STUDENT DECLARATION

I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution.

ABSTRACT

Background: With effective postural positioning a rider strives to be harmonious with the horse for optimum performance and communication. It is thought that asymmetry within a rider's posture has consequences on rider-horse harmony. However, limited empirical studies report on typical postural characteristics of riders and the potential effects of asymmetric postures. Furthermore studies are yet to report on corrective methods such as taping in order to positively adjust asymmetric postures. A study of female riders postures whilst riding sitting trot initiated in the hope of understanding postural characteristics and taping as a method of correction, is reported here.

Aim: To investigate the effects of athletic taping on asymmetric postures of female equestrian riders during sitting trot.

Methods Design: Within subjects repeated measures design.

Setting: Pilot testing within a movement analysis laboratory at the University of Central Lancashire full experimental testing at the indoor equine arena at Myerscough Agricultural College.

Participants: Ten female volunteer equine riders (BHS Level 2 and above) from the Myerscough Agricultural College staff and student base.

Interventions: Athletic tape applied to shoulder, scapular and thoracic spinal area.

Main Outcome Measures: This study investigated the immediate effects of a spinal taping method designed to adjust postural asymmetries and thus improve postural proprioceptive awareness. Riders acted as their own control during testing, the order of tape and no tape conditions were randomised. Movement data was collected with and without tape using Qualisys Movement Analysis Camera System (Oqus Series 3 Mobile 8).

Results: Statistical results for the trunk indicated a significant difference ($p<.05$) in the range (°) of lateral flexion of the riders trunk, with tape.

Conclusion: Dynamic postural characteristics of female equine riders can be established using 3D motion analysis and can quantify changes in riders' posture following the intervention of tape. The application of tape to the shoulder and thoracic spine region can significantly affect a rider's posture during sitting trot, specifically through trunk lateral flexion. Further research is necessary to continue the observation of rider posture and quantify characteristics on a larger scale and on both male and female riders. Continued research is required in the use of tape as a method to reduce the implications of asymmetric postures in riders, and what further effects it may have on torso and pelvic motions.

Key Words: Equine, Rider, Posture, Asymmetry, Taping, Biomechanics, Spine

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

University of Central Lancashire .... UCLan

Leg Length Discrepancy .... LLD

Leg Length Inequality LLI

Centre of Gravity .... COG

Posterior Superior Iliac Spine .... PSIS

Anterior Superior Iliac Spine .... ASIS

Acromion Process .... AC

Transverse Abdominals .... TA

British Horse Society .... BHS

Absolute Difference .... AD

Movement Asymmetry .... MA

ACKNOWLEDGEMENTS

This research work was carried out between April 2009-2011 and would not have been possible without the help of a number of people. I would like to thank firstly my Director of studies, Prof. James Selfe and supervisor Karen May for their continuous support and guidance throughout the study. In particular, Dr. Sarah Hobbs, for without her expertise and devotion to the project from the start this research would not have happened.

I would also like to acknowledge the great organisational skills of Alison Northrop, on behalf of the work carried out at Myerscough Agricultural College. Additional regards go to Charlotte Brigden and Kirsty Owen and all the volunteer staff and student riders from Myerscough who gave up their time to participant in this research.

I gratefully thank Laura Dagg for her assistance with the preparation of equines and data analysis equipment at Myerscough, through those early morning starts and long hours of data collection.

Thank You to Myerscough Agricultural College Equine Department for the use of their fantastic facilities, horses and staff who helped at various stages of the research.

INTRODUCTION

The opportunity to understand characteristics of rider posture and the effects on equine performance is vast. Understanding the way a rider sits and moves in harmony with a horse is key to enhancing collaborative rider and horse performance. Within scientific literature rider asymmetry is minimal, in spite of anecdotal association between asymmetric postures of riders and reduced performance in the horse. For the benefit of both coaches and riders, vague terminology has little impact on educating ideal postural characteristics.

Due to the lack of experimental studies within the field of quantifying rider postures, the availability of appropriate reliable and valid methods is limited. Therefore an initial objective of this study developed the methods of using three dimensional motion analysis whereby postural characteristics of riders can be quantified. Pilot studies recognise potential methodological limitations and report on the challenges overcome prior to data collection.

It is well known throughout rider environments that tape is used on riders to aid ideal posture; however scientific assessment of postural taping to improve postural symmetry in riders is non-existent. The mechanical effects of tape reflect the relevance of its use in the correction of asymmetrical riding postures in this study. When considering the biomechanical horse and rider relationship it is clear that quantification of equine rider postures during riding can aid research into the therapeutic methods of postural correction, such as taping. No study has demonstrated this dynamically using modern technology, and thus allows for massive potential of therapeutic methods to develop in this field. This study provides practical research quantifying the characteristics of rider postures, potential corrective methods and use of modern movement analysis technology for the equine industry and professionals working with riders.

CHAPTER 1

REVIEW OF LITERATURE

1.0 BIOMECHANICS AND ANATOMY OF HUMAN POSTURE

1.0.1 Introduction to Posture

Human posture and the biomechanics of spinal alignment are discussed extensively throughout clinical literature (Edmonston and Singer, 1997; Liebenson, 2001; Sahrmann, 2002; Kendall et al, 2005; Edmonston et al, 2007a; 2007b). The position of joints, body segments and muscle balance are used widely to define posture and collectively describe static postural alignment (Kendall et al, 2005). The spine executes demanding functional requirements such as; providing an attachment for powerful muscles for movement, balance, protecting the spinal cord against injury and acting as a shock absorber by distributing weight-bearing forces during functional movements (Edmonston and Singer, 1997; Palastanga et al, 2006). During sitting, quiet stance and functional movements the structures that support our spinal posture play a considerable role in balance, weight-bearing and the effectiveness of our biomechanical movement patterns (Sahrmann, 2002; Schamberger, 2002). Dynamic global spinal movements can be simply recognised as extension, flexion, lateral flexion and rotation (Drake et al, 2009) (Figure 1).

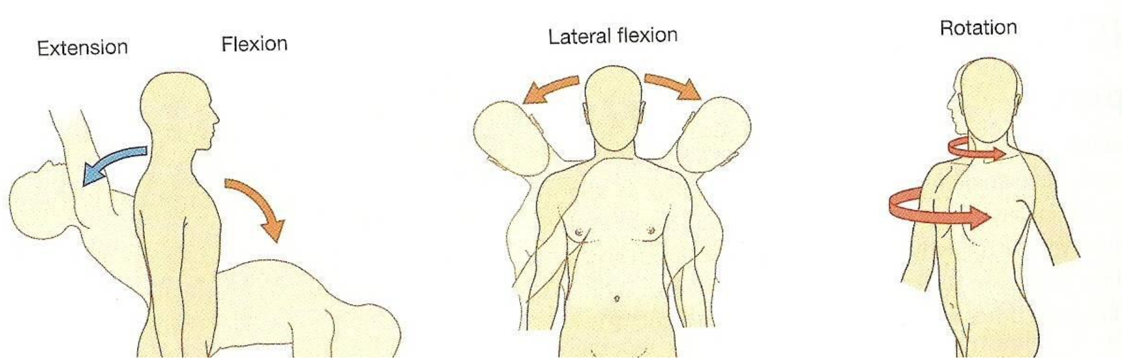


Figure 1. Basic dynamic movements of the spine recognised within clinical assessment of spinal posture and movement (Drake et al, 2009).

Split anatomically into four regions, cervical, thoracic, lumbar and sacral, the spine flows through four natural curvatures (Kisner and Colby, 2002). Passing in front of and behind the line of gravity these spinal curvatures allow for flexible support and resilience to axial forces. It must be remembered however that this line of gravity is not constant, although Palastanga et al (2006) reminds us that it is a useful aid into assessing balance and posture, and can be used to determine structural changes in postural biomechanics and pathologies of the spine. Clinical literature (Kendall et al, 2005) agrees that spinal posture with a small lordosis in the lumbar spine and small kyphosis in the thoracic spine presents as 'ideal' posture.

1.0.2 Thoracic Spine and Scapula

Due to technical difficulties when analysing thoracic movement, earlier studies reflect how in clinical presentations of spinal pain and dysfunctions the thoracic spine has not commonly been a source of implication (Raine and Twomey, 1994; Edmondston and Singer, 1997). However, recent perspectives acknowledge how the thoracic spine provides a central role in posture, dysfunctions and movement patterns in relation to the shoulder girdle and adjacent spinal regions (Edmondston et al, 2007a; 2007b). The thoracic spine portrays a slight posterior curve (kyphosis) in ideal alignment and is affected by lumbar and pelvis positions (Kendall et al, 2005). An example of how thoracic spinal curvature can affect overall posture alignment is demonstrated by Kendall et al, (2005); whereby repetitive motions and habitual positions can develop an increase in posterior curvature of the thoracic region, compensating for the anterior deviation occurring at the pelvis (Figure 2), also known as a sway-back posture.

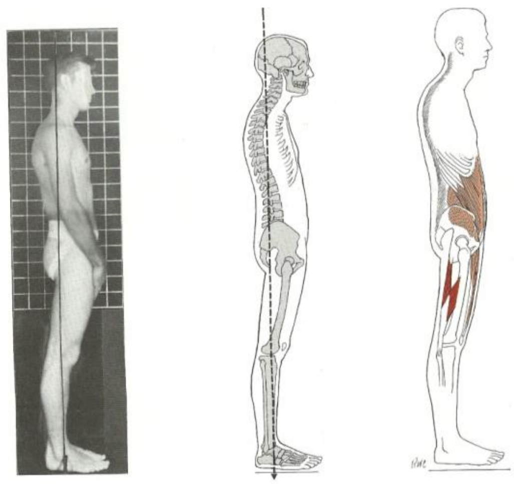


Figure 2. This postural characteristic is commonly recognised in clinical presentation as a 'sway-back' posture (Kendall et al, 2005).

The role of the scapula in relation to posture is often misunderstood or overlooked (Kibler, 1998; Kendall et al, 2005). Dysfunctions throughout thoracic, cervical and lumbar postures are known to have a direct link to scapula motion (Kibler, 1998). The positioning of the scapula and thoracic spine collectively affects shoulder alignment, and a faulty scapulae often leads to malaligment of the glenohumeral joint (Kendall et al, 2005). Previous research (Host, 1995; Kibler, 1998) focuses on overhead athlete scenarios with scapular function, biomechanics and shoulder injury providing the dominant themes. Limited studies touch upon the discussion of equine rider postures and scapular function; although an important contribution has been made by Terada et al, (2000), investigating rider muscle activity in relation to horse movement. It was reported how the rider's upper and middle trapezius muscle activity occurred at certain points of the horse's strides and footfall timing and therefore were considered to stabilise the rider's neck and scapula during impact of the horses' diagonal limbs (Terada et al, 2000). Muscle activity were observed using electromyographic (EMG) data collection and concluded that collectively the function of these muscles may be related to general postural control in equine riders.

1.0.3 Muscle Activity and Posture

In order to maintain ideal alignment of the spine and posture, anterior and posterior musculature attached to the pelvis work collectively (Kendall et al, 2005). For example anterior abdominal and hip extensor muscles simultaneously tilt the pelvis posteriorly and the posterior lumbar and hip flexor musculature collectively work to tilt the pelvis anteriorly, in order to achieve a neutral posture (Kendall et al, 2005). An innovative study by Reeve et al, (2009) found an increase in transverse abdominals (TA) musculature in 'ideal' sitting postures and a reduction when sitting in a 'slouched' position. During aligned positions the TA are more active therefore Reeve et al, (2009), proposed that the spine is more stable in this position. However due to the lack of standardisation within postural assessments or lack of agreement in measurement protocols (Al-Eisa et al, 2006) it is hard to compare the outcomes of previous postural studies. Furthermore earlier studies report difficulties encountered when trying to replicate the application of certain assessment tools within a clinical setting (Wrigley et al, 1991). Research suggests how lumbo-pelvic neutral posture may influence the recruitment of TA to functionally stabilise the spine and support posture re-education of this muscle (Reeve and Dilley, 2009).

In a review of posture (Raine and Twomey, 1994) conclusions suggest there were little evidence supporting the correlation between trunk muscle dysfunctions and spinal postures relating to low back pain (LBP); however a recent systemic review by Prins and Crous, (2008) suggests various sitting postures do influence the occurrence of musculoskeletal pain. This study supports work by O'Sullivan et al, (2006) indicating a correlation between spinal postures and LBP, and reductions in multifidus muscular activity in poor sitting postures. Collectively the clinical implications of these studies promote neutral or 'ideal' posture alignment in both sitting and standing postures and suggest postural muscles such as TA amongst others, as stabilisers of the lumbar spine, reducing the risks of LBP.

1.0.3i Posture and the Athlete

Ideal postural alignment in any athlete facilitates the opportunity for optimal movement, postural correction may be necessary if alignment is faulty prior to any motion initiated (Sahrmann, 2002). Altered joint position and dysfunction in motion are theorised to be a result of deviations in posture occurring from imbalances within muscular and articular systems (Lewis et al, 2005). With regards to equine riders, an improvement in the alignment of general posture may contribute to better riding posture, and generate greater performance and response from the horse (Gordon-Watson, 1995; Wanless, 2008; Symes and Ellis, 2009). Lewis et al, (2005) summarises how postural assessment to identify abnormal postures are important in order to implement suitable rehabilitation techniques, and restore muscular control and postural alignment.

1.0.4 Key Points

- Vast interest throughout current literature discussing human anatomy, directly related to postural alignment.
- Understanding human anatomy provides a correlation for postural dysfunctions to be discussed.
- Postural characteristics in equine riders can therefore be understood further.

1.1 POSTURAL DYSFUNCTIONS AND MOVEMENT IMPAIRMENTS

1.1.1 Presentations of Postural Dysfunctions

It is assumed that maximum posture alignment of the skeletal segments provide the most favourable performance of the components that support postural control and spinal stability (Sahrmann, 2002). Faulty alignment producing visible postural asymmetries reduce trunk and spinal stability, subsequently impairing movement patterns and muscle activity (Granata and Wilson, 2001). Gross movement impairments primarily caused by deviations in ideal arthrokinematics can lead to microtraumas, LBP and injury (Sahrmann, 2002). The risk of undue stress within joints and soft tissue structures is reduced if alignment is ideal (Sahrmann, 2002; Kendal et al, 2005).

The neutral positioning of the pelvis means that the anterior-superior iliac spines are in the same vertical planes as the pubis symphysis (Kendal et al, 2005). In contrast an abnormal posture may present with a tilt of the pelvis may occurring anteriorly, posteriorly or laterally, and can therefore involve instantaneous changes in movement of lumbar spine and hip joints. However, abnormal or asymmetric postures can originate from numerous anatomical regions and biomechanical influences, and is varied in discussion throughout the literature (Granata and Wilson, 2001; Sahrmann, 2002; Kendall et al, 2005; Schamberger, 2005; Symes and Ellis, 2009; Caneiro et al, 2010). Postural asymmetry can be caused by differential muscle development or commonly postural rotation of the lumbar spine (Sahrmann, 2002). Sahrmann (2002) explains how rotational motion within the lumbar spine may be restricted due to shortness or stiffness of oblique abdominal muscles. Gibbons and Tehan, (1998) agree with Sahrmann, (2002) whereby rotation and lateral flexion are coupled motions therefore impairment in the motion or alignment in one of these movements directly affects the other. If differential muscle development is the cause of asymmetry there are limitations in lateral flexion to the opposite side of the larger muscle than to the same side, due to stiffness in the larger muscle (Sahrmann, 2002). However if postural rotation is the cause of paraspinal asymmetry the movement of lateral flexion will be restricted to the same side as the asymmetry and normal movement range occurs on the opposite side (Sahrmann, 2002).

Sitting postures have been observed in previous clinical literature (Schuldt et al, 1986; O'Sullivan et al, 2002; 2006) and report different sitting postures affect the levels of muscle activity through the trunk and positioning of the shoulder (Bullock et al, 2005). The association to cervico-thoracic postures is limited, however, Caneiro et al, (2010) highlights the results of head and neck posture affected by thoracic-lumbar postural alignment. Their research supported Falla et al, (2007) study which suggested a relationship between faulty sitting postures and cervical posture / pain. However, Caneiro et al, (2010), was the only study to assess thoraco-lumbar posture as well as cervico-thoraco postures combined. Their findings support the adjustment of thoracic-lumbar spine in order to alter tissue patterns through the neck rather than focusing the management of the cervical spine in seclusion (Caneiro et al, 2010).

Comprehensive research into faulty postural alignments has been published by Kendall et al, (2005); their illustrations show the relationship between asymmetrical postures and bony or muscular imbalances and how they differ clinically in sideline and posterior views (Figure 3). Research by Al-Eisa et al, (2006) suggests asymmetry within lumbar biomechanics is a useful indicator of lumbar functional deficits. Although in contrast, Claus et al, (2009) suggests asymmetry in functional postures remain to be investigated thoroughly. Early studies demonstrate during sitting postures with the lumbar spine flexed, and supporting tissues relaxed, the greatest amount of rotation occurs (Pearcy, 1984). It is interesting to note that repetitive rotational motion during this position is a key cause in excessive lumbar rotation and thus is a causative factor in postural impairments and injury (Sahrmann, 2002).

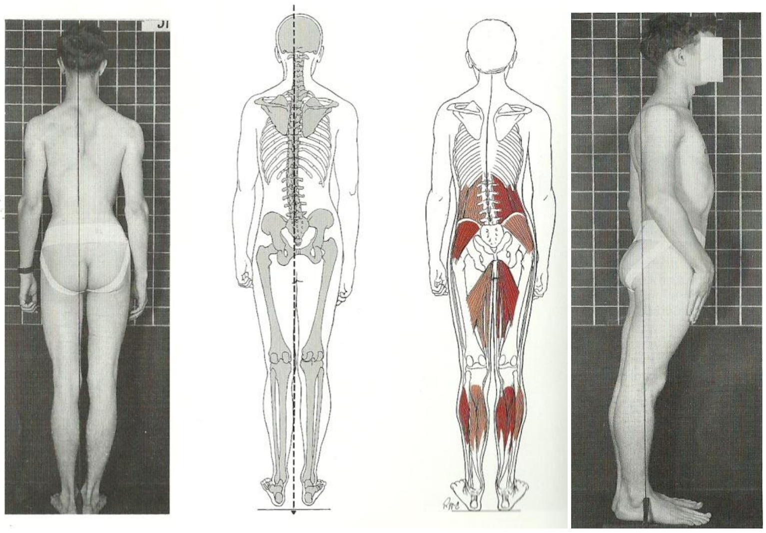


Figure 3. Posterior and lateral view of asymmetric posture and postural muscular imbalances (Kendall et al, 2005).

Pelvic asymmetry and the relationship it may have on body mechanics are well documented regarding the association with lower back pain (LBP) (Egan and Al-Eisa, 1999; Levangie, 1999; Granata and Wilson, 2001; Bussey, 2010). Al-Eisa, (2006) suggested that asymmetry in lumbar movement is coupled with pelvic asymmetry in normal populations. Sahrmann, (2002) clarifies pelvis rotation can occur from shortness of hip flexor muscles restricting hip extension therefore compensatory pelvic rotation often occurs. Recent studies support the work by Sahrmann, (2002) suggesting the relationship between pelvic asymmetry and lumbar spine mechanics show anatomical abnormalities directly link to altered lumbar spine mechanics (Al-Eisa et al, 2006). Tissue loading and distribution of forces through the lumbar spine are altered by pelvic asymmetry (Al-Eisa et al, 2006). Previous studies focus mainly on lateral pelvic tilt in the frontal plane and evidence supports the link between structural asymmetries occurring through the lumbar spine or pelvis and movement asymmetries (Al-Eisa et al, 2006). Further quantification of the influence pelvic asymmetry has on lumbar spine kinematics is required.

1.1.2 Handedness and the Effects on Posture

Kendall et al, (2005) discusses briefly the effect of handedness on posture and suggests variance in shoulder heights, pelvic deviations, unbalanced gluteal muscles and spinal divergence are some of the typical patterns that arise. The change in shoulder heights are explained as compensatory to the side of the higher hip and are usually corrected from the correction of the pelvic tilt (Kendall et al, 2005).

Literature has not gone as far as to suggest what extent handedness has within sporting postures, especially sports requiring symmetry such as horse riding to achieve performance. Equine based journals discuss the importance of how a rider is required to maintain an even connection from their hands through the reins to the horse via the 'bit' (Terada et al, 2006; Kang et al, 2010). Findings by Kendall et al, (2005) should therefore be taken into consideration; they suggest typically how a handedness postures can present with postural weaknesses through upper back extensors, anterior abdominal muscles, anterior neck muscles and middle and lower trapezius weaknesses.

1.1.3 Leg Length Discrepancies and the Effects on Posture

Leg-length discrepancy (LLD), is thought to affect lower limb gait mechanics and posture, causing the occurrence of clinical conditions such as low back pain, sacroiliac discomfort and potential injuries during running (Subotnick, 1981; Friberg, 1983; Beattie et al, 1990; Gibbons et al, 2002; Gurney, 2002). Conflicting research varies in what is considered to be a clinically significant LLD and therefore research struggles to agree as to what degree induces musculoskeletal problems such as these (Gibbons et al, 2002; Gurney, 2002; Beattie et al, 1990). Inconsistent findings in previous research with regards to clinically significant LLD, was reported by Beattie et al, (1990). Gurney, (2002) demonstrates similar findings that measure, both objectively and subjectively the magnitude of LLD clinically relevant to affect patients. Studies concluded that the magnitude of LLD required to induce musculoskeletal problems are still controversial, and findings that demonstrate a link to pathological conditions and LLD may be coincidental.

1.1.3i Measurement of LLD

Exhaustive research has been carried out on LLD (Gurney, 2002; Knutson, 2005; 2005a; Cooperstein, 2008; Cooperstein and Lew, 2009) and what the most effective method to measure it is (Beattie et al, 1990; Rhodes et al, 1995; Levangie, 1999; Hanada et al, 2001; Petrone et al, 2003; Sabharwal and Kumar, 2008; Anderson et al 2005). Alternative clinical methods widely used include measuring anatomical leg length using a soft tape measure (Beattie et al, 1990; Anderson et al, 2005). Potentially LLD may be of importance when observing equine rider postures; however the confusing literature that surrounds the importance of LLD must be considered. Suggestions sway towards a connection between functional postural dysfunctions at the pelvis and LLD (Young et al, 2000), although evidence is not convincing as to the strength of the correlation between the two. In consideration of this research, only one study discusses LLD and equine riders collectively (Symes and Ellis, 2009). However, this limited knowledge and lack of consistency between previous literature hardly helps to clarify any further the possible implications of LLD in equine riders.

1.1.4 Key Points

- Research provides a comprehensive understanding of motion impairments caused by structural changes or muscular differences.
- Considerations of the mentioned muscular imbalances resulting in postural dysfunctions are transferable to help the understanding of possible asymmetric postures in equine riders, as a result of their sport or habitual posture patterns.
- The demand and implication of quality assessments and management techniques of postural dysfunctions are widespread throughout the literature.

1.2 MOVEMENT ANALYSIS TECHNIQUES AND TECHNOLOGY

1.2.1 Human Movement Analysis

Diverse studies have contributed to the understanding of human movement and spinal posture dysfunctions through the application of motion analysis (Sahrmann, 2002; Merletti et al, 2007; Richards et al, 2008; Claus et al, 2009; Symes and Ellis, 2009; Hobbs et al, 2010). Within human medicine motion analysis has been extensively used for decades (Hobbs et al, 2010). By applying infrared vision and reflective marker systems to observe human locomotion, movement analysis camera technology has developed incredibly over recent years (Donati et al, 2007; Claus et al, 2009). However, Colborne, (2004) estimated the study of equine gait mechanics to be at least ten years behind that of human motion / gait analysis. Although equine movement analysis has developed extensively in current equine research, from simple high-speed cameras (Schils et al, 1993) to modern infrared biomechanical gait motion analysis cameras (Peham et al, 2004; Clayton and Schamhardt, 2001; Witte et al, 2009; Hobbs et al, 2010).

Modern motion analysis systems utilise a variety of methods to track movement in both two and three-dimensions (Richards, 2008), from the rapid development of hardware and software over the last ten years (Hobbs et al, 2010). The accuracy of the measurements recorded by the infrared cameras is dependent on the calibration and number of cameras applied (Hobbs et al, 2010). A minimum of two cameras, depending on the complexity of the biomechanical model, are required to collect 3D kinematic data (Richards, 2008). Research has discovered that the higher number of cameras used the lower the occurrence of errors in three-dimensional coordinates (Woltring, 1980). Depending on the speed of the activity, the camera speeds can be adjusted accordingly, for example an activity with a higher angular velocities require a higher camera speed, such as trotting or jumping in equine studies (Hobbs et al, 2010). For human movement analysis the simplest marker set applies markers over a bony anatomical landmark on the skin, a straight line between the markers can then define the position of the limb segment (Richards, 2008). However, to establish a dynamic coordinate system typically a minimum of three reflective markers are required, per bodily segment (Hobbs et al, 2010), in order to measure each segment using the calibrated anatomical system technique (CAST) proposed by Cappozzo et al, (1995). This technique of identifying anatomical landmarks is arguably the most reliable method to apply in order to achieve functional data analysis of joint centres (Richards, 2008). An example below (figure 4) demonstrates typical marker placements on equines transpiring from their use within human motion analysis.

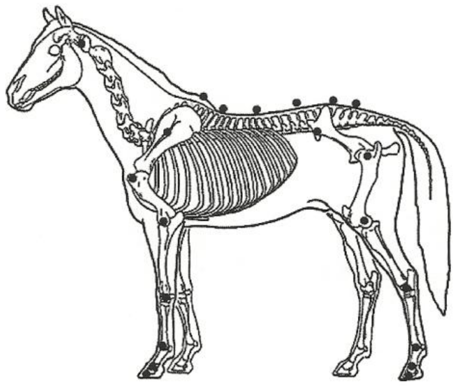


Figure 4. Common marker placement for equines, indicated by the black dots (Clayton and Schamhardt, 2001).

1.2.2 Observation of Rider Positions using Movement Analysis Techniques

The enhancement of technique or performance in other sports in comparison to equitation appears to be advanced in their use of motion analysis technology. The observations of rider postures using various motion analysis techniques are limited throughout equitation research. From the available literature, studies have compared skill levels of riders at different gaits by analysing relative joint angles (Schils et al, 1993; Lovett et al, 2004; Kang et al, 2010), the effects of rider skill levels (Peham et al, 2001) and rider presence (Peham et al, 2004) on motion pattern consistency in the horse. The results of previous work have however provided a base from which to identify kinematic variables in order to help define ideal rider positions. A recent study by Symes and Ellis, (2009) observes the postures of riders by determining shoulder displacement in order to examine postural asymmetries. They measured the angle of each shoulder to the craniocaudal line of the horse in various gaits to establish any asymmetry; however this study used digital camera software and therefore only observed postures in one plane. To quantify rider asymmetry to a higher degree the application of 3D motion analysis, viewing all planes of rider movement would provide original research in this area.

Other equitation based research has focused on rider movements and the forces acting on the horses back (Peinen et al, 2009; Peham et al, 2010), by using a combination of technologies to determine force distribution patterns and kinematic movement of the rider collaboratively. These studies combined have shown how an experienced rider provides a stabilising effect to the horse whilst on a treadmill (Figure 5) using motion analysis to observe the interaction of both horse and rider (Schőllhorn et al, 2006; Peham et al, 2004). A handful of studies have investigated the consistency of motion pattern (Witte et al, 2009) and combined the movements of horse and rider, using motion analysis in order to quantify harmony (Peham et al, 2001). A term often used during the discipline of dressage to describe a rider's ability and connection with the horse.

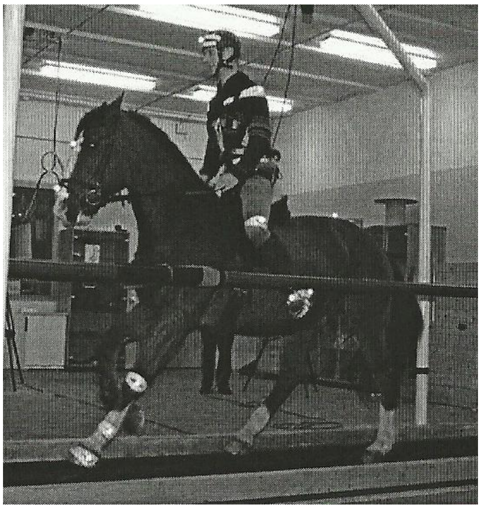


Figure 5. Equine on treadmill using motion analysis camera system to capture the motion patterns of a ridden horse (Peham et al, 2004).

1.2.3 Equine Movement Analysis

Farriers, clinicians, riders and trainers have been analysing the gait of equines previous to the development of any gait analysis system available (Colborne, 2004). Subjectively these techniques of assessing equine movement were reliable, economical and accurate in detecting lameness (Barrey, 1999; Clayton and Schamhardt, 2001). As the development of capturing moving images emerged many early studies utilised 2-dimensional images, currently still used today (Hobbs et al, 2010). Research has capitalised on previous studies using human participants of which, has had implications within modern day rehabilitation and orthopaedics (Colborne, 2004). Other methods that have accelerated contemporary knowledge of human and equine locomotion include; walkmats, electrogoniometers and accelerometers (Richards, 2008), however these methods do not come without their challenges. Originally designed for use on bipeds, applying them for use on horses is still under development in this area of research (Hobbs et al, 2010).

One concern with using infrared motion analysis cameras is the cost, consisting of expensive cameras and computer systems, mainly situated in an indoor purpose built laboratory (Colborne, 2004). The application of systems like these within an equine environment is emerging in innovative studies (Hobbs et al, 2011); new research in the area of equine biomechanical analysis is exciting, substantial work has been carried out by Clayton et al, (2001; 2010); Schamhardt et al, (2001) and Hobbs et al, (2009; 2010a; 2010b) covering aspects from equine joint kinematics to equine locomotion. Conversely there are still limited modern studies that apply movement analysis camera systems to assess the rider or both horse and rider simultaneously (Peham et al, 2004; Lagarde et al, 2005; Symes and Ellis, 2009).

1.2.4 Observing and Understanding Rider Postures

Previous equitation literature has provided advice for riders on how to achieve a better riding posture and seat, without the use of modern motion technology (Schamberger, 2005; Wanless, 2008). In conjunction with biomechanical explanations of how a riders' posture can affect a horses' motion, common rider faults and correctional methods for postural imbalances in riders were discussed by Wanless, (2008). However, to quantify potentially small kinematic changes as a result of a therapeutic intervention to adjust posture, the requirement of accurate tools is fundamental for comparable results to be established.

1.2.5 Key Points

- Rider and equine biomechanics and application of motion analysis technology to observe asymmetry in rider posture is minimal in modern research.
- To use 3D motion analysis is necessary to develop research in the area of equine rider postural characteristics.

