be standardized such that all participants use the same make of equipment including both the golf club and golf ball.

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APPENDIX A

SUBJECT INFORMATION AND CONSENT FORM

THE EFFECTS OF CHIROPRACTIC SPINAL MANIPULATION ON DRIVER CLUB HEAD SPEEDS OF ASYMPTOMATIC AMATEUR GOLFERS

Dear participant

The purpose of this study is to determine the effect of spinal manipulation on the distance that a golfer can hit the ball. This will involve the application of a manipulative thrust, which will be performed on the thoracic, lumbar and sacroiliac joints.

The possible benefits are to determine the effectiveness of chiropractic in increasing the efficiency of the golf swing to produce longer drives.

As the participant, you may experience some post-treatment discomfort, which is a normal occurrence in some people, but it should only last a day or two.

Participation in the study is voluntary and you, as the participant, are free to refuse to participate or to withdraw your consent and to discontinue participation at any time.

A signed copy of this consent form will be made available to you.

I, the researcher, have fully explained the procedures, identifying those, which are investigational, and have explained their purpose. I have asked whether any questions have arisen regarding the procedures and have answered these questions to the best of my ability.

Date:_____ Researcher:_____

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

Date:_____ Participant:_____

Or Guardian / Next of Kin:_____

APPENDIX B

PARTICIPANT HISTORY AND INFORMATION

Participant's name: _____

Participant's age: _____

Participant's handicap: _____

Participant's course of membership: _____

Past History:

Any incidence of back pain? _____

When? _____

Location? _____

Duration? _____

Treatment? _____

Outcome? _____

Any accidents or injuries to the spine? _____

When? _____

Location? _____

Treatment? _____

Outcome? _____

Any surgery? _____

Any current medication? _____

Any allergies? _____

Any recent blood tests? _____

Any recent radiographic examinations? _____

Lifestyle habits? _____

Family History:

Diabetes

Heart disease

TB

Hypertension

Stroke

Kidney disease

CA

Arthritides

Anaemia

Headaches

Thyroid disease

Epilepsy

Review of systems:

Skin _____

Head _____

Eyes _____

Ears _____

Nose / Sinuses _____

Mouth / Throat _____

Neck _____

Respiratory _____

Cardiac _____

Gastro-intestinal _____

Genito-urinary _____

Vascular _____

Musculoskeletal _____

Neurologic _____

Haematological _____

Endocrine _____

APPENDIX C

PERTINENT PHYSICAL EXAMINATION

Student Name: _____ **Signature: _____**

Doctor Name: _____ **Signature: _____**

Patient Information

Name: _____ Occupation: _____

Age: _____ Sex: _____

_____

Vitals:

Height_____ Weight_____

Pulse rate_____ Respiratory rate_____

Blood pressure_____

	Inspection	**Palpation**	**Percussion**	**Auscultation**
Thorax				
Abdomen				

	Inspection	**Palpation**	**Percussion**	**Auscultation**
	Cranial Nerves	**Motor System**	**Sensory System**	**Cerebellar Signs**
Neurological System				

APPENDIX D

THORACIC SPINE REGIONAL EXAMINATION

Date: _____

Patient: _____

Intern: _____ Signature: _____

Clinician: _____ Signature: _____

(1) Observation

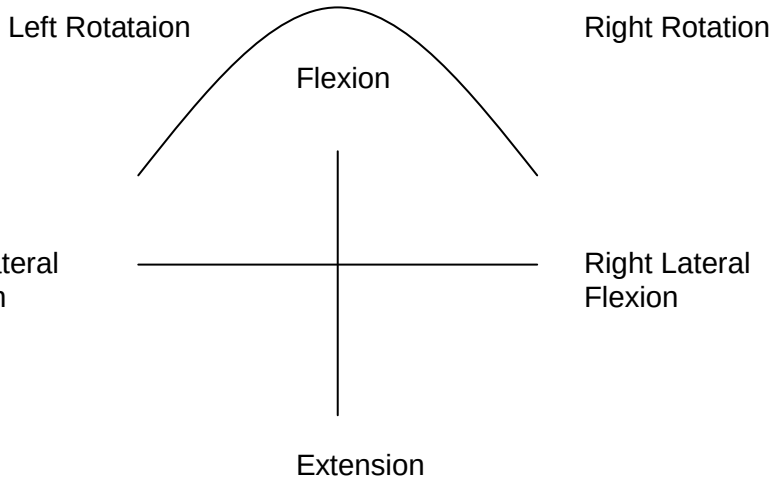
(a) Posture

- Kyphosis
- Scoliosis**:** Adam's position
- Chest deformities
- Scapular winging

(2) Examination

(a) Range of motion

- Forward flexion: 20°-45°
- Extension: 25°-45°
- L/R Lateral flexion: 20°-40°
- L/R Rotation: 35°-50°



(b) Neurological Evaluation

Dermatomes	Left	Right	Myotomes	Left	Right	Reflexes	Left	Right
T1			Finger Abduction T1			Abdominal upper T8,9,10		
T2			Finger Adduction T1			Abdominal lower T10,11,12		
T3								
T4								
T5								
T6								
T7								
T8								
T9								
T10								
T11								
T12								

(c) Special tests

- Slump test (sitting dural stretch test)
- First thoracic nerve root stretch
- Passive scapular approximation
- Kemp's test
- Facet joint challenge

(d) Motion Palpation

Left					Right			
Flex	Ext	Lat flex	Rot		Flex	Ext	Lat flex	Rot
				T1				
				T2				
				T3				
				T4				
				T5				
				T6				
				T7				
				T8				
				T9				
				T10				
				T11				
				T12				

APPENDIX E

TECHNIKON WITWATERSRAND
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Date: _____

Patient: _____ **File No:**_____

Clinician: _____ **Signature**:_____

Intern: _____ **Signature:**_____

STANDING

1. BODY TYPE
2. POSTURE
3. OBSERVATION:-

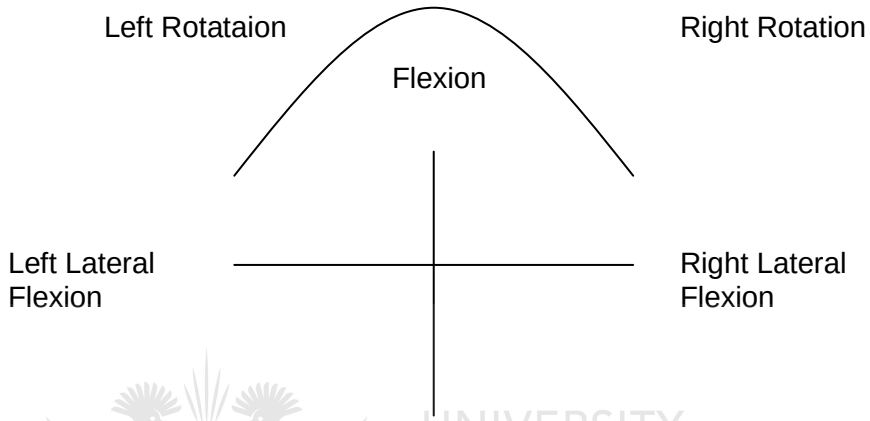
    - Muscle Tone
    - Bony + Soft Tissue Contours
    - Skin
    - Scars
    - Discolouration
    - Step deformity

4. SPECIAL TESTS

    - Schober's Test
    - Spinous Percussion
    - Treadmill
    - Minor's Sign
    - Quick Test
    - Trendelenburg Test

5. RANGE OF MOTION

Forward flexion	=	40° - 60° (15cm from floor)
Extension	=	55° - 70°
L/R Rotation	=	70° - 90°
L/R Lateral flexion	=	20° - 45°



/ = pain-free limitation // = painful limitation

6. GAIT

- Rhythm, pendulousness
- On Toes (S1)
- On Heels (L4,5)
- Half Squat on one leg (L2,3,4)
- Tandem Walking

