**TO WHAT EXTENT DOES FATIGUE INFLUENCE CORE ENDURANCE AND TRUNK ANGLE ASYMMETRY IN HORSE RIDERS?**

Phoebe Bolton

This Research Project is submitted as partial fulfilment of the requirements for the degree of Master of Science, St Mary’s University

First Supervisor: Hayley Legg

Second Supervisor: Daniel Cleather

**TABLE OF CONTENTS PAGE NO.**

List of Figures i

List of Tables ii

List of Appendices iii

ACKNOWLEDGEMENTS iv

ABSTRACT 1

**CHAPTER ONE**

1.0 Introduction 2

**CHAPTER TWO**

2.0 Materials and Methods 6

2.1 Participants 6

2.2 Equipment 6

2.3 Arena Layout 6

2.4 Data Collection 7

2.5 Data Processing 9

**CHAPTER THREE**

3.0 Results 10

3.1 Core tests 10

3.2 Direction 10

3.3 Phase of Gait 10

3.4 Time 10

**CHAPTER FOUR**

4.0 Discussion 12

4.1 Core Endurance 12

4.2 Trunk Angle 13

4.3 Asymmetry 14

**CHAPTER FIVE**

5.0 Conclusions and Practical Application 16

REFERENCES 17

**LIST OF FIGURES PAGE NO.**

Figure 1. Summary of asymmetric postures adopted by horse 4

Riders.

Figure 2. Arena layout showing cone placement, camera and 7

filming area.

Figure 3. Data collection schematic and timing of trials. 7

Figure 4. Two rider positions during front leg ground contacts 8

at the trot and canter.

Figure 5. Trunk endurance exercises; (A) supine, (B) left side 8

plank, (C) right side plank, (D) prone.

Figure 6. Positive trunk angle is shown here; vertical line is on 9

the right and the line on the left bisects the shoulder

marker.

Figure 7. Differences in mean trunk angle between left and right 11

sides at the rising trot (A) and canter (B) in each trial.

**LIST OF TABLES PAGE NO.**

Table 1. Participants’ descriptive statistics. 6

Table.2. Mean ± SD of core test scores pre and post riding 10

protocol.

**LIST OF APPENDICES PAGE NO.**

Appendix A. Participant Information Sheet 21

Appendix B. Participant Consent Form 25

Appendix C. Horse and Rider Details Form 27

Appendix D. Signed Ethics Form 28

**ACKNOWLEDGEMENTS**

I would like to thank all the horses and riders who gave their time and energy to be part of this project, especially as it was one of the coldest winters on record! This project would not have been possible without you, thank you so much.

I would also like to thank my fiancé Matt who frequently told me to “gather and apply” myself in moments of stress.

**ABSTRACT**

The aim of this research was to determine whether riders displayed asymmetry in their trunk angle or a reduction in core endurance during a fatiguing riding protocol. Twenty-seven female riders (18 - 50 years old) volunteered to participate on their horses. Participants completed four core endurance tests before and after a 35-minute riding protocol. 2D motion capture (60Hz) identified sagittal plane trunk angles using reflective markers placed on the shoulders and hips. Paired sampled *t-test* identified trunk test scores were significantly different post riding for prone (*p=0.003*) and left side plank (*p=0.043*), but not for right side plank (*p=0.055*) or supine (*p=0.457*). ANOVA for repeated measure with Bonferroni adjustment evaluated time, phase of gait and direction variables. For direction, right trunk angles were significantly greater than left trunk angles in the trot in all trials (F(1,26) =14.40, *p=0.001*): trot 1-inside (*p=0.017*), trot 1-outside (*p=0.001*), trot 2-inside (*p=0.015*), trot 2-outside (*p=0.027*). Overall, right trunk angles were greater than left trunk angles in the canter (F(1,26) =9.24*, p=0.005*) but only canter 1-inside was significant (*p=0.011*). Phase of gait significantly influenced trunk angle in the trot (F(1,26) =70.44, *p=0.000*) and canter (F(1,26) =93.98, *p=0.000*), with outside values being greater than inside values. No difference was observed in trunk angle for time in the trot (F(1,26) =1.95, *p=0.175*) or the canter (F(1,26) =0.22, *p=0.658*) and no interaction between phase of gait, direction and time was present. These results show that whilst riders experience some fatigue in their core musculature during a training session, rider asymmetry was present throughout the training session and not brought on by fatigue. Reducing rider asymmetry should be a focus for trainers, therapists and strength and conditioning coaches.

Key words: core strength, equitation, rider fitness, rider performance

Conflicts of interest: none.

**CHAPTER ONE**

**1.0 Introduction**

The biomechanical and metabolic requirements of horse riding vary greatly depending on the discipline (Roberts *et al*., 2010; Westerling, 1983), however, all require the rider to remain in a balanced and symmetrical position. Advanced riders are characterised by their ability to remain still and give the impression of doing very little, this enables effective communication and synchronous movement with the horse (Lagarde *et al*., 2005; Sung *et al*., 2015; Terada, 2000; Woolframm *et al*., 2013). Understanding which factors influence rider position is important in the development of rider strength and conditioning, an area which has received little attention from athletes and even less from researchers (Clayton and Hobbs, 2017; Wolframm, 2013).