- Methodology in which data is quantified needs to be reviewed to gain optimal methods of data collection.

1.3 EQUINE RIDER POSTURE AND ASYMMETRY

1.3.1 The Rider Athlete

The knowledge of underlying anatomic mechanisms helps to understand how the hip joints, sacrum, spine and neck of equine riders undergo huge physical strains during equestrian activities (Mason, 2006). Riding as a sport is as demanding and requires such skills as that of skiing, surfing, and snowboarding (Wanless, 2008). Athletes involved in these sports including equine riders are suggested by Wanless, (2008) to have high levels of isometric muscle tone in order to stabilise themselves on top of a moving and potentially unpredictable medium. The basic pre-requisite is to maintain a correct seat and riding position in order to apply effective aids and guide the horse (Schamberger, 2002; Dulak, 2006; Blockhuis et al, 2008).

1.3.2 Riding Disciplines and Posture

The 'classical' riding position (Figure 6) allows for maximum application of a rider's aids (body, seat, legs and hands) (Gordon-Watson, 1995). Although this is quite simple to achieve statically, it is a position attempted by riders through function riding gaits in most disciplines (Kang et al, 2010).

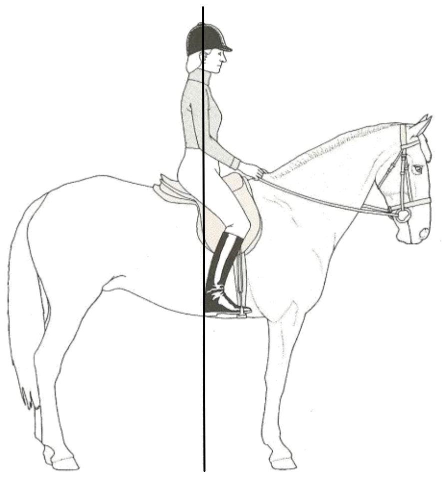


Figure 6. Classical riding position with rider positioned over the horses' centre of gravity, riders shoulder, hip and heel can be connected in this position (Gordon-Watson, 2005).

Whilst correctly positioned over the horses' centre of gravity during movement, effective aids are crucial to develop successful communication between rider and equine, stemming from a stable seat (Peham et al, 2010). The pressure and relaxation applied through rider's aids indicate how they want the horse to move, change pace or direction; the horse will react to these aids and respond to the rider's legs, seat and hands (Gordon-Watson, 1995). To remain harmonious with the horses' movements rider straightness without stiffness and suppleness without the rider being 'slack' are some of the underlying terms used within the literature describing a 'good seat' (Gordon-Watson, 1995; Kang et al, 2010).

1.3.3 Flatwork, Gaits and the Riders Seat

Flatwork riding underlies all other riding disciplines (Wanless, 2008) including the gait of trot. The gait of trot is symmetrical in motion; the horse goes from one diagonal pair of legs to another in a continuous movement which has a rhythmic two-time beat (Peham et al, 2004; Schamberger, 2002). During rising trot (Figure 7), in one complete stance the rider sits once per motion cycle (Peham et al, 2010) and is otherwise in a stance position in their stirrups. In comparison the rider performing sitting trot (Figure 8) is in continuous contact with the saddle (de Cocq et al, 2010), with the aim being to follow the horses' movement in a central, stable riding position (Peham et al, 2010). Sitting trot allows the rider to have ultimate control by using their seta and weight to encourage the horse to make upwards or downwards transitions in gait. Furthermore it shows a riders' equitation ability to move the horse.

Physically it is harder for the rider to ride sitting trot compared to rising trot, as riders' need active coordination of their lower back and core muscles to follow the horse's movements correctly. Biomechanically when in rising trot the rider adjusts their hip and lower back to account for the horses' inertia forces in this gait. By pushing themselves up into the stirrups the rider 'misses' the bounce that occurs. Not applied correctly, sitting trot can cause hollowing or stiffening of the horses back. This demonstrates the link between how a riders' posture can manipulate the outcome of forces of the horse during this gait. Together making it feel more comfortable to ride alongside better performance outcomes in the horse, taking into account welfare issues in the horse.

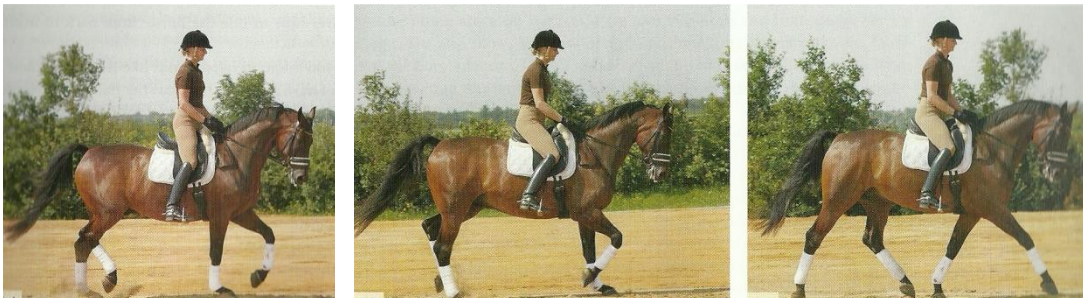


Figure 7. Riding gait of (rising) trot (Wanless, 2008).

Figure 8. Rider performing sitting trot, notice the constant relationship between her seat and the saddle in comparison to rising trot (Wanless 2008).

During flatwork the rider aims for their upper body to be positioned as vertically as possible over their sacrum and pelvis, with their shoulders depressed, slightly retracted but relaxed (Schamberger, 2002). The head should be in an upright position with the rider focusing ahead without pushing the chin forward. Equitation literature suggests riders should have a level, balanced pelvis and sacrum with an erect trunk, although the spine should move fluidly with the horse (Schamberger, 2002). Riders strive to achieve a deep seat, by allowing their thighs to lie flat against the saddle with substantial internal hip rotation and position the medial aspect of the knee correctly with the saddle. Keener and Levy, (2005) express how horses are unable to move correctly and to their optimal potential if the rider is unbalanced, which consequently reduces optimum communication between horse and rider (Gordon-Watson, 1995; Wanless, 2008). Literature agrees it is inevitable that horses are sensitive to a rider's stability and position of their centre of gravity alongside asymmetry in the rider's seat (Wanless, 2008; Blignault, 2009; Kang et al, 2010).

How well a horse and rider move and perform together is subjectively what is judged during competition standard for example (Keener and Levy, 2005). Following Peham et al, (2004) hypothesis that a rider exerts a stabilising affect by interfering when external unbalancing influences pressurise the horses motion pattern, control of speed and movement by the rider is thus increased to aid stability. Therefore could the opposite be true, potentially if a rider is asymmetric this could unbalance the horse by the rider negatively interfering with the motion pattern. Specifically, disproportion in the trot gait is known to cause the horse to bring down the foreleg which will strike the ground with more weight (Schamberger, 2002) leading overtime to potential injury and confusion in signals from rider to horse. Symes and Ellis, (2009) demonstrate an interesting point regarding the rider performing sitting trot in their study and suggest that if a rider is truly symmetrical then little difference should be seen in trot, which subsequently is a symmetrical gait itself. An interesting study by Keener and Levy, (2005) compared riders postures when mounted on two different horses and concluded that the hip kinematics of the rider's when riding the different horses were different. The outcome of this study is not surprising in the suggestion that the movement patterns of horses' can affect a rider's posture; however, it supports the idea that the more flexible and aligned a rider's posture is the better equipped the rider will be in order to achieve an effective seat and position on any horse to gain optimal performance.

1.3.4 Rider Experience and the Biomechanical Effects on Equine Motion

For a rider to manoeuvre a horse, they must establish coordinated movements which have a practical effect on a horse's balance (Peham et al, 2004; Lagarde et al, 2005; Blignault, 2009; Peham et al, 2010). An experienced rider has superior motor coordination skills and balancing abilities which are 'in tune' essentially with a horse's movement and balance, ultimately the horse's performance (Terada et al, 2006; Blignault, 2009). Schöllhorn et al, (2006) ascertained how an experienced rider can adapt their riding style and establish better communication, coordination and stability to the horses' motion patterns. Experienced riders exhibiting an ideal posture and can perform a balanced seat tend to have a spine that is mobile but also controlled; Schamberger, (2002) describes this motion as the spine moving laterally with ease from a concave position to a convex position. Mason, (2006) agrees this movement allows for the lower back of the rider to move backwards and forwards flowing with the movement of the horse. In a novice rider, generally, this movement of the spine is not achieved therefore the rider cannot aid the horse with the action of their spine and pelvis as an experienced rider can (Schamberger, 2002).

Peham et al, (2010) supports the suggestion of using experienced riders in studies measuring equine movement on a treadmill for example, due to the stabilising effect of the rider. An earlier study demonstrates the stabilising effect of a rider by comparing the motion pattern of a well-ridden horse to that of an un-ridden horse (Peham et al, 2004). The un-ridden horse had higher motion pattern variability compared to that of the ridden horse, and was therefore more stable with the rider, which became noticeable in the horses higher ability to adapt to the speed of the treadmill (Peham et al, 2004). Lagarde et al, (2005) reported how an experienced rider had the ability to closely synchronise their upper body movements with that of the horse's trunk motion during sitting trot compared to a novice rider. By measuring the riders' motions and comparing the oscillations it was clear to see the expert rider had more regular oscillations than the novice, whom was more passively perturbed by the horses' vertical motion force (Lagarde et al, 2005).

Schils et al, (1993) originally recognised how a novice rider's trunk tended to tilt forward, the skilled rider could maintain a vertical position, in a later study Terada et al, (2006) agreed with these findings and reported an almost vertical trunk orientation in the expert rider, with only a torso extension tilt of 4°. A current study by Kang et al, (2010) supports these findings and further concludes that certain postures of novice or inexperienced riders prohibit a rider from establishing a correct seat, therefore affecting motion pattern occurring from the horses propulsive forces.

1.3.5 Equine Adaptation to Riders' Weight Distribution

The evaluation of saddle types, pressure distribution over a horses back, and the effects a rider may have on an equines gait and the forces acting on the equines back have been discussed throughout scientific literature (Jeffcott et al, 1999; Robert et al, 2001; Frühwirth et al, 2004; Meschan et al, 2007; Peham et al, 2010; Witte et al, 2009). Research has identified that when a horse carries a rider the horses' kinematics change (Back and Clayton, 2000; Weishaupt et al, 2006). Studies have investigated the effect of rider weight (Clayton et al, 1999; de Cocq et al, 2004, 2009a, 2009b, 2010) on horse locomotion. Peham et al, (2010) observed the stability of the rider's seat during different positions in trot and compared the forces acting on the equines back. The results of this study indicated throughout rising trot the forces through the equines back are reduced when the rider is stood up in the stirrups (Peham et al, 2010). This motion during the rider's stance phase in the stirrups supports diagonals within an equines stride cycle and allows for asymmetric loading to take place through the equines back. Comparatively data signify how in sitting trot pressure forces were higher in comparison to that of rising trot. However, when reviewing the centre of pressure (COP) data, results indicated that the stability of the rider's seat was lowest during sitting trot and highest during rising trot. The stability of the rider's seat was measured by COP excursion, Peham et al, (2010) indicates that the higher the excursion of the COP, the lower the stability of the rider's seat. Therefore results indicate that rising trot is less demanding on the horse than performing sitting trot, and the rider is more stable during rising trot.

In contrast, de Cocq et al, (2009b) hypothesised that sitting trot in comparison to rising trot has a more extending effect on the horses back and heightens the head and neck position of the horse. However they concluded that rising trot was no less challenging for the horses back than when the rider is in sitting trot, disagreeing with Peham et al, (2010) findings. Results indicated that the back movements of the horse whilst the rider was in rising trot showed the same maximal back extension reached during sitting trot. In comparison to Peham et al, (2010) study, de Cocq et al, (2009b) did not quantify COP data, it may be possible that although kinematic data showed similar characteristics of movement in the horse during rising and sitting trot, the COP from the riders presence varies between rising and sitting trot, agreeing with an earlier study by Jeffcott et al, (1999). Furthermore the consideration of different equine breeds, use and training level may have affected the results in the Peham et al, (2010) study. The authors of this study additionally stress that muscle activity in the horses back from different trotting speeds influenced the pressure distribution under the saddle, therefore may have affected how stable the rider was perceived during sitting trot position from COP excursion results. Collectively these results are clinically relevant when considering how they may affect the efficiency of communication between horse and rider and supports previous literature (Schamberger, 2005, Mason, 2006). The fact that a rider is perceived as being more unstable during sitting trot than rising trot must be taken into account when considering the effect it may have on rider symmetry.

1.3.6 Asymmetry in Rider Postures

Riding is a complex, demanding sport and the quality of performance is dependent on postural skill and rider perception (Schils et al, 1993). For a horse to perform to its full potential and equally on both sides, a rider in any equitation discipline must have a 'deep seat' when in the saddle, which is directly related to an ideal riding posture alignment of the shoulders, spine and hips. Schamberger, (2002) clearly supports how a rider's seat is vital in recognising if rider-based malalignment is present and discusses that in the sagittal and transverse planes of motion the rider's pelvis must be symmetrical and level. Subsequently a horse will be well balanced and move freely allowing for equal movement and flexion through the horse's neck and body (Schamberger, 2002). Discussions and topical research regarding rider asymmetry alone is uncommon throughout scientific literature, even though there is, albeit minimal, subjective association between poor postural performance, rider injury and reduced equine performance within the literature available (Dyson, 2002; Symes and Ellis, 2009). It has been stressed by Symes and Ellis, (2009) that it is difficult to establish a controlled environment where the interface between horse and rider can be measured. However, Schamberger's, (2002) research into postural malalignment in athletes strongly advocates how asymmetry may be a result of a previous musculoskeletal or soft tissue injury. Habitual postures and asymmetry occurring in the equine, amongst other factors combined can be a factor for postural imbalances and asymmetry to occur in the rider (Symes and Ellis, 2009). Achieving the correct balance and ability to produce fluid movement can be compromised if a rider presents with a pelvis that is uneven for example (Schamberger, 2002). As Schamberger, (2002) suggests, more often than not a rider is unaware of any changes or postural imbalances that may have occurred over time or as a result of a previous injury, as they may not be in any pain to suggest a dysfunction in their posture. If a rider does have trouble sitting deep in the saddle, literature advocates that the rider's weight is therefore not distributed evenly (Mason, 2006; Wanless, 2008). Rotations in pelvic alignment or an incorrect seat due to asymmetry in a rider's spinal posture contribute to the ability of the rider to apply aids and have control over the horse (Schamberger, 2002).

The most recent study surrounding rider asymmetry by Symes and Ellis, (2009) expresses how the horse relies and responds to signals from the rider. The aim of this study was to determine an assessment for rider asymmetry in order to improve the techniques of coaches to address such issues. Furthermore welfare and performance issues were an outcome of this study as research postulates how asymmetric equine riders may have negative repercussions on the horses' performance (Schamberger, 2002; Symes and Ellis, 2009). They determined rider asymmetry by measuring displacement of the riders' shoulders and took into account leg length inequalities (LLI) of the riders. All riders used their own horse and saddle for consistency in testing; however it was not taken into account the standard or level of the riders or the potential influences of using their own horses, rather than horses of similar ability or use. The importance of correcting postural asymmetry in equestrian riders is understated in the literature. Conversely key aspects associated with the correction of rider asymmetry, in respect to postural impairments and the potential benefits, were of limited discussion in this study. Symes and Ellis, (2009) encourage further investigation into supporting the definition of asymmetry in riders, and most importantly from a clinical perspective, the assessment into clinical therapeutic correction methods of asymmetry in equine riders.

1.3.7 Examples of Typical Postural Dysfunctions in Riders

The following section discusses common postural defaults in everyday riders, including; tipping forward, leaning backwards, hollowing the back, rounding the back and asymmetries through the torso. In flat work forward tipping of the riders' head (Figure 9) originating from the cervical spine is commonly observed (Mason, 2006). This provides an example of how a change in the curvature of the spine can have a substantial reduction in the ability of a riders' spinal mechanics to move with the motion of the horse correctly. Consequently this postural change shifts the rider's body weight into a forwards position, which forces the weight down the horses' forehand (Mason, 2006). The overall result can be a reduction in range of motion in the horses' shoulders and a subsequent loss of impulsion.

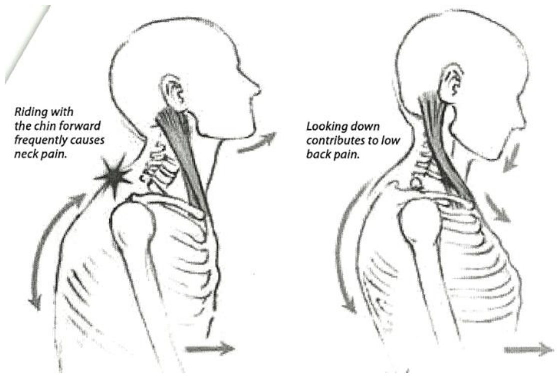


Figure 9. Common cervical and thoracic postures which inhibit torso balance and ideal riding seat (Mason, 2006).

1.3.7i Dysfunctions - Tipping Forward & Hollow Back

The way in which the lumbar spine should be positioned affects the motion occurring at the riders head (Wanless, 2008). If the rider is hinging forward through the lumbar spine the angle between thigh and torso is reduced and in this case the riders' ishial tuberosities will point backwards (Figure 10). Anatomically the rider's hip flexors are short and strong and extensors through the spine are weak and elongated. These muscular imbalances coincide with previous literature (Kendall et al, 2005) that discusses this type of dysfunction when in a standing position. It would be interesting to observe this rider in standing to understand how the impairment in riding transfers to an upright position, and if indeed the dysfunction is perceivable. Agreeing with previous research by Schils et al, (1993), Kang et al, (2010) reported that less-skilled or inexperienced riders tend to have a trunk that is tilted forwards, moving away from an effective riding position. An ineffective riding position is not only aesthetically incorrect from a coach or instructors point of view but has welfare implications for the horse (Symes and Ellis, 2009). In agreement with Symes and Ellis, (2009) the perception that the horse does not understand the riders intentions could arise from the rider giving confusing signals due to an ineffective riding position. This could further lead to frustration in the rider, and the possible application of stronger tack for the horse to manipulate its behaviour.

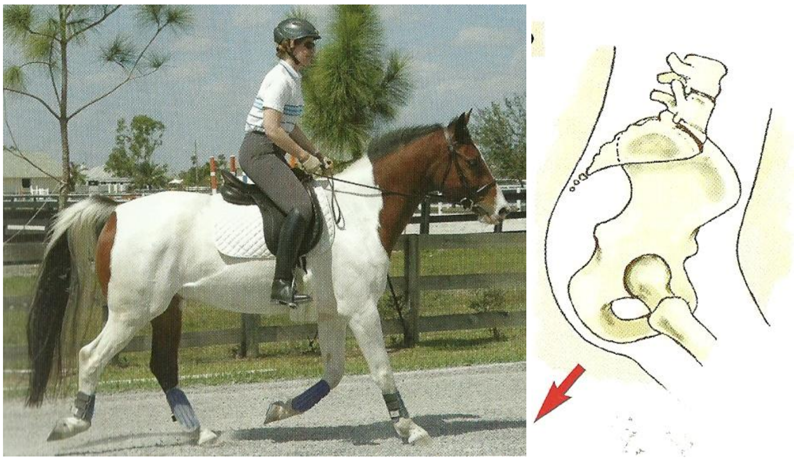


Figure 10. Tipping forwards and direction of the rider's ischial tuberosities (Wanless, 2008).

In contrast Blignault, (2009) suggests that although not aesthetically correct leaning forwards does not affect the placement of a horses' foreleg. However, contradicting this point Blignault, (2009) supports the connotation that when leaning forward the seat bones are 'off the saddle', i.e. as Wanless, (2008) describes 'pointing backwards'. Blignault, (2009) supports the suggestion that this position will not always allow for effective riding. Confusingly Blignault, (2009) proposes that it is more important to be an effective rider than to sit in a perfect position. However Wanless, (2008) would argue that to be an effective rider stems from achieving the most aligned postural position. Most studies agree that the correct application of riders' aids is accomplished through good seat positioning and postural alignment (Terada, 2000; Lovett et al, 2004; Wanless, 2008; Symes and Ellis, 2009; Kang et al, 2010). Research has demonstrated a link between asymmetrical seats and equine performance (Mason, 2006; Wanless, 2008). Yet Blignault, (2009) advocates that horses learn to adapt to a riders asymmetry and that it is a crooked saddle that is to blame for asymmetrical riders. Previous research demonstrates how saddle fit can affect motion variability in a horse (Peham et al, 2004; Peinen et al, 2009), however these studies did not make any suggestion that the saddle influenced asymmetry in a rider. Controversially if a horse is expected to adapt to a riders asymmetry the influence it has on the equines gait must be considered. It could be argued that adaptations in equine motion pattern stemming from the riders position, coincide with muscular imbalances and initiate change in natural movements of the horse. However, there is limited research that discusses this area in further detail. To summarise, the points made by Blignault, (2009) are extremely valid, however, scientific studies go beyond the discussion of how a horse can adapt its balance to a riders' position. The consideration of balance adaptation in the horse is important although recent literature concludes the significance of rider experience, postural riding position and weight distribution when discussing the potential effects of riding postures.

1.3.7ii Dysfunctions – Leaning Backwards & Rounded Back

Characteristics of riders determine how they sit in the saddle, a rounded back or leaning backwards initiates a chain reaction in the whole alignment of the riders' position. By leaning back in the saddle literature suggests the riders' ischial tuberosities point forward (Figure 11), rather than pointing straight down (Wanless, 2008). Without making ideal contact through the saddle, the ability of the rider to co-ordinate their aids is reduced (Blignault, 2009; Kang et al, 2010). The riders' centre of gravity (COG) in this position is now behind the horses COG and incorrect contact with the saddle occurs. The result in performance of the horse is the drive down into the equines foreleg, raising the croup during the canter gait for instance (Wanless, 2008). Fundamentally this imbalance can distort the weight bearing loads unevenly through the equines limbs and overtime leading to muscular asymmetries in the horse.

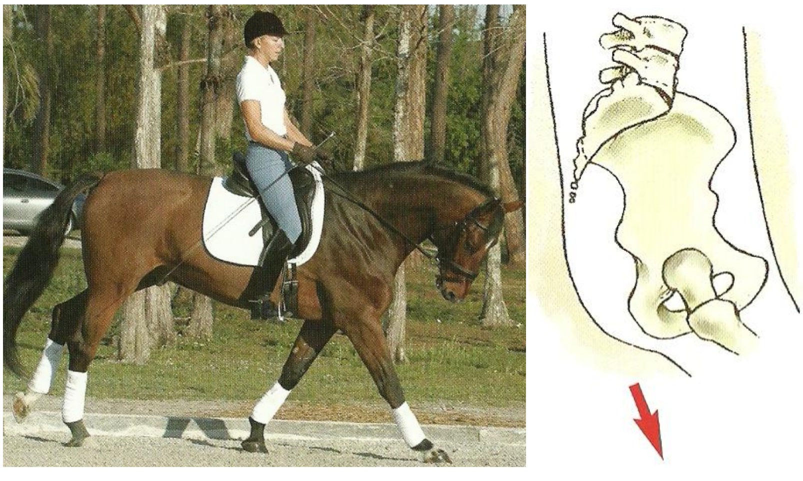


Figure 11. Direction of the rider's seat ischial tuberosities when leaning back (Wanless, 2008).

In this position the rider's body is opened up through the thigh and torso angle at the front, low torso isometric tone results (Wanless, 2008). Fundamentally the rider struggles to bring their ribcage over the base of support, which when performed would reduce the height of the pubic bone and angle the ischial tuberosities vertically. Subsequently this should engage the balance of postural muscles, or vice versa, whereby postural muscles of the spine engage to create the aligned position.

1.3.7iii Dysfunction - Rotational and Lateral Asymmetries

Schamberger (2002) demonstrates a rider with a 'C' curvature to the right here the riders right knee is raised and the foot sits forward (Figure 12). This imbalance in the rider's seat is enough to stop the horse from flexing and bending to the left without difficulty (Schamberger, 2002). In consideration of the balance through the riders' ischial tuberosities, this asymmetry makes the riders right ischial tuberosity heavy and forces it backwards.

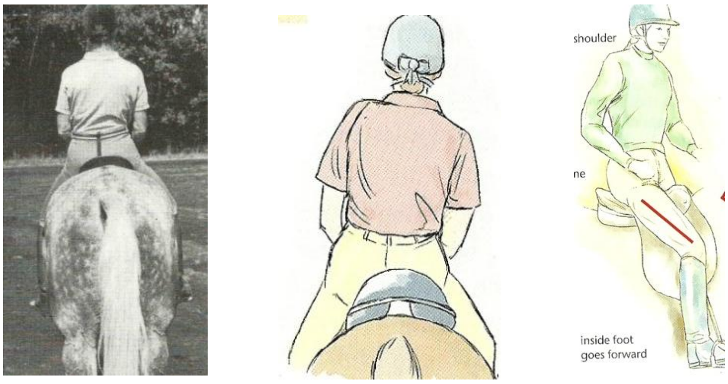
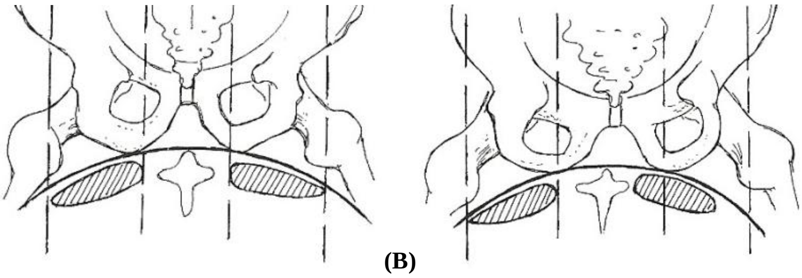


Figure 12. Asymmetry in a rider with pelvic/trunk rotation to the right and classic 'C' curvature (Schamberger, 2002). Wanless, (2008) demonstrates a slightly exaggerated illustration of this 'C' curve to the right.

Mason, (2006) describes how minimal variations in a rider's torso alignment can affect rhythm of a horses' movement, conversely a rider with optimal vertical alignment, correct balance and seat through their pelvis, spine and shoulders is easier for the horse to support and predict. Human biomechanics has determined how during spinal motion a side-bend (lateral flexion) is accompanied by a twist (rotation) (Wanless, 2008). Equine based literature explains that as a rider side-bends and rotates, their ischial tuberosity on the side they are leaning towards becomes heavier in the saddle, whilst the opposite ischial tuberosity becomes lighter (Figure 13) (Wanless, 2008).



4A) **(B)**

Figure. 13. Illustration (A) shows the ideal positioning of the rider's ishial tuberosities. Illustration (B) demonstrates a common asymmetry in rider's ishial tuberosities, with more pressure on one side (Wanless, 2008).

A study by de Cocq et al, (2009a) evaluated asymmetrical loading of the back of the horse by measuring force distribution. Results confirmed that when the rider side bends by 10° to the right in this case, this affected force distribution (Figure 14). This demonstrates the possible difference in force distribution of lateral asymmetries occurring in the rider, however as this was statically observed, the implications of this asymmetry and force distribution during functional riding needs to be challenged further.

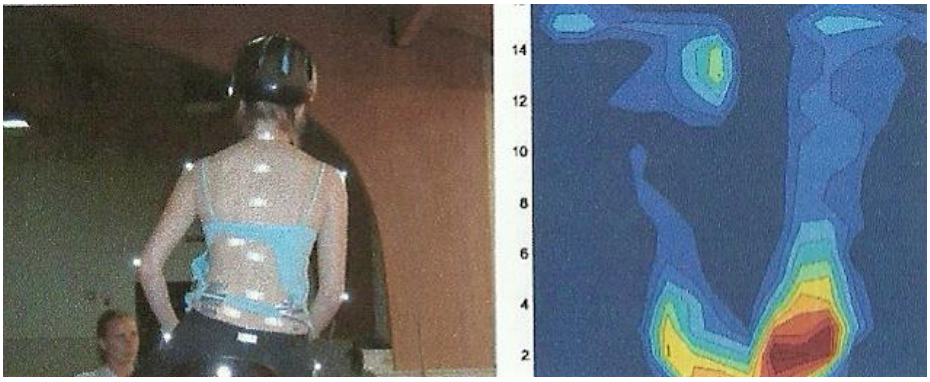
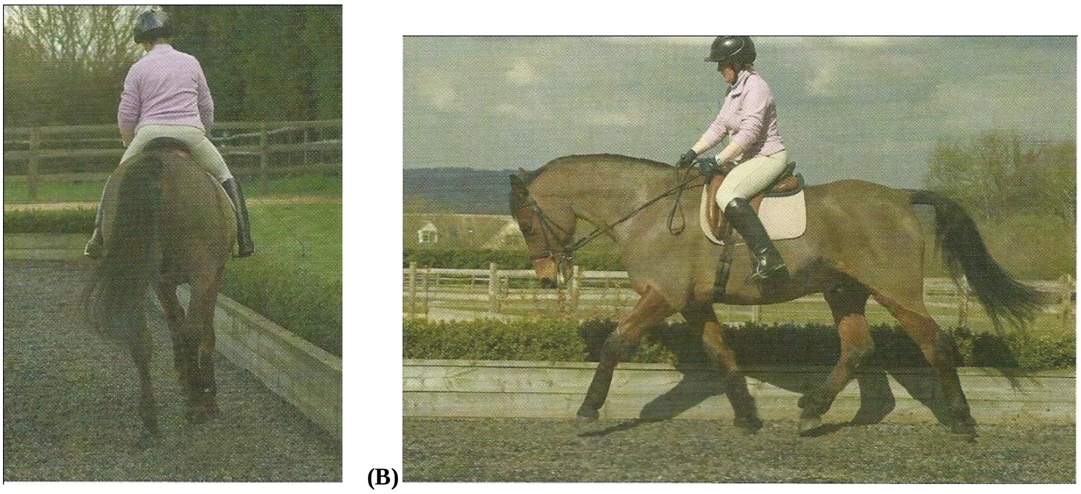


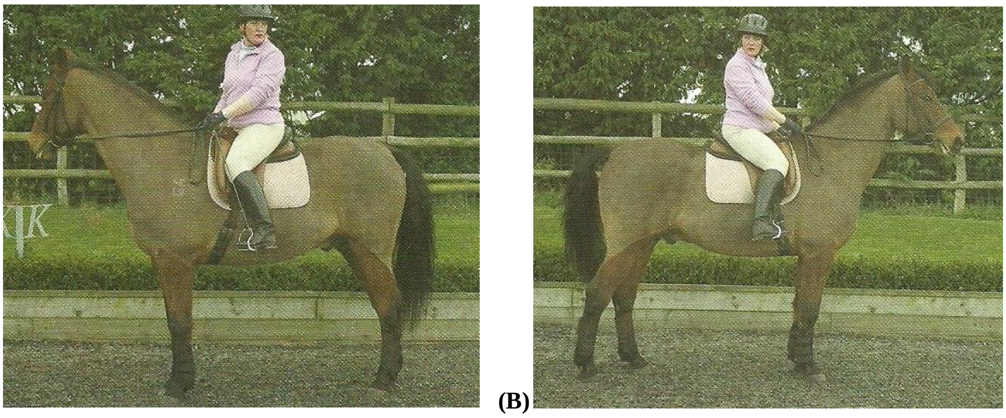
Figure 14. Still photograph of the riders movement corresponding to the map of normal force distribution under the saddle. The red area indicates the higher force pressure (de Cocq et al, 2009a).