7. MOTION PALPATION – sacroiliac joints

SITTING

1. SPECIAL TESTS

- Tripod Test
- Kemp's Test
- Valsalva Manoeuvre

2. MOTION PALPATION

Joint play			Left						Right			Joint play		
P/A	Lat	Fle	Ext	LF	AR	PR		Fle	Ext	LF	AR	PR	P/A	Lat
							T10							
							T11							
							T12							
							L1							
							L2							
							L3							
							L4							
							L5							
					U	L	S1	U	L					

SUPINE

1. OBSERVATION

    - Hair, Skin, Nails
    - Fasciculations

2. PULSES

    - Femoral
    - Popliteal
    - Dorsalis Pedis
    - Posterior Tibial

3. MUSCLE CIRCUMFERENCE

	LEFT	**RIGHT**
THIGH	cm	cm
CALF	cm	cm

4. LEG LENGTH

	LEFT	**RIGHT**
ACTUAL	cm	cm
APPARENT	cm	cm

5. ABDOMINAL EXAMINATION

- Observation
- Abdominal Reflexes
- Auscultation Abdomen and Groin
- Palpation Abdomen and Groin

Comments: _____

_____

_____

_____

6. NEUROLOGICAL EXAMINATION

Dermatomes	Left	Right	Myotomes	Left	Right	Reflexes	Left	Right
T12			Hip Flexion (L1/L2)			Patellar (L3,4)		
L1			Knee Extension (L2,3,4)			Medial Hamstring (L5)		
L2			Knee Flexion (L5/S1)			Lateral Hamstring (S1)		
L3			Hip Int. Rot (L4/L5)			Tibialis Posterior L4,5)		
L4			Hip Ext. Rot (L5/S1)			Achilles (S1/S2)		
L5			Hip Adduction (L2,3,4)			Plantar Reflex		
S1			Hip Abduction (L4/L5)					
S2			Ankle Dorsiflexion (L4/L5)					
S3			Hallux Extension (L5)					
			Ankle Plantar Flexion (S1/S2)					
			Eversion (S1)					
			Inversion (L4)					
			Hip Extension (L5/S1)					

7. SPECIAL TESTS

- SLR
- WLR
- Braggard's
- Bowstring
- Sciatic Notch Pressure
- Sign of the Buttock
- Bilateral SLR
- Patrick's FABER
- Gaenslen's Test
- Gapping Test
- "Squish" Test
- Gluteus Maximus Stretch
- Thomas' Test
- Rectus Femoris Contracture Test
- Hip Medial Rotation
- Psoas Test

LATERAL RECUMBENT

- Sacroiliac Compression
- Ober's Test
- Femoral Nerve Stretch Test
- Myotomes:
  - Quadratus Lumborum Strength
  - Gluteus Medius Strength

PRONE

- Facet Joint Challenge
- Myofascial Trigger Points
    * Quadratus Lumborum
    * Gluteus Medius
    * Gluteus Maximus
    * Piriformis
    * Tensor Fascia Lata
    * Hamstrings
- Skin Rolling
- Erichsen's Test
- Sacroiliac Tenderness
- Pheasant's Test
- Gluteal Skyline
- Myotomes:
    * Gluteus Maximus Strength

NON-ORGANIC SIGNS

- Pin-point pain
- Axial Compression
- Trunk Rotation
- Burn's Bench Test
- Flip Test
- Hoover's Test
- Ankle Dorsiflexion Test
- Pin-point pain

APPENDIX F

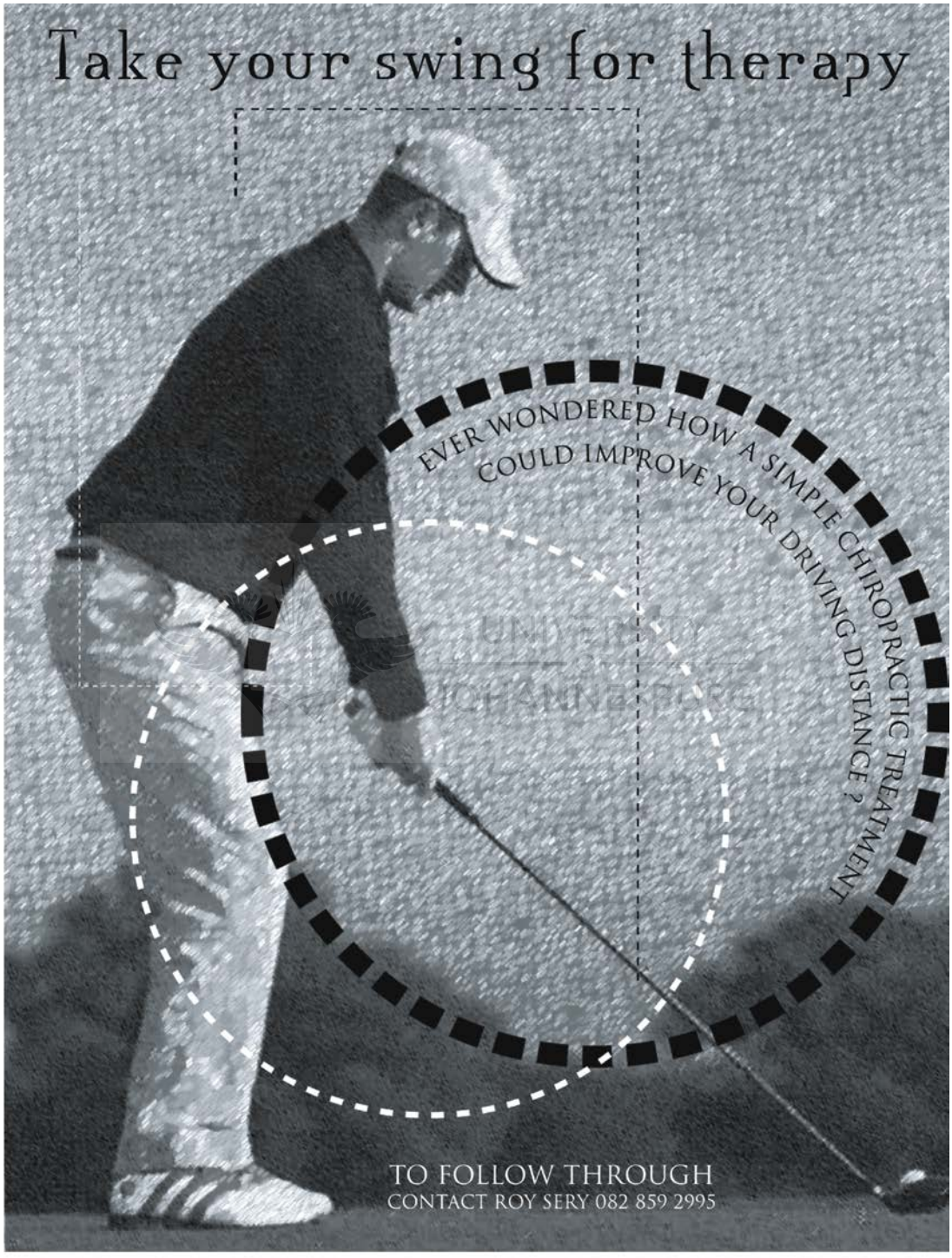
CONTRA-INDICATIONS TO MANIPULATION

Gatterman, M.I. (1990) Chiropractic Management of Spine Related Disorders, 1st edition, Williams and Wilkins, pp. 67, 68 (39).

1. Vascular complications
    - Atherosclerosis of major blood vessels
    - Abdominal Aortic Aneurysm
2. Tumours
    - Lung
    - Prostate
    - Bone
3. Bone Infections
    - Tuberculosis
    - Osteomyelitis
4. Traumatic
    - Fractures
    - Joint instability or hypermobility
    - Severe sprains or strains
    - Unstable spondylolisthesis
5. Arthritic Conditions
    - Rheumatoid Arthritis
    - Ankylosing Spondylitis
    - Psoriatic Arthritis
    - Unstable or Late-stage Osteoarthritis
6. Metabolic Disorders
    - Clotting Disorders
    - Osteopaenia
7. Neurological Complications
    - Disc Lesions
    - Space-occupying lesions

APPENDIX G

ADVERTISEMENT



If you are between the ages of 18 and 50 years old and have a handicap of 8 or less, you are a suitable candidate to participate in this FREE research.