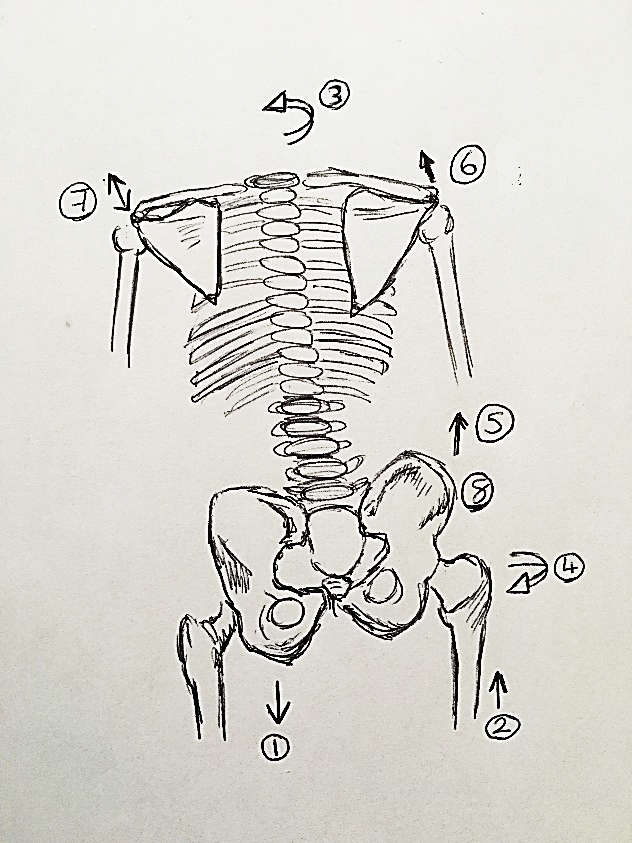
Core endurance is the ability to maintain appropriate position and muscular contraction over time (Michael *et al*., 2005), combining core stability, the ability to maintain spinal, trunk and pelvis positioning, and core strength, the muscular effort required to produce force during activity (Faries and Greenwood, 2007; Kibler *et al*., 2012; Nadler *et al*., 2002). Core strength is commonly stated by riders, trainers and therapists to be a key component of a good riding position (Wolframm, 2013), yet few studies have assessed core endurance or how it relates to rider position. The muscles of the trunk, the *lumbar erector spinae, multifidus, obliquus externus abdominis, obliquus internus abdominis, quadratus lumborum, transverse abdominis* and *rectus abdominis*, act to stabilise the rider’s position in sequence with the horse’s gait. Specific positions are adopted by the rider during each part of the horse’s stride; these consists of ground contact and suspension phases, which are commonly termed as the phase of gait (Engell *et al*., 2016; Terada, 2000). Two studies addressed rider core strength; Douglas (2017) assessed the difference in plank to fatigue scores in novice, intermediate and advanced level eventers, noticing significant increase in endurance scores in advanced compared to novice riders. Hampson and Randle (2015) identified increased symmetry in left-right saddle pressure during sitting trot in dressage riders after an eight-week core strength programme, unfortunately no mention of the type or duration of exercises was given. Lee et al. (2015) implemented an eight-week, whole body resistance exercise intervention on 18 riders and noted an increase in muscle endurance and muscle strength. Muscular endurance correlated with improved total test scores and an increase in effectiveness of the aids, whilst muscle strength approached a significant correlation with rider position. Meyers and Sterling (2000) assessed several physiological, haematological and exercise responses of collegiate riders compared to sporting counterparts and noted riders had better than average core strength, tested as reps/minute of the trunk curl up and reverse sit up. For all the other markers, riders exhibited lower than average scores. These studies suggest that core endurance is an important aspect of horse riding; unfortunately, none assessed rider position in conjunction with core endurance. The aim of the current study, therefore, is to bridge this gap.

Consideration must be given to how core musculature functions when riding; the relationship between core muscle strength and its ability to transfer force is widely acknowledged in the sports performance literature (Kibler *et al*., 2006), yet riding is somewhat different. Riders need to stabilise their position via isometric contractions, in a manner similar to postural stability, in order to maintain a consistent position whilst accommodating propulsive forces from the horse (Greves and Dyson, 2013; Terada, 2000; Terada *et al*., 2004). Novice riders demonstrate an inability to maintain this ideal trunk position (Eckardt and Witte, 2016; Kang *et al*., 2010; Schils *et al*., 1993; Terada, 2000; Terada *et al*., 2004), which in part is due to an inability to contract the core muscles appropriately (Pantall *et al*., 2009). In turn, novice riders recruit their *adductor magnus* muscles in an attempt to maintain balance, which reduces their synchronicity with the horse, and, thus, their balance (Terada, 2000).

The position of the rider changes depending on the gait (walk, trot rising, trot sitting and canter) and the phase of the gait (stance phase, suspension phase). The walk is the most variable, showing greatest angular displacement, least synchronicity and greatest variation between riders, making it a more difficult gait in which to study positional change, especially under fatigue (Lovett *et al*., 2005; Woolfram *et al*., 2013). The sitting trot is an advanced gait, requiring higher levels of balance and phase timing of muscular contraction to prevent a collapse in position (Bystrom *et al*., 2009; Clayton and Hobbs, 2017; Ecdkart and Witte, 2016; Terada *et al*., 2004); sitting trot is necessary for dressage riders only and so is not appropriate for a study including riders of all disciplines. In the rising trot contralateral limbs move together as a ‘diagonal’ and stance phases are separated by a suspension phase, causing biphasic movement of the rider’s seat in and out of the saddle (Clayton and Hobbs, 2017; Witte *et al*., 2009). The canter has three ground contacts and is the easiest gait to ride, identified as having the greatest synchronicity with the horse and least variation in trunk angle between novice and elite riders (Lovett *et al*., 2005; Woolfram *et al*., 2013). Hence, this study will focus on the rider’s position during the rising trot and the canter.

Previous research has measured joint angles to assess rider position; Schils *et al*. (1993) and Kang *et al*. (2010) compared joint angles in novice, intermediate and advanced riders at the walk and trot, observing greater (positive) trunk angle in less skilled riders. Nankervis *et al*. (2015) compared trunk, thigh and lower leg angle between elite and non-elite riders jumping 1.20m double and observed hip angle was smaller for the vertical and greater for the oxer in elite riders in the approach and a smaller trunk angle (i.e. more vertical) in suspension over the oxer in elite riders. This suggests that a variation in trunk angle is apparent between skill levels when jumping and that a more vertical trunk position is adopted by skilled riders when required. Lovett et al. (2005) identified that significant differences (p<0.05) in trunk angle occurred between diagonal limb contacts in the rising trot, but no differences were observed at the canter. The range of movement for the trunk-thigh angle at the trot was 4.1° and 4.7° for the canter, the latter occured due to the pitch of the horse as it moves from hind limb to fore limb ground contacts. However, these studies only assessed joint angles from one direction. This study will assess trunk angle from both directions to identify if rider position, specifically trunk angle, is equal on the left and the right rein, or whether asymmetry in the sagittal plane exist. The rationale for this is supported by the increasingly popular theme of rider asymmetry within the literature. Asymmetry is present in horse riders’ hips (Gandy *et al*., 2014), pelvis (Guire *et al*., 2017; Hobbs *et al*., 2014; Münz *et al*., 2013; Nevison and Timmis, 2013), shoulders (Hobbs *et al*., 2014; Symes and Ellis, 2009) and thorax (Baxter *et al*., 2014; Symes and Ellis, 2009). Interestingly, this asymmetry increases with greater riding experience (Hobbs *et al*., 2014) and occurs despite the rider perceiving they are sitting symmetrically (Guire *et al*., 2017); Figure 1 collates the following data on rider asymmetry.

Guire *et al*. (2017) identified greater pressure in the left ischial tuberosity in all riders (n=30) when sitting statically on a pressure mat, although rein tension was equal between left and right. This suggests pelvic asymmetry and possible thorax or shoulder rotation to ensure equal rein contact. Symes and Ellis (2009) noted a shorter right leg and left axial rotation in all participants (n=17), although no interaction between leg length inequality (LLI) and axial rotation was found. This corresponds with Baxter *et al*. (2014) who identified a higher right iliac crest during sitting trot (n=20) and Hobbs *et al*. (2014) who analysed rider posture sitting, standing and in sagittal plane movement using a four camera infra-red motion capture system (Qualisys Capture Systems, Gothenburg, Sweden), confirming a higher right iliac crest, higher right acromion process and reduced ability to side-bend to the left. Leg length was also measured by a physiotherapist when the patients were lying supine, although no significance was found (Hobbs *et al*., 2014), which conflicts with Symes and Ellis (2009).