In asymmetric postures that show visible curvatures to the left (Figure 15) through the riders' spine from a posterior view in sitting, Wanless, (2008) describes what occurs during riding. From a posterior observation the riders chin goes to the left of the horses midline, their left hand is behind the right, with the bit pulled through the horse's mouth slightly, and you can see more of the rider's chest than her back (Figure 16).



(A) (B)

Figure 15. Photo (A) demonstrates the curve of this rider's posture, and photo (B) the rider's chest is more visible indication of a twist, bringing the riders left hand backwards (Wanless, 2008).



(A) (B)

Figure 16. Difference between the riders range in rotation, turning right (B) she rotates mainly her neck and turning left (A) her torso is rotated further (Wanless, 2008).

Each asymmetry that occurs through the riders' position involves both sides of the body (Wanless, 2008). For example, if one side of the torso is laterally flexing and rotating then the opposite side will be stretching.

1.3.8 Rider Asymmetry and Leg Length Discrepancies

The most recent and significant study surrounding rider asymmetry by Symes and Ellis, (2009) confirms for the first time that the riders' in their study sat and moved asymmetrically. They suggest one reason behind the riders' asymmetry was leg length inequality (LLI), which in numerous texts is recognised as a key influential factor in functional and anatomical asymmetry. Anatomically LLI can theoretically cause thoracic and pelvic girdle tilt and rotation (Young et al, 2000); furthermore Symes and Ellis, (2009) stress how this can lead to changes in axial rotation (AR). It has previously been found that in riders AR preference is common, and may be the underlying contribution to rider-derived asymmetry (Symes and Ellis, 2009). Although literature is extensive in the area of LLI, poor agreement as to how much LLI is needed to cause biomechanical changes in posture, and thus how relevant this actually is to equine rider posture and asymmetries. As the riders legs are flexed at the knee during trot positions this may flaw the relevance of LLI, as LLI would be potentially compensated for in this position. The relevance of LLI in sitting trot is likely to be insubstantial, as LLI is currently accounted for by assessment of a straight leg, not bent. However, it would be interesting to note any correlations in this study with that of Symes and Ellis, (2009) regarding leg length data.

1.3.9 Key Points

- Similarities were prominent throughout the literature when discussing the biomechanical effects on the horse between novice and experienced riders.
- Research has established the recommendation for the use of experienced and skilled riders in equine rider posture or motion pattern analysis studies.
- Asymmetry in rider posture is critically analysed by Wanless (2008), without the use of motion analysis technology, rather her knowledge and biomechanical understanding of rider and equine motion.
- Limited clinical studies combine the use of modern day technologies to assess characteristics of dysfunctional rider postures.
- Currently only one scientific study discusses asymmetric postures in riders' (Symes and Ellis, 2009).
- Obvious gap throughout the literature and potential for research in this area to commence.

1.4 CORRECTION OF POSTURAL DYSFUNCTIONS

1.4.1 Background

Evidence suggests prolonged biomechanical stress exposure is damaging, the consequence likely to include pathological soft tissue changes, provoking postural dysfunctions (Liebenson, 2000; Caneiro et al, 2010) By applying clinical therapeutic methods, movement control and ideal postural alignment can be restored and musculoskeletal pain or impairments prevented (Kendall et al, 2005). There are mixed reviews throughout earlier literature as to what aspect to treat with regards to the symptoms, cause, and underlying biomechanical dysfunctions.

1.4.2 Posture Management in Riders

Back pain in riders is a common scenario (Kraft et al, 2007) and overuse postural injuries, such as muscle strain or ligamentous sprains can have a detrimental effect on symmetry within equine rider posture (Mason, 2006). Pilato et al, (2002) suggest that as riding is a seated activity, poor posture, causing malposition of the spinal motion segments, may have negative consequences for the health of a rider's spine. Minimal research (Wanless, 2008; Symes and Ellis, 2009) reports on rider asymmetry, combining the effects it can have on rider and horse performance or potential correction techniques. Substantial literature telling us what a rider should look like does not go on to discuss the potential tools that are available to encourage normal postural function in the correction of asymmetric postures presenting in equine riders. Repeatedly equine physiotherapists are called upon to assess postural alignment issues in the horse as a cause of poor performance; however literature proposes it is probably with the rider where the problem of postural alignment lies and not the horse (Schamberger, 2002: Blignault, 2009). However, Wanless, (2008) does discuss rider symmetry and demonstrates how this can affect the response from the horse, and provides a hands-on approach to posture realignment in the rider. Wanless, (2008) moves the rider into the correct position and modifies their posture whilst explaining to the rider what they should be feeling when they ride in their new position (Figure 17). This technique is based on biomechanical understanding of rider posture, function and therapeutic methods to modify structure, instigating posture alignments.

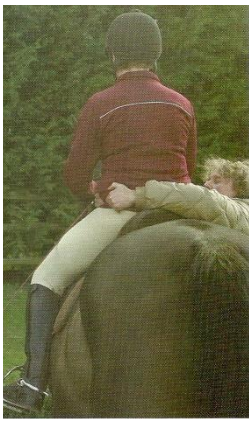


Figure 17. Adjusting the rider's hip and torso alignment balancing the weight through the rider's seat bones (Wanless, 2008).

One of the most utilised tools to enhance rider posture has been the application of Pilates exercises (Dulak, 2006). Exercises used in Pilates focus on control and quality of the movement and are low impact and non-weight-bearing. Body conditioning differs between athletes and sports, riders have specific requirements of body conditioning and the Pilates method has been found to meet these demands in order to improve rider posture and riding skills (Dulak, 2006). Dulak, (2006) suggests that to enhance a rider's ability to ride, basic exercise and keeping fit may not be enough. The introduction of exercises that are designed to utilise muscular requirements needed for equitation sports offer the rider more than just body conditioning. Evidence to support the principles and use of flexibility and stability exercises to aid a rider's posture are commonly performed off the horse (Blockhuis et al, 2008). Therefore it may be speculated as to how affective these exercises are in the functional sense whilst riding. An alternative method capable of assisting both structural and functional changes is the application of tape. No research combining the application of athletic tape on riders to enhance postural awareness, symmetry, rehabilitate postural dysfunctions or re-educate a rider's posture has been published to date. Theories behind the use of athletic tape for proprioceptive awareness are the reasoning behind this investigation into an alternative technique which could be used in conjunction with current methods which positively affect rider's posture. The following discusses the principles behind taping and current literature as the reasoning behind its application in this research.

1.4.3 Athletic Taping, Principles and Practice

Athletic taping methods are widely used by therapists aiding the rehabilitation of athletes (Morrissey, 2000; Kneeshaw, 2002; Bradley et al, 2009; Macdonald, 2009; Smith et al, 2009). The use of tape can be an important and successful treatment modality when applied accurately and applicable to the situation, alongside other physiotherapeutic techniques (Powers et al, 1997; Gerrard, 1998; Gilleard et al, 1998; Morrissey, 2000). Tape has been widely used as a useful adjunct to prophylaxis (Kneeshaw, 2002; Alexander et al, 2008) in the management of neuromusculoskeletal disorders. Macdonald, (2009) clearly summarises how tape should be applied to protect from further damage the injured tissues and / or to reinforce supportive structures in their normal relaxed position.

Although this therapeutic modality has previously been under contention throughout the literature (McNair et al, 1995; Perlau et al, 1995; Gilleard et al, 1998) recently the benefits of taping have been scientifically and clinically rationalised (MacDonald, 2009; Smith et al, 2009). Theories surrounding the rationale for taping as a clinical modality focus on the mechanical and proprioceptive effects, although as yet it is inconclusive as to the full mechanisms of action taping may have. The effects of taping most commonly described include: inhibition of overactive synergists or antagonists, promotion of proprioception, optimisation of joint alignment, pain reduction and unloading of irritable neural tissue (Host, 1995; Morrisey, 2000; MacDonald, 2009).

1.4.4 Proprioceptive Responses to Tape

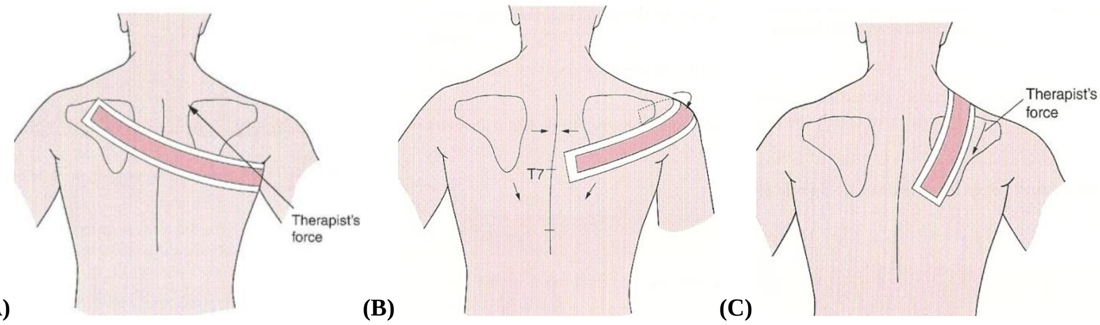
Previous literature (Parkhurst and Burnett, 1994; Alexander et al, 2003; Kneeshaw, 2002; Callaghan et al, 2002; 2008) suggests the proprioceptive effects of tape occur by stimulating neuromuscular pathways, through afferent feedback increases from cutaneous receptors; consequently the appropriate neuromuscular response will occur. Callaghan et al, (2002) found that patients with poor proprioceptive ability and joint position sense of the knee, significantly improved following the taping of the patella. Tension in the tape could have been consciously sensed by the patient when movement outside the parameters of the tape occurred (Morrissey, 2000). For effective cutaneous and proprioceptive biofeedback movement patterns overtime can be corrected as learned components (Morrissey, 2000). Studies have established the use of tape to reposition structures such as scapular re-location, or neutral patella taping, providing mechanical benefits and changes (Kneeshaw, 2002; Callaghan et al, 2002; 2008). Greig et al, (2008) found that postural taping of the thoracic spine in order to reduce thoracic kyphosis immediately reduced kyphosis in the thoracic spine. However, few studies have investigated the effects of spinal taping on posture.

A common presumption in current literature suggests taping can either facilitate or inhibit the muscle depending on the way it is applied (Alexander et al, 2003; 2008). For example, if tape is applied in the direction of the muscle fibres and applied under tension, it is suggested that this facilitates the underlying muscle fibres (Morrisey, 2000). Alternatively Tobin and Robinson, (2000) suggest tape applied across the belly of a muscle inhibits the muscle. Alexander et al, (2003) disagreed and found that taping along the length of the trapezius muscle inhibited the excitability of the muscle. Further studies on the triceps surae confirmed these earlier findings (Alexander et al, 2008). These studies suggested the unloading of the intrafusal muscle spindles was the mechanism behind the shortening or ‘inhibition’ of the trapezius and triceps surae (Alexander et al, 2003; 2008). However the effects and mechanisms are still controversial throughout current clinical literature, although the consensus supports the theory that proprioceptive and mechanical changes do occur. Research by Lewis et al, (2005) used taping as a method of changing the thoracic kyphosis and scapular position and reported that when compared to no tape the postural correction taping lead to an increase in shoulder movement in people both with and without shoulder symptoms. Whether taping is used as a means of altering muscle function, to give proprioceptive biofeedback, optimise joint alignment within static / dynamic postures to offload neural tissue irritations, in order to gain optimal results the aim of taping needs to be clear (Morrissey, 2000).

1.4.5 Shoulder Taping

Studies support the use of athletic taping as an important modality in shoulder rehabilitation and dysfunction (Gerrard, 1998; Morrissey, 2000; Watson, 2000; Lewis et al, 2005; Smith et al, 2009). It was found that taping stimulated an increase in proprioceptive feedback when applied to patients with shoulder dysfunction. The various methods of shoulder taping are extremely relevant to this study as the shoulder complex including and especially the scapular region plays a major role in the kinematics and muscular actions of the spine (Kibler, 1998; Kneeshaw, 2002).

Literature by Morrissey, (2000), Kneeshaw, (2002), and MacDonald, (2009), discuss relevant taping techniques for the shoulder complex, based on previous research, such as 'Watson's Strap' (Figure 22) and the 'Scapular-retraction strap technique' (Figure 18). Studies agree (Morrissey, 2000; Kneeshaw, 2002; Lewis et al, 2005; MacDonald, 2009) how the application of taping alongside the re-training of movement is beneficial to the shoulder dysfunction patient. Subsequently this method aids to alter the causative factors of overuse shoulder injury, reducing the risk of re-injury. Lewis et al, (2005) positively identifies how therapeutic taping can alter static postural measurements. However, they do not report any evidence to suggest the same outcomes occur during movement or athletic activity. Although this research supports the application of tape combined with corrective exercises to correct postures or muscular imbalances in the short term (Bennell et al, 2000; Lewis et al, 2005).



(A) (B) (C)

Figure 18. (A) Watson's strap taping method for neutral repositioning of the scapulae allowing for correct trapezius and rhomboid activation (MacDonald, 2009). (B) Scapular-retraction strap technique to reposition the scapular into neutral. (C) Taping of the shoulders by reducing over-activity of the trapezius muscles (MacDonald, 2009; Morrissey, 2000).

1.4.6 Athletic Taping in Equestrian Sports

Published research is non-existent when evaluating the effect and application of tape prior to equestrian riding to enable correct postural awareness or as a way to aid the correction of riders' asymmetric riding postures. Despite the anecdotal knowledge of the use of tape within equine circles currently only a couple of alternative products are available on the retail market (Figure

19). These products states they provide 'back and/or shoulder support' for riders in order to enhance their posture, eliminate back pain, retrain the upper body and encourage improved breathing (Robinsons, 2011). The concepts of this product are assumed to be similar to that of taping methods in order to adjust a person's posture whilst riding. At present no studies show the use of athletic taping on riders applied in a similar manner, in spite of its known use.

Figure 19. Two examples of back and shoulder support available on the market as a 'posture aid' for riders (Robinsons, 2011).

1.4.7 Key Points

- Concepts of taping methods underlie the hypothesis of this study, suggesting that riding postures both mechanically and proprioceptively, can be positively adjusted.
- Numerous studies compare the positive and negative aspects of therapeutic athletic taping methods.
- To what extent the application of athletic tape applied across the shoulders and spinal region of asymmetrical equine riders affects their postural awareness or alignment is non-existent in research.
- No current published body of clinical evidence discusses the use of athletic tape on equine riders, despite the known use.

1.5 LITERATURE REVIEW SUMMARY

Previous literature contributes relevant clinical evidence to aspects surrounding this study. However, research is extremely minimal and gaps were easily identifiable throughout the literature, specifically regarding the assessment of rider asymmetry and most importantly any methods available to support the correction of it. Subsequently any evidence reported was not convincing, although researchers were in agreement that further research is essential in this area. Similarities were prominent throughout the limited research regarding views on achieving an ideal rider posture for maximum benefit to the rider / horse performance outcomes and wellbeing / welfare issues.

1.5.1 Aim and Objectives

The aim of this study is to investigate the effects of athletic taping on the postures of female equestrian riders. This combines the clinical relevance of posture alignment and the influence taping has on proprioceptive awareness and adjustments in the postures of riders.

The objectives of this study are;

- To test 3D motion analysis equipment set up for the analysis of postural characteristics in female equestrian riders in a laboratory based pilot study.
- To establish optimal methods of data collection and select appropriate kinematic variables for analysis prior to full experimental protocol using horses.
- Determine the dynamic postural characteristics of female equine riders, using 3D motion analysis whilst riding in sitting trot on a horse.
- To quantify any changes in rider posture, following spinal taping whilst riding sitting trot on a horse.

CHAPTER 2

METHOD AND PILOT STUDIES

2.0 Participant Recruitment

Volunteer riders for this study were required to meet specific eligibility criteria in order to establish a minimum standard of riding across all participants (Table 1). This maintained the experience of the riders for health and safety, insurance reasons and in support of previous research, experienced riders have an increased stabilising effect on the horse than a less experienced rider (Blignault, 2009; Peham et al, 2010). Therefore all riders had to hold the British Horse Society (BHS) Stage Two certificate as a minimum requirement. The BHS proposes that to achieve Stage Two (Appendix A) a rider is required to have a good understanding of how the horse adjusts his balance to carry a rider and is capable of riding a horse in the countryside, public highway or school arena at a high level (British Horse Society, 2010).

Inclusion Criteria	Rider regularly takes part in equestrian activities and rides on a weekly basis.	Rider is registered at Level 2 standard of riding by The British Horse Society.	Rider is insured to ride at Myerscough College on any horse.	Rider is 18 years minimum
Exclusion Criteria	Rider has suffered from a spine, shoulder or hip injury in the last six months.	Rider has a known allergy to equines.	Rider has a known allergy to plasters or tape.	

Table 1. Inclusion / exclusion criteria met by each rider.

The entire population of riders from the student and staff base at Myerscough College were invited to take part in the pilot studies, however due to the necessity of the riders to be BHS stage two the expected number that would actually qualify was predicted to be low. Therefore the larger the number of riders that could be approached initially would allow for better recruitment to the study. Potential riders were approached via posters advertising the study at Myerscough campus, and via a letter, information pack and presentation of the study at Myerscough College. For the pilot studies sixteen riders took part in various trials in order to determine optimum methods for later data collection to take place at Myerscough.

2.1 Pilot Studies

Pilot studies were carried out in order to establish a clear understanding of data parameters and to familiarise data collection protocols. The pilot studies individually describe and discuss the various methods used to determine the optimal methods for the collection of data for the main study. All participants that took part in the pilot studies were given an information sheet (Appendix B) and provided written consent to take part in the research (Appendix C).

2.1.1 Pilot Study 1

Suitable riders were recruited in pilot study 1 and availability and practicality issues were identified. Leg length measurement and modeling of the pelvis and spine were also established. The objectives of pilot study 1 were:

- To practice of setting up the motion analysis equipment (Figure 20).
- To test camera capture.

Figure 20. Camera and equipment set up for pilot studies.

2.1.2 Sample Size and Riders

No studies were available at the beginning of this research in order to generate a sample size calculation. An estimated sample size of sixteen riders was therefore determined based on the practicalities of; rider availability and limited laboratory and equine arena time. Sixteen female riders with competitive riding experience at BHS stage two and above, took part in the pilot studies. Riders wore jodhpurs' a close fitting dark vest top, and no shoes. All data collection conformed to the Declaration of Helsinki with all participants providing written and informed consent prior to data collection. The study proposals (Appendix D, E) were approved by the

Faculty of Health Research Ethics Committee, University of Central Lancashire (Appendix F) and Myerscough Research Ethics Committee (Appendix G), Myerscough College. All aspects of the study were risk assessed throughout all stages (Appendix H, I).

2.1.3 Leg Length Measurements

Leg length measurements (Appendix J) were collected using an anatomical discrepancy measurement also called 'true leg length' method (Anderson et al, 2005) (Figure 21). This method is clinically applied to determine leg length discrepancies (LLD) within patients, it measures the distance from the anterior superior iliac spine (ASIS) to the distal edge of the medial malleolus using a flexible tape measure.

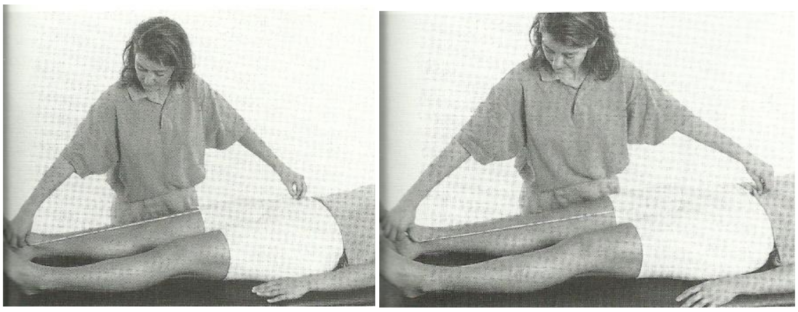


Figure 21. Leg length measurement (Anderson et al, 2005).

The riders measurements were taken when lying supine, making sure the ASIS levels were balanced and square, with the riders legs lying parallel to each other, with heels approximately 6-8 inches apart. The measurements were repeated on both legs so results were comparable. Leg length measurements were collected to observe any correlation between LLD and postural asymmetries or characteristics that may be observed in the riders.

2.1.4 Modeling of the Pelvis and Spine

The segments of shoulder, thoracic, lumbar and pelvic regions were modeled based on the calibrated anatomical systems technique (CAST), by defining an anatomical reference based on palpable anatomic landmarks (Capozzo et al, 1995). Manual palpation identified anatomical landmarks, and reflective markers 19mm in diameter were applied to the riders' acromion processes, either side of T1 & T12 spinous processes, anterior superior iliac spines (ASIS), posterior superior iliac spines (PSIS), iliac crests, greater trochanters (Figure 22).

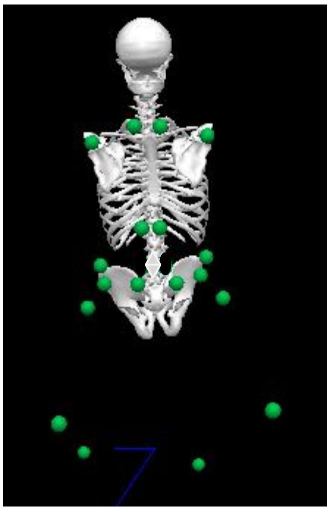


Figure 22. Marker set used on rider and horse throughout testing.

2.1.5 Tracking the Marker Set

Initially a static image of each rider standing in an anatomical position was taken, this calibration of one second of data collection defined anatomical coordinate systems. This ensured the position and orientation of each segment was identified in space. This type of modeling was applied due to its acceptable degree of accuracy in relation to the movements required to capture the ideal data for this study. The rider was then asked to sit on a stability ball in a relaxed riding position. At this point no tape was applied. The rider was then asked to lift their legs one at a time (3 times) and then sit in a natural position, this way the rider was not sitting in a rigid or forced position. The rider's arms were in a 'riding' position but relaxed. Infrared cameras captured ten seconds of data three times for each participant, to observe whether the cameras would be successful in capturing clear and reliable data from the markers.

2.1.6 Summary Pilot Study 1

Pilot study 1 helped determine a timescale of how long it may take to set up the equipment at Myerscough College inside the riding arena. This pilot test established the application of markers and the data set which will also be trialed at Myerscough prior to any data collection. The way in which leg length measurement data were collected was established in this trial, to determine the most efficient and reliable protocol. The data from these tests could be used in conjunction with the data gathered from the main study.

2.2 Pilot Study 2

Pilot study 2 aimed to determine the practicalities and issues surrounding the clothing and reflective markers required to be worn by the riders during testing whilst riding the horse.

2.2.1 Clothing

The type of clothing that the riders would wear was an important factor to consider, clothing that would be too loose would affect the marker placement and provide inaccurate data. However, any clothing that was too tight would restrict rider motion and affect postural analysis. Sports performance tops were trialed initially as they appeared to be skin tight and warm enough for the riders to wear without restricting motion. However these jackets (Figure 23) posed a few problems. The fabric was too thick so anatomical landmarks were not easily identifiable, the fabric was too restrictive on some riders and baggy on others even though numerous sizes were available, and because they were like a jacket the fabric bunched up around the riders waist area whilst sitting on the stability ball in a riding position.

Figure 23. Sports performance jackets trialed in pilot study 2.

The second option piloted was for the rider to wear a thin Lycra leotard (Figure 24). The leotards were successful as they were skin tight and unlike a top they stayed put without any bunching occurring around the waist, although they were not that warm. The rationale for using such a garment is due to the tight fit of the leotard around and over the lumbar and pelvic regions. Therefore the reflective markers could be more securely attached, enabling excellent data collection in relation to exact location of the required anatomical landmarks, and without the risk of the reflective markers becoming detached during data collection. Hazelwood, (1997) supports the use of Lycra garments for the attachment of markers to reduce skin displacement.

Marker position could also be adapted specifically to each participant more effectively, by having a range of leotards available (Figure 24).

Figure 24. Final leotards to be worn by the riders during data collection.

2.2.2 Reflective Markers

Problems arose with the attachment of the reflective markers which the riders would need to wear whilst on the horse. The main problem was keeping the markers attached to the riders clothing. Any movement occurring caused the markers to fall off, which would not be ideal during the data collection, time would be wasted re-attaching them, and precision in re-positioning whilst on the horse was predicted to be poor. Numerous marker sizes and methods of attachment were trialed and eventually a solution was found where markers were attached to a soft suede backing (Figure 25). This provided a large enough area for strong double-sided tape to attach the marker to the clothing or riders skin, but allowed for enough natural movement to occur without them falling off.

Figure 25. Reflective markers and application method used during data collection.

2.2.3 Summary Pilot Study 2

It was established that riders would wear a leotard and jodhpurs during the data collection and 19mm reflective markers would be attached using the soft suede backing applied with strong double sided tape.

2.3 Pilot Study 3

Pilot Study 3 established whether the method of taping determined from current clinical literature would be suitable for the study and to determine a timescale for applying the tape between riders.

2.3.1 Taping Application Technique

The type of athletic tape applied was a robust 5cm zinc oxide sports tape. The rider had tape applied to their scapular and spinal regions (Figure 26). Four strips, two either side of the spine were applied from proximal to distal from the top of the riders shoulders to the lumbar spine, level with L4. Six strips were used across the riders' thoracic region, three strips of tape were applied from the both left and right coracoid processes posteriorly over the acromion running under the contralateral scapula and ending at the axilla. All riders confirmed they were unaware of any skin sensitivity to tape prior to application. The technique of postural taping applied in this study was previously demonstrated by Morrissey (2000), Kneeshaw (2002) and Smith et al (2009) and combined with the taping methods demonstrated by MacDonald (2004), used by health professionals in current practice.

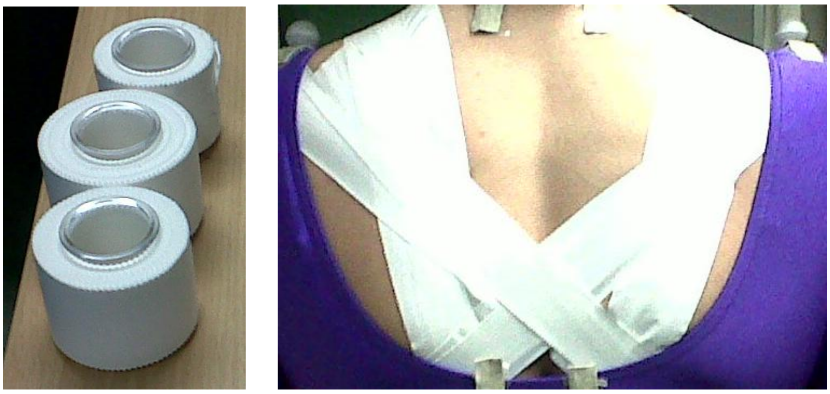


Figure 26. Tape used and rider demonstrating the taping technique.

Prior to the application of tape, riders firstly sat on a hard stool and were asked to sit in their natural riding position, and depending on each rider, shoulder positions and spinal postures, such as the lumbar area were adjusted. This method allowed for the application of tape to be applied correctly and uniformly between each participant. Following the adjustment of the riders' posture, participants were instructed to maintain the position during the application of the tape. Subsequently the rider was asked to sit in the same position on the stability ball and again to achieve their natural seated riding position. As before the rider was asked to move their legs alternately three times and then relax into their natural riding position. The practice of data collection commenced as described in pilot study 1.

2.3.2 Summary Pilot Study 3

This pilot study recognised the need for uniformity between each participant during the application of the tape. The practice of applying the tape guaranteed that a professional and efficient approach was used to ensure the consistency of the tape each time. From pilot studies 1-3 it was estimated that data collection would take approximately 60 minutes per participant but a pilot study at Myerscough was also used to confirm this timescale. This finalised the pilot studies in the laboratories at the University of Central Lancashire (UCLan) prior to the collection of data at Myerscough College.

2.4 Pilot Study 4

Pilot study 4 took place in one of the indoor equine arenas at Myerscough College to practice the set up of equipment and habituation of the horses. Camera set-up and practice of data collection commenced in order to find any flaws in the testing method regarding aspects such as the quality of data tracked the practicalities of using the Lycra leotard, reflective markers and arena layout. In order to plan a suitable timetable for data collection, timescales of equipment set-up and practicalities of preparing the rider were monitored.

2.4.1 Equipment Set-Up

The timescale of setting up and taking down the equipment helped to determine the number of riders possible to use on each day of data collection. Two days were allocated to collect all data therefore the setting up and taking down of all equipment had to be planned and efficiently organised. Eight cameras were used during the data collection, four cameras on either side of a runway (Figure 27). Placements of the first two opposing cameras were approximately 4 metres apart (at the entrance of the walkway) and became wider through the runway creating a V shape. Initially all cameras were set at approximately four meters apart, parallel to each other providing the same width of runway throughout; however when trialing a horse and rider through this set-up of cameras the markers did not track to the best capabilities and could not capture a full stride of the horse. By changing the cameras to a V shape, this allowed for a larger capture area and a full stride of the horse tracked. By tracking a full stride of the horse in trot provides movement data from the rider at all points through the stride. Due to the variety in sizes of horses the capture area had to be as long as possible without decreasing the accuracy of tracking the marker sets.