APPENDIX H

DATA CAPTURING SHEET

Shot No.	Before Treatment	After Treatment
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

APPENDIX I

RAW DATA AS CAPTURED FOR ALL PARTICIPANTS

APPENDIX J

RAW DATA STRUCTURED FOR STATISTICAL ANALYSIS

APPENDIX K

RESULTS OF THE ANCOVA ON AGE

All age	Degr. of	Before shots 1_15				Before shots 16_30			
Before	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	461958	461958	8691.77	0.000	472352	472351.9	9149.12	0
Handicap	1	1859	1859	34.98	0.000	2244	2243.5	43.46	0
Group	1	45.9	46	0.86	0.356	7.4	7.4	0.14	0.706
Error	77	4093	53			3975	51.6		
Total	79	6290				6454			
All age	Degr. of	After shots 1_15				After shots 16_30			
After	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	470784	470784	9490.72	0.000	476255	476255	10219.69	0
Handicap	1	1853	1853	37.35	0.000	1812	1812.1	38.88	0
Group	1	20.6	21	0.42	0.521	83.9	83.9	1.80	0.184
Error	77	3820	50			3588	46.6		
Total	79	5717				5404			
Under 30	Degr. of	Before shots 1_15				Before shots 16_30			
Before	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	417504	417504	8681.64	0.000	425347	425347.3	9177.36	0
Handicap	1	1333	1333	27.71	0.000	1593	1592.7	34.36	0
Group	1	11.4	11	0.24	0.628	1.5	1.5	0.03	0.860
Error	57	2741	48			2642	46.3		
Total	59	4187				4278			
Under 30	Degr. of	After shots 1_15				After shots 16_30			
After	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	423945	423945	9096.68	0.000	428713	428712.7	9952.89	0
Handicap	1	1307	1307	28.05	0.000	1265	1265.4	29.38	0.000001
Group	1	53.0	53	1.14	0.291	118.5	118.5	2.75	0.103
Error	57	2656	47			2455	43.1		
Total	59	3964				3738			
Under 36	Degr. of	Before shots 1_15				Before shots 16_30			
Before	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	453531	453531	9443.98	0.000	463493	463493.4	10112.89	0
Handicap	1	1417	1417	29.51	0.000	1706	1706.4	37.23	0
Group	1	75.7	76	1.58	0.213	17.2	17.2	0.37	0.542
Error	70	3362	48			3208	45.8		
Total	72	5084				5101			
Under 36	Degr. of	After shots 1_15				After shots 16_30			
After	Freedom	SS	MS	F	p	SS	MS	F	p
Intercept	1	461463	461463	10118.80	0.000	467021	467021.4	11046.67	0
Handicap	1	1405	1405	30.81	0.000	1380	1379.8	32.64	0
Group	1	14.1	14	0.31	0.580	53.5	53.5	1.26	0.265
Error	70	3192	46			2959	42.3		
Total	72	4619				4340			

Manipulation

Participant #	1		2		3		4		5		6		7		8	
Age	22		30		28		22		49		19		19		30	
Handicap	-6		-8		-3		-1		-8		0		-8		-8	
Shot No	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	116	121	102	92	107	109	111	107	92	89	113	118	106	102	98	100
2	126	123	102	98	105	106	109	104	95	93	113	116	102	101	94	104
3	125	123	98	99	109	111	106	103	89	96	114	116	96	102	96	102
4	124	123	98	94	113	106	111	112	94	87	117	117	100	101	98	101
5	119	124	99	96	114	107	113	110	90	96	115	115	107	100	95	102
6	121	123	95	97	113	105	103	112	93	96	118	115	103	100	104	105
7	117	125	98	97	11	111	112	105	90	94	115	118	100	100	105	103
8	123	123	101	99	110	109	105	107	88	95	120	119	94	101	96	103
9	123	121	100	98	109	109	109	104	94	95	118	119	102	104	97	103
10	118	119	98	101	109	107	114	109	88	96	117	119	102	102	104	104
11	120	126	94	102	112	115	113	109	90	95	116	115	103	104	102	100
12	118	124	98	104	109	112	109	107	90	91	121	120	100	102	100	107
13	119	123	96	96	107	109	118	109	93	97	120	119	100	105	102	104
14	115	125	95	101	115	109	124	109	87	99	117	119	104	105	96	102
15	122	122	100	100	112	115	109	110	90	97	116	119	103	105	100	107
16	124	124	97	98	110	112	110	110	90	96	117	120	101	105	104	105
17	125	124	102	98	112	112	109	107	92	90	115	121	96	105	105	109
18	120	123	96	94	112	112	103	105	90	97	119	118	98	105	101	107
19	118	125	98	98	112	111	110	109	91	95	120	120	101	103	101	110
20	127	124	100	95	112	113	113	107	93	98	115	118	98	103	101	108
21	120	125	96	100	110	112	111	105	92	100	121	117	102	100	106	109
22	125	121	98	102	104	116	109	109	88	101	119	119	103	105	106	107
23	124	124	100	98	114	114	118	111	88	95	120	121	98	102	102	108
24	125	120	97	99	117	115	110	111	87	97	119	116	101	100	103	103
25	125	119	94	103	109	108	105	105	89	96	121	120	98	105	105	106
26	122	125	101	99	122	113	107	107	86	100	121	117	99	103	102	108
27	126	124	98	99	115	119	110	110	88	101	121	121	95	103	105	109
28	125	124	95	101	109	116	108	108	89	100	118	122	100	104	100	105
29	117	119	96	102	112	114	103	119	88	100	118	125	96	102	105	107
30	125	125	95	97	114	115	114	112	87	101	118	119	99	107	103	107

Manipulation

Participant #	9		10		11		12		13		14		15		16	
Age	25		26		23		36		28		25		29		19	
Handicap	-7		-8		-3		-8		-8		-7		-6		-2	
Shot No	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	111	113	105	102	104	104	102	106	98	98	102	107	118	118	112	124
2	110	116	108	90	107	102	101	102	96	95	100	109	118	122	113	113
3	110	115	105	109	106	114	101	108	99	98	97	112	120	120	114	112
4	107	117	99	109	106	108	105	113	100	95	107	114	122	119	109	122
5	111	115	105	103	107	112	103	103	100	93	107	109	123	122	111	121
6	114	113	108	105	109	107	107	107	99	96	103	112	121	123	115	119
7	109	117	96	103	113	109	105	106	100	91	105	117	125	122	117	119
8	106	112	100	107	109	105	101	101	91	95	106	106	125	120	118	118
9	104	116	95	96	112	107	106	105	103	93	102	114	122	126	119	119
10	106	120	100	103	107	105	102	102	100	99	102	111	117	122	119	120
11	107	114	99	100	111	109	107	113	98	97	105	115	124	120	115	114
12	107	115	90	111	115	106	104	104	98	96	103	112	119	120	118	120
13	112	111	88	107	107	112	105	102	100	99	99	114	122	119	115	119
14	109	112	96	116	105	110	105	107	99	101	112	114	116	122	116	121
15	114	113	96	99	109	111	104	110	99	100	112	114	127	125	120	119
16	103	117	95	109	113	112	100	109	99	95	109	112	125	116	119	121
17	110	110	86	106	107	107	104	107	97	95	103	115	123	125	118	121
18	110	117	98	113	116	112	106	107	96	96	93	115	118	124	110	112
19	109	111	104	107	110	109	101	111	98	94	108	115	126	121	114	120
20	114	115	102	105	109	108	106	103	100	94	108	115	122	119	113	128
21	107	118	104	110	107	107	107	110	100	95	109	114	120	122	119	119
22	107	112	108	98	108	109	102	109	92	96	112	113	123	122	119	116
23	116	119	103	105	112	113	103	106	93	92	112	112	117	121	116	123
24	110	117	107	101	110	113	103	103	99	103	115	111	119	121	120	125
25	107	118	100	114	112	109	102	108	96	102	112	112	122	127	119	122
26	109	116	110	114	110	110	105	108	98	103	103	109	116	124	119	123
27	105	115	102	97	111	109	100	107	98	99	111	112	125	122	116	121
28	103	109	100	98	111	104	101	106	95	97	107	108	124	122	118	119
29	106	112	100	110	113	109	107	107	99	101	105	109	124	124	117	120
30	102	115	102	102	112	110	103	105	98	98	107	113	120	125	119	125