****

**Figure 1.** Summary of asymmetric postures adopted by horse riders. 1. Greater pressure in left ischial tuberosity (Guire *et al*., 2017); 2. Shorter right leg (Symes and Ellis, 2009); 3. Axial rotation left (Symes and Ellis, 2009); 4. Greater external rotation in the right hip (Gandy *et al*., 2014); 5. Raised right iliac crest (Baxter *et al*. 2014; Hobbs *et al*., 2014); 6. Greater displacement of the right shoulder (Hobbs *et al*., 2014; Symes and Ellis, 2009); 7. Greater variability in the left trunk angle (current study); 8. Greater tension observed in right pelvic musculature (Nevison and Timmis, 2013).

Functional LLI is associated with muscle imbalances around the pelvis, typically due to pelvic asymmetry and muscle weakness in the *gluteus maximus, gluteus medius, gluteus minimus, quadratus lumborum, iliopsoas* (Lee, 2011; McCaw, 1992). Nevison and Timmis (2013) identified asymmetry in pelvic pressure in 5/6 riders, with greater tension being observed in the muscles on right-hand side of the pelvis, which was reduced following massage treatment on the affected side. Hampson and Randle (2015) noted increased pressure under the saddle on the left, which was reduced after the rider core strengthening programme. Whilst it may appear that Nevison and Timmis (2013) conflicts with Guire *et al*. (2017) and Hampson and Randle (2015), the author contends that Guire *et al*. (2017) identified skeletal asymmetry, whereas Nevison and Timmis (2013) observed an asymmetry in muscular tension, this is supported by equal pressure recorded in the latter following treatment. Gandy *et al*. (2014) identified 83% of riders (n=8) had greater external rotation in the right hip compared to the left, contending that as the riders’ hips are vital for absorbing forces translated from the horse, any asymmetries in hip mobility will cause alterations in pelvic and thorax kinematics. Differences in hip asymmetry may be due to mounting, where the left leg is placed in the near stirrup and the right leg is swung over the back of the horse to the far stirrup; as a result, the rider’s entire body weight is placed in the left leg for stability affording mobility to the right hip. Thus, rider asymmetry in the sagittal plane is likely to be apparent; the aim of this study, however, is to identify whether this asymmetry is present when the rider starts their training session or only when they are fatigued. In addition, rider core endurance will be measured before and after riding to determine whether this has any influence on the rider’s trunk angle. The author hypothesises that (1) a relationship between core strength scores and trunk angle will be present and (2) differences between left and right trunk angles will exist.

**CHAPTER TWO**

**Materials and Methods**

*2.1 Participants*

Twenty-seven horse and rider combinations were recruited for this study. Participants were female and included three professional riders and twenty-four amateurs, who participate in dressage, show jumping, eventing, hunting and hacking; participant details are outlined in Table 1. Riding was the primary form of exercise for 89% of riders, although 43% did participate in other forms of exercise. The horses were a mixture of mares (n= 6) and geldings (n= 21) and were ridden in their usual tack. A Participant Information Sheet was emailed prior to data collection to ensure all participants were familiar with the riding protocol; riders provided informed consent to participate and signed the consent form on the day of testing. Riders wore black, tight fitting clothes and riding boots; reflective markers were placed on bony landmarks of the acromion, via palpation along the clavicle and the spine of the scapula, and the greater trochanter of the femur, identified by palpation of the superior lateral side of the leg, followed by abduction and adduction of the leg to ensure correct placement, just prior to mounting. Ethical approval for this study was granted by University Ethics Sub-Committee, St. Mary’s University, Twickenham, London.

**Table 1. Participants’ descriptive statistics.**

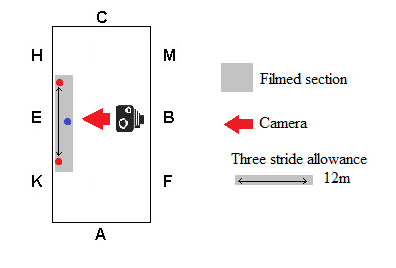
|  |  |
| --- | --- |
| **Descriptive Statistics** | **Mean (SD)** |
| Age (yrs) | 35.2 (7.9) |
| Height (cm) | 167.4 (7.1) |
| Years riding (yrs) | 26.1 (8.9) |
| Time per week (hrs) | 12.3 (12.5) |

*2.2 Equipment*

An iPhone 6s, (Apple Inc., Cupertino CL) placed on a 5ft high tripod was used for video footage; riders wore reflective markers of 4cm diameter, placed on their shoulder (acromion) and hip (greater trochanter) on the left and right side. A stopwatch was used for all trunk timings and trunk tests were undertaken on a yoga mat.

*2.3 Arena layout*

Cones were placed 12m apart, 1.5m in from the edge of the arena, to mark the area of data collection, a third cone at 6m marked the midpoint; the arena set up is shown in Figure 2. The camera was placed in line with the middle cone, perpendicular to the filmed section, at a distance where the whole data collection area was visible within the camera view; the tripod was triangulated using a tape measure from the widest cones. The right rein indicates movement in a clockwise direction and the left rein is anti-clockwise.

*2.4 Data Collection*

**Figure 2. Arena layout showing cone placement, camera and filming area.**

The schematic in Figure 3 outlines the process of data collection. This includes core strength tests before and after the 35-minute riding protocol and filming of rider positions in both directions at specific time intervals.

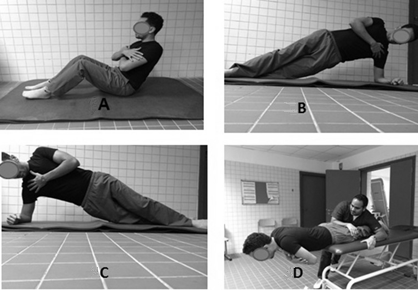
**Figure 3. Data collection schematic and timing of trials.**

Figure 4 identifies the ground contact phase during each diagonal, which affords the two rider positions during the rising trot; TR-I denotes when the inside front leg contacts the ground and the rider is at the highest point of the rising trot and TR-O when the outside front leg contacts the ground and the rider is at the sitting part of the rising trot. Similarly, in the canter, CR-I refers to the inside leg contacting the ground and the rider is sitting vertically and CR-O when the outside front leg contacts the ground and the horse’s hindlegs propel the rider into a more forward position.