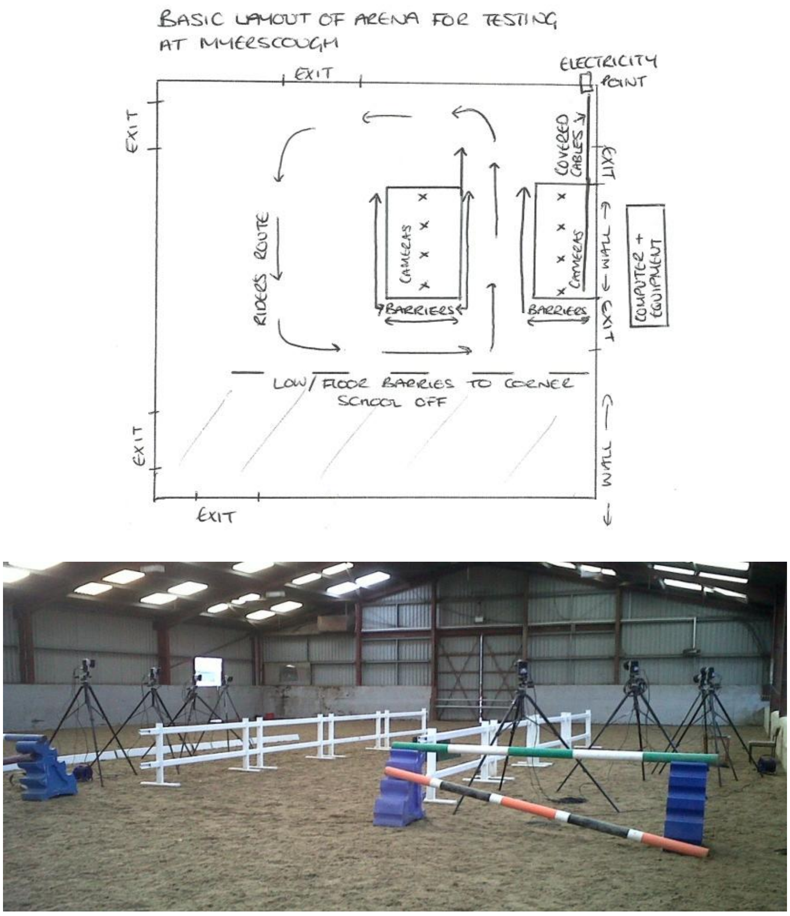


Figure 27. Floor plan prior to pilot study 4 to ensure maximum preparation for set-up and practice of the layout of cameras inside arena for pilot study 4.

In consideration of horse and rider safety, barriers were placed in front and around the cameras, approximately 3 metres apart, this also protected the cameras from damage if a horse was to spook during the data collection. The barriers (Figure 28) acted as a guide to the horse and rider by creating the walkway in which the horse would trot through and aided the rider in keeping the horse trotting forward and straight during data collection.

Figure 28. Layout of cameras, barriers and equipment creating a runway for the riders.

2.4.2 Habituation of Horses

To habituate the horses, a competent member of staff from Myerscough College walked each horse through the cameras, circled the horse and walked them back through the cameras until the horse was relaxed within the surroundings (Figure 29). Prior to any application of horses to the pilot study a yard induction was completed (Appendix K) which included health and safety briefing. A rider then rode the horse through the cameras using the same method that would take place on the day of data collection.

Figure 29. Rider trotting horse through camera set-up to habituate the horse to the surroundings.

2.4.3 Tracking the Marker Set

This pilot study was also used to monitor how well the data tracked from the marker set used and the environment in which the data was captured. Due to the camera layout the majority of markers were applied to anatomical landmarks on the riders back, capturing a posterior view. This also took into consideration the region in which the tape was applied and the optimal method of capturing the rider's movements from the objective of observing postural asymmetry through the trunk and pelvis. Markers were placed either side of T1, T12 and L4 in order to try and separate trunk, lumbar spine and pelvis. To ensure the markers were placed correctly on each anatomical landmark necessary for data collection a plinth was used. With the rider prone on the plinth, L4 spinous process could be palpated using a clinical palpation method and the markers applied either side of the L4 spinous process. The rider would then be asked to stand and the L4 markers position checked.

Due to the cold weather and the riders having to wear short sleeved thin Lycra leotards, it was decided that a warm room was required for the riders to get changed, which provided privacy and an area where tape and markers could be applied. The leotard was ideal for applying the tape to the rider as the rider could simply slip their arms out of the sleeves of the leotard, exposing the riders back and shoulder region for tape application.

2.4.4 Summary Pilot Study 4

Many aspects of data collection were trialed in pilot test 4; it was established that approximately 1.5 hours was required to set-up all the equipment and the same timescale again to put away the equipment. To collect data from each rider, with and without tape it would take approximately 1 hour per participant. This defined the number of riders as ten that could be processed over the two allocated days provided by Myerscough College for the use of their facilities. The practicalities of taping a rider whilst wearing a leotard were difficult in the environment in which the data were collected. A warm room was made available which would house the portable plinth, tape and markers and be the allocated area to apply the markers and tape to the rider. The final marker set tracked the pelvis and trunk; markers were applied to the following anatomical landmarks; acromion processes, either side of T1, T12, L4, ASIS, PSIS, iliac crests and greater trochanters.

2.5 Main Study Method

From the sixteen riders that took part in the pilot studies ten riders were required for the main phase of testing. All sixteen participants that took part in the pilot studies were eligible for the main study therefore the ten required participants were recruited on a first come first serve basis. Riders were expected to fully meet the eligibility criteria to take part (table 1, page 51). The final selection of riders that took part in the main study were ten female riders, with an average age of 29 years, body mass of 59.1 kg and an average height of 164.2 cm. All riders were right foot and right hand dominant (Appendix J). Riders' leg length's averaged 85.5 cm for rider's right legs and 85.6 cm for the rider's left legs.

2.5.1 Horses

Four horses that were habituated during pilot study 4 (Chapter 2.4 pages 62 & 63), from Myerscough Agricultural College were used over two days of data collection (Figure 29) (Appendix L) on a rota basis (Appendix M). The horses were changed for each rider, so they were not overworked or had to stand for long periods of time with their full tack on. Horses were chosen in collaboration with the yard manager for their symmetry, quietness, reliability and in consideration of rider's height and weight. The average height of the horses was 15.1 hh, average weight 538 kg and average age was 10 years old. Horses were tacked up and prepared by two members of staff at Myerscough College prior to testing.

HORSE 1

HORSE 2

HORSE 3 HORSE 4

Figure 30. Four horses used during data collection

2.5.2 Data Collection

The collection of data for each participant took a maximum of 60 minutes to complete. All participants gave written and informed consent (Appendix N) to take part in the main study, after reading the participant information sheet (Appendix O), and met all eligibility criteria for the study (table 1, chapter 2.0, page 51). Riders were required to wear a safety helmet that conformed to BS PAS 015 1998; BS EN 1384; ASTMF 1163 95. Reflective markers were applied to the riders using the same marker set as pilot studies 1 and 2. The only difference in the marker set compared to that of the pilot studies collection is the addition of markers to either side of L4, in order to define the pelvis and spinal regions clearly. Reflective markers were applied to specific anatomical landmarks on the horse (Figure 30), to define the horse and rider in relation to each other and in order to identify one full stride of the horse. This method, in light of current research (Symes and Ellis, 2009), takes into consideration that functional and anatomical asymmetries can both occur in horse and rider, and may be a contribution to rider asymmetry. Although this study focuses on rider asymmetry the influence of asymmetry occurring in the horse was taken into consideration, this was a factor in the choice of horses that were used during data collection.

Figure 31. Reflective markers highlighted on rider and horse.

When all markers were applied, the rider stood on a mounting block in the centre of the runway to establish a ‘static’ infrared image through the camera system which provides a reference point for the markers (Figure 32). To measure movement kinematics Qualisys Motion Analysis Capture System (Qualisys Medical AB, Gothenburg, Sweden) was utilised, consisting of eight ProReflex motion capture units emitting infrared beams which reflect off the skin surface markers. A moving three-dimensional image of the rider was recreated using Qualisys software.

Figure 32. Rider on mounting block capturing static image.

Once the static image was obtained the rider mounted the assigned horse and began by walking then trotting the horse around the arena. When the rider felt happy to commence they rode the horse through the cameras in sitting trot (Figure 33). The rider completed this sequence four times. The rider then dismounted the horse and either tape was applied or removed depending on the randomisation plan (Appendix P). During this period the horse was walked round the end of the arena by a member of staff at Myerscough so as not to get cold or restless.

Figure 33. Rider performing sitting trot through cameras on horse.

The same taping technique was applied and followed the methods used in pilot study 3 (Chapter 2.3, page 57). Markers were checked to ensure that they were still on the correct anatomical landmark and a second static image was collected. Following earlier instructions the rider once again mounted the horses and rode in sitting trot through the cameras and repeated this four times. Once completed the rider dismounted and all markers and tape if applicable were removed. The horse was taken away to be un-tacked by a member of yard staff at Myerscough, whilst another member of staff tacked up the next required horse. This completed the data collection protocol for each rider.

2.6 Data Processing

Data was captured using Oqus 3D motion analysis cameras. Markers on both horse and rider were tracked using Qualisys Track Manager (QTM). Each rider was captured riding three times in order to produce 3 trials of data for each rider. Markers were identified statically then converted to movement files to be exported then to Visual 3D software to be named. In Visual 3D a pipeline was created to process the files from each rider's data. This pipeline managed the files by preparation of events whereby a proportion of data was taken from each of the rider's 3 trials, which equaled to one complete horse stride per trial. One stride was determined as the time between consecutive impacts of the right forelimb. Two points were therefore observed through one stride, as the trot is a two-time beat. In Visual 3D files were executed for signal processing, models edited, and filters applied. The filter applied to this data was a Butterworth filter of low pass frequency of 6-7Hz. Reports were then created in Visual 3D presenting all data analysis steps based on the models processed allowing for the extraction of particular data relevant to the study. Data was then exported to excel files to be processed as SPSS files and used in the visual interpretation data tables to follow.

2.6.1 Statistical Analysis

Data exported into excel allowed for the calculation of asymmetry and motion patterns in the riders. This was determined by calculating the range, absolute difference and movement asymmetry with and without tape for each rider. The degree of movement range was calculated from the minimum and maximum values in each movement. The degree of absolute difference was calculated by subtracting left from right and to quantify asymmetry in the trunk and pelvis the following equation was applied: Movement asymmetry = 100[R – L / (R + L)]. This quantification of asymmetry previously applied by Al-Eisa et al (2006), a method used to observe pelvic asymmetry and trunk motion. The absolute difference in each movement was divided between the right and left sides by the total range from right to left (Al-Eisa et al, 2006). Movement asymmetry percentage from the total range of movement was established. Analyses were conducted using SPSS (SPSS Inc., Chicago, IL). The 0.05 level of significance was used during statistical analysis (Appendix Q). Variables that were normally distributed a repeated measures ANOVA was applied for statistical analysis. This was applied due to the data being measured multiple times, having the same group means and observed the changes from an intervention applied. See Appendix Q for SPSS data. Variables that were not normally distributed used a Wilcoxon signed rank test. This type of test was applied due to the various variables in starting positions of the riders, with a non-parametric test used to extract the best data. By applying this two sets of data from the same participant could be compared.

Results for lateral flexion in the trunk and pelvis determined side bending motion to the left as a negative value and motion side bending to the right as positive. Trunk and pelvis rotation to the left was determined by negative values and rotation to the right as positive. Anterior tilt of the pelvis was determined by a positive value and posterior tilt of the pelvis was determined by negative values. Forward flexion of the trunk was determined by positive values and extension of the trunk in the riders was determined by negative values.

CHAPTER 3

RESULTS

3.0 Statistical Results for Trunk and Pelvis

Statistical results (Appendix Q) indicated a significant difference (*p*<.05) in the range (°) of trunk lateral flexion, with tape intervention (Figure 34), this being the only significant difference following tape intervention. Although data were close to being significant in some areas of the pelvis no significant differences (*p*<.05) occurred when tape was applied.

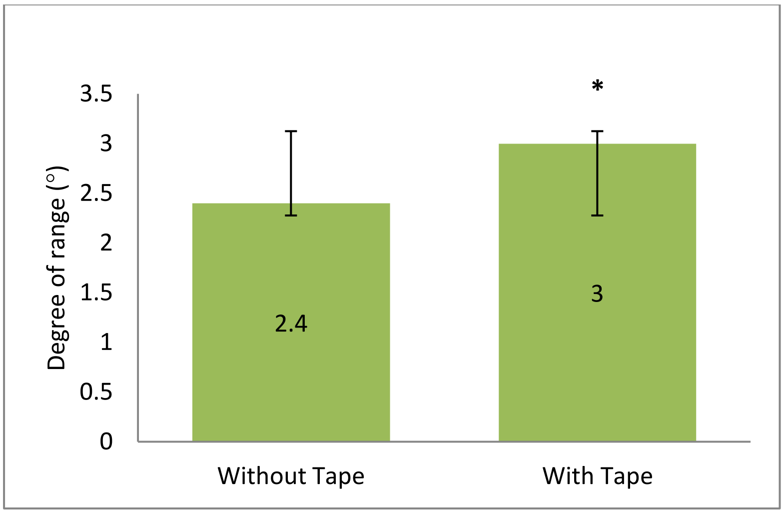
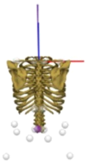
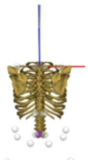
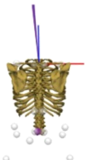
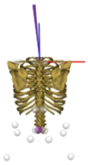
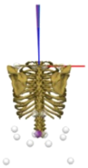
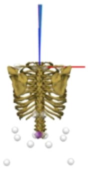
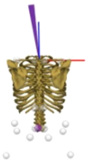
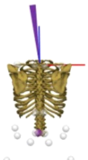
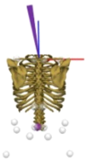
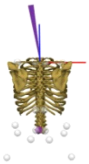
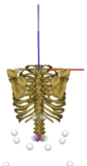
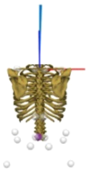
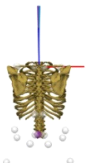
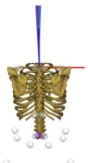
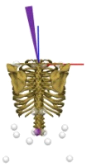
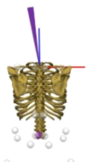
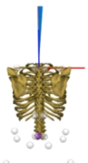
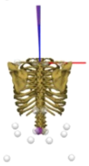
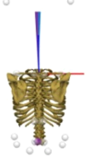
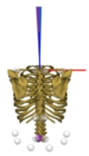


Figure 34. Difference in riders' range (°) of lateral flexion movement of the trunk without and with tape intervention.

3.0.1 Visual Interpretation of Results for Individual Riders

The following tables demonstrate findings for individual riders, with and without tape intervention including the values and a visual representation of the pelvis or trunk. Results show range (°) absolute difference (°) and movement asymmetry (%), for each plane of motion and rider. The images represent the mean minimum and maximum values for each rider. These results give an indication of how the tape affected each individual rider and helps to support the significant data results. Tables further indicate the percentage increase or decrease in individual riders' range (°) of motion, and describes whether the results are of clinical importance.

3.0.2 Trunk Lateral Flexion – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1				
Ra		1.6		2.2
AD		-1.0		0.0
MA		L		R
2				
Ra		1.2		1.6
AD		-2.2		-2.5
MA		L		L
3				
Ra		3.0		3.8
AD		-2.5		0.8
MA		L		R
4				
Ra		2.8		5.3
AD		-5.5		-5.7
MA		L		L
5				
Ra		1.3		2.2
AD		-5.4		-7.2
MA		L		L
6				
Ra		1.5		2.0
AD		-0.6		1.9
MA		L		R
7				
Ra		3.0		2.8
AD		-0.2		-2.1
MA		L		L
8				
Ra		3.4		3.0
AD		-6.8		-5.7
MA		L		L
9				
Ra		3.4		4.0
AD		3.6		2.9
MA		R		R
10				
Ra		2.8		3.4
AD		-1.6		-2.4
MA		L		L

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
L= Asymmetric movement to the Left
R= Asymmetric movement to the Right

Table 2. Trunk lateral flexion with and without tape, average values for each rider for range (°), absolute difference (°) and movement asymmetry (R/L).

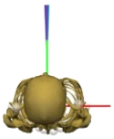
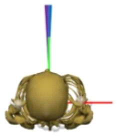
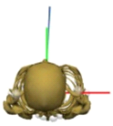
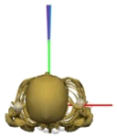
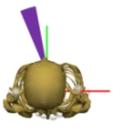
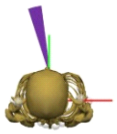
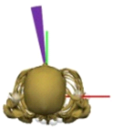
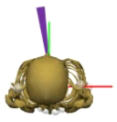
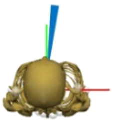
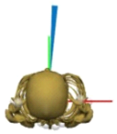
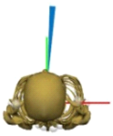
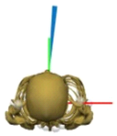
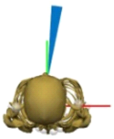
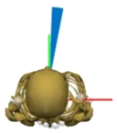
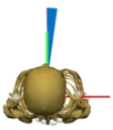
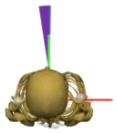
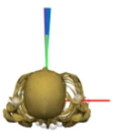
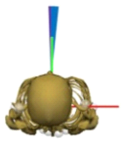
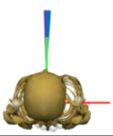
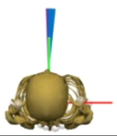
Table 2 indicates that eight out of ten riders had an increase in their range (°) of trunk lateral flexion following the application of tape. Two out of ten riders had a decrease in their range (°) of trunk lateral flexion with tape applied. Nine out of ten riders presented with a movement asymmetry of lateral trunk flexion to the left without tape. One rider had a movement asymmetry of lateral trunk flexion to the right without tape. A change of lateral trunk flexion to the right occurred in three out of the nine riders that originally presented with left lateral trunk flexion. With tape therefore six riders presented with left lateral trunk flexion and four with right lateral trunk flexion.

Rider	Range (°) Without tape	Range (°) With Tape	Increase or Decrease	Increase % With Tape	Decrease % With Tape
1	**1.6**	**2.2**	**Increase**	**37.5%**	**-**
2	**1.2**	**1.6**	**Increase**	**33.3%**	**-**
3	**3.0**	**3.8**	**Increase**	**26.6%**	**-**
4	**2.8**	**5.3**	**Increase**	**89.3%**	**-**
5	**1.3**	**2.2**	**Increase**	**69.2%**	**-**
6	**1.5**	**2.0**	**Increase**	**33.3%**	**-**
7	**3.0**	**2.8**	**Decrease**	**-**	**6.7%**
8	**3.4**	**3.0**	**Decrease**	**-**	**11.8%**
9	**3.4**	**4.0**	**Increase**	**17.6%**	**-**
10	**2.8**	**3.4**	**Increase**	**21.4%**	**-**
Average	**2.4**	**3.0**	**Increase**	**41% Increase**	**9.6% Decrease**

Table 3 Percentage increase or decrease in riders range (°) of trunk lateral flexion with tape.

Table 3 indicates the percentage changes in range (°), without and with tape. Eight riders had a percentage increase of between 17.6% and 89.3%, averaging at a 41% increase overall. Two riders had a decrease in their range (°) of trunk lateral flexion, rider 7 (6.7% reduction in trunk lateral flexion range (°)) and rider 8 (11.8% reduction in trunk lateral flexion range (°)). The average percentage was a 9.6% decrease. There are no related clinical literature that suggests these findings could be clinically significant; however an increase of 41% in the range (°) of movement within a group of riders would suggest to have clinical importance. It is interesting to note that the only significant ($p<.05$) data found in this study was for the range (°) of trunk lateral flexion. Therefore the results shown in table 3 support the significant data mentioned previously.

3.0.3 Trunk Rotation – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1				
Ra		6.4		6.1
AD		-1.7		-0.6
MA		L		R
2				
Ra		1.4		3.9
AD		0.4		-0.4
MA		R		R
3				
Ra		5.6		6.5
AD		-13.7		-11.3
MA		L		L
4				
Ra		3.8		4.8
AD		-8.9		-6.6
MA		L		L
5				
Ra		2.5		2.4
AD		6.3		3.2
MA		R		R
6				
Ra		2.6		3.4
AD		4.4		3.7
MA		R		R
7				
Ra		5.1		3.7
AD		8.5		9.0
MA		R		R
8				
Ra		8.7		9.6
AD		6.5		-6.7
MA		R		L
9				
Ra		5.6		7.0
AD		3.9		4.4
MA		R		R
10				
Ra		5.2		6.4
AD		3.0		5.0
MA		R		R

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
L= Asymmetric movement to the Left
R= Asymmetric movement to the Right

Table 4. Trunk rotation with and without tape, average values for each rider for range (°), absolute difference (°) and movement asymmetry (R/L).

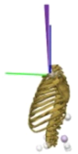
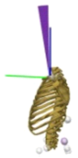
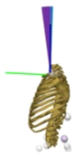
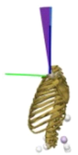
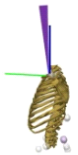
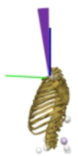
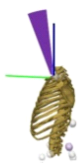
Table 4 indicates that seven out of ten riders had an increase in their range (°) of trunk rotation following the application of tape. Three out of ten riders had a decrease in their range (°) of trunk rotation with tape applied. Three out of ten riders presented with a movement asymmetry of left trunk rotation without tape. Seven riders had a movement asymmetry of right trunk rotation without tape. A change of movement asymmetry of trunk rotation to the left occurred in two out of the original seven riders that presented with right trunk rotation. With tape therefore three riders presented with a left movement asymmetry in trunk rotation and seven with right movement asymmetry in trunk rotation.

Rider	Range (°) Without tape	Range (°) With Tape	Increase or Decrease	% Increase With Tape	% Decrease With Tape
1	**6.4**	**6.1**	**Decrease**	**-**	**4.7%**
2	**1.4**	**3.9**	**Increase**	**178.5%**	**-**
3	**5.6**	**6.5**	**Increase**	**16.7%**	**-**
4	**3.8**	**4.8**	**Increase**	**23.6%**	**-**
5	**2.5**	**2.4**	**Decrease**	**-**	**4%**
6	**2.6**	**3.4**	**Increase**	**30.7%**	**-**
7	**5.1**	**3.7**	**Decrease**	**-**	**27.5**
8	**8.7**	**9.6**	**Increase**	**10.3%**	**-**
9	**5.6**	**7.0**	**Increase**	**25%**	**-**
10	**5.2**	**6.4**	**Increase**	**23%**	**-**
Average %	**4.7**	**5.9**	**Increase**	**44.4%**	**12.1%**

Table 5. Percentage increase or decrease in riders range (°) of trunk rotation with tape.

Table 5 indicates that six out of ten riders had an increase in their range (°) of trunk rotation following the application of tape. All six riders had a percentage increase of between 10.3% and 178.5%, averaging at a 44% increase overall. Four riders had a decrease in their range of trunk rotation, with an average percentage decrease of 9.6%. There are no related clinical literature that suggests these findings could be clinically significant; however it is interesting to note that previous data (table 3) showed an average increase of 41% in the range (°) of trunk lateral flexion also coinciding with a significant finding. In this plane of motion (trunk rotation), although the increase was 44%, more than the increase found in trunk lateral flexion, there were no significant changes noted in the data that this aspect would support. However an increase of 44% in the range (°) of movement within a group of riders would again suggest to have clinical importance.

3.0.4 Trunk Flexion-Extension – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1				
Ra		9.0		10.2
AD		11.8		11.9
MA		FF		FF
2				
Ra		3.3		6.2
AD		2.1		3.5
MA		FF		FF
3				
Ra		6.9		4.6
AD		7.8		7.5
MA		FF		FF
4				
Ra		9.6		10.3
AD		5.6		7.5
MA		FF		FF
5				
Ra		5.7		5.5
AD		3.6		6.0
MA		FF		FF
6				
Ra		3.2		3.1
AD		-5.0		3.7
MA		EX		FF
7				
Ra		8.6		8.7
AD		7.7		7.1
MA		FF		FF
8				
Ra		3.8		5.9
AD		2.2		1.8
MA		FF		FF
9				
Ra		8.2		7.4
AD		8.3		8.0
MA		FF		FF
10				
Ra		12.7		9.0
AD		18.0		4.4
MA		FF		FF

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
FF= Forward Flexion
EX= Extension

Table 6. Trunk flexion-extension, with and without tape, average values for each rider for range (°), absolute difference (°) and movement asymmetry (FF / EX).

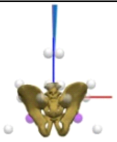
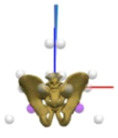
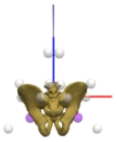
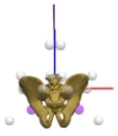
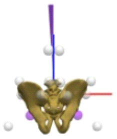
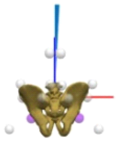
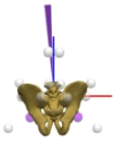
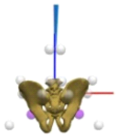
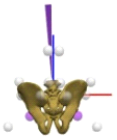
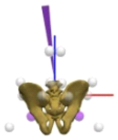
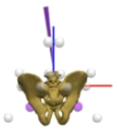
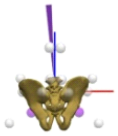
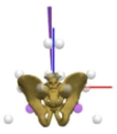
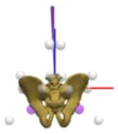
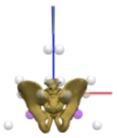
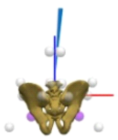
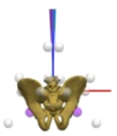
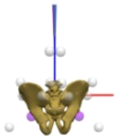
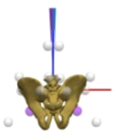
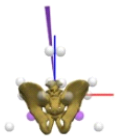
Table 6 indicates that five out of ten riders had an increase in their range (°) of trunk flexion-extension following the application of tape. Five out of ten riders had a decrease in their range (°) of trunk flexion-extension movement with tape applied. Nine out of ten riders presented with movement asymmetry of trunk flexion without tape. One rider had a movement asymmetry of trunk extension without tape. A change of trunk flexion movement occurred in the one rider that presented with trunk extension movement. With tape therefore all ten riders presented with forward movement asymmetry of trunk flexion.

Rider	Range (°) Without tape	Range (°) With Tape	Increase or Decrease	% Increase With Tape	% Decrease With Tape
1	9.0	10.2	Increase	13.3%	-
2	3.3	6.2	Increase	87.9%	-
3	6.9	4.6	Decrease	-	33.3%
4	9.6	10.3	Increase	7.3%	-
5	5.7	5.5	Decrease	-	3.5%
6	3.2	3.1	Decrease	-	3.1%
7	8.6	8.7	Increase	1.2%	-
8	3.8	5.9	Increase	55%	-
9	8.2	7.4	Decrease	-	9.8
10	12.7	9.0	Decrease	-	29.1
Average	7.1	7.09	-	33%	15.8%

Table 7. Percentage increase or decrease in riders range (°) of trunk flexion-extension with tape.

Table 7 indicates that five out of ten riders had an increase in their range (°) of trunk flexion-extension following the application of tape. Riders had a percentage increase of between 1.2% and 87.9%, averaging at a 33% increase overall. Five riders had a decrease in their range (°) of trunk flexion-extension, with an average percentage decrease of 15.8%. No related clinical literature suggests these findings could be clinically significant; however it is interesting to note that in the five riders that had an increase in their range (°) of trunk flexion-extension, the percentage increase was more than double that of the five riders that resulted in a decrease in trunk flexion-extension.

3.0.5 Pelvis Lateral Flexion – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1				
Ra		3.8		2.9
AD		1.8		1.1
MA		L		L
2				
Ra		1.2		1.0
AD		-0.4		-1.1
MA		L		R
3				
Ra		3.6		3.1
AD		-2.6		2.9
MA		R		L
4				
Ra		3.6		3.7
AD		-4.6		1.8
MA		R		L
5				
Ra		3.8		3.9
AD		-3.9		-4.8
MA		R		R
6				
Ra		1.4		2.1
AD		-3.3		-4.1
MA		R		R
7				
Ra		2.1		2.8
AD		-2.7		-2.6
MA		R		R
8				
Ra		2.5		3.5
AD		-0.4		2.1
MA		L		L
9				
Ra		2.7		3.1
AD		-0.9		-0.6
MA		R		L
10				
Ra		2.8		2.2
AD		-2.0		-3.4
MA		R		R

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
L= Asymmetric movement to the Left
R= Asymmetric movement to the Right

Table 8. Pelvis lateral flexion, with and without tape, average values for each rider for; range (°), absolute difference (°) and movement asymmetry (R/L).

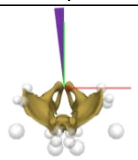
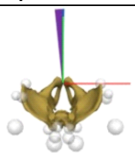
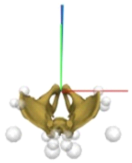
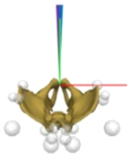
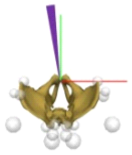
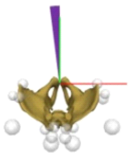
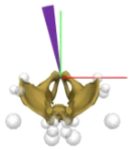
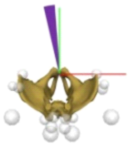
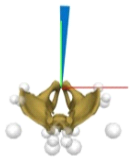
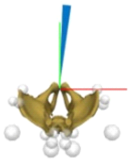
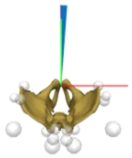
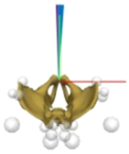
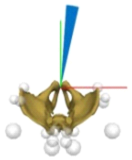
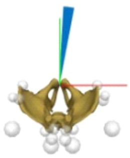
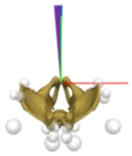
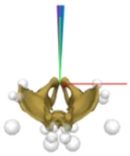
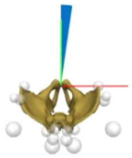
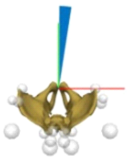
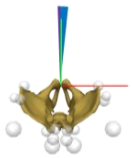
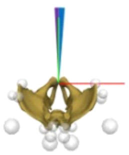
Table 8 indicates that six out of ten riders had an increase in their range (°) of pelvic lateral flexion following the application of tape. Four out of ten riders had a decrease in their range (°) of pelvic lateral flexion movement with tape applied. Nine out of ten riders presented with movement asymmetry of left pelvic lateral flexion without tape. One rider had a movement asymmetry of right pelvic lateral flexion without tape. A change to right pelvic lateral flexion movement asymmetry occurred in three riders that originally presented with left pelvic lateral flexion. With tape therefore, six riders presented with movement asymmetry of left pelvic lateral flexion and four riders presented with right pelvic lateral flexion.

Rider	Range (°) Without tape	Range (°) With Tape	Increase or Decrease?	% Increase With Tape	% Decrease With Tape
1	3.8	2.9	Decrease	-	23.6
2	1.2	1.0	Decrease	-	16.6
3	3.6	3.1	Decrease	-	13.8
4	3.6	3.7	Increase	2.7	-
5	3.8	3.9	Increase	2.6	-
6	1.4	2.1	Increase	50	-
7	2.1	2.8	Increase	33.3	-
8	2.5	3.5	Increase	40	-
9	2.7	3.1	Increase	14.8	-
10	2.8	2.2	Decrease	-	21.4
Average	-	-	-	23.9%	18.9%

Table 9. Percentage increase or decrease in riders range (°) of pelvic lateral flexion with tape.