Manipulation

Participant #	17		18		19		20		21		22		23		24	
Age	27		29		35		26		30		30		25		25	
Handicap	-7		-8		-6		-8		-8		-3		-6		-6	
Shot No	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	106	105	85	93	105	105	93	93	105	107	105	107	108	115	103	112
2	107	107	89	98	102	111	93	98	104	104	105	107	112	113	106	107
3	107	107	88	95	102	115	90	97	106	105	106	104	110	115	109	113
4	108	103	89	92	102	110	95	98	103	106	110	107	112	114	109	115
5	109	105	88	88	98	110	90	96	103	105	106	100	114	112	104	114
6	107	114	88	88	98	112	97	96	98	108	106	107	112	115	110	114
7	107	106	88	88	98	110	94	101	103	106	105	106	112	115	105	112
8	107	107	94	87	107	108	100	97	103	105	106	107	112	112	110	114
9	107	113	90	88	107	107	95	102	103	106	106	105	110	116	108	118
10	108	112	95	89	101	107	97	99	99	103	109	108	112	116	112	107
11	108	114	96	96	102	106	98	96	100	107	108	107	114	113	107	110
12	107	110	93	92	98	112	95	96	102	106	105	105	112	115	108	116
13	103	104	91	95	100	105	93	98	101	105	104	108	114	113	105	116
14	107	107	95	93	114	106	94	98	105	110	107	105	114	112	107	116
15	109	109	100	94	111	113	95	93	101	102	107	103	112	113	103	116
16	109	117	100	98	107	110	97	98	103	102	106	103	113	118	108	115
17	99	114	94	98	107	112	91	97	99	102	106	106	115	116	108	118
18	109	107	99	98	105	112	93	99	103	106	107	106	112	115	102	115
19	112	108	99	90	107	107	98	99	99	106	106	108	113	113	105	118
20	104	109	87	95	110	108	85	101	105	102	105	102	115	116	107	115
21	108	104	95	96	105	108	93	95	99	103	106	105	116	114	109	118
22	107	114	96	93	107	112	93	98	95	103	104	108	116	114	111	119
23	109	110	96	90	102	114	93	99	98	105	106	107	115	113	110	118
24	102	107	91	96	101	110	96	98	103	107	107	107	116	116	108	113
25	102	107	93	96	100	112	96	100	102	102	107	107	114	117	109	119
26	105	110	96	100	107	113	98	102	99	105	103	107	115	115	113	115
27	104	107	94	99	105	112	98	98	100	107	108	109	113	115	115	115
28	107	110	94	91	107	110	96	100	107	101	107	107	115	115	113	115
29	103	112	98	90	107	109	98	99	103	101	104	108	115	115	116	109
30	105	110	96	92	109	112	96	93	101	108	104	107	116	116	114	115

Manipulation

Participant #	25		26		27		28		29		30		31		32	
Age	23		34		49		35		28		24		37		33	
Handicap	-8		-7		-8		-8		0		-3		-7		-3	
Shot No	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	96	104	98	98	90	91	99	100	114	117	98	103	101	102	103	109
2	92	100	99	101	90	91	98	103	114	116	100	105	101	105	110	110
3	95	104	99	100	93	91	98	103	116	119	100	103	103	107	109	112
4	87	105	100	102	94	87	95	105	115	120	104	100	106	105	108	110
5	90	102	100	100	95	87	97	105	115	120	98	105	103	109	100	115
6	94	102	98	101	91	85	100	105	112	118	104	107	103	102	100	109
7	96	98	98	97	93	81	98	105	113	119	105	107	109	111	105	112
8	99	98	101	99	93	91	102	106	115	119	106	107	103	103	107	114
9	100	103	100	101	90	92	102	106	115	119	102	107	102	110	109	116
10	93	101	103	103	90	89	103	107	115	119	102	105	103	109	106	116
11	95	98	100	105	92	86	101	106	115	117	102	104	102	107	107	115
12	93	96	100	103	91	93	100	106	114	117	105	102	106	103	107	114
13	91	102	103	103	85	91	103	105	112	119	106	102	109	104	105	114
14	91	105	99	99	88	86	105	106	115	120	104	105	105	106	107	109
15	92	104	101	98	85	94	101	107	114	118	107	100	107	106	111	117
16	92	105	100	103	91	88	103	107	115	117	105	107	106	106	107	109
17	93	102	99	101	93	88	103	107	112	117	100	105	103	107	108	117
18	93	102	99	101	92	95	103	105	115	118	107	104	110	108	113	117
19	92	100	102	104	90	90	101	102	115	115	102	108	109	102	112	112
20	94	103	105	103	94	89	104	106	112	117	106	107	103	111	108	112
21	87	100	103	104	85	93	100	106	114	122	100	107	107	107	109	114
22	91	102	102	101	89	90	103	106	117	117	104	104	105	112	103	111
23	96	103	104	103	91	93	104	106	116	119	106	104	102	109	107	112
24	96	103	102	103	89	94	102	107	117	116	103	104	105	109	108	109
25	91	103	95	101	85	91	102	105	112	117	107	105	107	110	116	110
26	95	105	104	103	85	92	102	106	122	115	105	109	108	109	114	109
27	98	104	103	105	93	89	103	105	115	115	107	103	107	105	115	114
28	99	100	100	105	90	94	103	105	116	115	105	107	105	107	115	114
29	100	104	96	100	90	91	104	106	116	115	105	109	105	109	113	115
30	101	105	102	105	91	93	103	107	113	115	105	107	105	108	107	117

Manipulation

Participant #	33		34		35		36		37		38		39		40	
Age	23		19		18		18		19		19		18		29	
Handicap	3		0		-1		2		-8		-3		-1		2	
Shot No	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
1	125	125	115	123	107	107	119	121	112	107	95	102	113	109	120	127
2	122	125	117	119	108	107	121	121	112	105	97	102	114	112	122	124
3	125	124	119	123	109	110	124	119	112	112	98	100	115	119	116	125
4	123	125	117	123	107	109	117	119	112	112	98	100	115	119	123	131
5	125	126	119	122	109	109	119	119	109	113	100	101	113	119	128	128
6	123	124	118	125	108	109	120	119	110	115	100	101	114	117	121	131
7	124	127	118	122	111	110	120	119	112	112	99	98	116	115	125	127
8	123	125	119	124	110	109	120	119	112	111	100	102	115	114	122	130
9	126	126	119	125	108	107	119	119	112	112	98	102	116	115	127	126
10	124	126	120	123	107	109	118	119	110	109	99	100	112	115	125	127
11	125	126	122	127	107	109	118	117	108	112	100	102	119	112	125	129
12	124	125	124	126	105	107	119	120	109	112	98	100	118	118	122	124
13	125	126	123	125	105	107	118	119	110	112	96	102	118	119	114	129
14	124	125	125	125	105	109	120	120	112	114	94	97	117	116	127	126
15	124	124	122	127	107	107	119	118	110	112	99	100	115	118	122	130
16	125	127	123	125	106	109	121	121	102	111	96	103	117	117	122	122
17	124	126	122	124	105	112	121	121	105	109	100	103	116	116	126	127
18	125	128	121	125	107	112	119	121	107	113	101	103	115	117	122	126
19	125	126	120	127	107	107	121	120	106	114	103	103	117	112	127	124
20	125	126	122	126	108	109	121	123	109	110	102	103	111	116	125	127
21	125	125	123	126	109	111	120	118	107	109	101	103	117	115	124	126
22	124	125	123	125	107	111	119	119	112	111	100	104	114	118	125	125
23	125	126	125	123	106	107	120	119	110	115	98	103	118	115	127	126
24	125	127	123	126	107	112	119	115	107	112	97	104	119	114	122	130
25	125	126	123	124	107	109	120	119	109	114	96	103	116	118	125	131
26	125	126	124	123	107	110	119	118	109	113	100	101	116	110	127	131
27	125	126	125	125	106	111	120	119	112	112	96	100	118	113	125	126
28	124	127	122	125	107	109	120	120	112	118	93	102	114	122	124	130
29	124	125	124	125	107	109	119	119	113	117	99	102	115	121	126	125
30	125	130	122	128	108	109	119	119	111	109	102	98	115	120	127	124