****

**Figure 4. Two rider positions during front leg ground contacts at the trot and canter. TR-I front right leg is vertical and the rider is in the rising position; TR-O front left leg is vertical and the rider is in the sitting position; CR-I right leg is vertical and trunk is vertical; CR-O left leg is vertical and the trunk is forward.**

The core strength tests depicted in Figure 5 comprise four maximum effort holds (recorded in seconds) undertaken 10 minutes before and 10 minutes after the riding protocol. The trunk tests are McGill’s protocol for core endurance (McGill *et al*., 1999) and include a prone hold, supine hold, side plank left and side plank right. Familiarisation to the exercises occurred two minutes before the first trial; the order of the tests (A-D) was selected at random and one-minute rest was given between exercises. Core tests which utilised isometric contraction were chosen in this study to appropriately represent the postural control required in horse riding.

**Figure 5. Trunk endurance exercises; (A) supine, (B) left side plank, (C) right side plank, (D) prone (Abdelraouf and Abdel-aziem, 2016).**

During the riding protocol, filming took place at specific time intervals over a 35-minute training session. Participants were filmed for 12m and three strides were selected for analysis. Data capture took place at the beginning and end of the rising trot and the canter in both directions, resulting in 8 trials per participant. Riders were instructed to ride in a straight line between the cones and the outside of the arena when given the command ‘ride through the cones’. At the beginning of the trot, minute 6, participants rode on the right rein (TR1) through the filming area, changed direction and repeated on the left rein (TL1). At the end of the trot, this was repeated (TR2, TL2), the same protocol was then repeated for the canter (CR1, CL1, CR2, CL2).

During the trot and the canter, when no filming was taking place, riders were advised to school their horses in a similar manner to a typical training session, including changes of direction, circles, lateral work and transitions at a self-selected intensity, with a maximum of 3 strides permitted in another gait. Riders were asked to change rein if they had spent an extended period of time in one direction.

To identify trunk angle, an upwards vertical line from the hip marker was defined as ‘the vertical’, the angle of the shoulder marker from this line was defined as the ‘trunk angle’; positive values occurred when the trunk was leaning forward, and negative values occurred when the trunk was leaning back, a positive trunk angle is shown in Figure 6. Trunk angle was measured at two points in each stride, these points relate to whether the horse’s inside leg (-I) or outside leg (-O) was contacting the ground, as shown previously in Figure 4. Trial terms were given according to the gait (trot or canter), direction (left or right), timing (1 or 2) and phase of gait (-I or -O); thus, TR1-I refers to trot right 1 – inside and CL2-O refers to canter left 2 – outside.



**Figure 6. Positive trunk angle is shown here; vertical line is on the right and the line on the left bisects the shoulder marker.**

*2.5 Data Processing*

For each trial, the trunk angle was analysed over three strides using the angle measurement tool in Dartfish 360 (Fribourg, Switzerland) and recorded in Excel, where an average trunk angle (x̅) was calculated. Anthropometric data and trunk angles were then exported and analysed in SPSS 24 for PC (SPSS Inc., Chicago IL) with a significance level of *p<0.05*. A paired *t – test* was used to analyse (1) pre and post trunk scores. A repeated measure ANOVA with Bonferroni adjustment was used to evaluated time, phase of gait and direction variables.

**CHAPTER THREE**

**Results**

*3.1 Core tests*

Mean scores (seconds) are presented in Table 2. No significant differences existed between left and right-side planks scores pre (*p=0.786*) or post (*p=0.435*) riding.

**Table.2. Mean ± SD of core test scores pre and post riding protocol.**

|  |  |  |
| --- | --- | --- |
| **Core Test** | **Mean time (seconds)** **± SD** | |
| **Pre-Riding** | **Post Riding** |
| **Prone** | 159.6 ± 69.2 | 132.2 ± 63.6\*1 |
| **Left side plank** | 47.0 ± 25.2 | 42.5 ± 23.5\*2 |
| **Right side plank** | 45.4 ± 24.9 | 39.1 ± 20.9 |
| **Supine** | 119.0 ± 94.7 | 111.6 ± 115.2 |

\*=sig. difference to pre-tests, \*1 *p= 0.003*, \*2 *p=0.043*.

*3.2 Direction*

Right trunk angles were significantly greater than left trunk angles in the trot (F(1,26) =14.40, *p=0.001*) and the canter (F(1,26) =9.24*, p=0.005*). All trials were significant in the trot but only canter 1-inside was significant (*p=0.011*) in the canter, see Figure 7.

*3.3 Phase of gait*

Phase of gait significantly influenced trunk angle in the trot (F(1,26) =70.44, *p=0.000*) and canter (F(1,26) =93.98, *p=0.000*), with outside values being greater (more positive) than inside values.

*3.4 Time*

No difference was observed in trunk angle for time in the trot (F(1,26) =1.95, *p=0.175*) or the canter (F(1,26) =0.22, *p=0.658*) and no interaction between phase of gait, direction and time was present.

**Figure 7. Differences in mean trunk angle between left and right sides at the rising trot (A) and canter (B) in each trial. Significant differences\* between sides (p<0.05).**

**CHAPTER FOUR**

**Discussion**

*4.1 Core endurance*

This is the first study to measure horse riders’ performance at core endurance tests in this manner. Riders demonstrated a decline in posterior core muscle endurance after riding (*p<0.003*); however, as trunk angle did not change during the fatigue intervention, it is suggested that all riders had sufficient core endurance to cope with the demands of the protocol. Left side plank scores were significantly different after riding (*p<0.043*) and right side plank scores were not, although not entirely dissimilar (*p<0.055*). The supine test was not significantly different after riding and, indeed, some participants improved their score. This result was unexpected and could be explained by several hypotheses: (1) anterior trunk musculature is not required in horse riding and so no fatigue was experienced; (2) riders had sufficient strength to complete the protocol without anterior core musculature fatigue; (3) posterior trunk muscle strength is required more than anterior muscle strength when riding and so demonstrated greater fatigue. Understanding whether anterior or posterior core muscle strength is most necessary for horse riding may depend on the rider’s position, which is known to depend upon the rider’s skill level (Kang *et al*., 2010; Terada *et al*., 2004) and, likely, their discipline.

In the current study, 35.09% of trials had a negative trunk angle, 7.93% vertical (trunk angle = 0°), and the remaining 56.98% had a positive trunk angle, where the rider was inclined forward. A forward trunk angle is commonly seen in inexperienced riders and associated with *rectus abdominis* and the *lumbar erector spinae* contraction which is out of time with the horse’s movements; by contrast, riders with greater skill are better able to control their position and adopt a more vertical trunk angle (Terada, 2000). Increased forward trunk angle in this study is less likely due to inexperience; the novice riders in Terada (2000) had less than one-year riding experience, whilst participants in this study had been riding for an average of 26.1 years. Although time does not necessarily equate to expertise, a possible explanation for the higher percentage of positive trunk angles may be due to rider discipline. Participants in this study competed at dressage, show jumping, eventing and hunting, all of which require varying rider positions; for example, when jumping, riders are required to lean forward over the jump (Nankervis *et al.*, 2005) and so may habitually adopt a more forward position, by contrast, dressage riders are required to remain upright or slightly reclined (Bystrom *et al*., 2009; 2010; 2015). When riders adopt a forward trunk angle their centre of mass moves anteriorly; although this is a stable position it induces greater fatigue in the rider (Peham *et al*., 2010), possibly due to the posterior trunk doing greater work than the anterior musculature, in an attempt to maintain the rider’s balance. This may account for the significant reduction in prone strength post riding and the lack of change to anterior strength in the supine test.