Table 9 indicates that six out of ten riders had an increase in their range (°) of pelvic lateral flexion following the application of tape. Riders had a percentage increase of between 2.6% and 50%, averaging at a 23% increase overall. Four riders had a decrease in their range (°) of pelvic lateral flexion, ranging between 13.8% and 23.6%, with an average percentage decrease of 18.9%.

3.0.6 Pelvis Rotation – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1				
Ra		7.6		7.4
AD		-6.2		-4.8
MA		L		L
2				
Ra		2.2		5.3
AD		0.4		0.1
MA		R		R
3				
Ra		6.2		4.5
AD		-12.9		-7.6
MA		L		L
4				
Ra		7.8		7.7
AD		-9.9		-9.5
MA		L		L
5				
Ra		6.0		3.8
AD		7.3		6.3
MA		R		R
6				
Ra		4.6		5.4
AD		6.3		3.7
MA		R		R
7				
Ra		6.0		5.4
AD		9.5		9.7
MA		R		R
8				
Ra		6.6		6.1
AD		-3.7		-1.5
MA		L		R
9				
Ra		8.2		8.7
AD		8.1		8.2
MA		R		R
10				
Ra		8.2		8.0
AD		4.3		1.4
MA		R		R

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
L= Asymmetric movement to the Left
R= Asymmetric movement to the Right

Table 10. Pelvis rotation, with and without tape, average values for each rider for; range (°), absolute difference (°) and movement asymmetry (R/L).

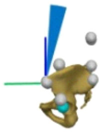
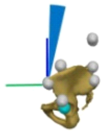
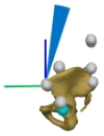
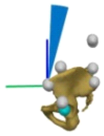
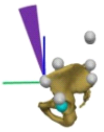
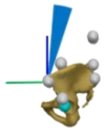
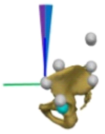
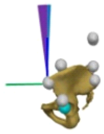
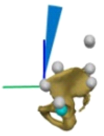
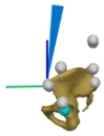
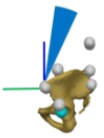
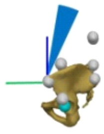
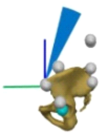
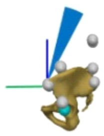
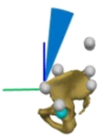
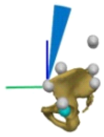
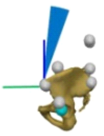
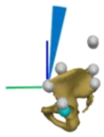
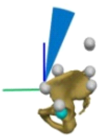
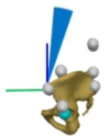
Table 10 demonstrates three out of ten riders had an increase in their range (°) of pelvic rotation following the application of tape. Seven out of ten riders had a decrease in their range (°) of pelvic rotation movement with tape applied. Six out of ten riders presented with a movement asymmetry of right pelvic rotation without tape. Four riders had a movement asymmetry of left pelvic rotation without tape. No changes in the direction of rotation movement occurred in any of the riders following the application of tape.

Rider	Range (°) Without tape	Range (°) With Tape	Increase or Decrease?	% Increase With Tape	% Decrease With Tape
1	7.6	7.4	Decrease	-	2.6
2	2.2	5.3	Increase	140	-
3	6.2	4.5	Decrease	-	27.4
4	7.8	7.7	Decrease	-	1.3
5	6.0	3.8	Decrease	-	57.9
6	4.6	5.4	Increase	17.4	-
7	6.0	5.4	Decrease	-	10
8	6.6	6.1	Decrease	-	7.5
9	8.2	8.7	Increase	6.1	-
10	8.2	8.0	Decrease	-	2.4
Average	6.3	6.2	Decrease	54.6%	15.6%

Table 11. Percentage increase or decrease in riders range (°) of pelvic rotation with tape.

Table 11 indicates that three out of ten riders had an increase in their range (°) of pelvic rotation following the application of tape. Riders had a percentage increase of between 6.1% and 140%, averaging at a 54.6% increase overall. Seven riders had a decrease in their range (°) of pelvic rotation, ranging between 1.3% and 57.9%, with an average percentage decrease of 15.6%. As mentioned previously when discussing trunk results, a 54.6% increase in the range (°) of pelvic rotation presented here may potentially support a clinically significant finding in this group of riders.

3.0.7 Pelvis Anterior-Posterior Tilt – Visual Interpretation

Rider	No Tape	Values	Tape	Values
1 Ra AD MA		11.4 -12.4 P		10.6 -12.1 P
2 Ra AD MA		5.1 -12.3 P		10.9 -13.5 P
3 Ra AD MA		10.4 9.4 A		12.7 -14.7 P
4 Ra AD MA		10.9 -1.2 P		10.5 5.2 A
5 Ra AD MA		9.9 -10.7 P		7.5 -8.8 P
6 Ra AD MA		7.2 -18.8 P		6.4 -16.8 P
7 Ra AD MA		10.5 -28.9 P		10.7 -29.8 P
8 Ra AD MA		9.2 -18.6 P		8.2 -13.6 P
9 Ra AD MA		8.2 -14.8 P		7.3 -10.7 P
10 Ra AD MA		10.8 -18.1 P		9.9 -15.4 P

KEY:

Ra= Range (°)
AD=Absolute difference
MA=movement Asymmetry
A= Anterior Tilt
P= Posterior Tilt

Table 12. Pelvis anterior-posterior tilt, with and without tape, average values for each rider for range (°), absolute difference (°) and movement asymmetry (anterior or posterior).

Table 12 demonstrates a visual interpretation of the riders’ pelvic motions with and without tape. Without tape nine out of ten riders sat with a posterior tilt of their pelvis. One rider sat and moved with an anterior tilt of their pelvis. With tape, although the numbers of riders with an anterior tilt or posterior tilt stayed the same, i.e. nine posterior tilted and one anterior tilted, one rider changed from being posteriorly tilted through their pelvis to sitting anteriorly tilted and another rider changed from being anteriorly tilted to posteriorly tilted through their pelvis. Table 12 further demonstrates three out of ten riders had an increase in their range (°) of pelvic anterior-posterior tilt following the application of tape. Seven out of ten riders had a decrease in their range (°) of pelvic anterior-posterior movement with tape applied.

Rider	**Range (°) Without tape**	**Range (°) With Tape**	**Increase or Decrease?**	**% Increase With Tape**	**% Decrease With Tape**
1	**11.4**	**10.6**	**Decrease**	**-**	**7**
2	**5.1**	**10.9**	**Increase**	**113**	**-**
3	**10.4**	**12.7**	**Increase**	**22.1**	**-**
4	**10.9**	**10.5**	**Decrease**	**-**	**3.6**
5	**9.9**	**7.5**	**Decrease**	**-**	**24.2**
6	**7.2**	**6.4**	**Decrease**	**-**	**11.1**
7	**10.5**	**10.7**	**Increase**	**1.9**	**-**
8	**9.2**	**8.2**	**Decrease**	**-**	**10.9**
9	**8.2**	**7.3**	**Decrease**	**-**	**11**
10	**10.8**	**9.9**	**Decrease**	**-**	**8.3**
Average	**9.4**	**9.5**	**Decrease**	**45.6%**	**11%**

Table 13. Percentage increase or decrease in riders range (°) of pelvic anterior-posterior tilt with tape.

Table 13 indicates that three out of ten riders had an increase in their range (°) of pelvic anterior-posterior tilt following the application of tape. Riders had a percentage increase of between 1.9% and 113%, averaging at a 45.6% increase overall. Seven riders had a decrease in their range (°) of pelvic anterior-posterior tilt, ranging between 3.6% and 24.2%, with an average percentage decrease of 11%. There are no related clinical literature that suggests these findings could be clinically significant; however an increase of 45.6% in the range (°) of movement within a group of riders would suggest to have potential clinical importance.

3.1 Trends in the Visual Representation of Riders Results

Clearly individual rider results in these tables support that of the significant differences noted earlier, although these results demonstrate a different way of interpreting the influence that tape may have during these riding postures. The visual representation of individual rider results demonstrate from a clinical view, rather than that of a statistical nature, the impact athletic tape may have when applied in this manner. In consideration of supporting the significant statistical results (range (°) of trunk lateral flexion), the largest difference of range (°) for lateral flexion of the trunk with the rider wearing tape was 2.5° (rider 4, table 2, page 69) resulting in an 89.3% increase in range (°) and considered in the current study to be a clinically important change in the range of trunk lateral flexion.

CHAPTER 4

DISCUSSION

4.0 Summary of Study Findings

The purpose of this study was to investigate the effects of athletic taping on postural asymmetry in equine riders. Pilot tests initially established optimal methods of data collection by testing 3D motion analysis equipment set up and select appropriate kinematic variables for analysis prior to full experimental protocol using horses at Myerscough Agricultural College. The main study quantified asymmetric movement patterns through riders' trunk and pelvis prior to the intervention of tape meeting objective three of the study. No significant changes were observed at the pelvis, although some data were close to significant. However, meeting objective four, changes in trunk postural movement were established with the application of tape. Significant adjustments were noted in the range (°) of lateral flexion in the riders trunk during sitting trot, with the rider wearing tape.

4.0.1 Pre-Tape Postural Characteristics Observed in Riders

Three-dimensional motion analysis observed pre-tape postural characteristics and asymmetries in all riders. Visual representations of these asymmetries are illustrated in chapter 3, indicating varied movement patterns in the riders. This supports previous work by Symes and Ellis, (2009) whereby riders sat and moved asymmetrically. The results of the current study support objective three, by quantifying postural characteristics in equine riders through the use of 3D motion analysis. Not previously reported using 3D motion analysis, these findings influence and support earlier findings in the preliminary investigation by Symes and Ellis, (2009). A common pre-tape postural characteristic, when observing riders individually, concurs with Wanless, (2008), with riders presenting with asymmetries in lateral flexion, rotation and forward flexion of the trunk (Figure 35). Rider 3 in the current study demonstrates this position and underpins suggestions by Wanless, (2008).

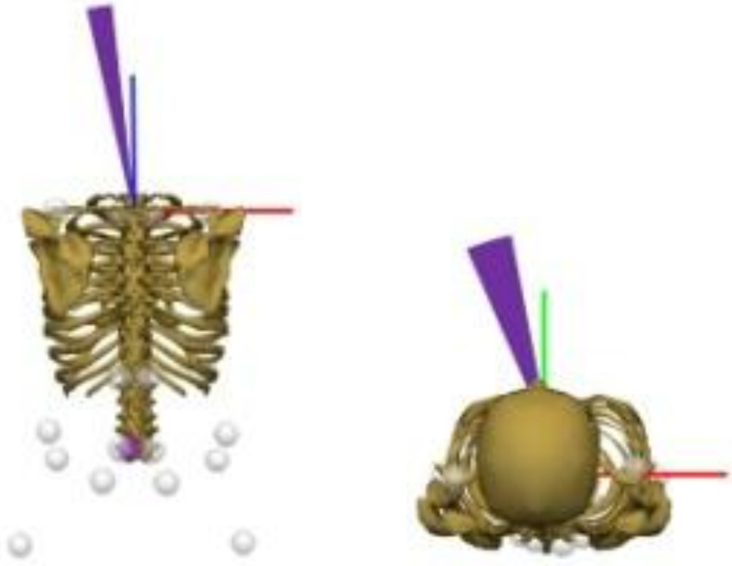


Figure 35. Visual representation of rider's asymmetric range of lateral flexion and trunk rotation prior to wearing the tape.

The potential effect from a rider with trunk axial rotation and lateral flexion is the change in weight distribution through the riders' seat. de Cocq et al, (2009) demonstrated an increase in force in the area of which the rider was leaning toward when measured using an electronic normal force distribution mat (Pliance Saddle System). Their findings suggest how the normal force distribution under the saddle is influenced by a riders' position. Furthermore they noted that the saddle used in the study did not compensate for the different positions. A rider who is balanced and aligned in their riding posture is easier for a horse to support (Mason, 2006). In consideration of weight distribution through the saddle the horse is free to swing their back if the riders' weight falls centrally. A disruption to a rider's trunk alignment is reported to affect a horse's motion (Schamberger, 2002). A common asymmetry found in the current study prior to intervention was trunk axial rotation clockwise. Rider 7 (Figure 36) demonstrates this finding; the illustration clearly presents a visual interpretation of the clockwise rotation of the rider's trunk pre-tape.

Figure 36. Rider 7 presenting with right trunk rotation pre-tape, a common characteristic found in the majority of riders in the current study.

Potentially riders presenting with this asymmetry prior to taping in the current study therefore deviated away from a central position on the saddle, resulting in an uneven distribution of weight. This can only be postulated in light of current research as no force pressures were measured in the current study. It is recognised that a heavier weight through a lever affects the amount of range it can sustain. It could be assumed that the side of the saddle of which the riders' weight falls heavier reduces the range of movement the horse has through its foreleg on the same side; therefore the rider's weight negatively affects the potential range of movement here. These assumptions would support earlier reports by Mason, (2006). The assumptions made here from the findings of the current study give riders a better understanding of how their positioning may affect the overall performance and movement outcomes of the horse.

Literature by Wanless, (2008) describes a similar scenario with an asymmetrical rider when riding a circle. Notice the restriction in the equines right shoulder due to the trunk rotating to the right and left shoulder advancing (Figure 37). Looking at the rider's jacket the horizontal line drops inferiorly to the right, indicating lateral flexion alongside the trunk rotation. The rider's asymmetry is clearly visible here, thus affecting hand and leg positioning. Wanless, (2008) describes a disorganised response from the horse in this case. Riders 5-10 in the current study presented with similar characteristics as represented previously by Wanless, (2008).

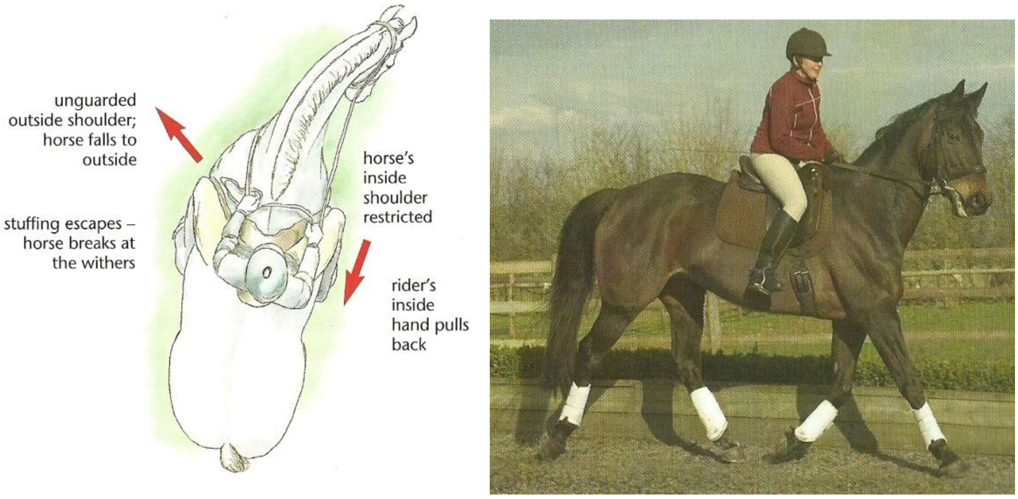


Figure. 37. Rider presenting with asymmetric trunk rotation, disorganised hand and leg positioning and negative response from the horse Wanless (2008).

Numerous studies agree that harmony and optimum performance outcomes between horse and rider can only occur from maintaining a balanced postural alignment (Schamberger et al, 2002; Lovett et al, 2004; Symes and Ellis, 2009: Kang et al, 2010). Traditionally the rider is told by riding instructors to sit deep in the saddle (Lagarde et al, 2005) allowing for optimum connection between rider and horse from balanced weight distribution through the riders ischial tuberosities. Asymmetry occurring through a rider's central pelvic and trunk posture for example has a secondary affect on the positioning of the riders legs and arms (Schamberger, 2002). However, literature is vague in describing ways in which asymmetric postures in riders affect other limb movements during riding. Previously suggested by Wanless, (2008), findings in the current study mirror the asymmetry that Wanless, (2008) suggests can affect a riders' limb position. For example, rider 5 (Figure 38) in the current study presented with right rotation of the trunk causing a forward advancement of the left shoulder as such demonstrated by Wanless, (2008) in figure 37. Following Wanless's suggestion that this position changes a riders' hand and leg position, it can be assumed this occurred in the current study in riders presenting with similar pre-tape postural characteristics. This characteristic was consistent in eight out of ten of the riders in the current study and presents information that would of interest to both riders and riding instructors. By observing this postural characteristic in the current study it aids the understanding of further repercussions it may have on rider's limbs and seat movements during riding. Professionals working with riders to improve their riding posture can use this information in order to understand the potential consequences of this postural characteristic.

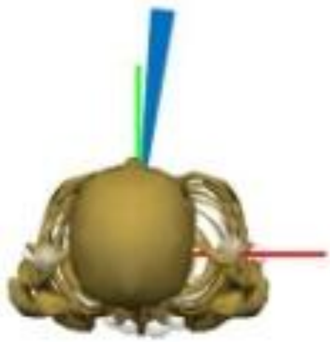


Figure 38. Rider 5 presenting with right trunk rotation pre-tape which forces a forward advancement of the riders left shoulder.

In addition to a change in a riders' weight distribution and its effects on equine motion, consideration should be taken into rider injury. Established previously (Al-Eisa et al, 2006) axial rotation causing postural asymmetry through the spine is linked to muscular asymmetries and imbalances in muscle activation. Spinal instability can be a result of muscular imbalances subsequently leading to injury (Al-Eisa et al, 2006). Potentially an asymmetric posture in the rider could unknowingly affect a rider's ability to enhance the synchronicity between themselves and the horse. Lagarde et al, (2005) expresses how tense or stiff movements need to be fluid and flexible in the rider in order to be sensitive to the horse's motion. Earlier studies establish how postural asymmetry can be a cause or result of muscular imbalances (Sahrmann, 2002). Shortness or stiffness of oblique abdominal muscles for example can affect rotational motion (Sahrmann, 2002).

In the current study a pre-tape characteristic in the riders was trunk rotation to the right, potentially the riders in the current study had muscular imbalances which may have affected their trunk symmetry. Subsequently this induced an imbalance within this plane of alignment. Rider's 1,2,5,6,7,8,9,10, for example, presented with right trunk rotation. In consideration of clinical literature, these riders may have asymmetry occurring through their abdominal muscles, with the potential to have short and stiff oblique abdominals through one side of the trunk compared to long and weak musculature on their opposite side. Riding instructors and professionals working with riders should consider the findings of the current study into one of the causes as to why a rider cannot synchronise their movements entirely with the horse. Wanless, (2008) previously described the way in which a rider corrects themselves in the saddle when told by an instructor that their posture is incorrect. For example figure 39 below demonstrates a rider presenting with right trunk rotation, the image then demonstrates how the rider thinks they are sitting, how they correct themselves and how in reality their posture looks.

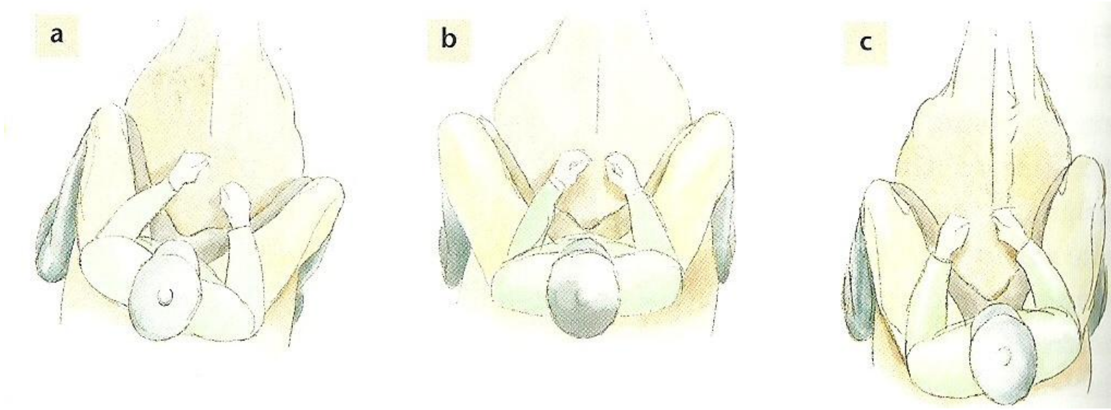


Figure 39. (A) The rider sits with a right trunk rotation; however the rider feels as though they are sitting correctly (B), therefore when they are told to correct their posture they sit as in image (C) Wanless, (2008).

The findings of the current study are extremely helpful in light of the suggestions made by Wanless, (2008). By using infrared camera technology to observe riders postures, a clearer view into how the rider is actually sitting in contrast to how they feel they are sitting would be beneficial to their progression within their sport. By observing a rider's posture in these circumstances would allow for an instructor to understand elements of the rider's posture that needs adjusting, and be better equipped to explain this to the rider.

If a muscle imbalance is of concern in a rider, a Sports Therapist or Physiotherapist would be able to confirm a muscle imbalance and introduce therapeutic methods in order to correct an imbalance. The use of this technology could observe the rider pre-treatment and following a course of therapeutic interventions and would give a detailed analysis of a rider's progression in their alignment of their posture. Potentially athletic tape may be considered as one method of muscle imbalance correction, supporting the outcomes of the current study.

Symes and Ellis, (2009) established that riders in their study mostly rotated their trunk to the left, in contrast riders in this study tended to rotate their trunk to the right prior to tape application. There may be many reasons behind the differences in trunk rotation; alternatively when comparing methods the difference in trunk rotation preference could be explained by the layout of the runway in which horse and rider rode though during data capture. In the current study riders rode down a walkway and then performed a left turn at the end, it may be postulated that riders were slightly rotated to the right prior to taping due to anticipating a left turn at the end of the walkway. Perhaps the riders were rotated to the right as a way of stopping the horse from drifting over to the left as it anticipated a left turn. To determine this in the future measurements of grip strength, and changes to the marker set to include the arms and hands of the rider could be suggested.

Another reason that may explain the contrast in findings compared to the results of Symes and Ellis, (2009) is the way in which asymmetry was determined. The displacement of the riders' shoulders to the craniocaudal line of the horse at certain points in the stride examined rider asymmetry. Each rider rode their own horse; therefore one concern of riders using their own horses is the possible inconsistency in achieving the same point on each horse from where the riders' shoulder displacement angles were quantified from. To achieve consistency in the collection of data it may have been more reliable to use one horse throughout. However, this is not always convenient to use only one horse to suit a range of riders of different heights and weights in a study such as this. Not reported by Symes and Ellis, (2009) were the possible asymmetries occurring in the equines used. Although Symes and Ellis, (2009) mentioned how asymmetries occurring in the equine can have a potential affect on rider asymmetry the study does not mention if any horses were observed for any obvious asymmetry in their gait prior to testing. Comparatively equines used in the current study were chosen for their straightness when trotting prior to any data collection. This minimised the effect of equine asymmetry on the rider. These findings are useful to riding instructors or researchers whom may be assessing a rider's postural asymmetry without the use of three-dimensional camera equipment. The importance of using a horse which is as straight as possible through its gaits is supported and recognised in the current study.

The difference in typical asymmetric posture presentations when comparing results to that of Symes and Ellis, (2009) may be the technical ability of the riders recruited for each study. Riders in the current study had to meet minimum ability criteria of BHS stage 2, comparable to a study by Lovett et al, (2004) whose riders met BHS stage 3 as a minimum. In contrast to the variety of riders, ranging from riding club to advanced dressage level, recruited by Symes and Ellis, (2009).

Literature demonstrates the differences in postures when comparing beginners to advanced riders (Peham et al, 2001; Lovett et al, 2004; Kang et al, 2010). Beginner riders could not maintain a stable posture to uphold a correct riding posture in order to absorb a horses' rhythm. Symes and Ellis, (2009) did not mention the standard of 'riding club' riders they recruited, so it is hard to make a comparison in rider skill level between each study. Alternatively they recruited riders from a dressage background; a positive choice in their research. The type of riding discipline each rider has experience in prior to a postural based study is important as it may affect the type of riding posture they present with. In the current study although riders were all of comparable ability, their background expertise in riding disciplines varied. Potentially the natural riding posture of a show jumper could be in a slightly forward flexed position, in comparison to an experienced dressage rider where an almost vertical trunk orientation should be maintained. By limiting the discipline to dressage riders Symes and Ellis, (2009) potentially reduced the variance between riders' postures, positive inclusion criteria that future research should perhaps adopt.

4.0.2 Postural Characteristics and the Effect on Significant Results

Due to the variability in riders starting postures in the current study this could be a reason behind the limited significant results following the application of tape. In effect the diversity in asymmetric postures may have made it difficult to achieve results that show a significant difference from the application of the tape when observing the riders as a group. For example, rider 7 (chapter 3, table 4, page 72) pre-tape is considerably rotated to the right through their trunk compared to rider 3 (chapter 3, table 4, page 72) presenting with left trunk rotation pre-tape. Another example is rider 9 (chapter 3, table 2, page 69) whom prior to tape application has lateral trunk flexion to the right compared to rider 8 (chapter 3, table 2, page 69) with left lateral trunk flexion. Potentially the variance in starting postures in these riders may cancel each other out when measuring kinematic changes following an intervention such as tape. In future research a consideration into postural characteristics prior to any intervention such as tape needs to be noted. This would then have a further adaptation to the type of taping method applied in order to align a riders' posture, dependent on the postural asymmetry the rider presents with. It would be beneficial for participants with similar postural characteristics observed through three-dimensional movement analysis. Research would become more specific to a type of asymmetry presented by riders and therefore influence the method of taping applied further.

Leaning back whilst in the saddle was noted in rider 6 (chapter 3, table 6, page 75). This postural characteristic was only reported in one rider pre-tape application in the current study. However riders and instructors should consider the negative outcomes of this postural positioning whilst on the horse. Rather than pointing inferiorly it would be expected that the rider's ischial tuberosities would be pointing in a forward facing position. Therefore fluid movement through the rider's seat is interfered. In the current study the rider presenting with this postural characteristic was taped using the same method as the other riders presenting with forward flexed trunk characteristics. The outcome demonstrated in the visual representation of rider 6 suggests the rider's posture changed from an extended trunk position, forward to a flexed position, however was overall more aligned than riding without the tape application. It seems that although this rider's starting postural position was different to the majority of positions of which the other riders presented with, the same method of taping applied here still controlled the positioning of the riders trunk and positively changed the way the rider sat and rode.

Interestingly this further suggests that the same taping method applied to all riders in the current study collectively changed the riders' flexion-extension trunk posture, regardless of the pre-tape postural characteristic of the riders. This view however does not support the suggestion that due to the difference in starting postures in all ten riders' the statistical results in some planes of motion did not appear significant. As it was originally thought that the difference in starting postures of the riders subsequently cancelled each other out during the statistical tests. However, when considering the mechanical constraints of the taping and the way in which it was applied it is not surprising that a change in posture (forward trunk flexion) in this rider was observed in the visual representation (chapter 3, table 6, page 75). Because the rider presented with trunk extension combined with a rounding of the back, the application of the tape across the thoracic region of the spine reduced the rounding which in turn anteriorly tilted the pelvis. The riders ischial tuberosities would then in theory be pointing inferiorly on the saddle, the overall positioning of the trunk would then appear to be in a slightly forward flexed but almost aligned position. Figure 40 demonstrates this change in the rider's alignment pre-tape and tape in the current study.

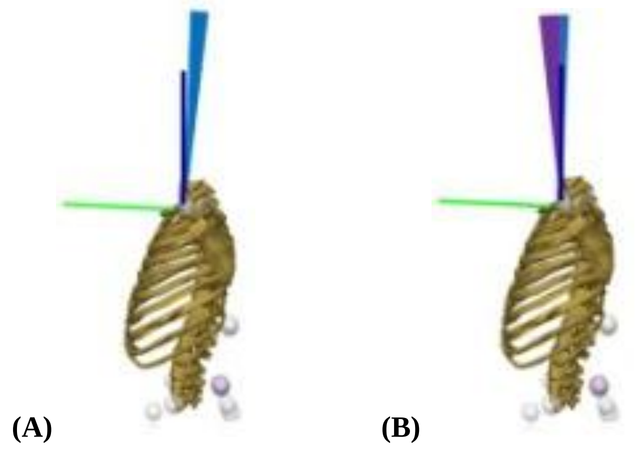

(A) (B)

Figure 40. (A) Pre-tape postural characteristic of leaning back in the saddle. (B) Wearing the tape the rider is now more aligned with a slight forward flexion of the trunk.

In the current study, riders with a forward flexed trunk became more aligned, with the tape in theory mechanically pulling the rider backwards, in order for the riders to become more centrally aligned over the middle of the saddle. In rider 6, with the tape applied in the same way, the tape has in theory mechanically opened up the riders' anterior aspect of the trunk, forcing the natural concave positioning of the lumbar spine and reducing the over-convexed thoracic spine whilst retracting the shoulders, but not a technique that pulls the riders' trunk backwards. Theoretically with rider 6 presenting with an improved trunk alignment whilst wearing the tape, a change in trunk position should have affected the positioning of the riders pelvis. When looking at the visual representation images (chapter 3) it is clear that a reduction in posterior tilt of the pelvis occurred. Although the image still demonstrates a posterior tilted pelvis in rider 6 (chapter 3, table 12, page 81), the reduction in the range (°) of posterior tilt is noticeable and considered an improvement in alignment in this rider overall. The percentage difference in this riders range (°) was a decrease of 11%. Clinically this change may be of importance; however, the method of taping applied in the current study was not enough to 'significantly' affect pelvic positioning and future research may adapt the taping method inferiorly down the spine, rather than only across the thoracic region. Furthermore it would have been interesting to have had more riders in this study that presented with this type of pre-tape postural characteristic (trunk extension, posterior pelvic tilt) in order to further test this type of taping method. Maybe then would this finding present as a significant change in the riders' postural characteristic.

Postural characteristics in riders previously demonstrated by Wanless, (2008), at an observational level, such as tipping forward, hollowing of the back, leaning backwards, rotational and lateral asymmetries and tipping forward are all supported in the findings of the current study. This supports the use of modern technology in order to provide valid quantification of the observation of riders' riding postures. Previous literature that has discussed the importance of riders' postures and made suggestions of what the 'ideal' seat should be can now progress their research forward as is demonstrated in this current study. It is possible to quantify a rider's posture using infrared camera technology whilst on a horse. Without being able to measure these movements in a 'real' equine environment research can only suggest the potential outcomes of a taping method applied in this way. However, the use of this technology has made advancements into the suggestion that tape has a beneficial effect on a rider's posture whilst riding and supported previous literature in the understanding of typical postural characteristics of riders.