Person	Group	Age	Handicap	BShot1	BShot2	BShot3	BShot4	BShot5	BShot6	BShot7	BShot8	BShot9	BShot10	BShot11	BShot12	BShot13	BShot14	BShot15
1	C	49	-6	89	86	88	93	86	90	90	87	87	90	82	91	90	86	91
2	C	29	-7	107	104	103	101	107	110	107	102	101	102	103	102	107	106	101
3	C	35	-8	115	121	120	119	124	118	120	120	115	115	118	115	119	117	121
4	C	18	-8	109	112	112	104	106	103	107	109	109	104	111	108	111	117	108
5	C	23	0	126	123	124	125	120	125	122	122	122	122	122	121	119	122	124
6	C	19	0	124	125	124	125	124	125	117	125	127	123	125	126	126	131	125
7	C	31	-8	97	95	93	99	100	100	99	99	95	99	95	99	93	99	97
8	C	32	-8	114	114	123	114	121	122	119	119	118	119	120	119	117	119	114
9	C	41	0	101	108	108	100	103	109	109	107	102	102	103	109	109	116	112
10	C	20	-7	117	119	109	117	121	119	118	121	119	119	117	118	120	119	121
11	C	18	0	117	119	128	103	127	109	125	121	109	103	119	129	127	129	127
12	C	18	-7	102	105	105	106	109	108	102	107	109	99	99	110	105	105	113
13	C	22	0	115	112	115	116	120	117	121	121	120	119	118	122	122	119	122
14	C	21	-2	112	111	111	109	112	112	111	109	114	114	109	109	107	108	112
15	C	18	-7	109	108	103	111	107	115	115	111	116	116	116	111	115	107	107
16	C	25	3	111	112	112	112	115	112	120	111	112	114	114	120	112	114	119
17	C	18	1	104	109	108	98	106	108	108	105	106	107	110	106	106	107	109
18	C	31	-3	103	108	109	103	105	105	108	102	105	108	107	107	104	102	107
19	C	24	1	105	109	105	105	103	107	108	105	107	107	106	105	112	110	112
20	C	19	-2	105	110	102	109	109	103	111	107	107	105	107	109	106	109	107
21	C	18	0	117	118	118	110	112	115	112	117	115	115	113	113	115	114	115
22	C	28	2	119	119	122	124	119	119	119	122	123	120	121	116	121	119	122
23	C	38	-6	103	99	104	90	108	98	98	107	105	97	96	96	98	104	105
24	C	18	-1	110	107	111	112	115	114	112	112	110	112	115	112	114	112	114
25	C	19	-1	111	113	111	115	110	117	115	113	110	113	111	119	119	113	116
26	C	18	1	123	123	123	120	119	123	122	120	122	121	125	122	123	120	120
27	C	22	-1	121	117	120	119	122	123	119	122	119	125	120	115	117	117	125
28	C	19	0	107	106	106	106	107	107	105	106	110	111	107	110	104	106	106
29	C	32	3	110	110	109	110	110	110	111	112	110	112	112	112	112	111	118
30	C	25	-3	114	118	113	115	116	115	117	117	115	112	117	115	115	115	117
31	C	20	-1	119	115	119	113	112	117	110	116	114	118	112	112	113	112	114
32	C	20	-3	111	112	112	112	112	113	112	109	113	111	112	113	114	112	113
33	C	23	1	102	103	109	107	110	100	105	108	109	107	102	105	105	107	107
34	C	18	-3	100	105	106	107	107	103	106	107	103	105	100	103	107	107	110
35	C	22	-8	115	111	116	120	121	117	119	122	119	120	112	119	114	120	119
36	C	21	-5	115	107	116	115	119	115	114	111	115	119	116	114	115	116	118
37	C	20	-8	84	85	87	100	83	89	88	95	95	89	101	99	105	89	107
38	C	20	-7	103	103	108	101	103	105	106	107	109	103	112	104	108	102	107
39	C	25	-4	108	112	105	103	109	104	103	106	105	112	107	107	107	109	105
40	C	28	-7	92	99	93	102	92	102	92	93	99	91	96	92	92	94	97
41	Man	22	-6	116	126	125	124	119	121	117	123	123	118	120	118	119	115	122
42	Man	30	-8	102	102	98	98	99	95	98	101	100	98	94	98	96	95	100
43	Man	28	-3	107	105	109	113	114	113	11	110	109	109	112	109	107	115	112
44	Man	22	-1	111	109	106	111	113	103	112	105	109	114	113	109	118	124	109
45	Man	49	-8	92	95	89	94	90	93	90	88	94	88	90	90	93	87	90
46	Man	19	0	113	113	114	117	115	118	115	120	118	117	116	121	120	117	116
47	Man	19	-8	106	102	96	100	107	103	100	94	102	102	103	100	100	104	103
48	Man	30	-8	98	94	96	98	95	104	105	96	97	104	102	100	102	96	100
49	Man	25	-7	111	110	110	107	111	114	109	106	104	106	107	107	112	109	114
50	Man	26	-8	105	108	105	99	105	108	96	100	95	100	99	90	88	96	96
51	Man	23	-3	104	107	106	106	107	109	113	109	112	107	111	115	107	105	109
52	Man	36	-8	102	101	101	105	103	107	105	101	106	102	107	104	105	105	104
53	Man	28	-8	98	96	99	100	100	99	100	91	103	100	98	98	100	99	99
54	Man	25	-7	102	100	97	107	107	103	105	106	102	102	105	103	99	112	112
55	Man	29	-6	118	118	120	122	123	121	125	125	122	117	124	119	122	116	127
56	Man	19	-2	112	113	114	109	111	115	117	118	119	119	115	118	115	116	120
57	Man	27	-7	106	107	107	108	109	107	107	107	107	108	108	107	103	107	109
58	Man	29	-8	85	89	88	89	88	88	88	94	90	95	96	93	91	95	100
59	Man	35	-6	105	102	102	102	98	98	98	107	107	101	102	98	100	114	111
60	Man	26	-8	93	93	90	95	90	97	94	100	95	97	98	95	93	94	95
61	Man	30	-8	105	104	106	103	103	98	103	103	103	99	100	102	101	105	101
62	Man	30	-3	105	105	106	110	106	106	105	106	106	109	108	105	104	107	107
63	Man	25	-6	108	112	110	112	114	112	112	112	110	112	114	112	114	114	112
64	Man	25	-6	103	106	109	109	104	110	105	110	108	112	107	108	105	107	103
65	Man	23	-8	96	92	95	87	90	94	96	99	100	93	95	93	91	91	92
66	Man	34	-7	98	99	99	100	100	98	98	101	100	103	100	100	103	99	101
67	Man	49	-8	90	90	93	94	95	91	93	93	90	90	92	91	85	88	85
68	Man	35	-8	99	98	98	95	97	100	98	102	102	103	101	100	103	105	101
69	Man	28	0	114	114	116	115	115	112	113	115	115	115	115	114	112	115	114
70	Man	24	-3	98	100	100	104	98	104	105	106	102	102	102	105	106	104	107
71	Man	37	-7	101	101	103	106	103	103	109	103	102	103	102	106	109	105	107
72	Man	33	-3	103	110	109	108	100	100	105	107	109	106	107	107	105	107	111
73	Man	23	3	125	122	125	123	125	123	124	123	126	124	125	124	125	124	124
74	Man	19	0	115	117	119	117	119	118	118	119	119	120	122	124	123	125	122
75	Man	18	-1	107	108	109	107	109	108	111	110	108	107	107	105	105	105	107
76	Man	18	2	119	121	124	117	119	120	120	120	119	118	118	119	118	120	119
77	Man	19	-8	112	112	112	112	109	110	112	112	112	110	108	109	110	112	110
78	Man	19	-3	95	97	98	98	100	100	99	100	98	99	100	98	96	94	99
79	Man	18	-1	113	114	115	115	113	114	116	115	116	112	119	118	118	117	115
80	Man	29	2	120	122	116	123	128	121	125	122	127	125	125	122	114	127	122