Previous studies have focused on anterior trunk tests; Douglas (2017) assessed core strength in eventers of three different skill levels using a plank to fatigue (PTF) test and the front abdominal power test (FAPT), where the distance a 2kg medicine ball was thrown after an explosive concentric contraction was measured. Results suggested that better scores were achieved by more experienced riders; results for the PTF test were as follows: 63.5±27.3 seconds (novice), 100.3±60.0 seconds (intermediate) and 146.7±91.9 seconds (advanced), which are not dissimilar values to the supine scores in this study: 119.0 ± 94.7 (pre-riding) and 111.6 ± 115.2 (post-riding). Meyers and Sterling (2000) noted better than average core endurance in riders compared to sporting counterparts in the curl up (57±16 reps/min) and reverse sit up (37±13 reps/min). These studies indicate that riders have average-to-good core strength off the horse yet made could not comment on how this influenced the rider’s position. The current study attempted to bride this gap, concluded that as the rider’s position did not change as they fatigued over time, anterior core strength was sufficient for the required protocol. This was supported by the lack of fatigue, and in some instances improvements in score, during the supine test. The decrease in prone endurance from 159.6 ± 69.2 (pre-riding) to 132.2 ± 63.6 (post-riding) is a novel finding for equestrian literature, as previous studies have analysed anterior strength only. The reduction in strength is likely due to the riding position, as discussed, and, thus, it would be interesting to repeat this study on discipline specific groups and compare posterior core endurance in showjumpers compared to dressage riders.

The difference between right and left side plank scores pre and post riding was not significant, yet left side plank post riding was significantly lower than left side plank pre-riding. This suggests that the left core musculature had poorer endurance than the right, although this difference was very slight. Hobbs *et al.* (2014) and Nevison and Timmis (2013) identified greater muscular tension in the right-hand side of riders, which was linked to a reduction in flexibility on the left-hand side and likely handedness patterns. These slight differences between the side plank scores may be accounted for by an increase in right shoulder strength, as would be found in the general, right hand dominant, population (Perrin *et al*., 1987), which would have enabled participants to hold to right side plank position for longer.

*4.2 Trunk angle*

Trunk angle did not change over time, suggesting that core endurance in the participants was sufficient to cope with the demands of the protocol. This was unexpected as the author hypothesised that as participants fatigued, their trunk angle would increase, particularly in the canter. The reason for the opposite occurring may have been due to participants working at a self-selected intensity, mimicking a typical riding session, and thus, some riders may have been working harder than others. This study could have been improved by asking riders to state their rate of perceived exertion (RPE) when they dismounted after riding. Equally, studying rider position during more demanding conditions could be an interesting progression from this study.

This study corresponded with previous literature that trunk angle and position are significantly difference in each phase of gait at the trot (Lovett *et al*., 2005), with greater trunk angle observed in the outside phase of gait, when the rider’s seat was out of the saddle. This confirms that the use of the horse’s forelimb ground contacts to determine points of the stride were appropriate. In right trot all trunk angles were positive and, thus, associated with a forward trunk lean; in left trot positive values were present during the outside phase of gait, the sitting position of the trot, and negative values were present in the inside phase of the gait, when the rider was rising out of the saddle. Greater variation in trunk angle was, therefore, seen in the left trot, which may correspond to the slightly higher levels of fatigue in left side plank after riding. The difference in trunk angles between the left and right side seems remarkable, yet, as demonstrated in Figure 1, riders are not symmetrical. The point of interest from this study is that this asymmetry did not increase as the riders fatigued.

Advanced level riders demonstrate a trunk angle closer to the vertical, i.e. an upright position (Kang *et al*., 2010). This requires increased muscular strength as the speed of the gaits increases, due to increasing propulsive forces from the horse (Back and Clayton, 2001). In the rising trot a negative trunk angle is observed just prior to mid stance (Engell *et al*., 2016) and is associated with core muscle contraction to aid pelvic stability (Terada *et al*., 2004). An inability to appropriately contract these muscles may be a reason for the positive trunk angle observed in novice riders (Kang *et al.,* 2010; Schils *et al.,* 1993; Terada, 2000). Engell *et al*. (2016) suggested that elite riders are more “active” in their seat which enables them to control their position and, thus, trunk angle, more effectively. This was demonstrated by analysing the change in trunk angle between elite riders riding passively, with a trunk angle range of 1.4 to 7.6°, and elite riders riding actively, which ranged from -2.0 to 4.8°. Although the mean trunk angle between these two positions was not significantly different, active riding favoured a more negative trunk angle. It could be suggested, therefore, that participants in the current study, who were predominantly amateurs, may have ridden their horses in a more ‘relaxed’ manner, similar to the passive riding style in Engell *et al*. (2016), which may account for the 56.98% of positive trunk angles.

The only significant asymmetry in the canter was during trial canter 1- inside, where right trunk angle was greater than left (*p=0.011*). During this phase of gait, the horse’s inside front leg is vertical and is the only leg in contact with the ground, thus inclining the horse and rider forward – see Figure 3. As the rider is propelled forward by the lifting of the hind limbs off the ground, trunk angle becomes positive, and any underlying asymmetry in the rider may be exaggerated due to the horizontal force from the horse. This difference would not be observed in the outside phase of gait as the horse’s position in more horizontal. As the canter is the easiest, most synchronous gait to ride (Wolframm *et al*., 2013), perhaps riders became more synchronous with the horse during the 7 minutes of canter, which accounted for the similarity in trunk angles in trials 2.

*4.3 Asymmetry*

Rider asymmetry has been a popular theme in equestrian literature, as shown in Figure 1, and this study is no exception, identifying that right trunk angle was always greater than left trunk angle. This position suggests that the rider right shoulder is forward compared to the left, which concurs with Symes and Ellis (2009), who also identified that asymmetric shoulder positioning was accompanied by a thorax which was axially rotated left. This could explain why the left shoulder in the current study varied between positive and negative trunk angle, dependent on the phase of gait in the trot, whilst the right shoulder remained positive. This greater range of movement in the left side may have contributed to the increased fatigue experienced by the left lateral musculature as greater fatigue is noted when musculature develops compensatory patterns associated with skeletal asymmetry (Page and Frank, 2007).