4.0.3 Percentage Differences in Riders' Range (°) – Clinical Importance

Tables 3, 5, 7, 9, 11 and 13 (chapter 3) demonstrate the percentage differences in each rider's range (°) with and without tape whilst riding. There are no known related clinical literature that may support these findings currently; however the results may be of clinical interest to riders, instructors and health professionals working in this environment. One example is the range (°) of trunk rotation of which increased by 44.4%, in seven out of ten riders (table 5, chapter 3, page 73). Although these results may not be of statistically significant value, they still support objective four of the current study to quantify any changes in rider posture, following spinal taping whilst sitting trot on a horse. The results however demonstrated in table 3 do coincide with the significant postural changes found in statistical tests. Table 3 (chapter 3, page 70) clearly shows a large average increase of 41% trunk lateral flexion, in eight out of the ten riders. Rider 4 in particular presents with an 89.3% increase in their trunk lateral flexion. Clinically this change in range (°) demonstrates the mechanical effects of athletic taping. The importance of this finding supports the theories behind taping methods discussed by MacDonald, (2009). The findings for the movement of trunk lateral flexion also demonstrate a theory that suggests if one part of a structure is strengthened mechanically then another part of that structure may become more flexible. This theory is demonstrated in the following section.

4.0.4 Significant Postural Changes (With Tape Application)

Findings in the current study reported the range (°) of trunk lateral flexion in riders significantly increased during tape application. The mechanical responses from the application of tape were to allow a combination of proper activation of thoracic musculature and passively reduce thoracic kyphosis promoting postural alignment. These methods of postural taping have been used previously to support ideal posture positioning (Bennell et al, 2000; Greig et al, 2008; MacDonald, 2009). It could be postulated that the increase in range (°) of trunk lateral flexion was due to the mechanical restrictions of the tape over the upper thoracic spine and shoulder region, an increase in compensatory movement occurred through the lumber region. Therefore it appears that in the current study the range (°) of trunk lateral flexion increases. Figure 41 demonstrates the proposition of this motion.

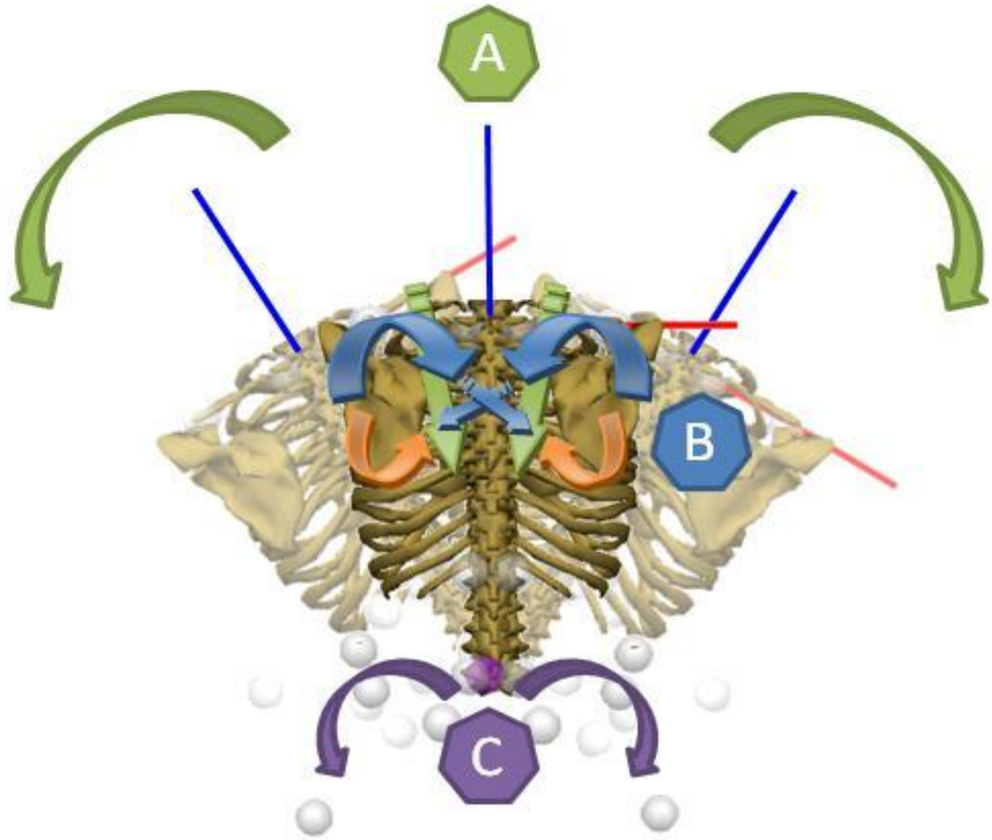


Figure 41. Point (A) demonstrates the increased gross motion as a result of compensatory lateral flexion movement through the lower spine (C), point (B) shows the restriction of the tape.

If this is the case, these findings underpin previous reports of tape providing a passive support to thoracic structures (Greig et al, 2008). Markers on either side of L4 were problematic during one of the two days of data collection, due to the light levels inside the arena. This resulted in L4 markers not tracking at their optimal application. Because of this limitation in tracking the rider it was decided not to use data from L4 markers during the processing stage. If these markers had tracked correctly, motion changes in lumbar spine may have been noted. This may have supported the assumption that more motion through the lumbar spine due to the passive restriction through the thoracic spine would have occurred for the rider to remain in harmonious contact during sitting trot with the horse. Future studies should consider this as a key objective in quantifying postural characteristics in riders. Pilot studies monitoring the application and validity of lumbar spine markers could quantify the use and application methods that may be useful for future studies.

4.0.5 Postural Asymmetry and Leg Length Inequalities

Symes and Ellis', (2009) preliminary study demonstrates rider asymmetry does occur and suggest leg length inequalities (LLI) were responsible for the cause of trunk axial rotation to the left in their riders. In agreement with Symes and Ellis, (2009) it is clear from the results in the current study that riders are asymmetric but as to what extent LLI is entirely responsible may only be one nominal aspect. Although LLI is known to cause pelvic and trunk lateral flexion and rotation, to date clinical research struggles to agree as to what amount of LLI is required clinically significant enough to modify axial rotation. Symes and Ellis, (2009) conclude results indicated no correlation between LLI and shoulder displacement. In the current study riders had 0.1cm difference in leg length, with the right being longer, however it is assumed coincidental that axial rotation occurred predominantly to the right in these riders. This agrees with Gibbons et al, (2002) whereby LLI of <1cm cannot be reliably or accurately detected. Due to the discrepancies among literature it is suggested that in the current study no correlation between LLI and axial rotation occurred in the current study. Furthermore riders sat and rode with a slight bend at the knee so it would be suggested that measurement of LLI may be inaccurately detected or compenstated when riding. Successively this supports the fact that no significant differences were found at the pelvis, from the application of three-dimensional analysis. Future studies need to be aware of the worthiness or value of collecting such data within similar research.

4.0.6 Close to Significant Statistical Results

Statistical data indicated some rider trunk motions as being close to significant in the current study, following the application of tape to the riders. It may be worth mentioning; as the numbers of participants were limited it could be assumed that with a larger population of participants significant data may have been reported. Potentially results could indicate that this method of taping may actually have a larger effect than originally established. Results close to being significant were; movement asymmetry (%) in lateral flexion of the trunk, range (°) of trunk flexion-extension and rotation. It can only be postulated that with a larger sample size these results may have reported as significant, a key consideration for future research.

4.0.7 Non-Significant Pelvic Results

The results made no suggestions of any significant changes occurring at the pelvis in response to tape. In consideration of where the tape was placed no passive or active influences affected pelvic posture, it could be suggested that if the tape were applied closer to the pelvis a larger effect on motion may have occurred. By further mechanically restricting movement lower down the riders spine the pelvis may increase in anterior-posterior motion. This would be therefore counteracting the restriction provided by the tape on the trunk but increasing in motion through the riders' pelvis, still providing a continuous connection between rider and horse. Alternatively the application of tape lower down the spine may be over restricting on pelvic motion and negatively affect the riders' ability to produce fluid harmonious motion coinciding with the horse. Potentially a larger group of participants and a change to the method of taping may influence the significance of these results.

Alternatively it is interesting to report the percentage differences found through the ranges (°) of pelvic movements. For example, an increase in range (°) of pelvic lateral flexion of 23.9% was noted in six out of ten riders. Although these statistics were non-significant the percentage difference demonstrates the effects of the tape at pelvic level. It seems the movement increase in lateral pelvic flexion supports the theory behind the increase in compensatory motion through the lower spine and into the pelvic region mentioned previously. Clinically these findings could be of potential importance to those applying tape in a similar manner on other types of athlete.

4.0.8 Theoretical Assumptions (Changing Taping Method) for Future Research

An assumption that if the application of tape was applied further down the riders' spine, i.e. superiorly from the riders shoulders running posteriorly to the riders sacrum, a potential reduction in AD (°) of trunk flexion-extension may have occurred. Due to the mechanical effects of the tape, restricting the ability to forward flex would therefore support previous postural taping research (Greig et al, 2008; Macdonald, 2009). In agreement with Greig et al, (2008), the reduction of forward curvature of the thoracic spine allows for postural muscles to facilitate optimal spinal arrangement. In turn, co-contraction of the trunk flexion-extension muscles result in a reduction of spinal loading (Greig et al, 2008), improving the rider's torso alignment. This coincides with previous work (Mason, 2006; Wanless, 2008) reporting how short-strong flexor muscles of the trunk can tip the rider forward, hinging the torso, which reduces the riders balance on top of the horse, overall affecting the equines back motion. Wanless, (2008) further comments that in this position, as the rider closes the angle between thigh and torso by bringing their shoulders forward, the riders' ischial tuberosities point backwards. Conversely in the current study visual representation of the riders' pelvic position with and without tape (chapter 3) did not indicate this. Individual images show anterior tilt of the riders' pelvis, which differ from the suggestions made by Wanless, (2008). It needs to be taken into consideration here that this is the first study to use three-dimensional cameras to quantify this movement whereas Wanless, (2008) uses a visual estimation. However, results for the pelvis should be taken with caution here, and in consideration with a number of factors. Marker placement on anatomical landmarks of ASIS and PSIS were required to capture pelvic data, however the position of a rider whilst on a horse and possible interference of the riders jodhpurs needs to be taken into account. The angle between torso and thigh potentially reduces the accuracy of ASIS marker placement and the thickness of the riders' jodhpurs may have increased the possibility for marker displacement. Wanless, (2008) proposes that during sitting trot the horse is 'urged forward' by a riders' pelvic position, increasing the action of the horses' gluteal muscles. Therefore, the suggestion here would be that an anterior tilt of the pelvis would facilitate this motion in sitting trot, demonstrated in the current study.

Although close to being significant an alternative suggestion as to how the AD (°) in trunk flexion-extension could have been reduced could be active support from the tape, i.e. increased muscle contraction from extensors of the spine. However, previous research (Greig et al, 2008) found no significant association with postural taping of the thoracic spine and trunk muscle activity in participants with increased kyphosis of the thoracic spine. Greig et al, (2008) suggested posture was adjusted passively achieved by tape, as opposed to the facilitation of spinal extensor musculature. However, the limited EMG measurements in their study may have been lacking in sensitivity in order to detect smaller muscle changes. EMG data were not recorded in the current study and therefore it cannot be determined if any combination of either passive or active support occurred from the taping of the riders' thoracic spine and shoulder region.

A rider with vertical shoulder/hip/heel line (chapter 1.3.1, page 29) exhibits the suggested isometric muscle control needed to sustain an ideal posture during riding (Wanless, 2008). If a larger sample size were to be used in future studies the reduction in AD (°) of trunk flexion-extension potentially supports the rider in achieving this. This would demonstrate how rider motion can be restricted in order to enhance riding posture through the mechanical effects of tape applied to the thoracic spine. Moreover the theories behind the mechanical effects of tape would be further supported.

4.0.9 Effects of Tape – Differences in Static and Dynamic Observations

Previous research demonstrates methods of taping on static postures (MacDonald, 2009). It is therefore interesting to note how in the current study there was a visible difference between the effects of tape between the static and dynamic postures of the riders. Dynamically the findings of the current study demonstrate that tape applied over the thoracic and shoulder region significantly increased the range (°) of trunk lateral flexion. Potentially a reason behind this finding could be due to the way in which the tape mechanically changed the riders dampening of the motion of the horse in order to maintain balance on the horse. Statically it is recognised that the taping method stiffened the riders' trunk, as the riders were placed into an 'ideal' riding position prior to taping application, as recommended throughout previous equine literature. Therefore the stiffness of the riders' trunks has improved statically, enhancing the alignment of the riders' posture.

It is interesting to consider how tape applied statically over the thoracic spine and shoulder region appears to 'stiffen' the riders overall posture, however dynamically, three-dimensional motion analysis suggests an increase of movement range, potentially occurring though the lumbar spine. Collectively this supports earlier rationale as to what the mechanics of this taping method are and the reasoning behind the significant results found in the current study. It supports the fact that certain taping methods can act as a support to structures, inhibit movement in one region, in turn manipulating an increase in overall motion in another region of the body. These suggestions are extremely important for any rider who uses a taping method currently to enhance their posture when riding. Health professionals working alongside riders may find this beneficial to the treatment or rehabilitation of riders in the future. It is recommended that tape applied in this manner could benefit rider's who present with asymmetries in their riding posture, although further research and application of other taping techniques would be required in order to strengthen these statements.

4.1 Study Challenges and Limitations

One limitation in the current study was the constraint in the number of volunteer riders. This unfortunately was a limitation with no resolution due to the availability of the facilities and horses at Myerscough, timescales and limits had to be worked within. Therefore the maximum number of riders that could be observed was ten. A larger sample size may have produced significant results in a wider range of postural movements following the application of tape.

Riders that volunteered for the current study met the inclusion and exclusion criteria of BHS Level Two standard or above, although the type of riding discipline preferred by each rider was not taken into account. Although not a limitation as such, some riders had more experience of dressage (flatwork riding), and some had professional interests and experience in show jumping or cross-country for example. One option of using only dressage riders such as in a preliminary study by Symes and Ellis, (2009) of high ability should be a priority concern for future work. Although it may limit the possible numbers of riders for a study, it could establish and observe common movement patterns in the postures of riders with similar ability and riding discipline. Dressage riders strive to achieve a consistent motion pattern (Witte et al, 2009), previous studies using motion analysis were able to quantify harmony within dressage riders (Peham et al, 2001). Investigation of postural asymmetry patterns previously established in a group of dressage riders, and quantifying the effects these postures have on motion pattern harmony could provide further insight into the effects of rider asymmetry. Challenges in the current study concerned numerous aspects although through pilot studies these issues were addressed. Future research should take into account the key findings from the pilot studies with regards to the methods used to support this type of complex data collection.

CHAPTER 5

CONCLUSION AND FUTURE RESEARCH

5.0 Conclusion

The results of the current study demonstrate implications for instructors and riders regarding the assessment of riding postures and provide an insight into how tape could potentially be used as a beneficial correction method to asymmetry. Although future studies are required in order to justify this further. These findings increase the understanding biomechanically of the rider athlete in motion. This research supports earlier studies in the use of 3D motion analysis to quantify postural characteristics of riders when on a horse.

5.0.1 Future Research Directions and Key Findings

The need for further investigation into rider posture and to understand the effects of postural asymmetry is crucial. The observation and definition of common movement patterns or spinal alignments in riders is necessary to develop this area of research. Studies have noted the effect of asymmetries occurring in the equine and its gaits, therefore the option of using a mechanical horse could be taken into account in future studies to eliminate an asymmetry occurring in the horse. One alternative direction would be to investigate the effect of asymmetric postures in riders on muscular activity. This could potentially establish how a rider with an asymmetric posture maintains postural stability throughout various gaits. Comparisons could be made to symmetrical riders. This would compare and contrast earlier interest in this area.

Potential investigations into the effects of asymmetric rider postures should combine three-dimensional movement analysis with force measurements under the saddle or applying a tool that could measure the force of the riders' weight going through the stirrups. This would combine previous work (de Cocq et al, 2009) and potentially strengthen the findings from this investigation further. Considerations could be made to compare sitting trot and rising trot whilst combining the 3D motion analysis and force distribution, under the same conditions in future research. This would bring together the work previously reported by Peham et al (2010) and de Cocq et al (2009).

The therapeutic options available to reduce asymmetric postures in riders need to be examined further to establish appropriate methods for these athletes. It is clear from the current study that new findings suggest tape can have an effect on movement and symmetry in riders, however further methods and clinical approaches need to be investigated. Aspects of the current study and future research have the opportunity to positively affect horse and rider performance and training, reduce the occurrence of musculoskeletal injuries and benefit equine welfare. Studies could take on either a clinical or biomechanical direction in future studies. Clinical based studies could encompass the knowledge gained here and develop research into injured riders as a candidate for the therapeutic aspect of taping. However the scope for further biomechanical research in this area is intriguing to further quantify rider characteristics using motion analysis, for the use in athlete performance related research.

Key findings from this Research:

- Data collection methods using appropriate kinematic variables were established in order to quantify rider postures.
- Postural characteristics can be quantified by the use of 3D motion analysis in riders whilst on a horse.
- Changes in riders' postures were quantifiable following spinal taping using 3D motion analysis whilst riding.
- The mechanical affects of taping were tested in new scenarios by means of commonly used clinical taping methods.

APPENDIX A

BRITISH HORSE SOCIETY STAGE TWO COMPETENCIES

Applicable from February 2008
HORSE KNOWLEDGE CARE & RIDING EXAMINATION

STAGE 2 Syllabus

Abbey Park
Stareton
Kenilworth
Warwickshire, CV8 2XZ
Tel: 01926 707700
Fax: 01926 707792
Registered Charity No. 210504 and SC038516

Open to members of the BHS who have reached the age of 16 years and are
keen to improve their knowledge of horses and riding.

Pre-requisites - Horse Knowledge, Care & Riding Stage 1
or S/NVQ Level 2 or 3 (Riding / Schooling Horses)
BHS Riding & Road Safety Certificate, (*Riding Section*)

It may be possible to apply for direct entry to this examination if you hold recognised equivalent qualifications, *(please contact the Examinations Office for further information.)*

The Riding and Care sections may be taken as separate tests

Pre-requisite - Horse Knowledge & Care Stage 1 for Care Section
Riding Stage 1 for Riding Section

STAGE TWO - Syllabus

Stage 2 - Riding

Candidates are required to demonstrate their ability to ride a quiet, experienced horse or pony in anenclosed space without assistance. Their balance and security should indicate the correct foundation for future progress. ***Candidates who are considered to be below the standard may be asked to retire.***

Unit code number S2RIDI
Learning Outcomes Element Assessment criteria Influence
The candidate should be able to; The candidate has achieved this outcome because s/he can:
1.1.1 Demonstrate correct posture in the saddle Compulsory
1.1.2 Show basic suppleness as required in the riding position Compulsory Ride a quiet experienced horse with an appropriate independent balance, depth & security of position. 1.2.1 Show an independent balance is maintained through turns, circles and transitions Compulsory
2.1.1 Show rhythm and balance are maintained through turns and circles Compulsory
2.2.1 Demonstrate ability to ride forward Compulsory Ride a quiet experienced horse forward at the correct speed for each gait.

2.3.1 Know when and when not to use artificial aids (whip) Compulsory
3.1.1 Show non restricting yet controlling rein contact Compulsory
3.2.1 Show balance and security without stirrups in walk, trot and canter Compulsory
3.2.2 Show balance, security and harmony without stirrups in walk, trot and canter Compulsory
Ride a quiet experienced horse with an appropriate rein length both with & without stirrups, and with the reins in one hand.
3.3.1 Show co-ordinated aids when riding with the reins in one hand Supporting
4.1.1 Show co-ordinated aid application Compulsory
4.1.2 Show preparation when making transitions Compulsory
4.2.1 Show correct canter strike-offs Compulsory
4.3.1 Show correctly sized school figures Supporting
Ride a quiet experienced horse applying correct aids for canter leads and school figures.
4.4.1 Ride on correct diagonals Compulsory
5.1.1Demonstrates calm confident riding in establishing horses' trust Ride in harmony a quiet experienced horse.
5.2.1 Show fluent unconstrained work of the horse Supporting
6.1.1 Demonstrate ability to ride safely in company Compulsory
6.1.2Demonstrate awareness of rules for riding in the open as well as in enclosed areas with others
Compulsory
6.2.1 Demonstrate an appropriately balanced position when riding over undulating ground Supporting
6.3.1. Show an ability to ride forward and influence gaits appropriately when riding in the open Compulsory
Ride in the open and jump adopting safe procedures throughout.
6.3.2. Demonstrate/discuss an awareness of undulating ground and weather conditions on a horses' balance Supporting
7.1.1 Demonstrate an appropriate length of stirrup for riding over undulating ground and a course of fences Compulsory
7.2.1 Show effective use of leg aids when riding over undulating ground and around a course of fences Compulsory
7.3.1 Show correct application of rein aids when riding over undulating ground and around a course of fences Supporting
Jump a quiet experienced horse with an appropriate rein length and contact, correct length stirrup and
ability to use the legs.
7.3.2Show correct use of the reins during all phases of the jump (approach, take off, flight, landing and departure) Supporting
8.1.1 Demonstrate correct forward jumping position when riding over undulating ground and around a course of fences Compulsory
8.1.2 Demonstrate a secure position when jumping Compulsory
9.1.1 Show effective control of pace Compulsory Jump a quiet experienced horse with security and balance, showing fold and follow over a fence.
9.2.1 Identify when and when not to use artificial aids (whip) Compulsory
10.1.1 Show effective calm confident riding while jumping Supporting
10.2.1 Show a fluently ridden course Compulsory Jump in harmony a quiet experienced horse, whilst riding correct lines of approach towards and departures around a course of fences to a max. 2'6" (.76m).
10.3.1 Demonstrate awareness of the importance of correct canter leads Supporting Candidate presentation 11.1.1 Candidate turnout and presentation as per guidelines on dress Compulsory

APPENDIX B

PARTICIPANT INFORMATION SHEET – PILOT STUDY

Dear Participant,

You have been invited to participate in a research study that is investigating the Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders. This information sheet provides basic information regarding the testing procedure and attached is a consent form for you to fill in which asks for your agreement to take part in the testing. The information and agreement form are referred to as informed consent. The following information aims to address any questions you may have about the testing. Please feel free to ask any additional questions to enable you to feel happy to provide consent to take part.

What will I have to do?

The pilot work will take place in the movement analysis laboratory lab at the University of Central Lancashire. The reason behind the laboratory based testing is to find out if your posture whilst sitting in a 'riding position' is symmetrical or asymmetrical. You will be required to attend a maximum one hour session during which your standing and sitting posture will be clinically examined. You will be asked to sit on a physio ball for 60 seconds whilst the infrared cameras track your natural movements via the reflective markers. If you're found to have an asymmetrical posture tape may be applied depending on your posture. You will then sit on the physio ball again for a further 60 seconds with the tape applied whilst the infrared cameras track the potential change in your posture. If you re found not to be asymmetrical you will not have tape applied and the testing will end at that point. This will finalise the end of the testing session.

Following the pilot study if you meet the eligibility criteria you will be asked to participate in the main study based at Myerscough College. If you do meet the eligibility criteria for the main study you will be supplied with another information sheet informing you of the testing procedure at Myerscough College, based in the equine arena using horses. If you do not meet the eligibility criteria following the pilot testing you will no longer be required to participate in this research study.

What are the risks of taking part?

The main risks of taking part in the pilot study are falling off the stability/physio ball during the assessment. However, safety precautions such as floor mats will be present; also any wires from the camera systems will be covered with rubber matting to prevent tripping. Reflective markers will be applied to your skin so that the cameras can monitor your movements; therefore a skin test will be performed prior to any application to make sure you do not have an allergic reaction to the adhesive tape. If you are aware that you may react to the adhesive tape please inform the researcher before testing commences.

It should be noted that the demands of the pilot testing you will experience are NOT anything different to that of a full clinical examination of posture using a stability/physio ball in a clinical situation. A full risk assessment has been carried out by UCLan (University of Central Lancashire), this has minimised any risks to yourself and the researchers.

Do you have to take part?

Participation in this study is entirely voluntary. You are free to withdraw from this study at anytime during the testing. Your data will be stored using numerical file names during testing, so once testing is complete you will not be able to withdraw it from the study as it will not be distinguishable from other participants' data.

What will happen to my data?

Any data collected during this research study will be stored numerically and no data will be traceable back to participants. All data collected is recorded as anonymous and will not be distinguishable from other participants' data for data protection purposes. The results obtained from the pilot testing will be analysed and written up as part of my MSc research study. All information provided by you regarding health status and consent will be stored anonymously on a password protected computer and will not be shared with any third parties. The overall results found during this study may be published by the University to peer reviewed journals and/or conferences.

Ethical Consent

This study will be* given ethical consent by the University of Central Lancashire for the Lab based study and by Myerscough College for the main study.*N.B. This will be changed to 'has been given' when approval is granted.

If you wish to participate in this study please sign the attached consent form. This is a requirement of the study that you provide a signature which provides your written consent to take part and perform the research.

All communications please contact

Dr. Sarah Jane Hobbs Senior Lecturer in Sports and Exercise,
Centre for Applied Sport and Exercise Sciences,
University of Central Lancashire,
Preston,

PR1 2HE

Tel: 01772 893328
Email: SJHobbs1@uclan.ac.uk

APPENDIX C

PARTICIPANT CONSENT FORM - PILOT STUDY

Consent Form

Participant Number:

Study Title: A Study Investigating the Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders.

Principal Researcher: Jill Alexander

Written Consent for Testing

I am fully aware of what is required of me during the testing of this study and understand the risks associated. I understand that the movement analysis cameras will record infrared images of me and no identifiable images are recorded throughout the testing. I understand that all data collected will be treated with confidentiality, however I am aware that the results produced from this research may be used in future publications. If I wish, the results will be available to me.

I willingly agree to participate in the study. I have read the attached information provided and understand that I can withdraw from the study at any point without reason.

Please initial if the following apply to you:

I regularly take part in equestrian activities and ride on a weekly basis ☐

I am registered at Level 3 Standard of riding by the British Horse Society (BHS) ☐

I have NOT suffered any spinal, shoulder or hip injuries that may affect the results of this research in the last 6 months ☐

I DO NOT have any known allergies to equines ☐

I DO NOT have any known skin sensitivity to athletic tape ☐

If you agree to take part in this study please give your written consent below:

Name of Participant

Print Name: ………………………………………………………………………………………………………

Participants Signature: …………………………………………………… Date: ………. /………. /……….

Researcher/Witness

Print Name: ………………………………………………………………………………………………………

Participants Signature: …………………………………………………… Date: ………. /………. /……….

Appendices D,E,F,G, redacted for reasons pertaining to Data Protection

APPENDIX H

RISK ASSESSMENT FOR PILOT STUDY

RISK ASSESSMENT TITLE	**PROGRAMME AREA**	**ASSESSMENT UNDERTAKEN**	**ASSESSMENT REVIEW**
A Study Investigating the Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders.	Participant Pilot Study – laboratory based	**Signed:** **Date: April 2009**	**Date: April 2009**

STEP ONE - RISK	**STEP TWO – WHO / WHAT IS AT RISK**	**STEP THREE – WHAT MEASURES WILL BE TAKEN TO PREVENT THE RISK**
Risk of back injury when moving or setting up equipment	Researcher and co-workers	Following health and safety lifting and handling regulations at UCLAN – lift items close to the body, no twisting or jerking movements, carry items with a straight back and use leg muscles to lift, do not try and carry anything that you feel you will struggle to lift on your own, always get help and use the correct number of people to carry the equipment.
Risk of harm from faulty electrical equipment	Researcher and co-worker	All electrical equipment will have been PAT tested before use and any equipment which needs to be connected to a main power supply will have a circuit breaker attached.
Risk of tripping over wires from camera and computer systems	Researcher, co-worker and participants	All wires will be covered with rubber matting to prevent any trips or falls.
Any injury occurring during testing	Researcher, co-workers and participants	First aid boxes and a first aider will be located before testing begins in case of an accident. The researcher will have a mobile phone to hand in case of an emergency.
Falling off the physio-ball during testing	Researcher, co-workers and participants	Soft tumble matting will be provided around the physio ball in case anyone becomes unbalanced and falls off. Whilst sitting on the ball both feet of the participant or otherwise will be on the floor for support.
Risk of an allergic reaction to the anatomical marker tape or the athletic tape used in the laboratory study	Researcher, co-workers and participants	All participants will be given a skin sensitive test to all tape applied prior to any testing to make sure no participant as an allergic reaction during data collection.