Person	Group	Age	Handicap	BShot16	BShot17	BShot18	BShot19	BShot20	BShot21	BShot22	BShot23	BShot24	BShot25	BShot26	BShot27	BShot28	BShot29	BShot30
1	C	49	-6	94	89	89	86	87	91	92	89	90	91	91	90	90	87	89
2	C	29	-7	101	109	101	111	103	96	105	102	98	100	105	103	106	107	102
3	C	35	-8	119	116	122	119	117	121	115	105	123	118	115	115	118	119	119
4	C	18	-8	102	107	107	106	105	112	103	109	115	109	105	108	106	112	112
5	C	23	0	121	119	126	118	126	123	119	120	121	119	123	118	120	121	120
6	C	19	0	128	125	131	126	126	127	128	130	120	132	129	129	125	129	128
7	C	31	-8	95	96	99	107	96	106	103	93	101	100	98	98	94	100	98
8	C	32	-8	120	122	116	121	120	123	119	118	123	113	118	122	120	117	121
9	C	41	0	104	109	107	102	109	110	109	112	110	109	112	112	103	106	109
10	C	20	-7	113	124	120	119	117	114	121	111	119	122	119	120	119	117	116
11	C	18	0	124	129	118	123	126	122	126	123	125	125	111	130	110	122	109
12	C	18	-7	103	104	104	96	102	102	105	107	109	112	103	109	108	102	103
13	C	22	0	121	123	116	121	118	120	120	119	120	120	117	117	119	117	119
14	C	21	-2	107	107	112	108	108	108	106	109	111	106	115	112	103	109	110
15	C	18	-7	110	114	107	109	102	117	116	109	112	111	112	117	119	112	108
16	C	25	3	113	115	111	116	121	118	115	112	112	114	116	115	115	112	112
17	C	18	1	109	105	111	107	106	108	106	106	102	112	109	105	107	107	107
18	C	31	-3	109	105	105	105	107	108	105	106	107	109	109	109	107	107	108
19	C	24	1	112	110	109	115	114	110	107	109	115	112	112	107	108	109	109
20	C	19	-2	103	106	112	110	110	111	113	107	111	109	105	109	107	105	105
21	C	18	0	116	116	115	110	112	110	114	117	109	117	116	113	114	118	113
22	C	28	2	120	117	124	125	119	121	119	125	125	126	122	125	122	119	124
23	C	38	-6	95	104	99	103	102	100	103	105	107	98	100	100	98	98	99
24	C	18	-1	114	113	112	114	114	114	111	114	110	112	113	117	110	114	114
25	C	19	-1	117	116	119	117	116	115	109	114	110	117	112	115	118	115	116
26	C	18	1	121	123	119	123	121	121	121	123	123	119	123	122	122	122	120
27	C	22	-1	123	115	117	124	120	115	117	112	115	117	112	118	115	119	123
28	C	19	0	109	108	107	105	105	106	107	106	109	110	108	110	109	111	110
29	C	32	3	118	119	116	111	112	112	117	120	121	118	122	115	119	112	109
30	C	25	-3	118	115	114	114	118	115	114	117	112	115	115	115	114	115	114
31	C	20	-1	115	116	113	116	115	112	115	109	113	116	109	117	113	113	119
32	C	20	-3	112	112	109	111	112	112	114	112	113	110	110	110	112	110	112
33	C	23	1	109	109	105	100	105	105	109	109	109	107	107	108	105	107	107
34	C	18	-3	110	110	110	106	103	110	104	105	106	106	101	107	107	107	110
35	C	22	-8	118	122	112	118	117	125	116	117	119	121	115	117	117	109	107
36	C	21	-5	115	115	113	115	112	109	116	111	115	115	117	112	115	109	118
37	C	20	-8	92	108	93	93	93	84	88	96	107	97	87	86	90	102	94
38	C	20	-7	104	101	102	109	105	103	102	103	104	103	105	103	103	105	105
39	C	25	-4	105	105	105	103	107	112	109	103	108	105	104	109	108	102	103
40	C	28	-7	98	98	93	98	95	95	93	94	96	93	92	97	93	96	96
41	Man	22	-6	124	125	120	118	127	120	125	124	125	125	122	126	125	117	125
42	Man	30	-8	97	102	96	98	100	96	98	100	97	94	101	98	95	96	95
43	Man	28	-3	110	112	112	112	112	110	104	114	117	109	122	115	109	112	114
44	Man	22	-1	110	109	103	110	113	111	109	118	110	105	107	110	108	103	114
45	Man	49	-8	90	92	90	91	93	92	88	88	87	89	86	88	89	88	87
46	Man	19	0	117	115	119	120	115	121	119	120	119	121	121	121	118	118	118
47	Man	19	-8	101	96	98	101	98	102	103	98	101	98	99	95	100	96	99
48	Man	30	-8	104	105	101	101	101	106	106	102	103	105	102	105	100	105	103
49	Man	25	-7	103	110	110	109	114	107	107	116	110	107	109	105	103	106	102
50	Man	26	-8	95	86	98	104	102	104	108	103	107	100	110	102	100	100	102
51	Man	23	-3	113	107	116	110	109	107	108	112	110	112	110	111	111	113	112
52	Man	36	-8	100	104	106	101	106	107	102	103	103	102	105	100	101	107	103
53	Man	28	-8	99	97	96	98	100	100	92	93	99	96	98	98	95	99	98
54	Man	25	-7	109	103	93	108	108	109	112	112	115	112	103	111	107	105	107
55	Man	29	-6	125	123	118	126	122	120	123	117	119	122	116	125	124	124	120
56	Man	19	-2	119	118	110	114	113	119	119	116	120	119	119	116	118	117	119
57	Man	27	-7	109	99	109	112	104	108	107	109	102	102	105	104	107	103	105
58	Man	29	-8	100	94	99	99	87	95	96	96	91	93	96	94	94	98	96
59	Man	35	-6	107	107	105	107	110	105	107	102	101	100	107	105	107	107	109
60	Man	26	-8	97	91	93	98	85	93	93	93	96	96	98	98	96	98	96
61	Man	30	-8	103	99	103	99	105	99	95	98	103	102	99	100	107	103	101
62	Man	30	-3	106	106	107	106	105	106	104	106	107	107	103	108	107	104	104
63	Man	25	-6	113	115	112	113	115	116	116	115	116	114	115	113	115	115	116
64	Man	25	-6	108	108	102	105	107	109	111	110	108	109	113	115	113	116	114
65	Man	23	-8	92	93	93	92	94	87	91	96	96	91	95	98	99	100	101
66	Man	34	-7	100	99	99	102	105	103	102	104	102	95	104	103	100	96	102
67	Man	49	-8	91	93	92	90	94	85	89	91	89	85	85	93	90	90	91
68	Man	35	-8	103	103	103	101	104	100	103	104	102	102	102	103	103	104	103
69	Man	28	0	115	112	115	115	112	114	117	116	117	112	122	115	116	116	113
70	Man	24	-3	105	100	107	102	106	100	104	106	103	107	105	107	105	105	105
71	Man	37	-7	106	103	110	109	103	107	105	102	105	107	108	107	105	105	105
72	Man	33	-3	107	108	113	112	108	109	103	107	108	116	114	115	115	113	107
73	Man	23	3	125	124	125	125	125	125	124	125	125	125	125	125	124	124	125
74	Man	19	0	123	122	121	120	122	123	123	125	123	123	124	125	122	124	122
75	Man	18	-1	106	105	107	107	108	109	107	106	107	107	107	106	107	107	108
76	Man	18	2	121	121	119	121	121	120	119	120	119	120	119	120	120	119	119
77	Man	19	-8	102	105	107	106	109	107	112	110	107	109	109	112	112	113	111
78	Man	19	-3	96	100	101	103	102	101	100	98	97	96	100	96	93	99	102
79	Man	18	-1	117	116	115	117	111	117	114	118	119	116	116	118	114	115	115
80	Man	29	2	122	126	122	127	125	124	125	127	122	125	127	125	124	126	127