Symes and Ellis (2009) noted a shorter right leg in all participants (n=17), correlating with the increased iliac crest height on the right observed by Hobbs *et al*. (2014) and Baxter *et al*. (2014) and an increase in pelvic muscle tension on the right in Hobbs *et al*. (2014) and Nevison and Timmis (2013). Guire *et al*. (2017) noted an increase in pressure on the left ischial tuberosity in all riders (n=30) and Hampson and Randle (2015) identified higher saddle pressures on the left-hand side 10 dressage riders during sitting trot, which reduced following an eight-week core strength programme. In addition, limited left side bending was observed 132 dressage riders and greater experience and year riding was linked with asymmetry (Hobbs et al., 2014). These authors suggested that increased muscular tension on the right was apparent from a predominantly right-handed population and caused a reduction in mobility on the left-hand side. Similarly, this pattern could have been attained by antalgic postures, as increased levels of pain were reported in riders of greater experience and years riding. The results of the current study, whilst appearing contentious initially, fit within the emerging pattern of rider asymmetry.

However, whilst identifying rider asymmetry is useful; understanding whether these asymmetries are habitual, acquired or developmental will be more important when trying to improve sports performance and equine welfare, which is markedly hindered by rider asymmetry (Byström *et al*., 2009; 2010; Clayton and Hobbs, 2017; Fruehwirth *et al*., 2004; Martin *et al*., 2016). The author recommends riders address their asymmetry as a primary focus, rather than their core strength. This study identified that core strength off the horse was equal, but that the left side fatigued slightly than the right more when riding, which could be due to an asymmetric position or an increase in right shoulders strength, and the posterior musculature fatigued more than the anterior. Horse riding appears to develop asymmetries; with more experienced riders and those who have been riding longer demonstrating greater asymmetry (Hobbs *et al*., 2014). Addressing differences in hip joint mobility and pelvic muscle tension may be an appropriate place to start, as this is the contact point with the saddle and horse.

Whilst there have been useful conclusions from this investigation; several limitations are associated with this study. The displacement of markers on tight fitting clothing to the bony landmarks underneath may occur, although, errors are likely to be consistent between individuals and so should not be material to the results. Video quality was reduced once files were imported to Dartfish, the use of a high-speed camera rather than an iPhone would have been preferable. The aim of this study was to test riders in field-based conditions to ensure ecological validity; speed, saddle type and stirrup length were not standardised, which may have contributed to the variation in trunk angles observed between participants. Future studies may wish to standardise intensity or increase the riding time or difficulty of the protocol, such as over a course of jumps, to increase the fatigue riders experience which may induce a change in trunk angle over time. Similarly, limiting the study to participants of the same discipline, or grouping results accordingly, may reduce the range of results and provide more specific recommendations. Equally, analysing asymmetry in a 3D motion capture suit or the Xsens body suit (Enschede, The Netherlands) will provide more accurate information on asymmetric rider positions and its associated impacts on rider strength and conditioning.

**CHAPTER FIVE**

**Conclusion and Practical Applications**

This study is the first to test rider core endurance and its potential influence on rider position. Greater fatigue was observed in posterior core musculature in this study, which may be due to 56.9% of trials having a positive trunk angle, or due to riders having above average anterior core endurance. Trunk angle did not change during the fatigue protocol, however, right trunk angle was greater than left trunk angle in all trials, suggesting rider asymmetry was present from the onset. Focus should be placed on reducing these asymmetries prior to addressing core endurance in order to improve rider performance and equine welfare.

**REFERENCES**

Abdelraouf, O. R., and Abdel-aziem, A. A., 2016. The relationship between core endurance and back dysfunction in collegiate male athletes with and without nonspecific low back pain. International Journal of Sports Physical Therapy 11: 337.

Alexander, J., Hobbs, S. J., May, K., Northrop, A., Brigden, C., and Selfe, J., 2015. Postural characteristics of female dressage riders using 3D motion analysis and the effects of an athletic taping technique: A randomised control trial. Physical Therapy in Sport 16:154-161.

Back, W., and Clayton, H. 2001. Equine Locomotion. Blackwell Publishing: London.

Back, W., Schamhardt, H. C., and Barneveld, A., 1997. Kinematic comparison of the leading and trailing fore‐and hindlimbs at the canter. Equine Veterinary Journal 29: 80-83.

Baxter, J., Hobbs, S., and Chohan, A., 2014. Preliminary Assessment of Dressage Asymmetry within Sitting Trot and Shoulder‐in. Equine Veterinary Journal 46: 5.

Byström, A., Rhodin, M., von Peinen, K., Weishaupt, M.A., and Roepstorff, L., 2009. Basic kinematics of the saddle and rider in high-level dressage horses trotting on a treadmill. Equine Veterinary Journal 41: 280-284.

Byström, A., Rhodin, M., Von Peinen, K., Weishaupt, M. A., and Roepstorff, L., 2010. Kinematics of saddle and rider in high‐level dressage horses performing collected walk on a treadmill. Equine Veterinary Journal 42: 340-345.

Byström, A., Roepstroff, L., von Peinen, K., Weishaupt, M.A., and Rhodin, M., 2015. Differences in rider movement pattern between different degrees of collection at the trot in high-level dressage horses ridden on a treadmill. Human Movement Science 41: 1-8.

Clayton, H. M., and Hobbs, S. J., 2017. The role of biomechanical analysis of horse and rider in equitation science. Applied Animal Behaviour Science 190: 123-132.

Douglas, J.L., 2017. Physiological Demands of Eventing and Performance Related Fitness in Female Horse Riders (Doctoral dissertation, University of Worcester).

Douglas, J. L., Price, M., and Peters, D. M., 2012. A systematic review of physical fitness, physiological demands and biomechanical performance in equestrian athletes. Comparative Exercise Physiology 8: 53-62.

Eckardt, F., and Witte, K., 2016. Kinematic Analysis of the Rider According to Different Skill Levels in Sitting Trot and Canter. Journal of Equine Veterinary Science 39: 51-57.

Engell, M.T., Clayton, H.M., Egenvall, A., Weishaupt, M.A., and Roepstorff, L., 2016. Postural changes and their effects in elite riders when actively influencing the horse versus sitting passively at trot. Comparative Exercise Physiology 12: 27-33.

Faries, M.D. and Greenwood, M., 2007. Core training: stabilizing the confusion. Strength and Conditioning Journal 29: 10.

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

Gandy, E. A., Bondi, A., Hogg, R., and Pigott, T. M., 2014. A preliminary investigation of the use of inertial sensing technology for the measurement of hip rotation asymmetry in horse riders. Sports Technology 7: 79-88.

Greve, L., and Dyson, S., 2013. The horse–saddle–rider interaction. The Veterinary Journal 195: 275-281.

Guire, R., Mathie, H., Fisher, M., and Fisher, D., 2017. Riders’ perception of symmetrical pressure on their ischial tuberosities and rein contact tension whilst sitting on a static object. Comparative Exercise Physiology 13: 7-12.