APPENDIX I

RISK ASSESSMENT FOR MYERSCOUGH TESTING

RISK ASSESSMENT TITLE	**PROGRAMME AREA**	**ASSESSMENT UNDERTAKEN**	**ASSESSMENT REVIEW**
A Study Investigating the Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders.	Equine/rider	**Signed:** **Date: June 2009**	**Date: June 2009**

STEP ONE	**STEP TWO**	**STEP THREE**
Positioning anatomical markers: horse may be startled by procedure; horse may bite, kick, stand on, or knock into handler.	The researcher and co-worker are at risk	The researcher and co-workers will have undergone Myerscough College yard safety training. Both the researcher and co-worker have experience with horses. The skin markers will be applied in the horses stable, the co-worker will be handling the horse and the researcher will be applying the anatomical markers to the ventral-caudal aspects of the tuber coxae and one cluster (4 markers) on the croup. The researcher will ensure that she is aware of her body position to the horse in case the horse decides to kick out. The co-worker will be wearing a suitable riding hat and gloves whilst the researcher will be wearing a suitable riding hat. The riding hat must be up to standard, PAS 015/BSEN 1384 or equivalent.
When handling the horse: damage to head, hands, feet and body	The researcher, rider, and co-worker are at risk	The researcher, rider and co-worker all have experience with horses and will be aware of the horse's behaviour at all times. They will all be wearing a suitable riding hat (PAS 015/BSEN 1384 or equivalent) gloves with grip, suitable clothing and footwear (sturdy boots with a gripped sole, no shoes or trainers).
Risk of back injury when moving equipment or injury if equipment is dropped	Researcher and co-workers	Follow the guidelines from the Myerscough College yard induction; load close to the body; feet apart; do not jerk, twist or shove; straight back; use thigh muscles to push; do not lift away from body; use the appropriate amount of people to carry the equipment
Habituation of the horse to the testing procedure: horse may spook at the lights, fence, camera, computer and personnel.	Rider, researcher and co-workers	The horse will be habituated gradually to the testing set-up, the rider, who is an experienced dressage rider and instructor at Myerscough College will walk and trot the horses around and through the camera setup to begin with until they are relaxed. The rider will then be asked to trot the horse through the set-up (in sitting trot). The rider will be wearing correct clothing as stated by Myerscough College rules. All riders will have completed an inducation (example in appendix K) (Myerscough College risk assessment for riding and Myerscough College risk assessment for entering and leaving the school.)
Injury to the horse during the habituation period and when performing the actual test in the	Horse, rider, researcher and co-workers	The set-up for the testing and habituation period in the arena will be as safe as possible. The site will be assessed for potential risks to both horse and people, risks assessed include: loose cables, uneven

international arena: injuring themselves on the equipment		surface, first aid kit, fire extinguisher, exit/entry doors, fire escapes and fire assembly points. Before the set-up is erected the nearest power supply will be located which is closest to the arena. The set up will ensure that the electrical cables from the infrared camera system and the laptop are situated as close to the edge of the arena as possible so the horse will not be worked anywhere near them. The cables from the camera system laid on the arena surface will be covered by a rubber mat to prevent the researcher, riders and co workers from tripping over the wires. The cables will be taped along the floor up to where they are plugged into the main power supply.
Risk of harm from faulty electrical equipment	Researcher, rider and co-workers	All electrical equipment will have been PAT tested before use and any equipment which needs to be connected to a main power supply will have a circuit breaker attached.
Risk of the rider falling off and injuring themselves	Rider	The rider will be wearing all the correct clothing as stated by Myerscough College safety rules. There will always be a first aider present on campus at Myerscough and the researcher who will be present at all times when the rider is riding will be carrying a mobile phone if the need arises to call the emergency services. The researcher, co-workers and riders will all be wearing a suitable riding hat and gloves whilst the researcher will be wearing a suitable riding hat. The riding hat must be up to standard, PAS 015/BSEN 1384 or equivalent.
Any injury occurring whilst the study is being carried out	Rider, researcher and co-workers are at risk	First aid boxes and the first aider will be located before the testing begins and again the researcher will always be carrying a mobile phone to call the emergency services if required.
Risk of horses contaminating or infecting anyone who has handled them: Zoonotic disease	Rider, researcher and co-workers are at risk	All persons involved with the trial will not be allowed to eat during the testing procedure and will wash their hands once the testing has finished.
Risk of slipping on tiles when exiting the arena due to a build-up of the surface on the soles of shoes	Researchers and co-workers	Clean shoes before exiting the arena by knocking any build-up of surface off the soles.
Risk to the horse on the day	Rider and horse	The rider will assess the horse during the habituation and warm-up period to ensure that it is eliciting normal behaviour. If the rider thinks the horse is showing abnormal behaviour before or during the exercise period then it will be removed from the study and attended to by a qualified person.
Risk to the researchers and co-workers during the testing procedure: tripping over the cables and being put in danger by the horse	Researchers and co-workers	The set – up will be designed so that it is fenced off in case the horse becomes loose. The set – up will also be designed so that the cables on the floor are cover by rubber matting ensuring that the researchers and co-workers do not trip. Signs will be put up warning the public that there are cables on the ground; these cables will be covered by rubber matting.
Lifting and carrying tack: injury to back and/or		Myerscough College risk assessment for lifting and carrying tack.

tripping over tack		
Injury whilst tacking up the horse	Rider, researcher and co-workers	Myerscough College risk assessment for tacking-up
Allergies brought on by horses	Rider, researcher and co-workers	The riders will have signed a participant information from prior to any work being carried out which asks them to inform the researcher of any known allergies to horses. If they are allergic to horses then they will be withdrawn from the study.

APPENDIX J

RIDER STATISTICS

Rider	Age (years)	Left Leg (cm)	Right Leg (cm)	Height (cm)	Weight (kg)	Right (R) or Left (L) hand dominant	Right (R) or Left (L) leg dominant
A	38	89	89	164	61	R	R
B	22	81	81	164	61.4	R	R
C	30	95	95	174	65	R	R
D	39	82	83	154	47	R	R
E	27	84	84	162.5	57.3	R	R
F	22	83	82	164	54.2	R	R
G	21	81	81	168	57	R	R
H	33	85	86	162.2	56	R	R
I	27	85	85	163	69.2	R	R
J	27	90	90	166	63	R	R
AVERAGE	29 years	85.5 cm	85.6 cm	164.2 cm	59.1 kg	Right hand	Right leg

Appendix K, redacted for reasons pertaining to Data Protection

APPENDIX L

EQUINE VITAL STATISTICS

HORSE	Weight Kg	Height HH*	Age	Breed
1	421	14.1	11 years	Welsh x TB
2	570	14.2	11 years	COB
3	560	16.1	8 years	ID X
4	599	16	10 years	ID X TB

*HH key: stands for Hands High – measurement of horses height

HORSE 1

HORSE 2

HORSE 3

HORSE 4

APPENDIX M

DATA COLLECTION PARTICIPANT ROTA FOR HORSES/RIDERS AT MYERSCOUGH

TIMES	HORSE	RIDER	HELPER	RESEARCHERS
8-9 SETUP	N/A	N/A	LAURA DAGG	JILL ALEXANDER
9-10			LAURA TACK HORSE 2	ʺ
10-11	HORSE 2	RIDER 1	LAURA TO UNTACK HORSE 2 EMMA TO TACK HORSE 3	ʺ
11-12	HORSE 3	RIDER 2	LAURA UNTACK HORSE 3	ʺ
12-12:15	BREAK	BREAK	BREAK – LAURA TO TACK HORSE 4	BREAK
12:15-1:15	HORSE 4	RIDER 3	LAURA TO UNTACK HORSE 4 & EMMA TO TACK HORSE 1	ʺ
1:15-2:15	HORSE 1	RIDER 4	LAURA TO UNTACK HORSE 1 & EMMA TO TACK HORSE 2	ʺ
2:15-3:15	HORSE 2	RIDER 5	LAURA DAGG TO UNTACK HORSE 2	ʺ

An Investigation into the Influence of Athletic Taping on the Postures of Female Equine Riders During Sitting Trot

Jill Alexander BSc (Hons)

TIMES	HORSE	RIDER	HELPER	RESEARCHERS
8-9 SETUP	N/A	N/A	LAURA DAGG	JILL ALEXANDER
9-10	HORSES IN ROTA DUE TO AVAILABILITY		LAURA DAGG TO TACK HORSE 1	″
10-10:45 AM	HORSE 1	RIDER 6	LAURA TO HOLD HORSE 1	″
10:45-11:30 AM	HORSE 1	RIDER 7	LAURA TO UNTACK HORSE 1 & EMMA TO HORSE 2	″
11:30 – 12:15	HORSE 2	RIDER 8	EMMA TO UNTACK HORSE 2& DANI TO TACK HORSE 3	″
12:15-1PM	HORSE 3	RIDER 9	EMMA TO UNTACK HORSE 3 & DANI TO TACK HORSE 2	″
1PM-1:45PM	HORSE 2	RIDER 10	EMMA TO UNTACK HORSE 2	″

DATA COLLECTION DAY 1 - ROTA FOR 3RD MARCH 2010 – RIDERS, HORSES, HELPERS AT MYERSCOUGH INDOOR ARENA (SMALL)

DATA COLLECTION DAY 2 - ROTA FOR 24TH MARCH 2010 – RIDERS, HORSES, HELPERS AT MYERSCOUGH INDOOR ARENA (SMALL)

*FOR MORE DETAILS PLEASE CONTACT JILL ALEXANDER OR ALISON NORTHROP (MYERSCOUGH).

APPENDIX N

CONSENT FORM FOR MYERSCOUGH PARTICIPANT RIDERS

Participant Number:

Study Title: A Study Investigating the Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders.

Principal Researcher: Jill Alexander

Written Consent for Testing

I am fully aware of what is required of me during the testing of this study and understand the risks associated. I understand that the movement analysis cameras will record infrared images of me and no identifiable images are recorded throughout the testing. I understand that all data collected will be treated with confidentiality, however I am aware that the results produced from this research may be used in future publications. If I wish, the results will be available to me.

I willingly agree to participate in the study. I have read the attached information provided and understand that I can withdraw from the study at any point without reason.

Please initial if the following apply to you:

I regularly take part in equestrian activities and ride on a weekly basis ☐

I am registered at Level 2 or above Standard of riding by the British Horse Society (BHS) ☐

I have NOT suffered any spinal, shoulder or hip injuries that may affect the results of this research in the last 6 months ☐

I DO NOT have any known allergies to equines ☐

If you agree to take part in this study please give your written consent below:

Name of Participant

Print Name: ……………………………………………………………………………………………………

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

Date: ………. /………. /……….

Researcher/Witness

Print Name: ……………………………………………………………………………………………………

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

Date: ………. /………. /……….

APPENDIX O

PARTICIPANT INFORMATION SHEET – MYERSCOUGH TESTING

Dear Participant,

You have been invited to participate in a research study that is investigating ***The Effects of Athletic Taping on Postural Asymmetry in Equestrian Riders.*** This information sheet provides basic information regarding the testing procedure and attached is a consent form for you to fill in which asks for your agreement to take part in the testing. The information and agreement form are referred to as informed consent. The following information aims to address any questions you may have about the testing. Please feel free to ask any additional questions to enable you to feel happy to provide consent to take part.

Aim of Study: To investigate whether taping affects postures of equine riders who exhibit asymmetric alignments in their sitting posture during riding.

What will I have to do?

Prior to this testing you will have taken part in the pilot study for this research and have met all the eligibility criteria and therefore are suitable to take part in the main study. The work of the main study will take place in the equine arena at Myerscough College. You will be required to attend a maximum one hour session where you will be expected to ride one horse for the duration of the testing. You will initially warm up the horse and habituate the horse to the testing procedure. The testing procedure requires you to trot the horse a number of times in a straight line whilst you are being assessed using infrared cameras. You will be required to be in sitting trot whilst your posture is being assessed by the infrared cameras. Initially, as in the pilot test you will have reflective markers applied to certain anatomical landmarks, additionally some markers will be applied to the horse. Following this, the same method of taping (if applicable) will be applied in order to potentially correct your posture. You will then be required to repeat the same process as before and ride in sitting trot in a straight line a number of times whilst the infrared cameras monitor your posture. Once you have finished the testing you will hand over the horse to the next participant who will follow the same testing procedure.

What are the risks of taking part?

The main risks of taking part in the main study are falling off the horse and injuring yourself. You have been invited to take part in this part of the study as you are a competent horse rider who rides regularly and rides to Level 3 BHS standard. Participant riders will be required to wear a safety helmet that conforms to **BS PAS 015 1998; BS EN 1384; ASTMF 1163 95**. The horses undergo the habitual period prior to each testing procedure to reduce any risk to you or the horse. N.B. please inform the researcher of any known allergies associated with horses prior to the study taking place as you will be asked to withdraw from the study. Additional risks from tripping over camera wires will be prevented by being covered with rubber matting. Reflective markers will be applied to your skin so that the cameras can monitor your movements; therefore a skin test will be performed prior to any application to make sure you do not have an allergic reaction to the adhesive tape. If you are aware that you may react to the adhesive tape please inform the researcher before testing commences.

It should be noted that the demands of the testing you will experience are NOT anything different to that of a basic flatwork training session on the horse. A full risk assessment has been carried out by Myerscough College and UCLan (University of Central Lancashire), which minimises any risks to you and the researchers.

Do you have to take part?

Participation in this study is entirely voluntary. You are free to withdraw from this study at anytime during the testing. Your data will be stored using numerical file names during testing, so once testing is complete you will not be able to withdraw it from the study as it will not be distinguishable from other participants' data.

What will happen to my data?

Any data collected during this research study will be stored numerically and anonymous therefore no data will be traceable back to participants. All data collected is recorded as anonymous and will not be distinguishable from other participants' data for data protection purposes. The results obtained from the pilot testing will be analysed and written up as part of my MSc research study. All information provided by you regarding health status and consent will be stored anonymously on a password protected computer and will not be shared with any third parties. The overall results found during this study may be published by the University to peer reviewed journals and/or conferences.

Ethical Consent

This study has been granted ethical consent by the University of Central Lancashire for the pilot study and by Myerscough College for the main study. If you wish to participate in this study please sign the attached consent form. This is a requirement of the study that you provide a signature which provides your written consent to take part and perform the research.

All communications please contact:

Dr. Sarah Jane Hobbs

Senior Lecturer in Sports and Exercise,
Centre for Applied Sport and Exercise Sciences,
University of Central Lancashire,
Preston,
PR1 2HE

Tel: 01772 893328
Email: SJHobbs1@uclan.ac.uk

APPENDIX P

RANDOMISATION PROTOCOL FOR MYERSCOUGH TESTING

A Randomization Plan

from

http://www.randomization.com

1. ____
    - No Tape
    - Tape

2. ____
    - Tape
    - No Tape

3. ____
    - No Tape
    - Tape

4. ____
    - Tape
    - No Tape

5. ____
    - No Tape
    - Tape

6. ____
    - No Tape
    - Tape

7. ____
    - No Tape
    - Tape

8. ____
   - Tape
   - No Tape

9. ____
   - Tape
   - No Tape

10. ____
   - No Tape
   - Tape

10 subjects randomized into 1 block
To reproduce this plan, use the seed 17188
Randomization plan created on Sunday, February 28, 2010 15:17:47

APPENDIX Q

STATISTICAL DATA

TrunkXRa

*Nonparametric Tests: Related Samples.NPTESTS/RELATED TEST(TrunkXRa TrunkXRaT) /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE/CRITERIA ALPHA=0.05 CILEVEL=95.

Nonparametric Tests

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The median of differences between TrunkXRa and TrunkXRaT equals 0.	Related-Samples Wilcoxon Signed Ranks Test	.012	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

GLM TrunkXAb TrunkXAbT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05) /WSDESIGN=factor1.

General Linear Model

Output Created		27-Apr-2011 08:09:05
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkXAb TrunkXAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.015

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sa

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkXAb

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkXAb
	2	TrunkXAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.011	.101[a]	1.000	9.000
	Wilks' Lambda	.989	.101[a]	1.000	9.000
	Hotelling's Trace	.011	.101[a]	1.000	9.000
	Roy's Largest Root	.011	.101[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.758	.011
	Wilks' Lambda	.758	.011
	Hotelling's Trace	.758	.011
	Roy's Largest Root	.758	.011

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.162	1	.162	.101
	Greenhouse-Geisser	.162	1.000	.162	.101
	Huynh-Feldt	.162	1.000	.162	.101
	Lower-bound	.162	1.000	.162	.101
Error(factor1)	Sphericity Assumed	14.408	9	1.601	
	Greenhouse-Geisser	14.408	9.000	1.601	
	Huynh-Feldt	14.408	9.000	1.601	
	Lower-bound	14.408	9.000	1.601	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.758	.011
	Greenhouse-Geisser	.758	.011
	Huynh-Feldt	.758	.011
	Lower-bound	.758	.011

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.162	1	.162	.101
Error(factor1)	dimension2	Linear	14.408	9	1.601	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source		factor1	Sig.	Partial Eta Squared
dimension1	factor1	dimension2	Linear	.758	.011

Tests of Between-Subjects Effects

Measure:MEASURE_1 Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	87.362	1	87.362	4.426	.065	.330
Error	177.628	9	19.736			

TrunkXMa

GLM TrunkXMa TrunkXMaT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Output Created		27-Apr-2011 08:09:28
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav

	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkXMa TrunkXMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.032

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sa

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkXMa
	2	TrunkXMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.173	1.880[a]	1.000	9.000
	Wilks' Lambda	.827	1.880[a]	1.000	9.000
	Hotelling's Trace	.209	1.880[a]	1.000	9.000
	Roy's Largest Root	.209	1.880[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.204	.173
	Wilks' Lambda	.204	.173
	Hotelling's Trace	.204	.173
	Roy's Largest Root	.204	.173

b. Design: Intercept Within Subjects Design: factor1

Tests of Between-Subjects Effects

Measure:MEASURE_1Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	29752.898	1	29752.898	3.638	.089	.288
Error	73605.752	9	8178.417			

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	2380.562	1	2380.562	1.880
	Greenhouse-Geisser	2380.562	1.000	2380.562	1.880
	Huynh-Feldt	2380.562	1.000	2380.562	1.880
	Lower-bound	2380.562	1.000	2380.562	1.880
Error(factor1)	Sphericity Assumed	11395.028	9	1266.114	
	Greenhouse-Geisser	11395.028	9.000	1266.114	
	Huynh-Feldt	11395.028	9.000	1266.114	
	Lower-bound	11395.028	9.000	1266.114	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.204	.173
	Greenhouse-Geisser	.204	.173

	Huynh-Feldt	.204	.173
	Lower-bound	.204	.173

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	2380.562	1	2380.562	1.880
Error(factor1)	dimension2	Linear	11395.028	9	1266.114	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source		factor1	Sig.	Partial Eta Squared
dimension1	factor1	dimension2	Linear	.204	.173

GLM TrunkYRa TrunkYRaT /WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ /CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:09:59
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkYRa TrunkYRaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.017

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.save

Within-Subjects Factors

Measure:MEASURE_1

factor1	Dependent Variable

dimension1	1	TrunkYRa
	2	TrunkYRaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.000	.000[a]	1.000	9.000
	Wilks' Lambda	1.000	.000[a]	1.000	9.000
	Hotelling's Trace	.000	.000[a]	1.000	9.000
	Roy's Largest Root	.000	.000[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.987	.000
	Wilks' Lambda	.987	.000
	Hotelling's Trace	.987	.000
	Roy's Largest Root	.987	.000

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]		
		Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1	factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.001	1	.001	.000
	Greenhouse-Geisser	.001	1.000	.001	.000
	Huynh-Feldt	.001	1.000	.001	.000
	Lower-bound	.001	1.000	.001	.000
Error(factor1)	Sphericity Assumed	17.214	9	1.913	
	Greenhouse-Geisser	17.214	9.000	1.913	
	Huynh-Feldt	17.214	9.000	1.913	
	Lower-bound	17.214	9.000	1.913	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.987	.000
	Greenhouse-Geisser	.987	.000
	Huynh-Feldt	.987	.000
	Lower-bound	.987	.000

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1		Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.001	1	.001	.000
Error(factor1)	dimension2	Linear	17.214	9	1.913	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1		Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.987	.000

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1006.781	1	1006.781	73.563	.000	.891
Error	123.175	9	13.686			

GLM TrunkYAb TrunkYAbT /WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:10:23
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkYAb TrunkYAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.000

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkYAb
	2	TrunkYAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.000	.002[a]	1.000	9.000
	Wilks' Lambda	1.000	.002[a]	1.000	9.000
	Hotelling's Trace	.000	.002[a]	1.000	9.000
	Roy's Largest Root	.000	.002[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.969	.000
	Wilks' Lambda	.969	.000

	Hotelling's Trace	.969	.000
	Roy's Largest Root	.969	.000

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.025	1	.025	.002
	Greenhouse-Geisser	.025	1.000	.025	.002
	Huynh-Feldt	.025	1.000	.025	.002
	Lower-bound	.025	1.000	.025	.002
Error(factor1)	Sphericity Assumed	136.320	9	15.147	
	Greenhouse-Geisser	136.320	9.000	15.147	
	Huynh-Feldt	136.320	9.000	15.147	
	Lower-bound	136.320	9.000	15.147	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.969	.000
	Greenhouse-Geisser	.969	.000
	Huynh-Feldt	.969	.000

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.969	.000
	Greenhouse-Geisser	.969	.000
	Huynh-Feldt	.969	.000
	Lower-bound	.969	.000

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.025	1	.025	.002
Error(factor1)	dimension2	Linear	136.320	9	15.147	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source		factor1	Sig.	Partial Eta Squared
dimension1	factor1	dimension2	Linear	.969	.000

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	762.613	1	762.613	24.088	.001	.728
Error	284.933	9	31.659			

GLM TrunkYMa TrunkYMaT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:10:47
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.

Syntax		GLM TrunkYMa TrunkYMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.031

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkYMa
	2	TrunkYMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.095	.947[a]	1.000	9.000
	Wilks' Lambda	.905	.947[a]	1.000	9.000
	Hotelling's Trace	.105	.947[a]	1.000	9.000
	Roy's Largest Root	.105	.947[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.356	.095
	Wilks' Lambda	.356	.095
	Hotelling's Trace	.356	.095
	Roy's Largest Root	.356	.095

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	1596.685	1	1596.685	.947
	Greenhouse-Geisser	1596.685	1.000	1596.685	.947
	Huynh-Feldt	1596.685	1.000	1596.685	.947
	Lower-bound	1596.685	1.000	1596.685	.947
Error(factor1)	Sphericity Assumed	15172.520	9	1685.836	
	Greenhouse-Geisser	15172.520	9.000	1685.836	
	Huynh-Feldt	15172.520	9.000	1685.836	
	Lower-bound	15172.520	9.000	1685.836	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.356	.095
	Greenhouse-Geisser	.356	.095
	Huynh-Feldt	.356	.095
	Lower-bound	.356	.095

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	1596.685	1	1596.685	.947
Error(factor1)	dimension2	Linear	15172.520	9	1685.836	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1	Sig.	Partial Eta Squared

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.356	.095

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	74285.861	1	74285.861	29.954	.000	.769
Error	22319.745	9	2479.972			

GLM TrunkZRa TrunkZRaT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:11:27
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkZRa TrunkZRaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.000

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkZRa
	2	TrunkZRaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.318	4.197[a]	1.000	9.000
	Wilks' Lambda	.682	4.197[a]	1.000	9.000
	Hotelling's Trace	.466	4.197[a]	1.000	9.000
	Roy's Largest Root	.466	4.197[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.071	.318
	Wilks' Lambda	.071	.318
	Hotelling's Trace	.071	.318
	Roy's Largest Root	.071	.318

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]		
		Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1	factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	2.381	1	2.381	4.197
	Greenhouse-Geisser	2.381	1.000	2.381	4.197

	Huynh-Feldt	2.381	1.000	2.381	4.197
	Lower-bound	2.381	1.000	2.381	4.197
Error(factor1)	Sphericity Assumed	5.104	9	.567	
	Greenhouse-Geisser	5.104	9.000	.567	
	Huynh-Feldt	5.104	9.000	.567	
	Lower-bound	5.104	9.000	.567	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.071	.318
	Greenhouse-Geisser	.071	.318
	Huynh-Feldt	.071	.318
	Lower-bound	.071	.318

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	2.381	1	2.381	4.197
Error(factor1)	dimension2	Linear	5.104	9	.567	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.071	.318

Tests of Between-Subjects Effects

Measure:MEASURE_1Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	507.025	1	507.025	58.383	.000	.866
Error	78.161	9	8.685			

GLM TrunkZAb TrunkZAbT /WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:12:30
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>

	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkZAb TrunkZAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.015
	Elapsed Time	00:00:00.031

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkZAb
	2	TrunkZAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.040	.376[a]	1.000	9.000
	Wilks' Lambda	.960	.376[a]	1.000	9.000
	Hotelling's Trace	.042	.376[a]	1.000	9.000
	Roy's Largest Root	.042	.376[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.555	.040
	Wilks' Lambda	.555	.040
	Hotelling's Trace	.555	.040
	Roy's Largest Root	.555	.040

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept

Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	4.050	1	4.050	.376
	Greenhouse-Geisser	4.050	1.000	4.050	.376
	Huynh-Feldt	4.050	1.000	4.050	.376
	Lower-bound	4.050	1.000	4.050	.376
Error(factor1)	Sphericity Assumed	96.820	9	10.758	
	Greenhouse-Geisser	96.820	9.000	10.758	
	Huynh-Feldt	96.820	9.000	10.758	
	Lower-bound	96.820	9.000	10.758	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.555	.040
	Greenhouse-Geisser	.555	.040
	Huynh-Feldt	.555	.040
	Lower-bound	.555	.040

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	4.050	1	4.050	.376
Error(factor1)	dimension2	Linear	96.820	9	10.758	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

		Source	factor1	Sig.	Partial Eta Squared
dimension1	factor1	dimension2	Linear	.555	.040

Tests of Between-Subjects Effects

Measure:MEASURE_1

Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3.528	1	3.528	.044	.839	.005
Error	729.262	9	81.029			

GLM TrunkZMa TrunkZMaT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ /CRITERIA=ALPHA(.05)/WSDESIGN=factor1.

General Linear Model

Notes

Output Created		27-Apr-2011 08:12:55
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM TrunkZMa TrunkZMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.014

[DataSet1] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_TrunkM.save

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	TrunkZMa
	2	TrunkZMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.082	.804[a]	1.000	9.000
	Wilks' Lambda	.918	.804[a]	1.000	9.000
	Hotelling's Trace	.089	.804[a]	1.000	9.000
	Roy's Largest Root	.089	.804[a]	1.000	9.000

a. Exact statistic

b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.393	.082
	Wilks' Lambda	.393	.082
	Hotelling's Trace	.393	.082
	Roy's Largest Root	.393	.082

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericityb

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]		
		Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1	factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	718.801	1	718.801	.804
	Greenhouse-Geisser	718.801	1.000	718.801	.804
	Huynh-Feldt	718.801	1.000	718.801	.804
	Lower-bound	718.801	1.000	718.801	.804
Error(factor1)	Sphericity Assumed	8047.364	9	894.152	
	Greenhouse-Geisser	8047.364	9.000	894.152	
	Huynh-Feldt	8047.364	9.000	894.152	
	Lower-bound	8047.364	9.000	894.152	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.393	.082
	Greenhouse-Geisser	.393	.082
	Huynh-Feldt	.393	.082
	Lower-bound	.393	.082

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	718.801	1	718.801	.804
Error(factor1)	dimension2	Linear	8047.364	9	894.152	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.393	.082

Tests of Between-Subjects Effects

Measure:MEASURE_1 Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	8450.161	1	8450.161	.720	.418	.074
Error	105554.285	9	11728.254			

PelXRa

```
SAVE OUTFILE='C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM_1.sav'
  /COMPRESSED.
DATASET ACTIVATE DataSet1.
DATASET CLOSE DataSet5.
GET
  FILE='C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav'.
DATASET NAME DataSet6 WINDOW=FRONT.
GLM PelXRa PelXRaT
  /WSFACTOR=factor1 2 Polynomial
  /METHOD=SSTYPE(3)
  /PRINT=ETASQ
  /CRITERIA=ALPHA(.05)
  /WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 07:59:49
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelXRa PelXRaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.016

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelXRa
	2	PelXRaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.037	.349[a]	1.000	9.000
	Wilks' Lambda	.963	.349[a]	1.000	9.000
	Hotelling's Trace	.039	.349[a]	1.000	9.000
	Roy's Largest Root	.039	.349[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.569	.037
	Wilks' Lambda	.569	.037
	Hotelling's Trace	.569	.037
	Roy's Largest Root	.569	.037

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.072	1	.072	.349
	Greenhouse-Geisser	.072	1.000	.072	.349
	Huynh-Feldt	.072	1.000	.072	.349
	Lower-bound	.072	1.000	.072	.349
Error(factor1)	Sphericity Assumed	1.858	9	.206	
	Greenhouse-Geisser	1.858	9.000	.206	

	Huynh-Feldt	1.858	9.000	.206	
	Lower-bound	1.858	9.000	.206	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.569	.037
	Greenhouse-Geisser	.569	.037
	Huynh-Feldt	.569	.037
	Lower-bound	.569	.037

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.072	1	.072	.349
Error(factor1)	dimension2	Linear	1.858	9	.206	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.569	.037

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	153.458	1	153.458	108.306	.000	.923
Error	12.752	9	1.417			

```
GLM PelXAb PelXAbT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:00:34
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelXAb PelXAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.031
	Elapsed Time	00:00:00.047

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelXAb
	2	PelXAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.129	1.338[a]	1.000	9.000
	Wilks' Lambda	.871	1.338[a]	1.000	9.000
	Hotelling's Trace	.149	1.338[a]	1.000	9.000
	Roy's Largest Root	.149	1.338[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.277	.129
	Wilks' Lambda	.277	.129
	Hotelling's Trace	.277	.129
	Roy's Largest Root	.277	.129

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]	
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	5.304	1	5.304	1.338
	Greenhouse-Geisser	5.304	1.000	5.304	1.338
	Huynh-Feldt	5.304	1.000	5.304	1.338
	Lower-bound	5.304	1.000	5.304	1.338
Error(factor1)	Sphericity Assumed	35.671	9	3.963	
	Greenhouse-Geisser	35.671	9.000	3.963	
	Huynh-Feldt	35.671	9.000	3.963	
	Lower-bound	35.671	9.000	3.963	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.277	.129
	Greenhouse-Geisser	.277	.129
	Huynh-Feldt	.277	.129
	Lower-bound	.277	.129

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2 Linear	5.304	1	5.304	1.338
Error(factor1)	dimension2 Linear	35.671	9	3.963	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2 Linear	.277	.129

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	38.364	1	38.364	5.127	.050	.363
Error	67.351	9	7.483			

```
GLMPelXMaPelXMaT/WSFACTOR=factor12Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:01:17
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelXMa PelXMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.015

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelXMa
	2	PelXMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.168	1.814[a]	1.000	9.000
	Wilks' Lambda	.832	1.814[a]	1.000	9.000
	Hotelling's Trace	.202	1.814[a]	1.000	9.000
	Roy's Largest Root	.202	1.814[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.211	.168
	Wilks' Lambda	.211	.168
	Hotelling's Trace	.211	.168
	Roy's Largest Root	.211	.168

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept
Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	4167.385	1	4167.385	1.814
	Greenhouse-Geisser	4167.385	1.000	4167.385	1.814
	Huynh-Feldt	4167.385	1.000	4167.385	1.814
	Lower-bound	4167.385	1.000	4167.385	1.814
Error(factor1)	Sphericity Assumed	20672.031	9	2296.892	
	Greenhouse-Geisser	20672.031	9.000	2296.892	
	Huynh-Feldt	20672.031	9.000	2296.892	
	Lower-bound	20672.031	9.000	2296.892	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.211	.168
	Greenhouse-Geisser	.211	.168
	Huynh-Feldt	.211	.168
	Lower-bound	.211	.168

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	4167.385	1	4167.385	1.814
Error(factor1)	dimension2	Linear	20672.031	9	2296.892	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.211	.168

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	22438.301	1	22438.301	4.014	.076	.308
Error	50312.155	9	5590.239			

```
GLMPelYRaPelYRaT/WSFACTOR=factor1Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:01:48
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelYRa PelYRaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.016
	Elapsed Time	00:00:00.015

[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelYRa
	2	PelYRaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.002	.022[a]	1.000	9.000
	Wilks' Lambda	.998	.022[a]	1.000	9.000
	Hotelling's Trace	.002	.022[a]	1.000	9.000
	Roy's Largest Root	.002	.022[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.884	.002
	Wilks' Lambda	.884	.002
	Hotelling's Trace	.884	.002
	Roy's Largest Root	.884	.002

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.061	1	.061	.022
	Greenhouse-Geisser	.061	1.000	.061	.022
	Huynh-Feldt	.061	1.000	.061	.022
	Lower-bound	.061	1.000	.061	.022
Error(factor1)	Sphericity Assumed	24.335	9	2.704	
	Greenhouse-Geisser	24.335	9.000	2.704	
	Huynh-Feldt	24.335	9.000	2.704	
	Lower-bound	24.335	9.000	2.704	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.884	.002
	Greenhouse-Geisser	.884	.002
	Huynh-Feldt	.884	.002
	Lower-bound	.884	.002