Person	Group	Age	Handicap	AShot1	AShot2	AShot3	AShot4	AShot5	AShot6	AShot7	AShot8	AShot9	AShot10	AShot11	AShot12	AShot13	AShot14	AShot15
1	C	49	-6	90	89	91	96	91	97	89	95	86	86	93	93	94	90	93
2	C	29	-7	100	95	100	99	106	93	96	95	102	99	104	102	105	99	95
3	C	35	-8	115	122	120	116	115	113	109	116	120	115	114	117	111	112	114
4	C	18	-8	110	116	105	105	103	108	109	110	112	111	109	110	107	114	109
5	C	23	0	125	124	120	120	123	119	125	123	119	122	122	128	124	117	121
6	C	19	0	125	120	118	122	121	119	128	124	125	125	125	123	127	116	109
7	C	31	-8	100	102	103	100	100	99	98	98	100	98	95	88	97	95	98
8	C	32	-8	119	117	120	102	112	121	120	109	119	118	120	119	121	120	120
9	C	41	0	107	115	108	110	109	115	107	107	115	107	115	105	109	107	109
10	C	20	-7	120	115	114	120	120	120	125	119	117	115	121	117	109	119	119
11	C	18	0	119	126	113	124	110	128	125	126	121	120	117	129	125	109	125
12	C	18	-7	102	105	100	101	107	107	99	100	104	108	102	112	100	98	103
13	C	22	0	120	113	115	116	118	118	120	125	118	123	123	119	121	119	121
14	C	21	-2	110	105	114	112	109	112	112	112	112	110	112	106	114	108	112
15	C	18	-7	103	109	111	106	109	103	109	105	115	115	111	105	106	107	107
16	C	25	3	107	109	108	112	110	112	109	110	117	114	115	115	116	111	112
17	C	18	1	104	104	105	105	106	107	107	105	106	105	108	109	109	108	104
18	C	31	-3	107	107	105	102	107	109	105	107	107	107	107	108	105	107	105
19	C	24	1	105	114	112	112	109	105	109	106	107	112	115	115	109	107	105
20	C	19	-2	110	105	108	112	109	109	107	110	105	107	112	108	107	112	109
21	C	18	0	112	113	115	115	117	113	114	114	115	112	110	112	111	113	113
22	C	28	2	119	119	125	123	125	119	119	119	122	120	123	123	117	123	119
23	C	38	-6	107	99	96	108	103	102	98	104	104	98	108	108	105	108	104
24	C	18	-1	111	113	113	115	109	114	117	112	115	114	114	107	113	114	114
25	C	19	-1	112	113	111	114	116	118	115	116	114	109	110	115	118	115	116
26	C	18	1	119	120	123	122	119	112	119	121	120	121	121	122	124	125	121
27	C	22	-1	119	116	114	110	122	119	118	115	116	123	120	121	122	120	118
28	C	19	0	107	107	106	104	102	106	106	108	103	108	106	105	105	106	107
29	C	32	3	114	109	109	108	109	115	116	116	115	112	110	109	109	109	113
30	C	25	-3	112	114	113	115	114	114	116	115	117	117	116	114	114	115	112
31	C	20	-1	114	114	114	115	115	112	115	117	116	114	114	114	115	113	115
32	C	20	-3	112	112	110	112	111	110	115	111	111	110	113	107	111	110	110
33	C	23	1	107	102	109	105	105	110	107	107	105	105	108	108	107	105	108
34	C	18	-3	107	106	105	105	109	109	103	105	105	105	105	108	104	106	104
35	C	22	-8	108	120	111	116	115	109	109	118	116	121	119	109	118	121	115
36	C	21	-5	116	113	110	117	116	119	117	113	110	113	110	107	116	119	115
37	C	20	-8	98	97	93	97	104	97	107	105	107	92	87	87	89	87	92
38	C	20	-7	106	100	105	102	102	106	107	108	103	104	103	109	107	105	104
39	C	25	-4	104	104	106	102	107	106	105	102	103	103	104	108	112	103	107
40	C	28	-7	97	98	98	98	96	94	98	99	96	96	96	93	94	93	97
41	Man	22	-6	121	123	123	123	124	123	125	123	121	119	126	124	123	125	122
42	Man	30	-8	92	98	99	94	96	97	97	99	98	101	102	104	96	101	100
43	Man	28	-3	109	106	111	106	107	105	111	109	109	107	115	112	109	109	115
44	Man	22	-1	107	104	103	112	110	112	105	107	104	109	109	107	109	109	110
45	Man	49	-8	89	93	96	87	96	96	94	95	95	96	95	91	97	99	97
46	Man	19	0	118	116	116	117	115	115	118	119	119	119	115	120	119	119	119
47	Man	19	-8	102	101	102	101	100	100	100	101	104	102	104	102	105	105	105
48	Man	30	-8	100	104	102	101	102	105	103	103	103	104	100	107	104	102	107
49	Man	25	-7	113	116	115	117	115	113	117	112	116	120	114	115	111	112	113
50	Man	26	-8	102	90	109	109	103	105	103	107	96	103	100	111	107	116	99
51	Man	23	-3	104	102	114	108	112	107	109	105	107	105	109	106	112	110	111
52	Man	36	-8	106	102	108	113	103	107	106	101	105	102	113	104	102	107	110
53	Man	28	-8	98	95	98	95	93	96	91	95	93	99	97	96	99	101	100
54	Man	25	-7	107	109	112	114	109	112	117	106	114	111	115	112	114	114	114
55	Man	29	-6	118	122	120	119	122	123	122	120	126	122	120	120	119	122	125
56	Man	19	-2	124	113	112	122	121	119	119	118	119	120	114	120	119	121	119
57	Man	27	-7	105	107	107	103	105	114	106	107	113	112	114	110	104	107	109
58	Man	29	-8	93	98	95	92	88	88	88	87	88	89	96	92	95	93	94
59	Man	35	-6	105	111	115	110	110	112	110	108	107	107	106	112	105	106	113
60	Man	26	-8	93	98	97	98	96	96	101	97	102	99	96	96	98	98	93
61	Man	30	-8	107	104	105	106	105	108	106	105	106	103	107	106	105	110	102
62	Man	30	-3	107	107	104	107	100	107	106	107	105	108	107	105	108	105	103
63	Man	25	-6	115	113	115	114	112	115	115	112	116	116	113	115	113	112	113
64	Man	25	-6	112	107	113	115	114	114	112	114	118	107	110	116	116	116	116
65	Man	23	-8	104	100	104	105	102	102	98	98	103	101	98	96	102	105	104
66	Man	34	-7	98	101	100	102	100	101	97	99	101	103	105	103	103	99	98
67	Man	49	-8	91	91	91	87	87	85	81	91	92	89	86	93	91	86	94
68	Man	35	-8	100	103	103	105	105	105	105	106	106	107	106	106	105	106	107
69	Man	28	0	117	116	119	120	120	118	119	119	119	119	117	117	119	120	118
70	Man	24	-3	103	105	103	100	105	107	107	107	107	105	104	102	102	105	100
71	Man	37	-7	102	105	107	105	109	102	111	103	110	109	107	103	104	106	106
72	Man	33	-3	109	110	112	110	115	109	112	114	116	116	115	114	114	109	117
73	Man	23	3	125	125	124	125	126	124	127	125	126	126	126	125	126	125	124
74	Man	19	0	123	119	123	123	122	125	122	124	125	123	127	126	125	125	127
75	Man	18	-1	107	107	110	109	109	109	110	109	107	109	109	107	107	109	107
76	Man	18	2	121	121	119	119	119	119	119	119	119	119	117	120	119	120	118
77	Man	19	-8	107	105	112	112	113	115	112	111	112	109	112	112	112	114	112
78	Man	19	-3	102	102	100	100	101	101	98	102	102	100	102	100	102	97	100
79	Man	18	-1	109	112	119	119	119	117	115	114	115	115	112	118	119	116	118
80	Man	29	2	127	124	125	131	128	131	127	130	126	127	129	124	129	126	130