Hampson, A., and Randle, H., 2015. The influence of an 8-week rider core fitness programme on the equine back at sitting trot. International Journal of Performance Analysis in Sport 15: 1145-1159.

Hobbs, S.J., Baxter, J., Broom, L., Dagg, L.A., Sinclair, J.K., and Clayton, H.M., 2014. Posture, flexibility and grip strength in horse riders. Journal of Human Kinetics 42: 113-125.

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

Kibler, W. B., Press, J., and Sciascia, A., 2006. The role of core stability in athletic function. Sports Medicine 36: 189-198.

Koblbauer, I. F., van Schooten, K. S., Verhagen, E. A., and van Dieën, J. H., 2014. Kinematic changes during running-induced fatigue and relations with core endurance in novice runners. Journal of Science and Medicine in Sport 17: 419-424.

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

Lee, D. G., 2011. The Pelvic Girdle: An integration of clinical expertise and research. Elsevier Health Sciences.

Lovett, T., Hodson-Tole, E., and Nankervis, K., 2005. A preliminary investigation of rider position during walk, trot and canter. Equine and Comparative Exercise Physiology 2: 71-76.

Martin, P., Cheze, L., Pourcelot, P., Desquilbet, L., Duray, L., and Chateau, H., 2016. Effect of the rider position during rising trot on the horse’s biomechanics. Journal of Biomechanics 49: 1027-1033.

McCaw, S. T., 1992. Leg length inequality. Sports Medicine 14: 422-429.

McGill, S. M., 2015. Low Back Disorders, 3rd Edition. Human Kinetics.

McGill, S. M., Childs, A., and Liebenson, C., 1999. Endurance times for low back stabilization exercises: clinical targets for testing and training from a normal database. Archives of Physical Medicine and Rehabilitation 80: 941-944.

Michael, A.T., McManus, A.M., and Masters, R.S., 2005. Development and validation of a core endurance intervention program: implications for performance in college-age rowers. Journal of Strength and Conditioning Research 19: 547.

Meyers, M.C., and Sterling, J.C., 2000. Physical, hematological, and exercise response of collegiate female equestrian athletes. Journal of sports medicine and physical fitness 40: 131.

Münz, A., Eckardt, F., Heipertz-Hengst, C., Peham, C., and Witte, K., 2013. A preliminary study of an inertial sensor-based method for the assessment of human pelvis kinematics in dressage riding. Journal of Equine Veterinary Science 33: 950-955.

Münz, A., Eckardt, F., and Witte, K., 2014. Horse–rider interaction in dressage riding. Human Movement Science 33: 227-237.

Nadler, S.F., Malanga, G.A., Bartoli, L.A., Feinberg, J.H., Prybicien, M., and DePrince, M., 2002. Hip muscle imbalance and low back pain in athletes: influence of core strengthening. Medicine and Science in Sports and Exercise 34: 9-16.

Nankervis, K., Dumbell, L., Herbert, L., Winfield, J., Guire, R., and Launder, E., 2015. A comparison of the position of elite and non-elite riders during competitive show jumping. Comparative Exercise Physiology 11: 119-125.

Nevison, C., and Timmis, M., 2013. The effect of physiotherapy intervention (PI) to the pelvic region of experienced riders on seated postural stability and symmetry of pressure distribution to the saddle: a preliminary study. Journal of Veterinary Behaviour 8: 261-264.

Page, P., and Frank, C., 2007. The Janda approach to chronic musculoskeletal pain. TheraBand Academy. Available at: http://www.thera-bandacademy.com/elements/Clients/docs/The-Janda-Approach-Musculoskeleta-Pain\_\_011606\_151616.pdf

Pantall, A., Barton, S., and Collins, P., 2009. Surface electromyography of abdominal and spinal muscles in adult horse riders during rising trot. XXVII International Conference on Biomechanics in Sport, Limerick, Ireland.

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

Peham, C., Kotschwar, A.B., Borkenhagen, B., Kuhnke, S., Molsner, J., and Baltacis J., 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. The Veterinary Journal 184: 56-59.

Perciavalle, V., Di Corrado, D., Scuto, C., Perciavalle, V., and Coco, M., 2014. Attention and blood lactate levels in equestrians performing show jumping. Perceptual and Motor Skills 118: 733-745.

Perrin, D.H., Robertson, R.J., and Ray, R.L., 1987. Bilateral isokinetic peak torque, torque acceleration energy, power, and work relationships in athletes and nonathletes. Journal of Orthopaedic and Sports Physical Therapy 9: 184-189.

Roberts, M., Shearman, J., and Marlin, D., 2009. A comparison of the metabolic cost of the three phases of the one-day event in female collegiate riders. Comparative Exercise Physiology 6: 129-135.

Schils, S.J., Greer, N.L., 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.

Schöllhorn, W.L., Peham, C., Licka, T., and Scheidl, M., 2006. A pattern recognition approach for the quantification of horse and rider interaction. Equine Veterinary Journal 36: 400-405.

Sung, B.J., Jeon, S.Y., Lim, S.R., Lee, K. E., and Jee, H., 2015. Equestrian expertise affecting physical fitness, body compositions, lactate, heart rate and calorie consumption of elite horse riding players. Journal of Exercise Rehabilitation 11: 175–181.

Symes, D., and Ellis, R., 2009. A preliminary study into rider asymmetry within equitation. The Veterinary Journal 181: 34-37.

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: 89-93.

Terada, K., Mullineaux, D.R., Kiyotada, K., and Clayton, H.M., 2004. Electromyographic activity of the rider’s muscles at trot. Equine and Comparative Exercise Physiology 1: 193-198.

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.

Westerling, D., 1983. A study of physical demands in riding. European Journal of Applied Physiology and Occupational Physiology 50: 373-382.

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

Wolframm, I.A., 2013. The Science of Equestrian Sports: Theory, Practice and Performance of the Equestrian Rider. Routledge.

Wolframm, I. A., Bosga, J., and Meulenbroek, R.G., 2013. Coordination dynamics in horse-rider dyads. Human Movement Science 32: 157-170.

Yoshizaki, K., Hamada, J., Tamai, K., Sahara, R., Fujiwara, T., and Fujimoto, T., 2009. Analysis of the scapulohumeral rhythm and electromyography of the shoulder muscles during elevation and lowering: comparison of dominant and nondominant shoulders. Journal of Shoulder and Elbow Surgery 18: 756-763.

**APPENDIX A**

**PARTICIPANT INFORMATION SHEET**

**Name of Researcher**: Phoebe Bolton

**Contact Details**: 07912629350, 156558@stmarys.ac.uk

**Title of Study**: To what extent does horse rider trunk angle relate to rider core strength? (working title)

Thank you for expressing interest in this study. Your participation will be greatly appreciated and in doing so you are helping shape the future for evidence based practice within the equestrian community. The aim of this research is to investigate whether rider position is related to rider core strength. Several studies have looked at the timing of core muscle activation in riders, but none have looked at the relationship between core strength and rider position. This is important as riders are frequently told by instructors that they need to use their core muscles more; this study will help inform riders and trainers about how much core strength is required.