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.061	1	.061	.022
Error(factor1)	dimension2	Linear	24.335	9	2.704	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.884	.002

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1772.845	1	1772.845	337.538	.000	.974
Error	47.271	9	5.252			

```
GLM PelYAb PelYAbT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:02:12
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelYAb PelYAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.015
	Elapsed Time	00:00:00.017

[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelYAb
	2	PelYAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.002	.019[a]	1.000	9.000
	Wilks' Lambda	.998	.019[a]	1.000	9.000
	Hotelling's Trace	.002	.019[a]	1.000	9.000
	Roy's Largest Root	.002	.019[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.893	.002
	Wilks' Lambda	.893	.002
	Hotelling's Trace	.893	.002
	Roy's Largest Root	.893	.002

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]		
		Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1	factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.722	1	.722	.019
	Greenhouse-Geisser	.722	1.000	.722	.019
	Huynh-Feldt	.722	1.000	.722	.019
	Lower-bound	.722	1.000	.722	.019
Error(factor1)	Sphericity Assumed	339.688	9	37.743	
	Greenhouse-Geisser	339.688	9.000	37.743	
	Huynh-Feldt	339.688	9.000	37.743	
	Lower-bound	339.688	9.000	37.743	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.893	.002
	Greenhouse-Geisser	.893	.002
	Huynh-Feldt	.893	.002
	Lower-bound	.893	.002

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.722	1	.722	.019
Error(factor1)	dimension2	Linear	339.688	9	37.743	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

		Source	factor1	Sig.	Partial Eta Squared
dimension1	factor1	dimension2	Linear	.893	.002

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3292.178	1	3292.178	22.547	.001	.715
Error	1314.132	9	146.015			

```
GLM PelYMa PelYMaT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:02:39
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelYMa PelYMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.000
	Elapsed Time	00:00:00.079

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelYMa
	2	PelYMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.029	.267[a]	1.000	9.000
	Wilks' Lambda	.971	.267[a]	1.000	9.000
	Hotelling's Trace	.030	.267[a]	1.000	9.000
	Roy's Largest Root	.030	.267[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.618	.029
	Wilks' Lambda	.618	.029
	Hotelling's Trace	.618	.029
	Roy's Largest Root	.618	.029

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1	factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect		Epsilon[a]		
		Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1	factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	313.632	1	313.632	.267
	Greenhouse-Geisser	313.632	1.000	313.632	.267

	Huynh-Feldt	313.632	1.000	313.632	.267
	Lower-bound	313.632	1.000	313.632	.267
Error(factor1)	Sphericity Assumed	10561.858	9	1173.540	
	Greenhouse-Geisser	10561.858	9.000	1173.540	
	Huynh-Feldt	10561.858	9.000	1173.540	
	Lower-bound	10561.858	9.000	1173.540	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.618	.029
	Greenhouse-Geisser	.618	.029
	Huynh-Feldt	.618	.029
	Lower-bound	.618	.029

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	313.632	1	313.632	.267
Error(factor1)	dimension2	Linear	10561.858	9	1173.540	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source		factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.618	.029

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	130734.450	1	130734.450	38.439	.000	.810
Error	30609.620	9	3401.069			

```
GLM PelZRa PelZRaT/WSFACTOR=factor1 2 Polynomia/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:03:26
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelZRa PelZRaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.015
	Elapsed Time	00:00:00.015

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelZRa
	2	PelZRaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.006	.058[a]	1.000	9.000
	Wilks' Lambda	.994	.058[a]	1.000	9.000
	Hotelling's Trace	.006	.058[a]	1.000	9.000
	Roy's Largest Root	.006	.058[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.815	.006
	Wilks' Lambda	.815	.006
	Hotelling's Trace	.815	.006
	Roy's Largest Root	.815	.006

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.060	1	.060	.058
	Greenhouse-Geisser	.060	1.000	.060	.058
	Huynh-Feldt	.060	1.000	.060	.058
	Lower-bound	.060	1.000	.060	.058
Error(factor1)	Sphericity Assumed	9.405	9	1.045	
	Greenhouse-Geisser	9.405	9.000	1.045	
	Huynh-Feldt	9.405	9.000	1.045	
	Lower-bound	9.405	9.000	1.045	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.815	.006
	Greenhouse-Geisser	.815	.006
	Huynh-Feldt	.815	.006
	Lower-bound	.815	.006

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.060	1	.060	.058
Error(factor1)	dimension2	Linear	9.405	9	1.045	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.815	.006

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	790.025	1	790.025	155.788	.000	.945
Error	45.640	9	5.071			

```
GLM PelZAb PelZAbT/WSFACTOR=factor1 2 Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:03:52
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM PelZAb PelZAbT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.015
	Elapsed Time	00:00:00.016

```
[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
```

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelZAb
	2	PelZAbT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.015	.140[a]	1.000	9.000

	Wilks' Lambda	.985	.140[a]	1.000	9.000
	Hotelling's Trace	.016	.140[a]	1.000	9.000
	Roy's Largest Root	.016	.140[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.717	.015
	Wilks' Lambda	.717	.015
	Hotelling's Trace	.717	.015
	Roy's Largest Root	.717	.015

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	.392	1	.392	.140
	Greenhouse-Geisser	.392	1.000	.392	.140
	Huynh-Feldt	.392	1.000	.392	.140
	Lower-bound	.392	1.000	.392	.140
Error(factor1)	Sphericity Assumed	25.288	9	2.810	
	Greenhouse-Geisser	25.288	9.000	2.810	
	Huynh-Feldt	25.288	9.000	2.810	
	Lower-bound	25.288	9.000	2.810	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.717	.015
	Greenhouse-Geisser	.717	.015
	Huynh-Feldt	.717	.015
	Lower-bound	.717	.015

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2	Linear	.392	1	.392	.140
Error(factor1)	dimension2	Linear	25.288	9	2.810	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

	Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2	Linear	.717	.015

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	4.232	1	4.232	.040	.845	.004
Error	944.108	9	104.901			

```
GLM PelZMa PelZMaT/WSFACTOR=factor12Polynomial/METHOD=SSTYPE(3)/PRINT=ETASQ/CRITERIA=ALPHA(.05)/WSDESIGN=factor1.
```

General Linear Model

Notes

Output Created		27-Apr-2011 08:04:13
Comments		
Input	Data	C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav
	Active Dataset	DataSet6
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	10
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.

Syntax		GLM PelZMa PelZMaT /WSFACTOR=factor1 2 Polynomial /METHOD=SSTYPE(3) /PRINT=ETASQ /CRITERIA=ALPHA(.05) /WSDESIGN=factor1.
Resources	Processor Time	00:00:00.031
	Elapsed Time	00:00:00.031

[DataSet6] C:\Users\Sarah\Documents\Uni Stuff\Jill A\April 11_PelvisM.sav

Within-Subjects Factors

Measure:MEASURE_1

factor1		Dependent Variable
dimension1	1	PelZMa
	2	PelZMaT

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
factor1	Pillai's Trace	.041	.383[a]	1.000	9.000
	Wilks' Lambda	.959	.383[a]	1.000	9.000
	Hotelling's Trace	.043	.383[a]	1.000	9.000
	Roy's Largest Root	.043	.383[a]	1.000	9.000

a. Exact statistic
b. Design: Intercept Within Subjects Design: factor1

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
factor1	Pillai's Trace	.551	.041
	Wilks' Lambda	.551	.041
	Hotelling's Trace	.551	.041
	Roy's Largest Root	.551	.041

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
dimension1 factor1	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

b. Design: Intercept Within Subjects Design: factor1

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
dimension1 factor1	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.
a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.
b. Design: Intercept Within Subjects Design: factor1

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F
factor1	Sphericity Assumed	66.978	1	66.978	.383
	Greenhouse-Geisser	66.978	1.000	66.978	.383
	Huynh-Feldt	66.978	1.000	66.978	.383
	Lower-bound	66.978	1.000	66.978	.383
Error(factor1)	Sphericity Assumed	1572.882	9	174.765	
	Greenhouse-Geisser	1572.882	9.000	174.765	
	Huynh-Feldt	1572.882	9.000	174.765	
	Lower-bound	1572.882	9.000	174.765	

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Sig.	Partial Eta Squared
factor1	Sphericity Assumed	.551	.041
	Greenhouse-Geisser	.551	.041
	Huynh-Feldt	.551	.041
	Lower-bound	.551	.041

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1	Type III Sum of Squares	df	Mean Square	F
factor1	dimension2 Linear	66.978	1	66.978	.383
Error(factor1)	dimension2 Linear	1572.882	9	174.765	

Tests of Within-Subjects Contrasts

Measure:MEASURE_1

Source	factor1	Sig.	Partial Eta Squared
dimension1 factor1	dimension2 Linear	.551	.041

Tests of Between-Subjects Effects

Measure:MEASURE_1
Transformed Variable:Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1545.282	1	1545.282	.112	.746	.012
Error	124205.518	9	13800.613			

REFERENCES

Al-Eisa, E., Egan, D., Deluzio, K., and Wassersug, R., (2006). Effects of Pelvic Skeletal Asymmetry on Trunk Movement. Three Dimensional Analysis in Healthy Individuals Versus Patients with Mechanical Low Back Pain. Spine. 31 (3), 71-79.

Alexander, C.M., Stynes, S., Thomas, A., Lewis, J., Harrison, P.J., (2003). Does tape facilitate or inhibit the lower fibres of trapezius? Manual Therapy. 8, 37-41.

Alexander, C.M., McMullan, M., Harrison, P.J., (2008). What is the effect of taping along or across a muscle on motorneurone excitability? A study using Triceps Surae. Manual Therapy. 13, 57-62.

Anderson, M.K., Hall, S.J., and Martin, M. (2005). Foundations of Athletic Training: Prevention, Assessment and Treatment. Lippincott, Williams and Wilkins. 3rd Edition. United States of America.

Back and Clayton (2000). Equine Locomotion. Saunders. Harcourt Health Sciences. London.

Barrey, E. (1999). Methods, Application and Limitations of Gait Analysis in Horses. The Veterinary Journal. 157, 7-22.

Beattie, P., Isaacson, K., Riddle, D L., and Rothstein, J, M. (1990). Validity of derived measurements of leg-length differences obtained by use of a tape measure. Physical Therapy. 70 (3), 150-157.

Bennell, K., Khan, K.M., McKay, H.A. (2000). The role of physiotherapy in the prevention and treatment of osteoporosis. Manual Therapy. 5 (4), 198–213.

Blignault, K. (2009). Equine Biomechanics for Riders. Great Britain. Robert Hale Limited.

Blockhuis, M. Z., Aronsson, A., Hortman, E., Von Reenen, C, G., and Keeling, L., (2008). Assessing the riders' seat and horse's behavior; difficulties and perspectives. Journal of Applied Animal Welfare Science. 11, (3), 191-203.

Bradley, T., Baldwick, C., Fischer, D., and Murrell, G, A, C. (2009). Effect of taping on the shoulders of Australian football players. British Journal of Sports Medicine. 43, 735-738.

British Horse Society. http://www.bhs.org.uk.

Bullock, M. P., Foster, N.E., Wright, C.C., (2005). Shoulder impingement: the effect of sitting posture on shoulder pain and range of motion. Manual Therapy. 10, 28-37.

Bussey, M, D., (2010). Does the demand for asymmetric functional lower body postures in lateral sports relate to structural asymmetry of the pelvis? Journal of Science and Medicine in Sports. 13 (3), 360-364.

Callaghan, M. J., Selfe, J., Bagley, P. J., and Oldham, J. A. (2002) The effects of Patellar taping on knee joint proprioception. Journal of Athletic Training. 37 (1), 19-24.

Callaghan M, Selfe J Henry A, Oldham J (2008) Effects of patellar taping on knee joint proprioception in patients with patellofemoral pain syndrome. Manual Therapy 13, 192 – 199.

Caneiro, J.P., O'Sullivan, P., Burnett, A., Barach, A., O'Neil, D., Tveit, O., and Olafsdottir, K., (2010). The influence of different sitting postures on head/neck posture and muscle activity. Manual Therapy. 15, (1), 54-60.

Cappozzo, A., Catani, F., Della Croce, U., and Leardini, A., (1995). Position and orientation of bones during movement: anatomical frame definition and determination. Clinical Biomechanics. 10, 171-178.

Claus, A.P., Hides, J.A., Moseley, G.L., and Hodges, P.W., (2009). Is 'ideal' posture real?: Measurement of spinal curves in four sitting postures. Manual Therapy. 14, 404-408.

Clayton, H. M., and Schamhardt, H, C. (2001). Measurement Techniques for Gait Analysis. Equine Locomotion. 55-76.

Clayton, H, M., Lanovaz, J.L., Schamhardt, H. C., and Van Wessum, R. (1999). The effects of a rider's mass on ground reaction forces and fetlock kinematics at the trot. Equine Veterinary Journal Supplement. 30, 218-221.

Clayton, H, M. (2010). Biomechanics of the Distal Interphalangeal Joint. Journal of Equine Veterinary Science. 30 (8), 401-405.

Colborne, G.R., (2004). Guest Editorial. Gait analysis: technology looking for a place to happen? The Veterinary Journal. 168, 112-113.

Cooperstein, R. (2008). Relationship of pelvic torsion and anatomical leg length inequality. Journal of Chiropractic Education. 22, (1), 53.

Cooperstein, R., Lew, M., (2009). The relationship between pelvic torsion and anatomical leg length inequality: a review of the literature. Literature Review. Journal of Chiropractic Medicine. 8, 107-118.

de Cocq, P., Van Weeren, P. R., Back, W. (2004). Effects of girth, saddle and weight on movements of the horse. Equine Veterinary Journal. 36 (8), 758-763.

de Cocq, P., Clayton, H.M., Terada, K., Muller, M., Van Leeuwen, J. L. (2009a). Usability of normal force distribution measurements to evaluate asymmetrical loading of the back of the horse and different rider positions on a standing horse. The Veterinary Journal. 181, 266-273.

de Cocq, P., Prinsen, H., Springer, N, C., van Weeren, P, R., Schreuder, M., Muller, M., van Leeuwen, J, L. (2009b). The effect of rising and sitting trot on back movement and head-neck posture of the horse. Equine Veterinary Journal. 41, (5), 423-427.

de Cocq, P., Mariken Duncker, A., Clayton H. M., Bobbert, M. F., Muller, M., and Van Leeuwen, J. L. (2010) Verticsl forces on the horse's back in sitting and rising trot. Journal of Biomechanics. 43, 627-631.

Donati, M., Camomilla, V., Vannozzi, G., Cappozzo, A., (2007). Enhanced anatomical calibration in human movement analysis. Gait and Posture. 26 (2), 179-185.

Drake, R., Vogl, A.W., and Mitchell, A. W. M., (2009). Gray's Anatomy for Students. Churchill Livingstone. 2nd Edition.

Dulak, J. (2006). Pilates for the dressage rider. Half Halt Press, Inc. United States of America.

Dyson, S., (2002). Poor performance: cannot or will not? The elite dressage and three-day event horse. In: Conference on Equine Sports Medicine and Science. Taschenbuch, Essen.

Edmondston, S, J., and Singer, K, P., (1997). Thoracic Spine: anatomical and biomechanical condsiderations for manual therapy. Manual Therapy. 2, 3, 132-143.

Edmondston, S. J., Aggerholm, M., Elfving, S., Flores, N., Ng, C., Smith, R., and Netto, K. (2007a). Influence of posture on the range of axial rotation and coupled lateral flexion of the thoracic spine. Journal of Manipulative and Physiological Therapeautics. 30, (3), 193-199.

Edmondston, S. J., Chan, H. Y., Chi Wing Ngai, G., Linda, M., Warren, R., Williams, J. M., Glennon, S., and Netto, K. (2007b). Postural neck pain: An investigation of habitual sitting posture, perception of 'good' posture and cervicothoracic kinaesthesia. Manual Therapy. 12, 363-371.

Egan, D.A., Al-Eisa, E., (1999). Pelvic skeletal asymmetry, postural control, and the association with low back pain: a review of the evidence. Critical Review of Physiology, Rehabilitation and Medicine. 11, 299-338.

Falla, D., O'Leary, S., Fagan, A., Jull, G. (2007). Recruitment of the deep cervical flexor muscles during a postural-correction exercise performed in sitting. Manual Therapy. 12, (2), 139-143.

Friberg O. (1983). Clinical symptoms and biomechanics of lumber spine and hip joint in leg length inequality. Spine. 8, (6), 643-651.

Frühwirth, B., Peham, C., Scheidl, M., Schobesberger, H., (2004). Evaluation of pressure distribution under an English saddle at walk, trot and canter. Equine Veterinary Journal. 36, 754-757.

Gerrard, D, F., (1998). External Knee Supports in Rugby Union. Effectiveness of Bracing and Taping. Sports Medicine. 25, 5, 313-317.

Gibbons, P., and Tehan, P. (1998). Muscle energy concepts and coupled motion of the spine. Manual Therapy. 3, (2), 95-101.

Gibbons, P., Dumper, C., Gosling, C., (2002). Inter-examiner and intra-examiner agreement for assessing simulated leg length inequality using palpation and observation during a standing assessment. Journal of Osteopathic Medicine. 5 (2), 53-58.

Gilleard, W., McConnell, J., Parsons, D., (1998). The effect of patella taping on the onset of vastus medialis obliquus and vastus latrialis muscle activity in persons with patellofemoral pain. Physical Therapy. 78 (1), 25-32.

Gordon-Watson, M. (1995) The handbook of riding. Michael Joseph Publishing. UK.

Granata, K.P., and Wilson, S.E., (2001). Trunk posture and spinal stability. Clinical Biomechanics. 16, 650-659.

Greig, A.M., Bennell, K.L., Briggs, A.M., and Hodges, P, W., (2008). Postural taping decreases the thoracic kyphosis but does not influence trunk muscle electromyographic activity or balance in women with osteoporosis. Manual Therapy. 13, 249-257.

Gurney, B., (2002). Leg length discrepancy. Gait and Posture. 15, 195-206.

Hanada, E., Kirby, R. L., Mitchell, M., and Swuste, J. M. (2001). Measuring leg-length discrepancy by the 'iliac crest palpation and book correction' method: reliability and validity. Archives of Physical Medicine and Rehabilitation. 82, (7) 938-942.

Hobbs, S, J., Mather, J., Rolph, C., Richards, J. (2009). The effects of limb posture on relationships between in vitro radial hoof strain, load and joint angles. Equine Veterinary Journal. 41 (3), 229-232.

Hobbs, S, J., Levine, D., Richards, J., Clayton, H., Tate, J., Walker, R. (2010a). Motion Analysis and its use in equine practice and research. Veterinary Medicine Austria. 97, 55-64.

Hobbs, S, J., Orlande, O., Edmundson, C, J., Northrop, A, J., and Martin, J, H. (2010b). Development of a method to identify foot strike on an arena surface: application to jump landing. Comparative Exercise Physiology. 7 (1), 19-25.

Hobbs, S.J., Licka, T., and Polman, R. (2011). The difference in kinematics of horses walking, trotting and cantering on a flat and banked 10 m circle. Equine Veterinary Journal. 43 (6), 686-694.

Host, H., (1995). Scapular taping in the treatment of anterior shoulder impingement. Physical Therapy. 75, 803-812.

Jeffcott, L, B., Holmes, M, A., and Townsend, H, G, G. (1999) Validity of Saddle Pressure Measurements Using Force-sensing Array Technology. Preliminary Studies Original Research Article. The Veterinary Journal. 158 (2), 113-119.

Kang, O., Ryu, Y., Ryew, C., Oh, W., Lee, C., Kang, M. (2010). Comparative analyses of rider position according to skill levels during walk and trot in Jeju horse. Human Movement Sciences. 29, 956-963.

Keener, L. E., and levy, M., (2005). 20th Conference – ASB 29th Annual Meeting July 31st - August 5th Cleveland Ohio. Comparison of Dressage Rider Posture when Mounted on different Horses.

Kendall, F.P., McCreary, E.K., Provance, P.G., Rodgers, M, M., Romani, W.A., (2005). Muscles Testing and Function with Posture and Pain. 5th Edition. Lippincott Williams and Wilkins. United States of America.

Kibler, B., (1998). The Role of the Scapular in Athletic Shoulder Function. The American Journal of Sports Medicine. 26, 2, 325-337.

Kisner, C., and Kolby, L. A., (2002). Therapeutic Exercise Foundations and Techniques. 4th Edition. Pgs. 592-594.

Kneeshaw, D., (2002). Shoulder Taping in the Clinical Setting. Journal of Bodywork and Movement Therapies. 6, 1, 2-8.

Knutson, G.A., (2005). Anatomic and functional leg-length inequality: a review and recommendation for clinical decision-making. Part 1, anatomic leg-length inequality: prevelance, magnitude, effects and clinical significance. Chiropractic and Osteopathy. 13, (1), 11.

Knutson, G.A., (2005a). Anatomic and functional leg-length inequality: a review and recommendation for clinical decision-making. Part II, the functional or unloaded leg-length asymmetry. Chiropractic and Osteopathy. 13, (1), 12.

Kraft, C.N., Urban, N., Ilg, A., Wallny, T., Scharfstädt, A., Jäger, M., Pennekamp, P.H., (2007). Influence of the riding discipline and riding intensity on the incidence of back pain in competitive horseback riders. Sportverletz Sportschaden. 21, 29-33.

Lagarde, J., Peham, C., Licka, T., and Kelso, J.A.S., (2005). Coordination dynamics of the horse-rider system. Journal of Motor Behaviour. 37, (6), 418-424.

Levangie, P. K. (1999). The association between static pelvic asymmetry and low back pain. Spine. 24, (12), 1234-1242.

Lewis, J. S., Green, A., Wright, C. (2005). Subacromial impingement syndrome: The role of posture and muscle imbalance. Journal of Shoulder and Elbow Surgery. 14, (4), 385-392.

Liebenson., C. (2000). The quadrates lumborum and spinal stability. Journal of Bodywork and Movement Therapies. 4, (1), 49-54.

Liebenson, C., (2001). Self-treatment of the slump posture. Part Two: Intermediate exercises. Journal of Bodywork and Movement Therapies. 5, 3, 196-197.

Lovett, T., Hodson-Tole, E., and Nankervis, K. (2004). A preliminary investigation of rider position during walk, trot and canter. Equine and Comparitive Exercise Physiology. 2 (2), 71-76.

Macdonald, R., (2009). Taping Techniques Principles and Practice. Second Edition. Butterworth-Heinemann.

Mason, H., (2006). Our sixth sense of balance. British Dressage Publication. Available from: http://www.britishdressage.co.uk/

[Accessed 24th April 2009]

McNair, P.J., Marshall, R.N., Maguire, K., Brown, C., (1995). Knee joint effusion and proprioception. Archives of Physical Medicine and Rehabilitation. 76 (6), 566-568.

Merletti, R., and Parker, P. A. (2004). Electromyography; Physiology, Engineering and Non-invasive Applications. John Wiley and Sons. United States of America.

Meschan, E., Peham., C., Schobesberger, H., Licka, T., (2007). The influence of the width of the saddle tree on the forces and the pressure distribution under the saddle. The Veterinary Journal. 173, 578-584.

Morrissey, D., (2000). Proprioceptive Shoulder Taping. Journal of Bodywork and Human Movement. 4 (3), 189-194.

O'Sullivan, P.B., Grahamslaw, K.M., Kendell, M., Lapenskie, S.C., Moller, N.E., Richards, K.V. (2002). The effect of different standing and sitting positions on trunk muscle activity in a pain-free population. Spine. 27 (11), 1238-1244.

O'Sullivan, P. B., Mitchell, T., Bulich, P., Waller, R., and Holte, J. (2006). The relationship between posture and back muscle endurance in industrial workers with flexion-related low back pain. Manual Therapy. 11, 264-271.

Parkhurst, T.M., and Burnett, C.N., (1994). Injury and proprioception in the lower back. Journal of Orthopaedic and Sport Physical Therapy. 19 (5), 282-294.

Palastanga, V., Soames, R. W., Field, D., (2006). Anatomy and Human Movement: Structure and Function. Butterworth-Heinemann. 5th Edition.

Pearcy, M,J. and Tibrewal, S.B. (1984). Axial rotation and lateral bending in the normal lumbar spine measured by three-dimensional radiography. Spine. 9 (6), 582-587.

Peham, C., Licka, T., Kapaun, M., Scheidl, M., (2001). A new method to quantify harmony of the horse-rider system in dressage. Sports Engineering. 4, 95-101.

Peham, C., Licka, T., Schobesberger, H., and Meschan, E. (2004). Influence of the rider on the variability of the equine gate. 23, 663-671.

Peham, C., Kotschwar, A.B., Borkenhagen, B., Kuhnke, S., Molsner, J., and Baltacis, A., (2010). A comparison of forces acting on the horse's back and the stability of the rider's seat in different positions at the trot.

Peinen K., Wiestner, T., Bogisch, S., Roepstorff, L., Weeren, P.R., Weishaupt, M.A. (2009). Relationship between the forces acting on the horse's back and the movements of rider and horse while walking on a treadmill. Equine Veterinary Journal. 41 (3), 285-291.

Perlau, R., Frank, C., Fick, G., (1995). The effect of elastic bandages on human knee proprioception in the uninjured population. The American Journal of Sports Medicine. 23 (2), 251-255.

Petrone, M.R., Guinn, J., Reddin, A., Sutlive, T.G., Flynn, T.W., Garber, M.P. (2003). The accuracy of the Palpation Meter (PALM) for measuring pelvic crest height difference and leg length discrepancy. 33 (6), 319-325.

Pilato, M.L., Shifrin, S., and Bixby-Hammet, D., (2002). Overuse injuries in the equestrian population: A Sports medicine Approach.
Available From:
http//:fitfocusedforward.us/…/overuseinjuriesintheequestrianpopulationfinaldraftv2.pdf
[Accessed Online 17th May 2009]

Powers, C., Landel, R., Sosnick, T. (1997). The effects of patella taping on stride characteristics and joint motion in subjects with patellofemoral pain. Journal of Orthopaedic Sports and Physical Therapy. 26 (6), 286-291.

Prins, Y., Crous, L. (2008). A systematic review of posture and psychological factors as contributors to upper quadrant musculoskeletal pain in children and adolescents. Physiotherapy Theory and Practice. 24 (4), 221-242.

Raine, S., and Twomey, L. (1994). Attributes and qualities of human posture and their relationship to dysfunction or musculoskeletal pain. Critical Reviews in Physical and Rehabilitation Medicine. 6, 409-437.

Reeve, A., and Dilley, A., (2009). Effects of posture on the thickness of transverses abdominis in pain-free subjects. Manual Therapy. 2, (8), 1-6.

Rhodes, D. W., Mansfield, E. R., Bishop, P. A., Smith, J. F. (1995). The validity of the prone leg check as an estimate of standing leg length inequality measured by x-ray. Journal of Manipulative and Physiological Therapeutics. 18, (6), 343-346.

Richards, J., Thewlis, D., and Selfe, J., (2008). Biomechanics in Clinic and research: An interactive teaching and learning course. Churchill Livingstone.

Robert, C., Audigie, F., Valette, J.P., Pourcelot, P., Denoix, J.M., (2001). Effects of treadmill speed on the mechanics of the back in the trotting saddle horse. Equine Veterinary Journal. (Supplement 33), 400-405.

Robinsons: http://www.robinsonsequestrian.com

Sabharwal, S and Kumar, A. (2008). Methods for assessing leg length discrepancy. Clinical Orthopaedics and Related Research. 466, (12), 2910-2922.

Sahrmann, S, A., (2002). Diagnosis and Treatment of Movement Impairment Syndromes. London. Mosby.

Schamberger, W., (2002). The Malalignment Syndrome: Implications for Medicine and Sport. Churchill Livingstone.

Schils, S. J., Greer, N. I., Stoner, L. J., and Kobluk, C, N., (1993). Kinematic analysis of the equestrian – Walk, posting trot and sitting trot. Human Movement Science, 12, 693-712.

Schőllhorn, W. I., Peham, C., Licka, T., Scheidl, M. (2006). A pattern recognition approach for the quantification of horse and rider interactions. Equine Veterinary Journal. 36, 400-405.

Schuldt, K., Ekholm, J., Harms-Ringdahl, K., Nemeth, G., Arborelius, U.P. (1986). Effects of changes in sitting work posture on static neck and shoulder muscle activity. Ergonomics. 29 (12), 1525-1537.

Smith, M., Sparkes, V., Busse, M., Enright, S. (2009). Upper and lower trapezius muscle activity in subjects with subacromial impingement symptoms: is there imbalance and can tape change it? Physical Therapy in Sport. 10, 45-50.

Subotnick, S. I. (1981). Limb length discrepancies of the lower extremity (the short leg syndrome). Journal of Orthopaedic and Sports Physical Therapy. 3 (1), 11-16.

Symes, D., and Ellis, R, (2009). A preliminary study into rider asymmetry within equitation. The Veterinary Journal. In Press.

Terada, K. (2000). Comparison of head movement and EMG activity of muscles between advanced and novice horseback riders at different gaits. Journal of Equine Science. 11 (4), 83-90.

Terada, K., Clayton, H, M., and Kato, K. (2006). Stabilization of wrist position during horseback riding at trot. Equine and Comparative Exercise Physiology. 3, 179-184.

Tobin, S., and Robinson, G., (2000). The effect of McConnell's vastud lateralis inhibition taping technique on vastus lateralis and vastus medialis obliquus activity. Physiotherapy. 86 (4), 173-183.

Wanless, M. (2008). The New Ride With Your Mind Clinic. Trafalgar Square Books, Vermont, United States of America.

Watson, L,. (2000). Level 1 and 2 Lyn Watson Shoulder Course. Lecture Notes . Australian Physiotherapy Association-sanctioned course, Sydney, Australia.

Weishaupt, M. A., Wiestner, T., von Peinen, K., Waldern, N., Roepstorff, L., van Weeren, R., Meyer, H., and Johnston., C. (2006). Effect of head and neck position on vertical ground reaction forces and interlimb coordination in the dressage horse ridden at walk and trot on a treadmill. Equine Exercise Physiology. 7, 387-392.

Wrigley, T., Green, R., and Briggs, C. (1991). Microcomputer video image processing technology in working posture analysis: application to seated posture of keyboard operators. Applied Ergonomics. 22, 2-8.

Witte, K., Schobesberger, H., and Peham, C. (2009). Motion pattern analysis of gait in horseback riding by means of Principle Component Analysis. Human Movement Science. 28, 394-405.

Woltring, H. J. (1980). Planar control in multi-camera calibration for three-dimensional gait studies. Journal of Biomechanics. 13, 39-48.

Young, R.S., Andrew, P.D., and Cummings, G.S., (2000). Effect of simulating leg length inequality on pelvic torsion and trunk mobility. Gait and Posture. 11, 217-223.