Person	Group	Age	Handicap	AShot16	AShot17	AShot18	AShot19	AShot20	AShot21	AShot22	AShot23	AShot24	AShot25	AShot26	AShot27	AShot28	AShot29	AShot30
1	C	49	-6	91	88	87	88	87	92	88	90	89	89	94	93	94	92	93
2	C	29	-7	99	100	107	100	102	99	105	103	105	105	98	105	97	100	112
3	C	35	-8	114	115	114	112	114	115	112	115	122	114	112	108	111	115	115
4	C	18	-8	103	102	105	112	103	106	110	107	109	105	104	109	103	102	108
5	C	23	0	119	122	121	119	119	121	115	125	123	121	119	119	120	121	121
6	C	19	0	117	121	122	118	124	122	120	120	120	124	125	124	124	131	133
7	C	31	-8	104	103	100	96	96	99	95	103	91	99	95	101	102	101	100
8	C	32	-8	121	115	121	114	120	117	115	116	123	115	116	117	125	123	119
9	C	41	0	108	112	107	105	107	106	109	110	109	107	109	109	109	114	112
10	C	20	-7	117	117	115	119	115	119	119	118	115	117	118	119	118	119	117
11	C	18	0	124	128	111	126	124	117	125	123	123	119	125	124	123	125	115
12	C	18	-7	103	110	106	104	112	107	101	105	103	107	105	111	101	102	103
13	C	22	0	124	119	115	119	119	119	119	118	119	119	119	121	118	115	119
14	C	21	-2	110	108	112	109	107	105	108	109	112	112	112	115	115	111	113
15	C	18	-7	109	109	111	105	107	107	102	107	108	115	115	105	107	112	104
16	C	25	3	115	111	111	112	111	112	112	117	113	115	115	112	109	112	111
17	C	18	1	103	103	105	107	109	107	103	106	107	107	107	107	103	109	108
18	C	31	-3	109	110	107	105	109	109	106	105	106	107	107	109	109	109	105
19	C	24	1	109	109	109	112	108	112	114	108	112	114	114	110	105	108	109
20	C	19	-2	108	105	105	108	107	105	112	108	109	107	107	105	105	108	112
21	C	18	0	115	117	114	115	121	115	115	115	110	117	117	110	114	112	120
22	C	28	2	120	118	121	124	123	123	125	119	120	121	119	121	119	124	126
23	C	38	-6	98	95	102	101	106	103	98	108	102	103	108	97	98	104	101
24	C	18	-1	112	114	114	109	115	113	114	115	111	112	115	115	104	115	113
25	C	19	-1	115	114	115	112	116	109	115	115	115	116	115	112	114	115	116
26	C	18	1	119	119	121	121	121	121	119	125	120	119	123	120	123	118	122
27	C	22	-1	118	116	117	114	114	116	120	123	121	120	121	119	116	117	115
28	C	19	0	107	109	107	105	105	108	107	106	106	106	107	109	109	107	103
29	C	32	3	109	110	108	109	107	109	112	114	119	116	120	116	114	120	114
30	C	25	-3	113	117	119	115	117	116	114	115	115	117	120	119	115	120	117
31	C	20	-1	115	119	117	118	118	114	115	115	116	114	114	119	115	117	114
32	C	20	-3	111	113	112	109	112	111	111	112	109	111	113	112	112	109	114
33	C	23	1	106	107	105	105	105	105	102	108	107	105	107	102	103	103	105
34	C	18	-3	104	103	107	107	105	104	108	105	103	110	107	108	104	107	106
35	C	22	-8	117	115	111	111	114	112	109	112	119	118	114	115	117	120	116
36	C	21	-5	112	114	112	113	113	114	115	118	113	115	110	116	112	113	117
37	C	20	-8	95	89	86	89	103	102	95	99	102	89	85	93	94	103	105
38	C	20	-7	104	103	107	104	103	102	102	104	102	104	103	105	110	102	104
39	C	25	-4	107	107	114	108	105	103	105	104	108	107	106	105	106	106	110
40	C	28	-7	93	93	93	95	101	100	98	97	99	96	96	101	95	98	98
41	Man	22	-6	124	124	123	125	124	125	121	124	120	119	125	124	124	119	125
42	Man	30	-8	98	98	94	98	95	100	102	98	99	103	99	99	101	102	97
43	Man	28	-3	112	112	112	111	113	112	116	114	115	108	113	119	116	114	115
44	Man	22	-1	110	107	105	109	107	105	109	111	111	105	107	110	108	119	112
45	Man	49	-8	96	90	97	95	98	100	101	95	97	96	100	101	100	100	101
46	Man	19	0	120	121	118	120	118	117	119	121	116	120	117	121	122	125	119
47	Man	19	-8	105	105	105	103	103	100	105	102	100	105	103	103	104	102	107
48	Man	30	-8	105	109	107	110	108	109	107	108	103	106	108	109	105	107	107
49	Man	25	-7	117	110	117	111	115	118	112	119	117	118	116	115	109	112	115
50	Man	26	-8	109	106	113	107	105	110	98	105	101	114	114	97	98	110	102
51	Man	23	-3	112	107	112	109	108	107	109	113	113	109	110	109	104	109	110
52	Man	36	-8	109	107	107	111	103	110	109	106	103	108	108	107	106	107	105
53	Man	28	-8	95	95	96	94	94	95	96	92	103	102	103	99	97	101	98
54	Man	25	-7	112	115	115	115	115	114	113	112	111	112	109	112	108	109	113
55	Man	29	-6	116	125	124	121	119	122	122	121	121	127	124	122	122	124	125
56	Man	19	-2	121	121	112	120	128	119	116	123	125	122	123	121	119	120	125
57	Man	27	-7	117	114	107	108	109	104	114	110	107	107	110	107	110	112	110
58	Man	29	-8	98	98	98	90	95	96	93	90	96	96	100	99	91	90	92
59	Man	35	-6	110	112	112	107	108	108	112	114	110	112	113	112	110	109	112
60	Man	26	-8	98	97	99	99	101	95	98	99	98	100	102	98	100	99	93
61	Man	30	-8	102	102	106	106	102	103	103	105	107	102	105	107	101	101	108
62	Man	30	-3	103	106	106	108	102	105	108	107	107	107	107	109	107	108	107
63	Man	25	-6	118	116	115	113	116	114	114	113	116	117	115	115	115	115	116
64	Man	25	-6	115	118	115	118	115	118	119	118	113	119	115	115	115	109	115
65	Man	23	-8	105	102	102	100	103	100	102	103	103	103	105	104	100	104	105
66	Man	34	-7	103	101	101	104	103	104	101	103	103	101	103	105	105	100	105
67	Man	49	-8	88	88	95	90	89	93	90	93	94	91	92	89	94	91	93
68	Man	35	-8	107	107	105	102	106	106	106	106	107	105	106	105	105	106	107
69	Man	28	0	117	117	118	115	117	122	117	119	116	117	115	115	115	115	115
70	Man	24	-3	107	105	104	108	107	107	104	104	104	105	109	103	107	109	107
71	Man	37	-7	106	107	108	102	111	107	112	109	109	110	109	105	107	109	108
72	Man	33	-3	109	117	117	112	112	114	111	112	109	110	109	114	114	115	117
73	Man	23	3	127	126	128	126	126	125	125	126	127	126	126	126	127	125	130
74	Man	19	0	125	124	125	127	126	126	125	123	126	124	123	125	125	125	128
75	Man	18	-1	109	112	112	107	109	111	111	107	112	109	110	111	109	109	109
76	Man	18	2	121	121	121	120	123	118	119	119	115	119	118	119	120	119	119
77	Man	19	-8	111	109	113	114	110	109	111	115	112	114	113	112	118	117	109
78	Man	19	-3	103	103	103	103	103	103	104	103	104	103	101	100	102	102	98
79	Man	18	-1	117	116	117	112	116	115	118	115	114	118	110	113	122	121	120
80	Man	29	2	122	127	126	124	127	126	125	126	130	131	131	126	130	125	124