This study is being conducted by Phoebe Bolton, she is a human and equine osteopath who is completing her masters in strength and conditioning at St. Mary’s University. The results of this study will be publicly available online as part of Phoebe’s thesis. This study will be designed and funded by Phoebe Bolton, please do not hesitate to contact her if you have any questions; her phone number and email can be found at the top of the page.

You have been contacted to take part in this study because you are a competent, amateur horse rider in the Gloucestershire area. You are eligible because you are between the ages of 18-50, have been riding for more than three years, own your own horse and riding is your predominant form of exercise. Unfortunately, people with chronic back problems or scoliosis, spinal or abdominal surgery, and chronic respiratory or cardiopulmonary issues cannot be included in this study. You can refuse to take part in this study and you may opt out at any time, without justification; please fill in the Withdraw from Study section on the consent form and send it to Phoebe.

**Phoebe will come to your yard to do the filming, please make sure there is space for her to use a clean stable for the exercises and also an arena for the riding**. This study will require your horse will be ridden in his usual tack, please ensure he is sound and capable of 35 minutes of work, predominantly trot and canter. No change of clothes will be necessary during the day, but please wear **DARK**, tight fitting jodhpurs and long sleeve top. As always, riding hats and boots must be worn at all times when mounted. You will do 4 core stability tests 10 minutes before riding for 35 minutes and then repeat these tests afterwards. There is no ‘intervention’ in this study, the researcher will simply be looking at how long you can hold the core stability tests for and your position when riding. As a result, there will be no added risk or side effects to you or your horse and no need for special precautions, above and beyond those already required for horse riding. It is unlikely that you should feel tired after the trunk tests; however, if you would like to take some more time before mounting your horse because you feel tired then please just take a break and let Phoebe know. Please find below an outline of the riding protocol, so you can familiarise yourself with the sequence of events.

**Exercise protocol:** Core exercises will be demonstrated to you on the day and will be done before and immediately after riding. There are 4 exercises and you will be given 2 minutes rest between each one, totalling 10 minutes. The riding protocol below will take 35 minutes, followed by 10 minutes more of core exercises. Your participation today will require you for a total of 80 minutes.

**Riding Protocol:** The directions in **bold** are when data will be collected. A 20 second countdown will be given for you to enter the data collection area (between H and K). Please don’t rush or panic, there is a whole minute to collect the data so if you are the other side of the arena when the 20 seconds is called just continue at the same pace and enter when you are ready. Once one set of data has been collected, e.g. minute 28 canter right, you will need to change the rein and enter the data collection area in the opposite direction, this is to make sure we have data from your left and right side at as similar a time as possible. During the ‘working trot’ and ‘working canter’ sections, minutes 8-17 and 22-27, please change the rein once or twice.

|  |  |
| --- | --- |
| **Minutes** | **Gait and direction** |
| **0-5** | Warm up in walk and trot |
| **6** | **Trot left between H and K, change rein FXH** |
| **7** | **Trot right between K and H** |
| **8-17** | Working trot on both reins |
| **18** | **Trot left between H and K, change rein FXH** |
| **19** | **Trot right between K and H** |
| **20** | **Canter right between K and H, change rein MXK** |
| **21** | **Canter left between H and K** |
| **22-25** | Working canter on both reins |
| **26** | **Canter right between K and H, change rein MXK** |
| **27** | **Canter left between H and K** |
| **38-32** | Cool down at trot and walk, followed by dismount |
| **35** | Repeat core endurance tests |

**Confidentiality:**

All your details will be kept locked and your videos stored securely online. Your results will be numbered and so you will not be identifiable in the results. There is no financial gain for joining in this study, but the results will be given to you by email at the end of the study. Please retain a copy of this form and the consent form until the end of the study. If you have any questions, please do not hesitate to contact me using the details below

Again, many thanks for your participation

Kind regards,

**Phoebe Bolton**

**APPENDIX B**

**PARTICIPANT CONSENT FORM**

**Name of Researcher**: Phoebe Bolton

**Contact Details**: 07912629350, 156558@stmarys.ac.uk

**Research Supervisor**: Hayley Legg **Contact Details**: [Hayley.legg@stmarys.ac.uk](mailto:Hayley.legg@stmarys.ac.uk)

**Title of Study**: To what extent does horse rider trunk angle relate to rider core strength?

**Name of Participant**:……………………………………………………………………..

**Phone number**………………………………………………………………………………

**Email**…………………………………………………………………………………………….

Many thanks for agreeing to be part of this study. Please read the following carefully as sign at the bottom. Please retain this form and a copy of the Participant Information Sheet until the end of this study. Please contact the researcher if you have any questions or queries.

Participant declaration:

* I willingly agree to take part in the above research. I have read and understand the Participant Information Sheet attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
* I am aware horse riding is an unpredictable sport and am undertaking this riding protocol at my own risk to my myself and my horse.
* I am not aware of any health or medical problems which could interfere with these results.
* I agree to being filmed when riding and for these results being published online, in journals, as part of an MSc dissertation and elsewhere at the discretion of the researcher.
* I have been informed that the confidentiality of the information I provide will be safeguarded, in accordance with the Data Protection Act.
* I understand that I am free to withdraw from the research at any time, for any reason and without prejudice. Please email Phoebe.
* I am free to ask any questions at any time before and during the study.
* I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Signed………………..…………………………………………………. Date………………………….........

**APPENDIX C**

**HORSE AND RIDER DETAILS FORM**

**RIDER**

Name………………………………………………………………………………………….

Age…………………………………… Height…………………… Gender Male / Female

Years spent riding ………………………………………………… ………………….……..

Hours riding per week ……………………………………………………………………….

Typical riding week (hack/jump/school)……………………………………………………...

……………………………………………………………………………………………………………………………………………………………………………………………………

Current Riding level: Unaffiliated Dressage / Unaffiliated SJ/eventing / BD / BSJA / BE

……………………………………………………………………………………………………………………………………………………………………………………………………

Previous Riding level (if different): Unaffiliated Dressage / Unaffiliated SJ/eventing / BD / BSJA / BE

Is riding your primary form of exercise Yes / No

If no, give details of other exercise………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

Previous injuries/surgery/hospitalisations……………………………………………………..

…………………………………………………….…………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

**HORSE**

Breed………………………………Height……………………Age……………………..

Sex: Gelding / Mare / Stallion

Saddle type: GP / Dressage / Jumping

Injuries/Surgeries……………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………

**APPENDIX D**

**ETHICS APPROVAL FORM**

